4 Externalities and Public Policy

When the European settlers arrived on the Atlantic coast of North America, they found one of the richest cod fisheries in the world on the Grand Banks and Georges Bank off Newfoundland and New England. This fishery proved to be a rich economic resource, and it played no small role in the early economic development of North America as a source of exports. By 1992, the government of Canada had to close the Grand Banks fishery because of plummeting fish harvests; in New England, the Georges Bank fishery was closed two years later. What went wrong here? Why didn't the invisible hand of market forces lead those who were dependent on the fishery for their livelihood to husband this valuable resource to prevent its depletion?

A fishery is a good example of an industry plagued by an externality. An **externality** is present when an action by an individual producer or consumer affects other parties, without payment or compensation for the cost or benefit affecting them. An externality exists in the fishery because one person's fishing activity decreases the stock of fish, making it necessary for others to fish longer in order to catch a given quantity of fish. The individual fisher ignores this external cost on others when deciding how much to fish. Many economic activities, as well as fishing, have external costs. These costs may result from the excessive depletion of resources, hazards to the public's safety, the pollution of air and water, and other things. The presence of externalities is a form of market failure, meaning that the market allocation of resources is not efficient. The inefficiency caused by externalities means that the government can improve efficiency and potentially make everyone in the economy better off. The government does this with policies controlling the activities that have externalities. For example, a large body of government regulation is directed at controlling activities that pollute the environment.

TYPES OF EXTERNALITIES

The concept of an externality is quite general, and economists have identified and classified many different types of externalities. In this section, we identify and describe externalities according to the most common classifications.

Cost and Benefit Externalities

Perhaps the most important defining characteristic of externalities is whether they are cost or benefit externalities. An activity with a *cost externality* imposes net costs on other people without their being compensated. The fishing industry has a cost externality, and so does producing or consuming goods that cause pollution, such as gasoline. An activity with a *benefit externality* confers a benefit on other people without their having to pay for it. Immunization against a communicable disease confers a benefit externality. For example, when a child is immunized against polio, other children benefit because the immunized child cannot contract polio and infect them. Since the children who benefit indirectly do not have to pay the child who is immunized, the benefit is uncompensated and therefore an externality.

Sometimes benefit and cost externalities are described as positive and negative externalities respectively. We should not think, however, that a benefit externality is a positive thing for the economy. As we see below, benefit externalities create inefficiencies just as cost externalities do. Benefit and cost externalities are also called external economies and external diseconomies.

Consumption and Production Externalities

Another classification is based on whether an externality is caused by consuming or producing a good. In some cases, externalities are caused by both processes. For example, gasoline consumption imposes a cost externality because motorists pollute the air when they drive, and gasoline production imposes a cost externality because air quality is reduced around the oil refineries. On the other hand, paper consumption does not cause significant externalities (except, perhaps, litter), while paper production causes air pollution and puts hazardous wastes, such as dioxin, into rivers and lakes. Hence we can classify the paper industry as subject to a production externality.[1] The distinction between consumption and production externalities may be important for the design of the government policies that control the problem.

Production externalities can be further classified as *output* externalities and *input* externalities. The distinction concerns whether the external benefit or cost is directly related to the output of the firm or to the firm's use of particular factors of production (inputs). For example, the production of electricity often causes a cost externality by polluting the air, but this externality depends on the quantities of inputs used—for instance, the amount and type of fuel used by the generating plant (say, high- or low-sulfur coal)—and not on the output of electricity per se. The quantity of electricity produced by hydroelectric plants causes little or no air pollution. In contrast, the externality in the fishing industry is an output externality because the external cost depends on the quantity of fish caught rather than the means used to catch them.

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[1]For example, imported paper does not cause an external cost in the country where it is consumed—only in the country where it is produced.

Network Externalities

An interesting type of externality is called a **network externality,** because there is an external benefit (or cost) associated with being part of a "network." With this type of externality, the benefit or cost of a good or service to one user depends on the number of people using the good, rather than on the amount consumed or produced. A good example is a person's decision to get a telephone or to subscribe to an e-mail service. When individuals get a telephone, not only can they call others, but others can call them.[2] A telephone would be of no use if no one else had one. The consumer's benefit from a telephone depends on the number of users on the telephone network.

Recently, economists have focused their attention on network externalities because of the importance of technology adoption and communication in modern economies. Network externalities introduce the phenomenon of the *industry standard,* which develops when a product or a technology is adopted by a new user simply because "everyone else uses it." Even if a cheaper and better substitute is available, consumers will choose a good or process that is established as the industry standard because it is more costly for individuals to "go it alone." That is, a network externality may create an inefficiency when an inferior good is established as the industry standard. Examples of an industry standard include the VHS videotape format (which eclipsed the earlier beta format by the late 1980s), PC computer technology (which accounts for about 85 percent of personal computers sold), and the "QWERTY" keyboard on the computer, which is a holdover from typewriter technology.

EXTERNALITIES AND THE EFFICIENCY OF MARKETS

Externalities are a major reason that an economy might not rely solely on an unfettered market system to allocate resources (hence the interest by public finance economists in them). Specifically, the market quantity of a good is greater than the efficient quantity when an external cost is present, whereas the market quantity of a good is less than the efficient quantity when an external benefit is present. That is, too much of the economy's resources is devoted to producing goods with cost externalities, and too little is devoted to producing goods with benefit externalities.

Inefficiency caused by a cost externality is shown in Figure 4.1, which gives supply and demand for a good with an external cost: the car burglar alarm. This is a good with an external consumption cost because it disturbs the neighbors when it goes off accidentally in the middle of the night. The height of the demand curve indicates the marginal willingness to pay (MWTP) by the buyer of the car alarm, and the height of the supply curve indicates the marginal cost of producing the alarms. The market equilibrium quantity of alarms, found by the intersection of the supply and demand curves, is Q_e. The prevailing market price of alarms is P_e, which is equal to the MWTP of the buyer and the marginal cost of production.

The marginal external cost (MEC) of a car alarm, caused by disturbing the neighbors, is not included in the market price and is disregarded by the consumer when choosing to buy an alarm.[3] If we add MEC to the supply price (the marginal private

[2]Of course, that external benefit may be a cost to person getting the telephone, as those annoying telemarketing calls at dinner time illustrate.

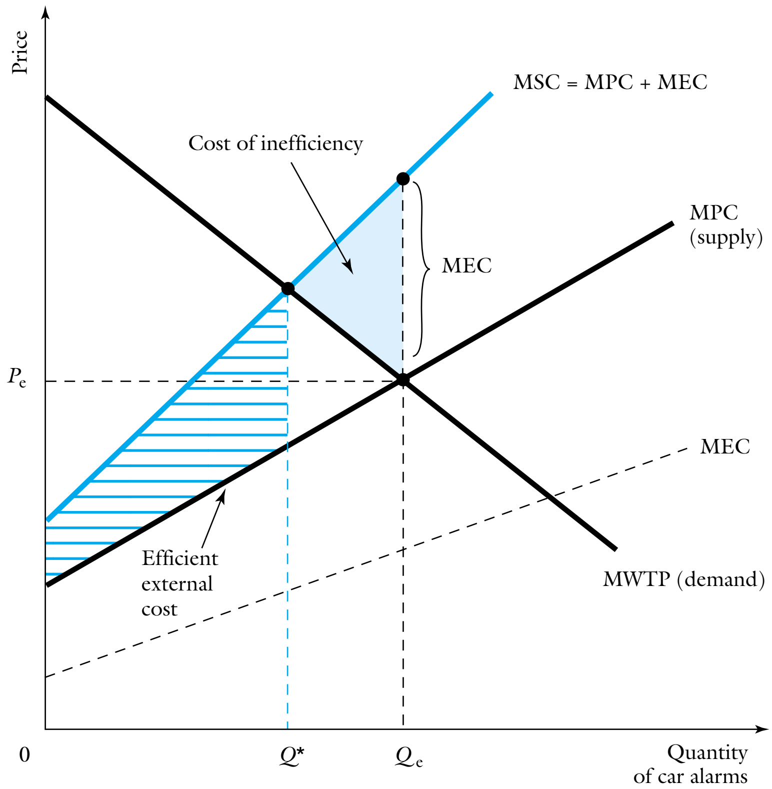

Figure 4.1

A Good with a Cost Externality

The marginal social cost (MSC) of car alarms exceeds the marginal private cost (MPC) because of the marginal external cost (MEC) caused by annoyance to third parties. The market equilibrium quantity Q_e is greater than the efficient quantity Q^* because market participants buy alarms as long as their MWTP exceeds the MPC of the alarm. The cost of inefficiency (or deadweight loss) is equal to the area of the shaded triangle. At the efficient quantity Q^*, the external cost of alarms is not zero. However, the MWTP of a buyer of an alarm is equal to the MSC of the alarm.

cost, MPC), we get the *marginal social cost* (MSC) of a car alarm. In Figure 4.1, the vertical distance between the MSC curve and the supply curve is MEC per alarm.

The efficient quantity Q^* of car alarms is the one at which the buyer's MWTP is equal to MSC. The efficient quantity is found by the intersection of the demand curve and the MSC curve. As we see, Q^* is smaller than the market equilibrium quantity because of the external cost. The reason the market quantity is greater than the efficient quantity is that the buyer does not take into account the marginal external cost of the alarm, only its market price. Car alarms appear cheaper to the buyers than they really are to the economy as a whole. The disturbance cost borne by the neighbors is part of the cost of a car alarm to the economy, but it is external to the buyers and they disregard it.

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[3]This assumes that the costs of waking up the neighbors are not directed back to the alarm owner—say, in the form of nasty phone calls.

The cost of the inefficiency caused by the externality is measured by the area of the shaded triangle in Figure 4.1. This area is the excess of the MSC of the alarm over the MWTP of the buyers for the excess quantity of car alarms purchased (Q_e minus Q^*). The area of this triangle is equal to half the excess quantity of car alarms times the marginal external cost at the market output. In other words, we can measure the cost of the inefficiency created by a cost externality as

$$\frac{1}{2} \cdot \text{MEC} \cdot (Q_e - Q^*).$$

Note that the cost of inefficiency caused by the externality is not the same as the total cost imposed on the neighbors. At the efficient quantity Q^* there is no cost from inefficiency, but the neighbors still suffer the nuisance of car alarms going off in the night, albeit fewer of them. In other words, the existence of an external cost does not mean we should ban car alarms in order to eliminate the external cost altogether. Nor does efficiency require that the neighbors be compensated for being disturbed. While compensating disturbed neighbors seems like a fair thing to do, it is not necessary for efficiency, because equity and efficiency are different things. The inefficiency caused by the cost externality simply means that too many car alarms are purchased as a result of market forces. Efficiency requires that the quantity of car alarms be that at which the total cost of the alarm, including the external cost, is equal to the buyer's willingness to pay for it.

