2 The Economic Approach: Property Rights, Externalities, and Environmental Problems

The charming landscape which I saw this morning, is indubitably made up of some twenty or thirty farms. Miller owns this field, Locke that, and Manning the woodland beyond. But none of them owns the landscape. There is a property in the horizon which no man has but he whose eye can integrate all the parts, that is, the poet. This is the best part of these men's farms, yet to this their land deeds give them no title.

—Ralph Waldo Emerson, *Nature* (1836)

Introduction

Before examining specific environmental problems and the policy responses to them, it is important that we develop and clarify the economic approach, so that we have some sense of the forest before examining each of the trees. By having a feel for the conceptual framework, it becomes easier not only to deal with individual cases but also, perhaps more importantly, to see how they fit into a comprehensive approach.

In this chapter, we develop the general conceptual framework used in economics to approach environmental problems. We begin by examining the relationship between human actions, as manifested through the economic system, and the environmental consequences of those actions. We can then establish criteria for judging the desirability of the outcomes of this relationship. These criteria provide a basis for identifying the nature and severity of environmental problems, and a foundation for designing effective policies to deal with them.

Throughout this chapter, the economic point of view is contrasted with alternative points of view. These contrasts bring the economic approach into sharper focus and stimulate deeper and more critical thinking about all possible approaches.

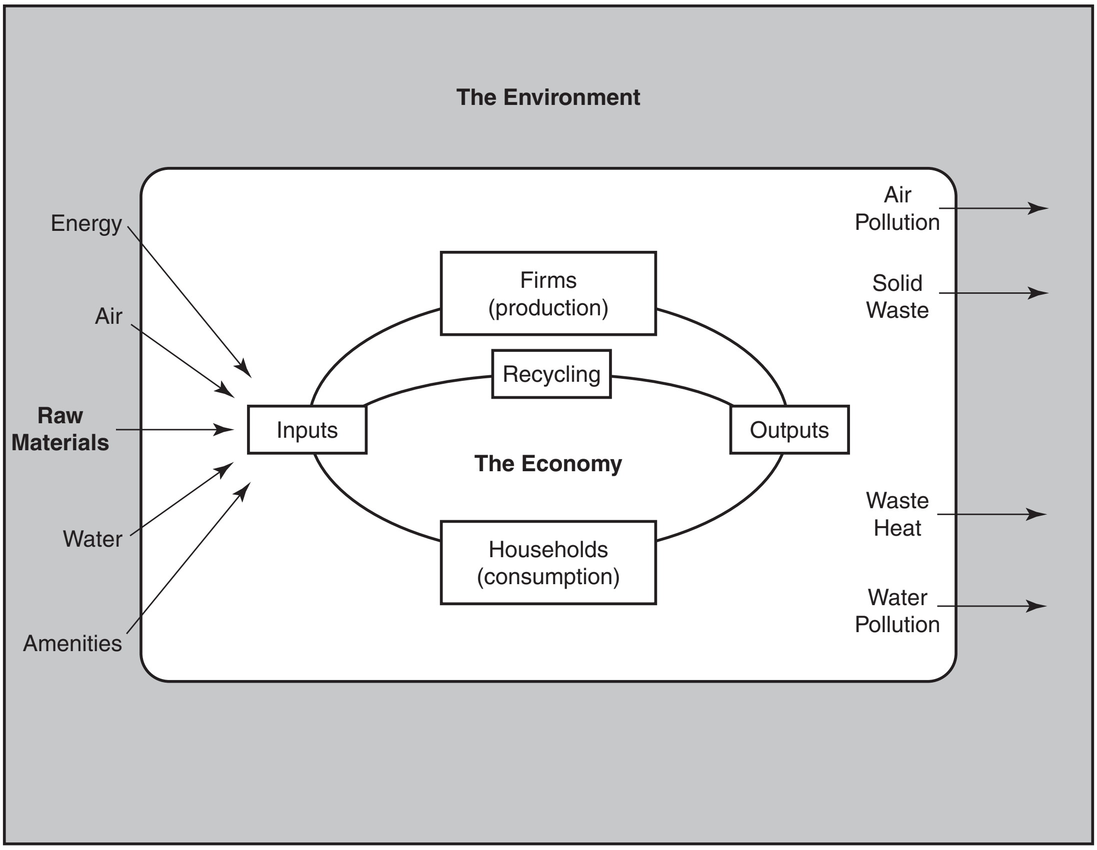
The Human–Environment Relationship

The Environment as an Asset

In economics, the environment is viewed as a composite asset that provides a variety of services. It is a very special asset, to be sure, because it provides the life-support systems that sustain our very existence, but it is an asset nonetheless. As with other assets, we wish to enhance, or at least prevent undue depreciation of, the value of this asset so that it may continue to provide aesthetic and life-sustaining services.

The environment provides the economy with raw materials, which are transformed into consumer products by the production process, and energy, which fuels this transformation. Ultimately, these raw materials and energy return to the environment as waste products (see Figure 2.1).

FIGURE 2.1 The Economic System and the Environment



The environment also provides services directly to consumers. The air we breathe, the nourishment we receive from food and drink, and the protection we derive from shelter and clothing are all benefits we receive, either directly or indirectly, from the environment. In addition, anyone who has experienced the exhilaration of white-water canoeing, the total serenity of a wilderness trek, or the breathtaking beauty of a sunset will readily recognize that the environment provides us with a variety of amenities for which no substitute exists.

If the environment is defined broadly enough, the relationship between the environment and the economic system can be considered a *closed system*. For our purposes, a closed system is one in which no inputs (energy or matter) are received from outside the system and no outputs are transferred outside the system. An *open system*, by contrast, is one in which the system imports or exports matter or energy.

If we restrict our conception of the relationship in Figure 2.1 to our planet and the atmosphere around it, then clearly we do not have a closed system. We derive most of our energy from the sun, either directly or indirectly. We have also sent spaceships well beyond the boundaries of our atmosphere. Nonetheless, historically speaking, for *material* inputs and outputs (not including energy), this system can be treated as a closed system because the amount of exports (such as abandoned space vehicles) and imports (e.g., moon rocks) are negligible. Whether the system remains closed depends on the degree to which space exploration opens up the rest of our solar system as a source of raw materials.

The treatment of our planet and its immediate environs as a closed system has an important implication that is summed up in the *first law of thermodynamics*—energy and matter can neither be created nor destroyed.[1] The law implies that the mass of materials flowing into the economic system from the environment has either to accumulate in the economic system or return to the environment as waste. When accumulation stops, the mass of materials flowing into the economic system is equal in magnitude to the mass of waste flowing into the environment.

Excessive wastes can, of course, depreciate the asset; when they exceed the absorptive capacity of nature, wastes reduce the services that the asset provides. Examples are easy to find: air pollution can cause respiratory problems; polluted drinking water can cause cancer; smog obliterates scenic vistas; climate change can lead to flooding of coastal areas.

The relationship of people to the environment is also conditioned by another physical law, the *second law of thermodynamics*. Known popularly as the *entropy law*, this law states that "entropy increases." *Entropy* is the amount of energy unavailable for work. Applied to energy processes, this law implies that no conversion from one form of energy to another is completely efficient and that the consumption of

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[1]We know, however, from Einstein's famous equation ($E = mc^2$) that matter can be transformed into energy. This transformation is the source of energy in nuclear power.

energy is an irreversible process. Some energy is always lost during conversion, and the rest, once used, is no longer available for further work. The second law also implies that in the absence of new energy inputs, any closed system must eventually use up its available energy. Since energy is necessary for life, life ceases when useful energy flows cease.

We should remember that our planet is not even approximately a closed system with respect to energy; we gain energy from the sun. The entropy law does remind us, however, that the flow of solar energy establishes an upper limit on the flow of available energy that can be sustained. Once the stocks of stored energy (such as fossil fuels and nuclear energy) are gone, the amount of energy available for useful work will be determined solely by the solar flow and by the amount that can be stored (through dams, trees, and so on). Thus, in the very long run, the growth process will be limited by the availability of solar energy and our ability to put it to work.