Figure 4.2 illustrates the case of a good with a benefit externality: smoke alarms in apartments. This is a good example of a private good with a benefit externality. When individuals buy smoke alarms for their apartments, they confer a benefit on their neighbors. The early detection of a fire in the purchaser's apartment reduces the danger and loss of property for the neighbors, even if they have their own alarms. Therefore everyone in an apartment building, not just the person purchasing the alarm, derives benefits from the purchase.[4]

In Figure 4.2 we see the demand and supply curves for smoke alarms by people in the apartment building. The height of the demand curve equals the purchaser's marginal *private* willingness to pay (MPWTP) for a smoke alarm, and the height of the supply curve is the marginal private cost (MPC) of producing smoke alarms as given by the market price of smoke alarms. The market equilibrium quantity of smoke alarms Q_e is found by the intersection of the supply and demand curves, and the equilibrium market price is P_e. At this price, everyone with an MWTP for a smoke alarm at least as high as the market price will purchase one.

The marginal *social* willingness to pay (MSWTP) for a smoke alarm is greater than the purchasers' MWTP because of the marginal external benefit (MEB). The marginal external benefit is the marginal willingness of everyone living in the building to pay for a smoke alarm in the purchaser's apartment. This marginal external benefit is ignored by the purchaser of the alarm, who cannot charge the other apartment dwellers for the benefit he or she confers on them by purchasing an alarm.

[4]The smoke alarm is not a public good in the sense that one smoke alarm is enough to benefit everyone. Each apartment dweller has his or her own smoke alarm, but an alarm in another apartment provides some benefits as well.

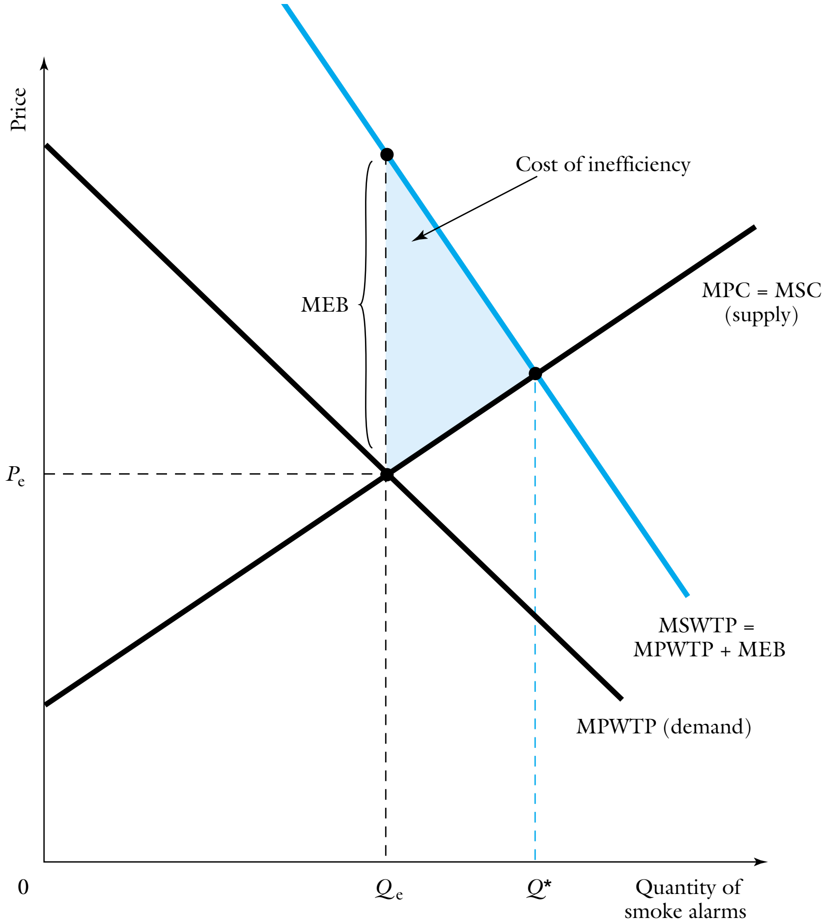

Figure 4.2

A Good with a Benefit Externality

The marginal social willingness to pay (MSWTP) for smoke alarms is greater than the marginal private willingness to pay (MPWTP) by the buyers because of the marginal external benefit (MEB) conferred on neighbors. The market equilibrium quantity Q_e is less than the efficient quantity Q^* because market participants buy alarms only if their MWTP is equal to the MPC of the alarm. They ignore the external benefit for the neighbors. The cost of inefficiency (or deadweight loss) is equal to the area of the shaded triangle.

Adding the marginal external benefit to the purchaser's MWTP gives the MSWTP. The vertical distance between the MPWTP (demand) curve and the MSWTP curve is the MEB. The efficient quantity of smoke alarms Q^* is found where the MSWTP curve intersects the supply curve.

In Figure 4.2, we see that a benefit externality causes a cost from inefficiency, just as a cost externality does. In this case, market forces bring forth a quantity of smoke alarms that is less than the efficient quantity, causing an inefficiency cost. It is equal to the area of the shaded triangle in Figure 4.2, which is the amount by which the market quantity falls short of the efficient quantity (Q^* minus Q_e units) multiplied by one-half the excess of the MSWTP over the marginal cost at the market equilibrium quantity.

Relevant and Irrelevant Externalities

An old adage says that "when you have a hammer in your hand, everything looks like a nail." This is true for externalities. Because of the importance of externalities to policy, once the concept is understood there is a tendency to find them everywhere. This is not hard to do because the modern economy is very interdependent—"everything depends on everything." However, we must be careful because many of the "externalities" are not a cause of market failure after all. For this reason, economists often identify externalities as *relevant* and *irrelevant* to the question of economic efficiency.

An example of an irrelevant externality is a good that has an inframarginal externality. An **inframarginal externality** occurs when the size of the external benefit or cost imposed on others does not depend on small changes in the quantity of the good around the market equilibrium quantity. With an inframarginal externality, changes in the market quantity do not affect efficiency. To give a unimportant example, when people walk by a newspaper box they often read the headlines. This is an external benefit from selling newspapers, but it does not depend on the quantity of newspapers sold (assuming the same number of boxes). Whether 1 paper or 20 papers are sold does not affect the benefits to the passersby.

No inefficiency is caused by inframarginal externalities. We see this result in Figure 4.3. Instead of newspapers, we consider a more important case: education. It is sometimes argued that education is a positive externality activity because educating people benefits others as well as the people educated. This observation is no doubt true, but it may not mean that people choose too little education.[5] For example, one external benefit from education comes from literacy. When an individual is made literate, this benefits others in the economy because they can communicate in writing with him or her. Imagine, for example, how inconvenient it would be not to write letters (or e-mail) to friends because they are illiterate.

If the external benefit from literacy is realized after fewer years of education than people would acquire for themselves, literacy is an inframarginal benefit. For instance, suppose people are fully literate after 10 years in school, but everyone goes to school for at least 12 years. Increasing education will increase private benefits but not the external benefit from literacy. In Figure 4.3, the private MWTP for education is shown by the downward-sloping curve, and the marginal cost of education is assumed to be constant. We assume that an inframarginal benefit externality is generated by the first 10 years of education. Adding the external benefit to the private MWTP, we obtain the curve labeled MSWTP, which is equal to the marginal social willingness to pay for a year of education less than 10 years. No marginal external benefit is present in education beyond 10 years. As shown, the individual has an incentive to acquire more than 10 years of education, so the full external benefit has

[5]The following example is meant to suggest, not that education does not have a marginal external benefit, but that some of the external benefits of education do not necessarily lead to inefficient private decisions.

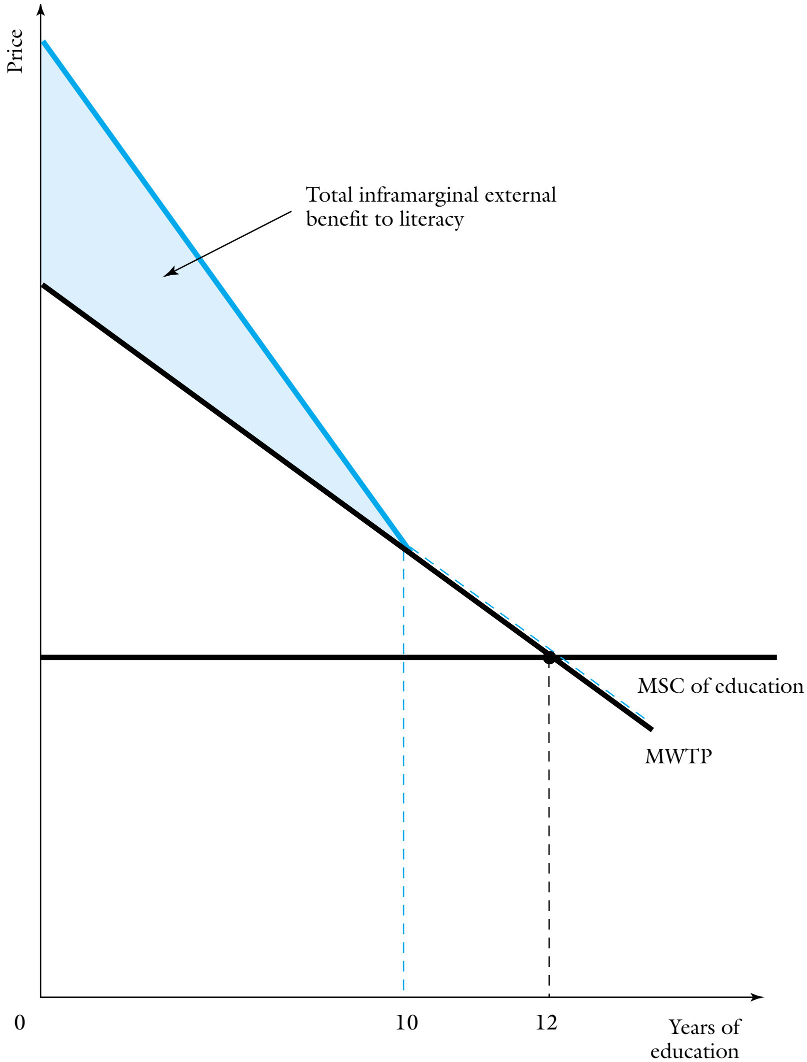

Figure 4.3
An Inframarginal Externality
The market equilibrium is efficient if an external benefit or cost is *inframarginal.* In this example a marginal external benefit (perhaps from increased literacy) is present for the first 10 years of an individual's education, but not for more. The MSWTP is equal to the MPWTP beyond 10 years of education. Since the MSWTP for education is equal to the MC of education at 12 years, the quantity of education chosen by the individual is efficient.

been realized, and the government need not provide incentives to increase educational attainment.