The Economic Approach

Two different types of economic analysis can be applied to increase our understanding of the relationship between the economic system and the environment: *Positive* economics attempts to describe *what is*, *what was*, or *what will be*. *Normative* economics, by contrast, deals with what *ought to be*. Disagreements within positive economics can usually be resolved by an appeal to the facts. Normative disagreements, however, involve value judgments.

Both branches are useful. Suppose, for example, we want to investigate the relationship between trade and the environment. Positive economics could be used to describe the kinds of impacts trade would have on the economy and the environment. It could not, however, provide any guidance on the question of whether trade was desirable. That judgment would have to come from normative economics, a topic we explore in the next section.

The fact that positive analysis does not, by itself, determine the desirability of some policy action does not mean that it is not useful in the policy process. Example 2.1 provides one example of the kinds of economic impact analyses that are used in the policy process.

A rather different context for normative economics can arise when the possibilities are more open-ended. For example, we might ask, how much should we control emissions of greenhouse gases (which contribute to climate change) and how should we achieve that degree of control? Or we might ask, how much forest of various types should be preserved? Answering these questions requires us to consider the entire range of possible outcomes and to select the best or optimal one. Although that is a much more difficult question to answer than one that asks us only to compare two predefined alternatives, the basic normative analysis framework is the same in both cases.

EXAMPLE 2.1

Economic Impacts of Reducing Hazardous Pollutant Emissions from Iron and Steel Foundries

The U.S. Environmental Protection Agency (EPA) was tasked with developing a "maximum achievable control technology standard" to reduce emissions of hazardous air pollutants from iron and steel foundries. As part of the rule-making process, EPA conducted an *ex ante* economic impact analysis to assess the potential economic impacts of the proposed rule.

If implemented, the rule would require some iron and steel foundries to implement pollution control methods that would increase the production costs at affected facilities. The interesting question addressed by the analysis is how large those impacts would be.

The impact analysis estimated annual costs for existing sources to be $21.73 million. These cost increases were projected to result in small increases in output prices. Specifically, prices were projected to increase by only 0.1 percent for iron castings and 0.05 percent for steel castings. The impacts of these price increases were expected to be experienced largely by iron foundries using cupola furnaces as well as consumers of iron foundry products. Unaffected domestic foundries and foreign producers of coke were actually projected to earn slightly higher profits as a result of the rule.

This analysis helped in two ways. First, by showing that the impacts fell under the $100 million threshold that mandates review by the Office of Management and Budget, the analysis eliminated the need for a much more time and resource consuming analysis. Second, by showing how small the expected impacts would be, it served to lower the opposition that might have arisen from unfounded fears of much more severe impacts.

Source: Office of Air Quality Planning and Standards, United States Environmental Protection Agency, "Economic Impact Analysis of Proposed Iron and Steel Foundries." NESHAP Final Report, November 2002; and National Emissions Standards for Hazardous Air Pollutants for Iron and Steel Foundries, Proposed Rule, FEDERAL REGISTER, Vol. 72, No. 73 (April 17, 2007), pp 19150–19164.

Environmental Problems and Economic Efficiency

Static Efficiency

The chief normative economic criterion for choosing among various outcomes occurring at the same point in time is called *static efficiency*, or merely *efficiency*. An allocation of resources is said to satisfy the static efficiency criterion if the economic surplus derived from those resources is maximized by that allocation. Economic surplus, in turn, is the sum of consumer's surplus and producer's surplus.

Consumer surplus is the value that consumers receive from an allocation minus what it costs them to obtain it. Consumer surplus is measured as the area under the demand curve minus the consumer's cost. The cost to the consumer is the area under the price line, bounded from the left by the vertical axis and the right by the quantity of the good. This rectangle, which captures price times quantity, represents consumer expenditure on this quantity of the good.

Why is this area thought of as a surplus? For each quantity purchased, the corresponding point on the market demand curve represents the amount of money some person would have been willing to pay for the last unit of the good. The *total willingness to pay* for some quantity of this good—say, three units—is the sum of the willingness to pay for each of the three units. Thus, the total willingness to pay for three units would be measured by the sum of the willingness to pay for the first, second, and third units, respectively. It is now a simple extension to note that the total willingness to pay is the area under the continuous market demand curve to the left of the allocation in question. For example, in Figure 2.2 the total willingness to pay for Q_d units of the commodity is the shaded area. Total willingness to pay is the concept we shall use to define the total value a consumer would receive from the five units of the good. Thus, total value the consumer would receive is equal to the area under the market demand curve from the origin to the allocation of interest. Consumer surplus is thus the excess of total willingness to pay over the (lower) actual cost.

Meanwhile, sellers face a similar choice (see Figure 2.3). Given price P^*, the seller maximizes his or her own producer surplus by choosing to sell Q_s units. The

FIGURE 2.2 The Consumer's Choice

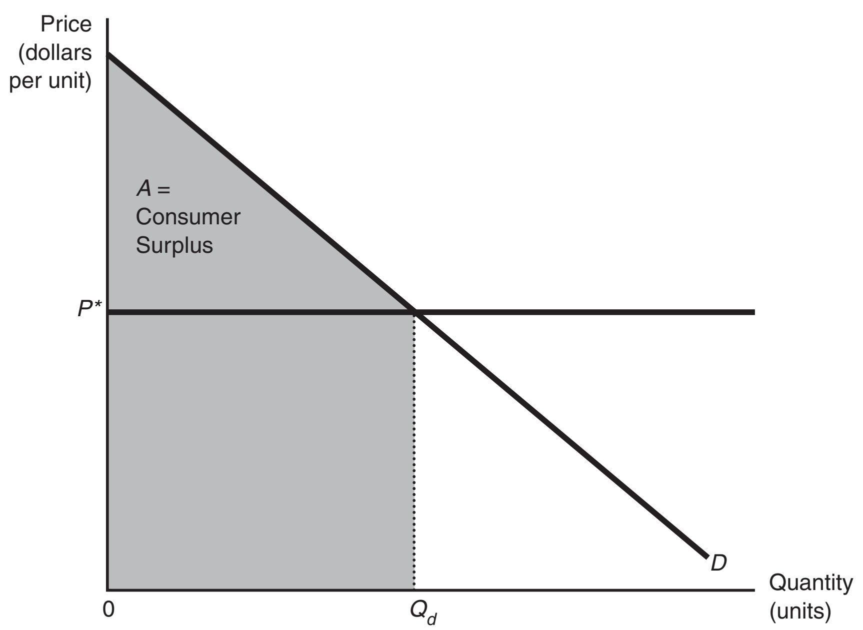
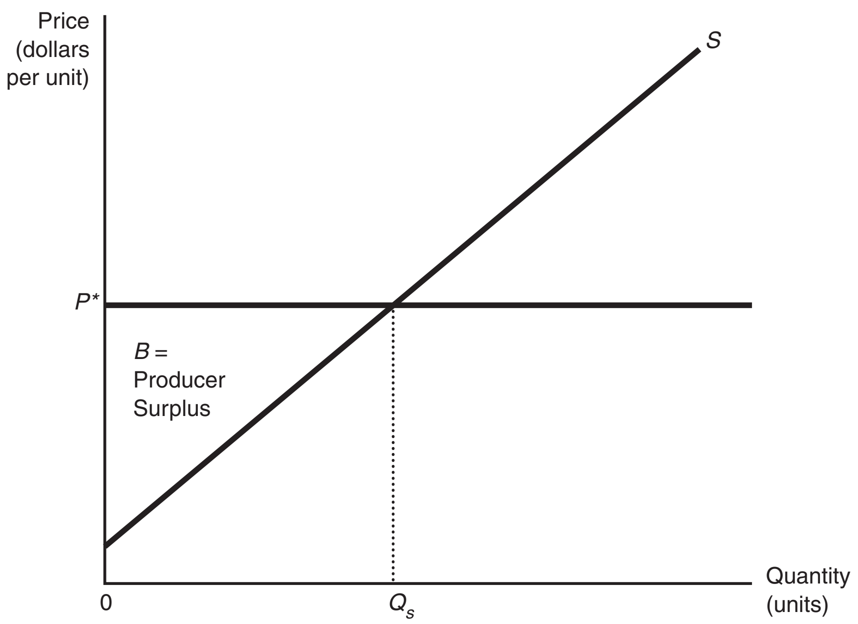