Another example of an irrelevant externality is a pecuniary externality. A **pecuniary externality** occurs because an individual's decision affects others through a change in market prices. Suppose a consumer who wants a brighter smile decides to buy more toothpaste. The position of the market demand curve, which includes the purchase decisions of all consumers of toothpaste, determines the market price. The change in the consumer's demand shifts the market demand curve slightly to the right, which increases the price of toothpaste if the supply curve is upward-sloping. Of course, the effect on price is very small, perhaps a fraction of a cent, so the individual ignores it when deciding to buy more toothpaste. That sounds like an externality. Millions of other toothpaste consumers pay a slightly higher price because this consumer decided to buy more toothpaste. How is this different from the case of the individual fishing boat that catches more fish and creates external costs for other fishing boats?

The difference is that an *offsetting* externality is present in this case. Although an individual's increase in consumption raises the price slightly, this does not cause a net loss to the economy. Consumers pay more, but toothpaste producers receive a higher price and earn a higher profit (that is, higher producer's surplus). In other words, the decision to consume more toothpaste just transfers consumer's surplus into producer's surplus.[6] This affects the distribution of income in the economy but does not make it more or less efficient.

EXTERNALITIES AND PROPERTY RIGHTS

Sometimes an institution is so ingrained and so natural that we don't notice it until it is missing. Such is the case with the institution of property rights. A *property right* is a legal rule of entitlement that grants the owner of a property the right to enjoy the benefits it provides, to command payment (emolument) if the property is used for the benefit of others, to prevent trespass, and to sue for compensation (damages) in the event that he or she loses the benefits from the property because of actions by others. Although the fundamental theorem of welfare economics described in Chapter 2 does not mention property rights, the existence of property rights is presumed for a well-functioning market system. For market forces to direct an economic resource into its highest-valued use, a complete and unambiguous system of property rights to the resource is needed. Property rights allow the owner to appropriate the benefits of finding the more highly valued use. When property rights are missing or ambiguous, the market is not likely to perform this function. The main point of the subsequent discussion is that the absence of property rights is one reason externalities exist.

The Tragedy of the Commons

In the medieval English village there was a pasture, or commons, where all villagers were free to graze their cattle. Villagers were allowed to graze as many cattle as they liked on the commons, and the result was severe overgrazing. In comparison with the commons, privately owned pastures were rich with grass. Despite an overgrazed commons that supported few cattle, no villager had an incentive to restrain his or

[6] Consumer's surplus was explained in Chapter 2. Producer's surplus is the area above the supply curve below the price received by the sellers. It is equal to the economic profit of the producers.

her own grazing and let the grass grow. Any benefits from an act of conservation would mostly benefit the other villagers, while the cattle of the person who showed restraint would get less food.

In 1968, the ecologist Professor Garrett Hardin of the University of California at Santa Barbara described seemingly irrational outcomes like that of the overgrazed commons as the "tragedy of the commons." In fact, the tragedy of the commons is just the prisoner's dilemma problem explained in Chapter 3. When a pasture is owned in common, the individual villagers make a rational decision to let their own cattle graze as much as possible, even if that outcome is inefficient and makes everyone in the village worse off. More than a decade before Hardin, the tragedy of the commons in the unregulated fishery was described by Professor H. Scott Gordon of Indiana University. Gordon showed that free access to a common fishing ground will lead to overfishing, even to the point of depleting the stock of fish. It is ironic that in light of this knowledge, and despite government regulation, we should see the tragedy of the commons at the Grand Banks and Georges Banks fishery 40 years later.

Gordon was the first to point out that a stock of fish swimming in the water of a fishery to which everyone has free access is a **common property** resource. A common property resource is rival and nonexcludable: When more is used by one person, less is available for others; and because a common property resource is owned by everyone, no one can be excluded. In this case, no one has an incentive to conserve the resource because he or she cannot reap the benefit of conservation. Gordon pointed out that the problem in the fishery is that no property right is assigned to a fish until it is caught. Just as medieval villagers could claim rights to the pasture only by letting their cattle graze on the commons, so fishers can claim rights to the fish only by catching them. The result is competitive overfishing of the commons and drastic reductions in the stocks of fish, to the detriment of all.

How does the fact that fish in the sea are common property show up as a cost externality? The cost of catching a fish is determined largely by how long it takes the fisher to catch it. When the stock of fish is small, it is necessary to fish longer in order to catch a fish. If the fishing ground is severely depleted, it may be difficult or impossible to land a catch of a given size. In other words, when one fisher takes a fish from the sea, he or she imposes a cost on the others in the fishery. However, individual fishers do not bear the costs they impose on the others, unlike the "private" costs they must pay (such as the costs of the boat, fuel, gear, and labor). Since individual fishers do not bear this "external" cost, they ignore it and catch more fish than they would if they had to pay it. In other words, we have a cost externality in fishing, so the amount of fishing activity is too high for efficiency.

In this section we have seen that the externality in the fishing industry is a symptom of a deeper problem—the absence of property rights to a rival resource. If the fishery were privately owned, no externality would be present. For example, if fish are raised in a privately owned lake rather than roaming free in the sea, the owner has no incentive to overfish. In fact, the private ownership of fisheries has become common in the form of aquaculture, or "fish farming." The owner of a fish farm lets fish reproduce and grow, and then catches them at the best possible time. Owners do not overfish, because the cost of depleting the stock is borne wholly by themselves. Even if an owner lets many other people fish in the lake, no externality occurs: The price charged to each customer includes the cost an additional fisher imposes on others, so all costs of catching a fish are private costs.

The Reciprocal Nature of Externalities

It is perhaps human nature to perceive social problems in terms of victim and perpetrator, or right and wrong. This is no less true for externalities. When smokers light up in a public place, they impose an external cost on nonsmokers, who prefer smoke-free air. It is natural to view the smoker as the perpetrator of a wrong, and the nonsmoker as a victim who should be compensated. The same is true when a factory chimney spews noxious pollutants into the air.

However, as we have seen, the concept of economic efficiency is silent about the desirability of different distributions of utilities. As a result, we can understand the inefficiency of externalities without considering the philosophical issue of who should pay. Instead, we can explain externalities as simply an inefficient resolution to a conflict about how a resource is used. On this view, rather than being perpetrator and victim, the smoker and nonsmoker are simply people with conflicting desires over how the air in the room is to be used. The nonsmoker wants to keep the air smoke-free. The smoker gets enjoyment by smoking, which requires (among other things) exhaling used smoke into the air in the room.

An important insight following from this view is that all externalities are reciprocal in their impact, rather than having a one-way impact from perpetrator to victim. It is true that when smokers exhale smoke, they impose a cost on the nonsmoker, but it is also true that the nonsmokers' desire for a smoke-free room imposes a cost on the smoker. The smoker cannot enjoy smoking. We do not need to make a moral judgment about smoking in order to analyze the externality. If smokers have the right to light up in public places, they will consider only their own enjoyment and ignore the external cost they impose on the nonsmokers around them. The externality may lead to too much smoking (that is, inefficiently high levels of smoking) in public places. On the other hand, if nonsmokers have the right to demand that smokers do not smoke in public areas, they too consider only their own benefits and ignore the external cost they impose on the smokers. As an economic problem, externalities are a two-way street.

As economists, the question we want to answer is: What is the efficient amount of smoking, and how can it be brought about? To answer this, we'll consider a simplified case. Suppose two people—one smoker and one nonsmoker—occupy a room. The smoker wants to smoke and has a willingness to pay of $5 to light up. The nonsmoker wants the room smoke-free and has a willingness to pay of $10 to keep it that way. We assume that both people are fully informed about the dangers of tobacco smoke to their health and take these costs into account in their willingness to pay. No one else is in the room.

Is it efficient for the scarce resource—the air in the room—to be used for smoking or kept smoke-free? The answer, given the specified willingness to pay, is that it should be kept smoke-free because the nonsmoker's willingness to pay for clean air is more than the smoker's willingness to pay to light up. Keeping the air smoke-free is the highest-valued use for the air; therefore, not allowing the smoker to smoke is the efficient outcome. Will this outcome be realized? It seems that it will be realized only by making the room nonsmoking. If smoking is allowed, the smoker will light up and enjoy the $5 benefit while ignoring the $10 external cost on the nonsmoker. However, if the smoker has a willingness to pay of $10 and the nonsmoker has a willingness to pay of only $5, making the room nonsmoking is inefficient. If nonsmokers have the right to clean air in this case, it seems that the outcome is inefficient. Apparently we have to know the efficient outcome before we assign property rights. Or do we?

Bargaining and the Coase Theorem

Professor Ronald Coase of the University of Chicago, who won the Nobel Prize in economics in 1991, recognized that if people act rationally, and if bargaining (or transactions) costs are sufficiently low, the assignment of transferable property rights to a resource will lead to an efficient outcome regardless of who is given the property rights. A *transferable* property right is one that the owner has the right to sell.[7] In other words, whether the property rights to the air in the room are given to the smoker or the nonsmoker, the air in the room will be put to its highest-valued use.

The main idea is illustrated as follows. Suppose again that the smoker's willingness to pay to light up is $5 and the nonsmoker's willingness to pay for clean air is $10. Obviously, if the nonsmoker is given the rights, the room will be nonsmoking, and that is the efficient outcome. But what if the smoker is given the rights? Coase argued that if bargaining costs are low and the property rights are transferable, the room will still remain nonsmoking. The reason is that the nonsmoker is willing to pay up to $10 to keep it that way and thus can bribe the smoker not to smoke. For instance, if the nonsmoker offers the smoker $6 not to smoke, the smoker will accept (that is, sell his or her right to smoke). Refusing a $6 bribe to refrain from smoking is equivalent to paying $6 to smoke, which is more than the smoker's willingness to pay.