FIGURE 2.3 The Producer's Choice



producer surplus is designated by area *B*, the area under the price line that lies over the marginal cost curve, bounded from the left by the vertical axis and the right by the quantity of the good.

Property Rights

Property Rights and Efficient Market Allocations

The manner in which producers and consumers use environmental resources depends on the property rights governing those resources. In economics, *property right* refers to a bundle of entitlements defining the owner's rights, privileges, and limitations for use of the resource. By examining such entitlements and how they affect human behavior, we will better understand how environmental problems arise from government and market allocations.

These property rights can be vested either with individuals, as in a capitalist economy, or with the state, as in a centrally planned socialist economy. How can we tell when the pursuit of profits is consistent with efficiency and when it is not?

Efficient Property Rights Structures

Let's begin by describing the structure of property rights that could produce efficient allocations in a well-functioning market economy. An efficient structure has three main characteristics:

1. *Exclusivity*—All benefits and costs accrued as a result of owning and using the resources should accrue to the owner, and only to the owner, either directly or indirectly by sale to others.
2. *Transferability*—All property rights should be transferable from one owner to another in a voluntary exchange.
3. *Enforceability*—Property rights should be secure from involuntary seizure or encroachment by others.

An owner of a resource with a well-defined property right (one exhibiting these three characteristics) has a powerful incentive to use that resource efficiently because a decline in the value of that resource represents a personal loss. Farmers who own the land have an incentive to fertilize and irrigate it because the resulting increased production raises income. Similarly, they have an incentive to rotate crops when that raises the productivity of their land.

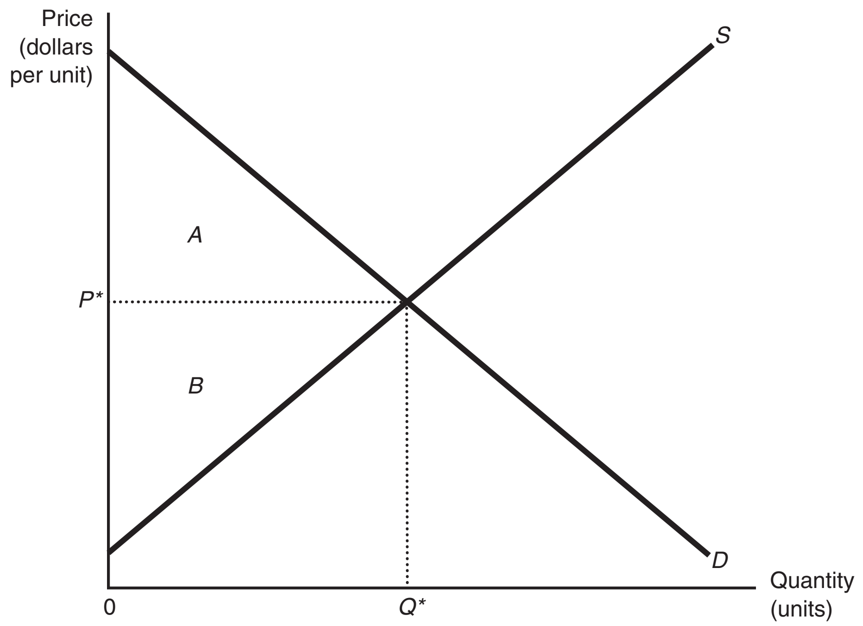
When well-defined property rights are exchanged, as in a market economy, this exchange facilitates efficiency. We can illustrate this point by examining the incentives consumers and producers face when a well-defined system of property rights is in place. Because the seller has the right to prevent the consumer from consuming the product in the absence of payment, the consumer must pay to receive the product. Given a market price, the consumer decides how much to purchase by choosing the amount that maximizes his or her individual consumer surplus.