Why don't we ever see this happening—in a restaurant, say? If the smokers in a no-smoking restaurant have a higher willingness to pay to smoke than the nonsmokers have for clean air, why don't they offer a payment? Several reasons come to mind. First, to the extent that a no-smoking policy gives rights to the nonsmokers, these are not likely to be transferable rights. In other words, nonsmokers cannot sell their right to a smoke-free environment. Second, tradition and custom constrain the things people do and do not bargain for. Just as it is customary to haggle over the price in a store selling Persian rugs but not over the price of a garment in a clothing store, it is not customary to bargain over the right to smoke. Third, and most important, bargaining and transactions costs are present, and the total amount to be gained by the people in the restaurant is not likely to be great. If there are many people in the restaurant, the bargaining costs are likely to be very high. How do the smokers decide what payment to make and how to divide the payment among themselves? At the same time, even if the smokers can organize and collectively agree to make the payment, one of the nonsmokers may threaten to veto the

[7]Not all property rights are transferable. For instance, we each have the property rights on our labor, but we cannot sell ourselves into slavery.

agreement unless he or she gets a bigger share of the payment. In other words, when many nonsmokers are in a room, a smoke-free environment is a public good, with all the difficulties of private provision that we discussed in Chapter 3.

The difficulties of applying the Coase theorem in everyday life are illustrated well in A Case in Point 4.1.

ENVIRONMENTAL POLLUTION AS A COST EXTERNALITY

Perhaps the most important cost externality in the United States economy is pollution. Many economic activities cause the quality of the environment to be

A CASE IN POINT

4.1 Coase Goes to Hollywood

A news item on how filmmakers on location pay residents thousands of dollars to keep quiet while they are shooting a scene illustrates the Coase theorem in action, and its shortcomings.

> In his seven years as a location manager in the film industry, Patrick McIntire has rented noisy chain saws just so he could turn them off and paid lawn crews to stop clacking their shears and revving their leaf-blowers. Loud radios, barking dogs and immovable people have cost him a bundle.
>
> Mr. McIntire is not alone. In Los Angeles and other California areas popular for filming, residents are sometimes making thousands of dollars from movie crews by promising to vacate outdoor sets, tone down noise or otherwise stop harassing them. The problem has become so acute that the state legislature has stepped in, drafting laws to make harassing film crews for profit a criminal offense.
>
> "It's gotten to the point where at almost every shoot, somebody has their hand out," said State Senator Herschel Rosenthal, Democrat of Van Nuys, the sponsor of one such bill. "People blow horns, walk through shots, make their dogs bark or crank their stereos. And they all demand money to stop." (*New York Times,* July 27, 1995.)

The noise and disturbance of activities by residents are a cost to filmmakers on location, but keeping quiet is a cost to the residents. (Note the reciprocal nature of the externality.) The residents effectively have the property rights and can make whatever noise they want within the law. Filmmakers adopt the Coasian solution of paying them to keep quiet near the set. If the value of quiet to filmmakers is more than the cost to the residents, an efficient outcome is reached. But filmmakers claim that people are manipulating the system by creating noise or causing disturbance on purpose, simply to elicit a payment from the filmmakers. Such "attracting the nuisance" is a form of bargaining cost.

Critically analyze the following:

- If passed, how would Senator Rosenthal's bill alter the distribution of property rights? Do you think the amount of on-location filming would be affected by the change in property rights?
- If Rosenthal's bill passed, is it likely that residents would bribe filmmakers not to shoot in their neighborhoods? Why or why not?
- Suppose that, before shooting, filmmakers must report to a third party (such as the local government) how much it is worth to them to shoot, and that residents must report how much it is worth to them to avoid the disruption. The assignment of property rights will be determined afterwards by the flip of a coin. As a result, none of the parties knows, at the time they report their valuations, whether they will receive payment or be required to pay. Would this lead to a more efficient outcome? Why or why not?

degraded. Exhaust from automobiles and fumes from fireplaces create smog, along with pollutants from industry chimney stacks. Sulfur dioxide from coal-fired electricity-generating plants creates acid rain that destroys fish, trees, and marble buildings. Phosphorus and nitrogen from detergents in wastewater nourish plants that remove oxygen from lakes, making the lakes anaerobic and foul-smelling. Pesticide runoff from irrigated fields and toxic wastes dumped from industrial plants pose significant health-related hazards.

Many environmentalists view pollution as something that is simply wrong, perhaps immoral. While many economists share the environmentalists' concerns about pollution, they view the problem differently. In the economist's view, the problem is that the level of pollution is too high (that is, it is inefficiently high) because the costs of pollution are mainly external to the polluter. Since a firm that causes pollution does not have to pay the costs of increased air or water pollution, it has no profit incentive to reduce them. If the firm considers these costs at all, it is because of a desire to be a "good citizen." Such a sentiment may not be strong enough to warrant spending millions of dollars on equipment to abate pollution, especially if the firm's competitors don't—the expenses would then place the firm at a competitive disadvantage in the marketplace.

The argument that an individual polluter ignores the costs of pollution remains valid even when the polluter, such as a commuter in a smoggy city, suffers along with everyone else. The individual commuter driving to work contributes a very small amount to the total pollution in the air, but the cost of even this small increase affects everyone in the city. If an individual's decision to drive to work increases the cost of air pollution to everyone by only one-hundredth of a cent, the external cost of the decision is $100 in a city of 1 million. If the commuter were charged $100 to drive to work, he or she probably wouldn't do it.

Commuters drive to work because the private cost of polluting (that is, the cost to themselves) does not outweigh the benefits they get from driving. They ignore the external cost of their decision on everyone else. Like the medieval villagers who found it rational to graze their cattle and not to worry about overgrazing the commons, modern commuters find it rational to drive to work and not to worry about the brown haze hanging in the air.

Is it possible to have too little pollution? The idea that pollution is a problem of economic efficiency rather than morality leads naturally to the concept of an "efficient" level of pollution. Many people may think that the best level of pollution is none at all, but this is not the case. Some amount of pollution is one of the costs we must pay to enjoy a given material standard of living. Just as we need to get up at 7:00 A.M. each weekday to feed, clothe, and shelter ourselves, so we need to suffer some level of environmental pollution as part of the economic cost of enjoying goods and services. The problem is to make sure that this pollution is not excessive in the sense that the cost outweighs the benefits from having more consumer goods.

As always, consumers prefer more of everything, but the reality of life dictates that this is not possible. To have a cleaner environment, the economy must produce less output or use some of its economic resources to produce pollution-abatement equipment rather than consumer goods. For example, cleaner air requires that we drive less or have costly emissions control equipment installed in our cars.

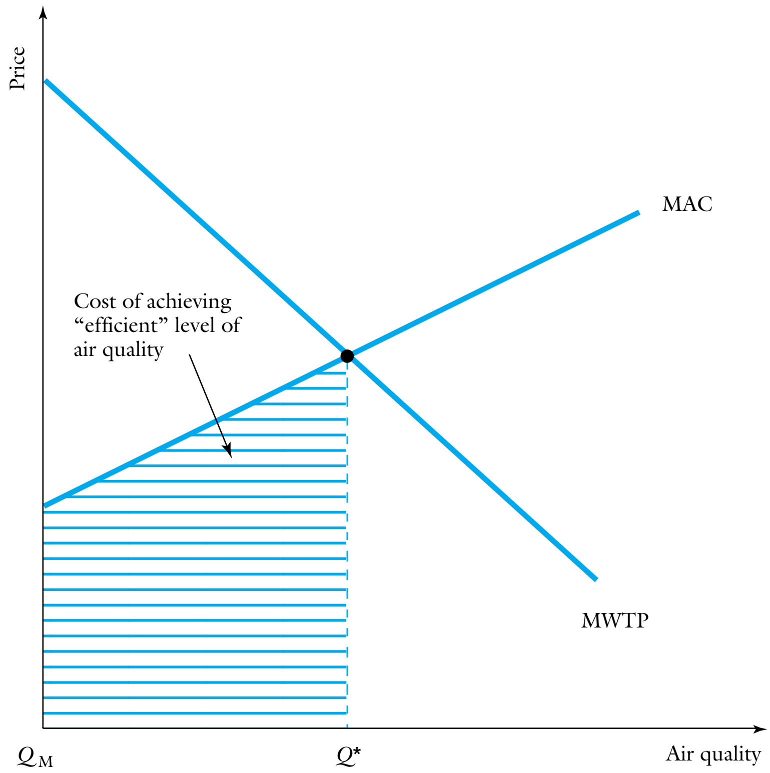

Figure 4.4

The Efficient Level of Air Quality

Although the market equilibrium air quality Q_M is less than the efficient level, the efficient outcome is not to have no air pollution at all. Air quality is a good for which people have an MWTP, but abating pollution has a cost. At the efficient level Q^*, the MWTP for air quality by citizens is equal to the marginal abatement cost (MAC). A higher level of air quality would be inefficient because the MAC is greater than the MWTP.

The concept of an efficient level of air quality is illustrated in Figure 4.4. We measure the level of air quality (visibility, absence of pollutants, etc.) on the horizontal axis. The level of air quality at the origin is assumed to be the level corresponding to the unregulated market level Q_M. At Q_M, air quality is low because most of the cost of pollution is external and people and firms have no incentive to reduce activities that cause pollution. The marginal cost of achieving better air quality is given by the height of the curve labeled **marginal abatement cost (MAC)**. The marginal cost of air quality is the marginal cost of abating pollution either by reducing production of consumer goods or by installing abatement equipment. As more abatement is done (giving higher air quality), the marginal abatement cost rises because firms exhaust "cheap fixes" and must resort to more costly alternatives. The community's marginal willingness to pay for air quality is shown by the downward-sloping demand curve labeled MWTP. The MWTP slopes downward because as air quality gets high, people are willing to pay less to make it a little bit higher.

The efficient level of air quality is not pristine air. Instead, we want to increase air quality up to the point where the MWTP for air quality is equal to the marginal abatement cost, MAC. The efficient level of air quality is denoted Q^* in Figure 4.4, and the pollution remaining in the air at this point is the efficient level of pollution. The area under the MAC curve is the cost of abating pollution to its efficient level.

Even without making the air pristine, the cost of abatement is large. One estimate of total cost in 1997 incurred by firms to comply with environmental regulations, including those that require firms to purchase and install pollution-abatement equipment—such as precipitators, filters, and scrubbers in factory chimney stacks—is $210 billion, or 2.6 percent of GDP.[8]

GOVERNMENT POLICIES FOR CONTROLLING EXTERNALITIES

Given that externalities cause economic inefficiency and impose costs on the community, we are not surprised to find that societies have devised various means of controlling them. Sometimes the means is a social convention, like etiquette. In the United States and other countries, children are taught from a young age to "give a hoot—don't pollute." In old Hawaii, society was governed by a rigid convention called *kapu,* administered by a priestlike *kahuna*. Many of the strictures concerned fishing. It is likely that these rules were used to control the problem of externality in the Hawaiian fishery, especially given that it was the mainstay of the Hawaiian economy.[9] Another way of controlling externalities is the law. Activities with external costs can be outlawed, while those with external benefits can be made compulsory. In industrial countries, child labor is illegal and basic schooling is compulsory. While this is done mainly to protect children, adult society benefits because children who are denied education can impose a large cost on everyone else.

Government in the United States has a long history of controlling externalities through regulation. The federal government's involvement in controlling water pollution dates back to the *Refuse Act* of 1899; its involvement in controlling air pollution began in 1955 with the *Air Pollution Control Act,* the predecessor of the Clean Air Act. Regulations controlling air pollution by local governments began as early as the 1880s. The federal government has regulated and managed the offshore fisheries since the *Magnuson Fishery Conservation and Management Act* of 1976. A large amount of regulation also protects people from hazards at home, in public, and in the workplace. For brevity, however, we restrict our discussion of government policies to those dealing with pollution and the management of fisheries.

Policies to control externalities can be grouped into two types: correction or internalization. A policy of **correction** adjusts activities with externalities by creating a corrective penalty or reward. A policy of **internalization** adjusts activities with externalities by changing the institutional arrangements that led to the externalities in the first place.

With a cost externality, firms do too much of the activity, so a corrective policy might subject them to a penalty unless they reduce it. The penalty could be a fine

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[8]United States Environmental Protection Agency, "Environmental Protection: Is It Bad for the Economy?" July 1999.

[9]Of course, the rules also served to reserve the lion's share of the fish for the priestly class.

or punishment for exceeding specified limits, or a tax on the activity. Alternatively, the industry could be rewarded for reducing the activity. A corrective policy for activities that have a benefit externality is to reward the firm for increasing the activity, as by a subsidy. Alternatively, the firm could be penalized for reducing the activity below prescribed levels.

In contrast, a policy of internalization changes institutional arrangements so that the external cost or benefit becomes internal to the firm doing the activity. Suppose several firms operate in an industry and some activities by individual firms cause benefits or costs to all firms in the industry. For instance, when a firm provides training for its employees, the other firms in the industry may benefit because the employee may work for them in the future. Since the individual firm takes into account only its own benefit and not the benefit to the other firms, it "free rides" and provides too little training. However, if the firms are merged into one, the external costs and benefits become internal costs and benefits to the merged firm. For instance, if many firms are merged into one multiplant firm, so that employees have no place to work other than at one of its plants, the managers of the merged firm no longer have an incentive to free ride on training. All of the benefits will accrue to the merged firm no matter where the employees work.

Of course, the firms should not need any help from the government to plan an efficiency-improving merger. The presence of externalities makes it profitable for the firms to merge of their own accord. The internalization policy of the government might be to remove any artificial barriers that prevent the firms from merging. Another form of internalization policy is where the government creates property rights for common property resources or creates markets for permits that allow firms to engage in externality-generating activities. A good example of the latter is a recent policy that allows firms to trade permits for emitting sulfur dioxide. We discuss this type of policy below.

Command and Control Policies

In the United States, most government policies toward externalities are **command and control** policies, consisting of regulations that command polluters to do certain things, such as purchase pollution-control equipment, and to control their polluting activities. For instance, the amounts and types of waste products (effluents) that a firm can discharge into the environment are controlled and must be less than specified limits. Some substances, such as hazardous wastes, cannot be dumped at all.

A typical command and control policy specifies *quantity standards* that set limits on the externality-generating activities of firms and individuals. Technology standards specify the equipment and processes that firms and individuals must use. For example, two types of quantity standards limit the levels of air pollutants the firms can emit under the Clean Air Act. First, the ambient quality standards set the acceptable levels of pollutants in the environment in total. For clean air regulation, the National Ambient Air Quality Standards (NAAQS) specify upper limits on the amounts of particulate matter, sulfur dioxide, ozone, and other pollutants that can be present in the air on average over a period of time. Second, emissions standards specify the maximum level of pollutants that can be discharged by individuals or firms over a period of time. The emissions standards are set so as to attain the ambient standards. If the ambient standards are not attained, the emissions standards are tightened. An example of a technology standard is rules that require firms to use the best available control technology (BACT) for controlling emissions.

Setting standards is one thing; enforcing them is another. In the case of air pollution, enforcement requires monitoring both the ambient levels of pollution (*ambient monitoring*) and the level of compliance by individual emitters (*compliance monitoring*). It also must provide for punishment of polluters who violate the standards. Ambient monitoring is done mainly to gauge the overall success of compliance monitoring (if the air is bad, perhaps a lot of violators are not being caught) as well as to judge the overall achievements of the policy.

Variable and Tradable Permits

With a command and control policy, ambient quality standards are attained by setting fixed quantitative limits (emissions standards) on the amount of pollutants that can discharged by a stationary source, such as an industrial plant. The limit is fixed regardless of the cost the firm must incur to comply with the standard. Such a policy almost certainly makes the cost of pollution abatement higher than it needs to be.

The reason for the excessive cost is shown in Figure 4.5. Suppose that there are two plants in a region, and that in order to attain the ambient standard, a certain reduction in the total emissions of the two plants is needed. The total pollution abatement that must be done by the two plants combined is measured by the horizontal distance 0^A0^B. For instance, this distance could represent the combined reduction in sulfur dioxide emissions needed to attain the NAAQS for this pollutant set by the EPA. The amount of abatement by plant A is measured to the right of the origin 0^A, and the amount by plant B is measured to the left of the origin 0^B. Thus any point on the line divides up the total abatement into the amounts done by each plant.

The marginal abatement cost (MAC), which is the cost to the plant of reducing emissions by 1 unit, for plant A is shown by the curve MAC^A. The curve is upward-sloping because as plant A's abatement increases (moving to the right along the horizontal axis from 0^A), it gets more costly per unit. The marginal abatement cost of plant B is shown by curve MAC^B. The marginal abatement cost curve of B is also upward-sloping as B's abatement increases (moving to the left of 0^B).

Although the MAC schedules of the two plants have the same general properties, they may be different. As shown, MAC^B is higher and rises more rapidly than MAC^A, perhaps because of B's location. Typically, regulators will set emissions standards for the individual plants that require them to abate equal amounts of pollution.[10] Point *M* denotes the midpoint of the axis 0^A0^B, so at this point the plants abate equal amounts.

The total cost of abatement to a plant is equal to the area under its MAC curve at each level of abatement. The height of MAC is the cost of the next unit of abatement, so the area under the curve sums the costs over all units. The lightly shaded area in

[10]Alternatively, the required amounts of abatement may be proportional to the size of the plant.

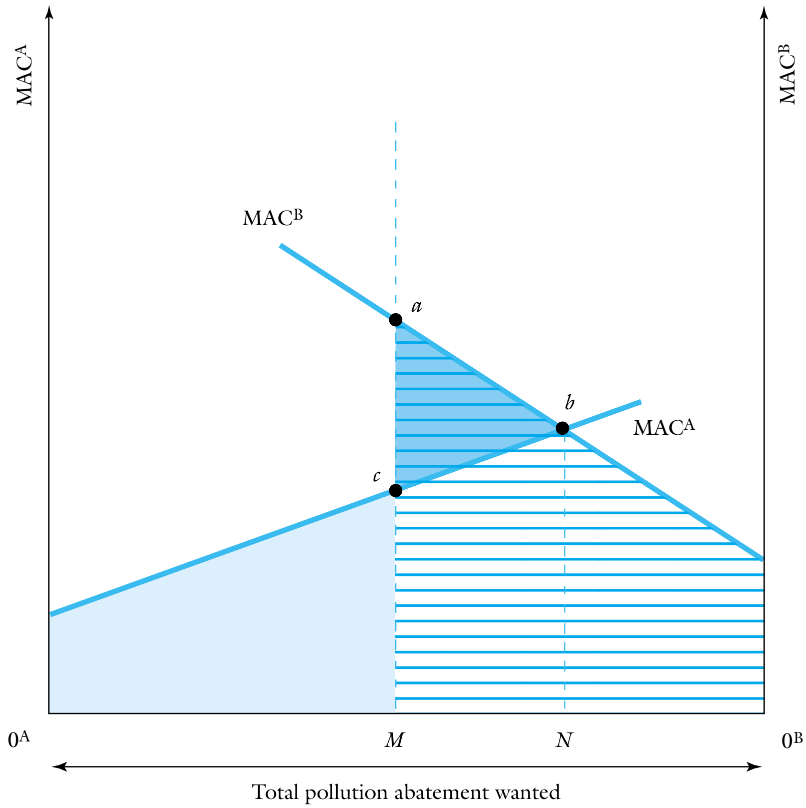

Figure 4.5

Minimizing the Cost of Pollution Abatement

To minimize the cost of reducing pollution, abatement should be allocated to the firms with the lowest marginal abatement cost (MAC). When firms A and B do the same amount of abatement, firm A has a lower MAC than firm B. The cost of this inefficient allocation of abatement is equal to the area of the shaded triangle *abc*. The efficient allocation of abatement is for firm A to do $0^A N$ units of abatement and firm B to do $0^B N$ units. At this allocation, the MACs of the two firms are the same.

Figure 4.5 is the total abatement cost of plant A, and the horizontally shaded area is the total abatement cost of plant B. When the two plants do equal amounts of abatement, the combined total abatement cost is the sum of the two shaded areas. We can easily see that the combined abatement cost (the sum of the areas under the two MAC curves) is smaller if plant A does one unit more of abatement and plant B does one unit less. B's abatement cost falls by MAC^B while A's rises by the smaller amount MAC^A. In fact, the total abatement cost is minimized by letting B reduce its abatement to $0^B N$ and letting A increase its abatement to $0^A N$. At this point, the marginal abatement costs of the two plants are equal and no further cost saving is possible by reallocating abatement. The total saving in abatement cost by using this minimum abatement cost allocation is equal to the area of the triangle *abc*.

The Clean Air Act of 1990 introduced what is now called *emissions trading* into the realm of environmental regulation in the United States. The amendments to the Clean Air Act allowed the creation of a market in **transferable discharge permits** for sulfur dioxide. Economists have promoted the concept of transferable discharge permits for the last 25 years. The main idea is that rather than setting emissions standards for individual firms and plants, the government issues transferable discharge permits equal to the total level of emissions that it wishes to allow and then lets firms buy the permits they need in order to emit. The firms with the highest cost of abating pollution will bid the most for the permits, whereas the firms with lower abatement costs will choose to sell their permits and reduce their emissions instead. This ensures that a given total abatement is achieved at least cost, as described in Figure 4.5. If one plant has a higher abatement cost than another, the first will purchase more permits while the second does more abatement. In the market-clearing equilibrium, the distribution of permits will be allocated to the highest bidders, and the combined abatement cost of all emitters is minimized.

A highly debated question about transferable discharge permits is how to determine the initial allocation of permits. The Coase theorem implies that the initial allocation of permits is not important for the purpose of achieving economic efficiency. The final distribution of permits will bring about the least costly allocation of abatement and the initial allocation simply determines who bears the cost of abatement.

One distribution of permits, called the **polluter-pays policy,** leaves the entire initial allocation of permits with the government and requires the polluters to purchase permits for all emissions they make. A second distribution is called the **government-pays policy,** though it would more properly be called a "taxpayer-pays" policy. This second approach allocates permits to polluters in sufficient quantities for them to continue at the unregulated emissions levels. The government must buy permits back from the polluters to reduce the total emissions to the desired level. A third alternative, called the **Pareto improving policy,** grants polluters sufficient transferable permits to emit at the emissions standards that exist under regulation. Plants that want to emit above the emission standard must purchase permits from other plants. This is a Pareto improvement because no plant is worse off than emitting at the existing standards (since any plant can retain its permits), and the plants that trade in permits must be better off doing so. Therefore the policy is viewed favorably by all plants, making it easier to enact. Probably for this reason, the Clean Air Act amendments of 1990 adopted the Pareto improving policy by allocating most of the tradable sulfur dioxide permits to existing electricity utilities.

Why do we need to issue tradable permits to reduce the cost of abatement to a minimum? Wouldn't it be easier for the government to simply maintain the regulation policy but lower the emissions standards for plants with high abatement costs and raise them for the plants with low costs? The problem is that the government cannot readily ascertain which are the high- and low-costs plants. The advantage of tradable permits is that it doesn't have to determine this. The plant owners, who know their costs of abatement, will determine how the permits are ultimately allocated.

Another advantage of transferable permits is that this policy rewards plants who invest in abatement equipment or find other ways of reducing their emissions below the existing standard. With command and control regulation, a polluter that reduces emissions below the existing standard gets no reward. A polluter that emits more than the standard, and is caught, is punished, so there is an incentive to reduce emissions to the standard. But if a plant's emissions are at or below the standard, no action is taken by the regulators. Since abatement is costly, and no rewards are given for further reductions, plants will emit at levels equal to the standard—no higher or lower. Tradable permits do provide incentives for plants to find ways to reduce emissions further. Suppose a plant uses its permits to emit at 100 percent of the standard. If the firm finds a way to reduce emissions further, it can sell some of its permits in the market for cash. Thus it reaps a reward for reducing its emissions.

Effluent Charges and Corrective Taxes

A policy similar to transferable permits is one that imposes on polluters an **effluent charge or fee,** a dollar price charged to plants per unit of effluent (smoke or dirty water) they discharge into the air or watershed. (The basic idea should be familiar to people who have a wastewater charge added to their utility bills each month.) An effluent charge has been used in Germany since 1976.

The effect of an effluent charge on a plant's decision to dump is shown in Figure 4.6, where the quantity of effluent dumped is measured on the horizontal axis. The downward-sloping curve MWTP indicates the plant's marginal willingness to pay to dump effluent. This MWTP is determined by the marginal abatement cost of the plant, since abatement is the alternative to dumping. A smaller quantity dumped means more abatement, and the marginal abatement cost increases with the amount of abatement. For this reason, the MWTP to dump curve is downward-sloping. The upward-sloping curve MEC is the marginal external cost, or marginal damages, caused by dumping. If no effluent charge or standard is set, the plant would dump Q_M units of effluent into the environment. Because the firm ignores the marginal external cost of dumping, the amount it dumps is greater than the efficient quantity of dumping Q^*. If the government can monitor the quantity of dumping and charge the plant accordingly, it can set an effluent charge (price) per unit of effluent dumped—say, P dollars. Facing this price, the plant dumps only if the effluent charge is less than its MWTP to dump. If the effluent charge is P dollars, the plant dumps Q' units, and abates Q_M minus Q' units. The firm pays P dollars times Q' for dumping.

By setting the effluent charge, the government can achieve whatever quantity of dumping it wants. For instance, it could stop dumping altogether by setting a very high charge. A better policy is to set the effluent charge at the estimated marginal external cost of dumping, measured at the efficient quantity of dumping Q^*. The efficient effluent charge is shown as MEC* in Figure 4.6. Facing this effluent fee, the firm dumps Q^* units of effluent, which is the efficient quantity to dump.

Since an effluent charge generates revenue for the government, it is a *polluter-pays* policy. Oddly, some people concerned about the environment condemn effluent charges (and transferable discharge permits) because they allow plants to "pollute for a price." However, the existing system of standards allows plants to pollute up to the standard without paying a price. Since the same amount of pollution can be achieved with an effluent charge, and the government gets a source of revenue as well, effluent charges are viewed positively by economists.

A CASE IN POINT

4.2 Polluting for a Price: How Well Does It Work?

Tradable pollution permits have advanced from academic idea to real-world fact. Several pollution permit markets now exist, the most visible being the Regional Clean Air Incentives Market (RECLAIM) in southern California and the EPA's Acid Rain Program. Title IV of the 1990 Clean Air Act Amendments created a national market in tradable sulfur dioxide (SO_2) allowances for electricity-generating plants. (Tradable allowance programs also exist for other pollutants such as Nitrogen Oxide [NO_x].) Each SO_2 allowance permits the owner to emit one ton of SO_2. These allowances are traded privately, purchased through brokers, or bought through an EPA auction administered by the Chicago Board of Trade.

Phase I of the program, which began in 1995, placed caps on the SO_2 emissions of the nation's largest and most polluting coal-fired electric power plants. In exchange, the plants received annual allocations of tradable SO_2 allowances based on their fossil-fuel consumption between 1985 and 1987. The allowances can be used by the plant, transferred to another plant within the company, sold to another party, or banked for future use. The emissions of the plants are continuously monitored, and each plant must hold allowances of no less than its emissions during the year. Excess emissions are subject to a penalty of $2000 per ton. In Phase II, which began January 2000, the caps are tightened, and the program is extended to all fossil-fuel plants larger than 25 megawatts. This brings many smaller, cleaner plants into the program.

Economists are now assessing the success of the program. Overall, the program is a major success. SO_2 emissions have been reduced nearly 50% at less than 50% of the estimated cost under command and control regulation.[1] The General Accounting Office has confirmed these benefits and projects that allowance trading will yield cost savings as much as $3 billion per year over the command and control approach. Nonetheless, some results have puzzled analysts. The volume of transactions has been less than anticipated and the price of the allowances is less than the marginal abatement cost (MAC) of most plants.

Further information on the program including prices and transactions is available on the EPA's Acid Rain Program site at http://www.epa.gov/docs/acidrain/overview.html.

Critically analyze the following questions:

- SO_2 allowances traded at about $150 each as of December 1999. This is much less than the estimated marginal abatement cost of the plants in the program, which is around $300 per ton of SO_2.[2] Many theories have been proposed to explain this divergence. One theory stresses that most of the electric utilities are subject to rate-of-return regulation, which limits the profit the company can make. Why would this depress the price of allowances? (Hint: Under rate-of-return regulation, who would be the beneficiaries of abatement cost savings?) Would the allowance price have been higher if the government had adopted a polluter-pays policy of allowance allocation?
- As the Phase II plants join the program in 2000, how do you expect this will affect the allowance price? Remember that they will receive allowances as well as will need them. (Hint: Do you think the marginal abatement cost of newcomers will be higher or lower than that of the Phase I plants?)
- Individuals and groups may purchase allowances to reduce the level of SO_2 and NO_x emissions. For example, the Clean Air Conservancy (CaC) will purchase an allowance on your behalf and issue you a "Clean Air Certificate" at their homepage http://www.cleanairconservancy.org/. Suppose that a group of citizens has a combined marginal willingness to pay for a one-ton reduction in SO_2 that exceeds the market price of an allowance. Will they necessarily buy an allowance? Why or why not?

[1] Dallas Burtraw, "Trading Emission to the Clean the Air; Exchanges Few but Savings Many," *Resources for the Future,* Winter 1996, p. 1 (available at http://www.rff.org/resources_articles/files/trade_emit.htm).

[2] Carlson, Curtis, et al. "Sulfur Dioxide Control by Electric Utilities: What Are the Gains from Trade?" Discussion paper 98-44, *Resources for the Future,* July 1998.

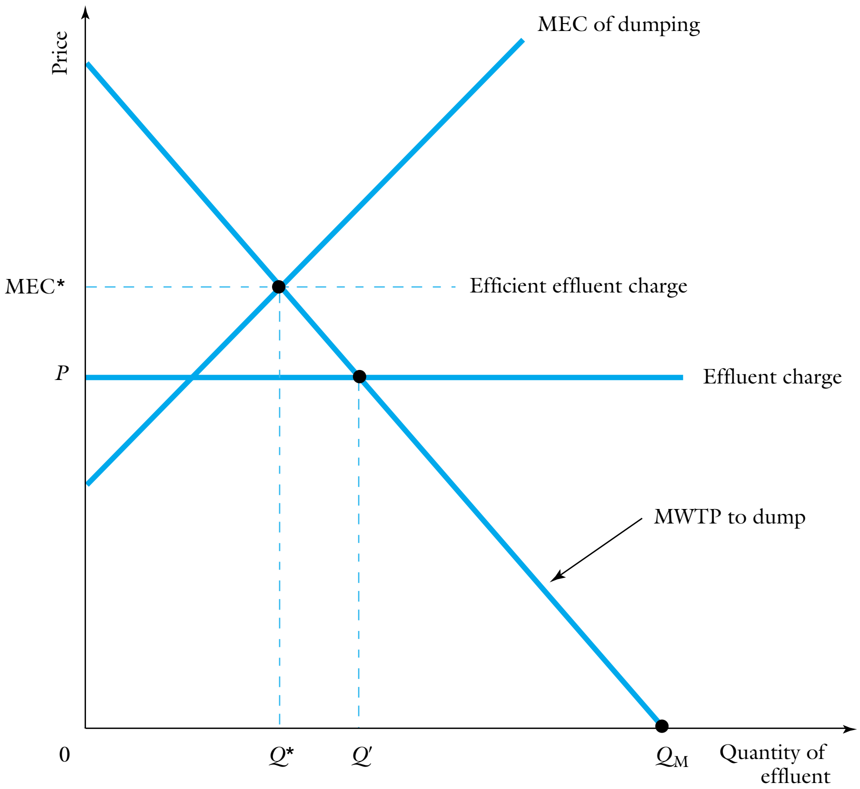

Figure 4.6

The Effect of an Effluent Fee

At the efficient quantity of effluent, the marginal external cost (MEC) of dumping on citizens is equal to the MWTP to dump by the firms. Without a policy, firms dump Q_M units of effluent because they ignore the MEC. If faced with an effluent fee of *P*, firms would dump *Q′* units where their MWTP is equal to the fee. An efficient policy charges the firms a fee equal to MEC*, the MEC at the efficient quantity of effluent *Q**. Facing this fee, firms dump the efficient quantity of pollution.

Closely related to effluent charges are corrective taxes and subsidies.[11] A **corrective tax** is imposed on a good or service subject to a production or consumption cost externality, and a **corrective subsidy** is imposed on a good subject to a production or consumption benefit externality. An example of a good with a cost externality is gasoline, which causes air pollution when used in automobiles. We saw earlier, in Figure 4.1, that the equilibrium quantity is too high for economic efficiency in a market with a cost externality. In Figure 4.7, the equilibrium quantity of gasoline Q_e is greater than the efficient quantity Q^*. The equilibrium quantity is found by the intersection of the demand and supply curves; the efficient quantity is found by the intersection of the demand curve and the marginal

[11]Corrective taxes and subsidies are also called Pigouvian taxes and subsidies, after the great welfare economist A. C. Pigou, who first suggested them in his book *The Economics of Welfare*, 1918.

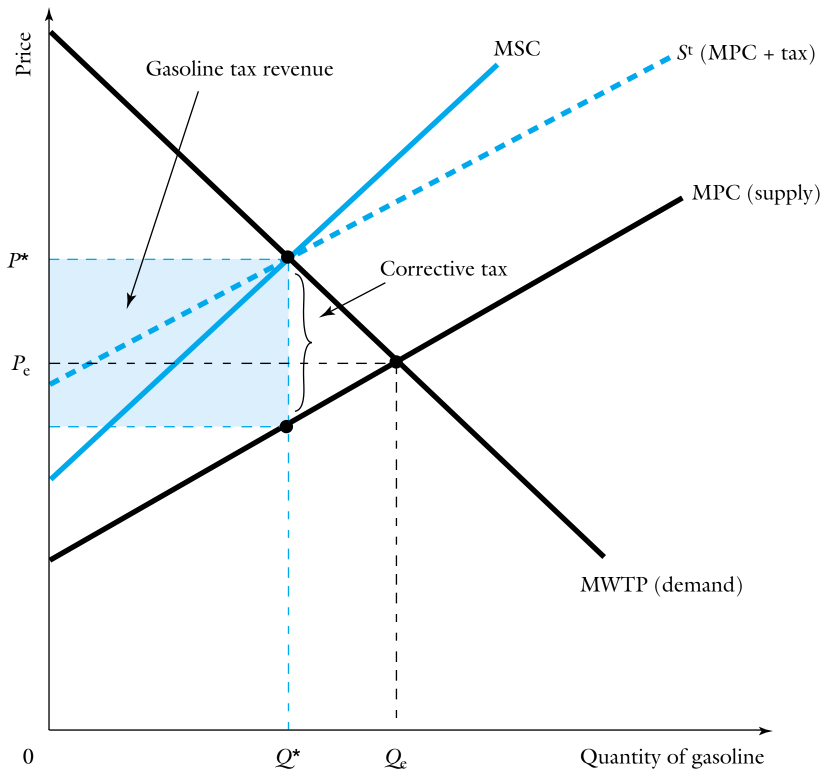

Figure 4.7

A Corrective Excise Tax on Gasoline

The equilibrium quantity Q_e of gasoline determined by supply and demand is greater than the efficient quantity because the MSC of gasoline exceeds the MPC. The MEC of gasoline consumption is ignored by market participants. A corrective excise tax set equal to the MEC at the efficient quantity shifts the supply curve up so that the market equilibrium quantity is reduced to the efficient quantity Q^*. In the process the government collects tax revenue, which can be used to reduce other taxes for a "double dividend."

social cost curve MSC. The MSC curve is found by adding the marginal external cost of gasoline consumption (from the increase in air pollution caused by consuming a gallon of gasoline) to marginal private cost (MPC) given by the supply curve.

There are several ways that the government can improve efficiency by reducing air pollution caused by consuming gasoline. The federal government has adopted a policy of commanding automobile manufacturers to install pollution-control equipment in new cars so that these cars emit less pollution per gallon of gasoline. Firms are also required to build cars that get better gas mileage, so less gasoline is used per mile. (Regulations also require gasoline manufacturers to change the formulation of gasoline in urban areas during winter months.) These technology standards for cars have significantly reduced the amount of pollution per mile driven. For instance, a 1994 automobile emits just 2 percent of the volatile organic compounds (a major cause of smog) per mile emitted by a pre-1970 automobile. However, these policies have not reduced the number of miles people drive; in fact, they have increased the number of miles driven by lowering the cost per mile. The cost of the new abatement equipment is built into the price of the car as a fixed cost, and it does not increase the variable cost of driving. However, the higher fixed cost has caused people to delay buying new, less polluting cars. The increase in the number of miles driven has offset much of the gain in air quality obtained through reduced emissions per mile.

Many economists believe that the best way to reduce air pollution is to reduce the number of miles people drive by significantly increasing the price of gasoline. Although gasoline is already taxed, the revenue from this tax goes into the highway trust fund and is spent on road improvements and maintenance. Thus, the existing tax is more a user fee than a tax. A still higher tax on gasoline is needed to reduce gasoline consumption toward the efficient level.

The impact of a corrective tax on gasoline is shown in Figure 4.7. The supply curve facing gasoline consumers, including the corrective tax, is labeled S^t. If the gasoline tax rate is chosen properly, the supply price of gasoline including the tax is high enough so that S^t intersects the demand curve at Q^*. That is, with the appropriate corrective tax, the market equilibrium quantity of gasoline will be equal to the efficient quantity.

With this policy, the cost of the inefficiently high levels of gasoline consumption is avoided, although the policy does not eliminate the automobile as a source of air pollution. The objective of a gasoline tax is more modest. It ensures that the level of air pollution created is efficient given the current technology. Also, more expensive gasoline provides a profit incentive for firms to develop cars that emit less pollution, and for consumers to embrace them when they arrive.

Policies like effluent fees and corrective taxes are said to yield a "double dividend." Unlike command and control policies, they encourage polluters to abate pollution in the least costly way. (For example, the least costly way of reducing vehicular air pollution for many people is to drive less, but current policies have not encouraged this.) Second, the revenue collected by effluent fees and corrective taxes is a source of revenue to the government and can be used to reduce other taxes, like the income tax. As we discuss later, in Chapter 12, most taxes have an "excess burden" because they distort economic decisions. For instance, high income tax rates discourage work and production in general. Proponents of environment taxes argue that it is better to discourage activities with cost externalities and improve efficiency than to discourage work and reduce efficiency.

Assigning Property Rights

We'll end this chapter where it began, at the fishery. Even before H. Scott Gordon's classic article on the externality in the fishery, governments recognized the dangers of overfishing and subjected the industry to regulation. These regulations provide for quotas that limit the total harvest of fish in a season. By limiting the annual harvest to a sustainable yield, the regulators hope to prevent overfishing. A *sustainable yield* is one that maintains the stock of fish so that a constant harvest is possible from year to year.

Because fisheries span international waters and because regulators are under constant pressure from the fishing industry to increase quotas, or to maintain quotas in the face of declining stocks, overfishing has remained a problem. One reason is the way individual rights to fish are acquired under existing regulation. In most fisheries, an overall quota on the size of the harvest is imposed and individual fishing boats can land fish until the overall quota is reached. Once the quota is reached, the fishery is closed for the season. This is called the "derby system" because it allots individual rights to the fish to the first boats that catch them, creating a race (or derby) to catch the fish.

The derby system causes an inefficient race among fishing boats to catch the fish. As soon as the fishing season opens, the boats try to land as many fish as possible as soon as possible. This floods the markets with fresh fish, driving down prices. As soon as the overall quota is reached, the supply of fresh fish stops, and consumers can buy only frozen fish. This causes at least two large inefficiencies. First, the timing of the supply of fish to the market is inefficient. Instead of getting a steady supply of fresh fish throughout the fishing season, the consumers get a flood of fresh fish at the beginning and must consume inferior frozen fish after that. Second, the derby system encourages firms to invest large sums in bigger and faster fishing boats. With the allowable seasonal harvest disappearing fast, no fishing boat wants to leave the fishing grounds to land its catch, so a large boat capacity is desired. And the bigger the boat motor, the faster the boat can go to and return from the fishing grounds. All this has added to the cost of fishing.

The derby system has also exacerbated the natural conflict between the fishing industry and the regulators. Fishers with large amounts of capital invested in their boats cannot afford to have the overall catch reduced. It is understandable that they will pressure regulators to maintain or even increase the fishing quotas, despite evidence of declining stocks.

The shortcomings of the derby system make clear the advantages of an alternative policy, sometimes called "privatizing the fishery."[12] This is done by assigning individual transferable quotas to fishing firms. An **individual transferable quota (ITQ)** is the right to catch a given fraction of the total fish catch each year. Only fishing boats with ITQs can enter the fishery, and they can catch only the quantity of fish allowed by their quotas. A one-time allocation of ITQs is assigned or sold to the individual fishing firms. Since the rights to the fish are preassigned, there is no early-season rush to catch fish (as there is under the derby system), nor do the firms have an incentive to invest in expensive large, fast boats. In fact, the firms that have the lowest cost of catching fish can land more fish by purchasing the ITQs from other, higher-cost fishers. The ITQs in fishing are analogous to individual transferable permits for discharging pollutants. They ensure that a given harvest is caught when it is most appropriate according to market conditions, and in the least costly manner. This system has been adopted in the Pacific halibut and sablefish fisheries with good results.

A fishery is privatized because ITQs give a right to catch a given *percentage* of the annual harvest in the future as well as in the current year. In effect, each fishing firm owns a fraction of the stock of fish in the fishery, just as a condominium owner owns a fraction of the building. As co-owners, the fishing firms find it in their own interest

[12]See "One Answer to Overfishing: Privatize the Fisheries" by Peter Passell, *New York Times,* May 11, 1995.

to conserve the stock in order to achieve a sustainable yield. The common property externality is eliminated because property rights to the fish stock are assigned.

A divisive practical problem that remains is the method of initially assigning the ITQs. Should they be sold to the highest bidders, or given to the fishing firms already in the industry? And if they are given to firms already in the industry, how should they be allocated? Although the Coase theorem predicts that the initial assignment does not matter for achieving economic efficiency, it is of intense interest to those in the industry. Recently the Magnuson Act, the main federal legislation controlling American fisheries, was amended to prevent further ITQ policies from being considered until October 2, 2000. This amendment was instigated by Senator Ted Stevens of Alaska primarily because the Alaskan fishing industry believes that it loses out on the assignment of ITQs.

CONCLUSION AND SUMMARY

In Chapter 3 we saw that certain goods, described as public goods, are likely to lead to market failure. In the present chapter, we have seen that external costs and benefits lead to market failure. The discussion of environmental pollution suggests that these two concepts, although distinct, overlap. On the one hand, pollution is an economic problem because the costs of pollution are external costs and are disregarded by individuals in deciding on private actions. On the other hand, the quality of the environment is a good example of a public good because it is both nonrival and nonexcludable.

What exactly is the difference between externalities and public goods? For one thing, the concept of externality is somewhat broader than the concept of a public good. Although public goods can cause externalities, other things—such as an absence of property rights—cause them as well. A more important difference is the matter of emphasis. The analysis of public goods and services concentrates on the *properties of the goods and services* to explain market failure. The analysis of externalities concentrates on the properties of *markets and institutions*. For instance, it is the absence of property rights that causes the tragedy of the commons, but it is the nonrival and nonexcludable property of national defense that explains why governments provide it and finance it with taxes.

The distinction between externalities and public goods has implications for government policies. The implication of public goods is that market forces will produce little or none of them, so the government can improve efficiency by providing them and financing them by taxes. The implications of externalities are somewhat broader. In addition to government production and tax finance, the policies that can be used to correct for externalities include institutional changes such as the creation of property rights.

- An externality is present when an activity causes an uncompensated cost or confers an unpriced benefit on persons and firms that are not parties to a market transaction. Because consumers and producers ignore the external costs and benefits, the market equilibrium quantities of the goods may be, respectively, too high or too low for efficiency.

- Externalities can be classified in several ways, including whether they are consumption or production externalities. If the total benefit or cost to others is fixed, an externality is called inframarginal, meaning that the external cost or benefit is not affected by changes in market quantity. Inframarginal externalities do not cause market failure.
- An important cause of externalities is poorly defined property rights. A rival resource to which everyone has free access is called a common-property resource. Typically, externalities reflect conflicting desires over how a common-property resource is to be used. As such, externalities are reciprocal in nature.
- The Coase theorem states that if property rights to a resource are clearly defined and bargaining costs are low, the resource will be used efficiently regardless of who gets the property rights.
- One reason pollution is considered a social problem is that pollution is an external cost in many production processes. As a result, the level of pollution in a market economy is inefficiently high. At the efficient level of pollution, the marginal willingness to pay (MWTP) for environmental quality is equal to the marginal cost (MC) of reducing pollution.
- Most policies directed at externalities are command and control policies that regulate the activities of persons and firms. Alternatively, the government can control externalities with market incentive policies that charge firms for the external costs they cause and reward them for external benefits they confer.
- An unregulated fishery is a common-property resource, so overfishing results. Overfishing can be eliminated by assigning property rights to the fish in the sea, a policy called individual transferable quotas (ITQs).

QUESTIONS FOR DISCUSSION AND REVIEW

1. Identify the type of externality associated with each of the following activities: (a) using a leaf blower to clear your driveway; (b) shoveling the snow off the sidewalk in front of your house; (c) learning to play bridge.

2. Citing the health hazards from smoking, the Clinton administration recently expressed interest in tightening the regulation of the tobacco industry. To what extent is such regulation of tobacco justified by the theory of externalities?

3. Some people object strenuously to government policies that promote "safe sex," beyond an informational role, on the grounds that sex is a personal matter and the government should stay out of it. Use the theory of externality to identify the public interest in this matter. What sorts of corrective policies does the theory suggest?

4. Farmers in the dry Western states irrigate their crops by drilling wells into the Ogallala aquifer, a huge underground reservoir left after the last Ice Age. As farmers pump more and more water from the aquifer, all must drill deeper to reach water; and the deeper the well, the more costly it is to pump the water. Identify the missing property rights in this instance. Is there an economic argument for limiting the amount of water farmers can pump from their wells? What kind of policy do you suggest?

5. In Japan, the government-owned mass transit system employs people to push the crowds of commuters into the departing trains. Does this make sense? Doesn't each person have ample incentive to get into the train quickly before it leaves?

6. To combat unsightly graffiti, some cities have adopted a policy of fining property owners unless they promptly remove graffiti on their property. Indignant property owners have complained that they are being victimized twice—once by the vandals and then by the city. Use the Coase theorem to discuss this policy as a response to an externality.

7. To comply with the Clean Air Act, a region must abate (reduce) pollution emissions by 300 units. Before regulation, two firms emit 600 units of pollutants. The marginal abatement cost (MAC) of firm A is given by the schedule

$$MAC^A = \frac{1}{2} Q^A$$

where Q^A is the quantity of pollution abated by the firm. The MAC for firm B is $MAC^B = Q^B$.

a. Suppose the EPA requires each firm to abate by 150 units. What is the MAC for each firm under this command and control regulation? Is it the least-cost allocation of abatement?

b. What is the least cost (efficient) allocation of abatement for the two firms? What is the reduction in the abatement cost made possible?

c. Suppose the EPA auctions off 300 pollution permits at a competitive auction. Each permit allows a firm to pollute by one unit. What is the market price of these permits?

8. A pulp mill has the right to discharge waste into a river. The waste reduces the number of fish, causing damage for recreational fishing. Let Q denote the quantity of waste dumped. The marginal damage (the value of lost fish for an extra unit of waste), denoted MD is given by the equation

$$MD = 2 + 5Q.$$

The marginal benefit (MB) of dumping waste (the cost of shipping an extra unit of waste to another dump site) is given by the equation

$$MB = 30 - 2Q.$$

a. Draw a diagram showing the efficient quantity of waste that can be dumped in the river, and the quantity dumped by a firm that ignores the damage it causes for fishing.

b. Calculate the efficient quantity of waste. What is the effluent fee in dollars per unit of waste that would cause the firm to dump only an efficient quantity of waste?

8. Internet Exercise. Table 405 of the *Statistical Abstract of the United States, 1999* (http://www.census.gov/prod/www/statistical-abstract-us.html) lists levels of National Air Pollutant Emissions from 1970 to 1997. Which of the major emissions fell the most between 1970 and 1997? Nitrogen oxide emissions from automobiles have remained relatively constant. How does this compare with the rise in vehicle miles traveled in Table 1047? Are these data sufficient for you to conclude that environmental policy in the United States has been very successful? What other data would you need to draw a conclusion?

9. Internet Exercise. Read about the history of the U.S. lobstering industry at http://www.gma.org/lobsters/allaboutlobsters/lobsterhistory.html. In Colonial times, lobsters were so plentiful that they were considered "poverty food." Immigrant indentured servants, who were required to work for seven years in exchange for their passage, wrote into their contracts that they not be required to eat lobster more than three times a week. With the depletion of the natural stocks of lobsters, lobster is now an expensive delicacy. How do the Maine "lobster gangs" limit the harvest of lobsters? How can this be considered a response to an externality? The lobster gangs of Monhegan Island limit their fishing to the winter months—the worst time of year to be in a lobster boat. Why might this be more efficient?

SELECTED REFERENCES

A classic early treatment of externalities and policies regarding them is A. C. Pigou, *The Economics of Welfare,* 1918. The fishery as a common property resource is described clearly in H. Scott Gordon, "The Economic Theory of a Common Property Resource: The Fishery," 1954.

The Coase theorem is enunciated in Ronald H. Coase, "The Problem of Social Cost," 1960. Practical problems with the Coase theorem are discussed in Joseph Farrell, "Information and the Coase Theorem," 1987.

A good discussion of recent issues about externalities is found in "Symposium on Network Externalities," 1994.

Chapter 7, "Making Markets Work for the Environment," *Economic Report of the President, 2000* (http://w3.access.gpo.gov/eop/index.html) is a good discussion of market incentive–based environmental policy.

USEFUL INTERNET LINKS

Sites specializing in environmental economics include EPA's Economics and Environment at http://www.epa.gov/economics/, World Bank Group's Environmental Economics and Indicators at http://www-esd.worldbank.org/eei/ and Resources for the Future at http://www.rff.org/.

As anyone living near an airport or freeway knows, noise is another externality. Everything you want to know about noise pollution is available from the Noise Pollution Clearing House at http://www.nonoise.org/.

Professor Stan Liebowitz at the University of Texas at Dallas has much information on network externalities at http://wwwpub.utdallas.edu/~liebowit/ netpage.html.