Is this allocation efficient? According to our definition of static efficiency, it is clear the answer is yes. The economic surplus is maximized by the market allocation and, as seen in Figure 2.4, it is equal to the sum of consumer and producer surpluses (areas $A + B$). Thus, we have established a procedure for measuring efficiency, and a means of describing how the surplus is distributed between consumers and producers.

This distinction is crucially significant. Efficiency is *not* achieved because consumers and producers are seeking efficiency. They aren't! In a system with well-defined property rights and competitive markets in which to sell those rights, producers try to maximize their surplus and consumers try to maximize their surplus. The price system, then, induces those self-interested parties to make choices that are efficient from the point of view of society as a whole. It channels the energy motivated by self-interest into socially productive paths.

Familiarity may have dulled our appreciation, but it is noteworthy that a system designed to produce a harmonious and congenial outcome could function effectively while allowing consumers and producers so much individual freedom in making choices. This is truly a remarkable accomplishment.

FIGURE 2.4 Market Equilibrium



Producer's Surplus, Scarcity Rent, and Long-Run Competitive Equilibrium

Since the area under the price line is total revenue, and the area under the marginal cost curve is total variable cost, producer's surplus is related to profits. In the short run when some costs are fixed, producer's surplus is equal to profits plus fixed cost. In the long run when all costs are variable, producer's surplus is equal to profits plus rent, the return to scarce inputs owned by the producer. As long as new firms can enter into profitable industries without raising the prices of purchased inputs, long-run profits and rent will equal zero.

Scarcity Rent. Most natural resource industries, however, do give rise to rent and, therefore, producer's surplus is not eliminated by competition, even with free entry. This producer's surplus, which persists in long-run competitive equilibrium, is called *scarcity rent*.

David Ricardo was the first economist to recognize the existence of scarcity rent. Ricardo suggested that the price of land was determined by the least fertile marginal unit of land. Since the price had to be sufficiently high to allow the poorer land to be brought into production, other, more fertile land could be farmed at an economic profit. Competition could not erode that profit because the amount of high quality land was limited and lower prices would serve only to reduce the supply of land below demand. The only way to expand production would be to bring additional, less fertile land (more costly to farm) into production; consequently, additional production does not lower price, as it does in a constant-cost industry. As we shall see, other circumstances also give rise to scarcity rent for natural resources.

Externalities as a Source of Market Failure

The Concept Introduced

Exclusivity is one of the chief characteristics of an efficient property rights structure. This characteristic is frequently violated in practice. One broad class of violations occurs when an agent making a decision does not bear all of the consequences of his or her action.

Suppose two firms are located by a river. The first produces steel, while the second, somewhat downstream, operates a resort hotel. Both use the river, although in different ways. The steel firm uses it as a receptacle for its waste, while the hotel uses it to attract customers seeking water recreation. If these two facilities have different owners, an efficient use of the water is not likely to result. Because the steel plant does not bear the cost of reduced business at the resort resulting from waste being dumped into the river, it is not likely to be very sensitive to that cost in its decision making. As a result, it could be expected to dump too much waste into the river, and an efficient allocation of the river would not be attained.

This situation is called an externality. An *externality* exists whenever the welfare of some agent, either a firm or household, depends not only on his or her activities, but also on activities under the control of some other agent. In the example, the increased waste in the river imposed an external cost on the resort, a cost the steel firm could not be counted upon to consider appropriately in deciding the amount of waste to dump.

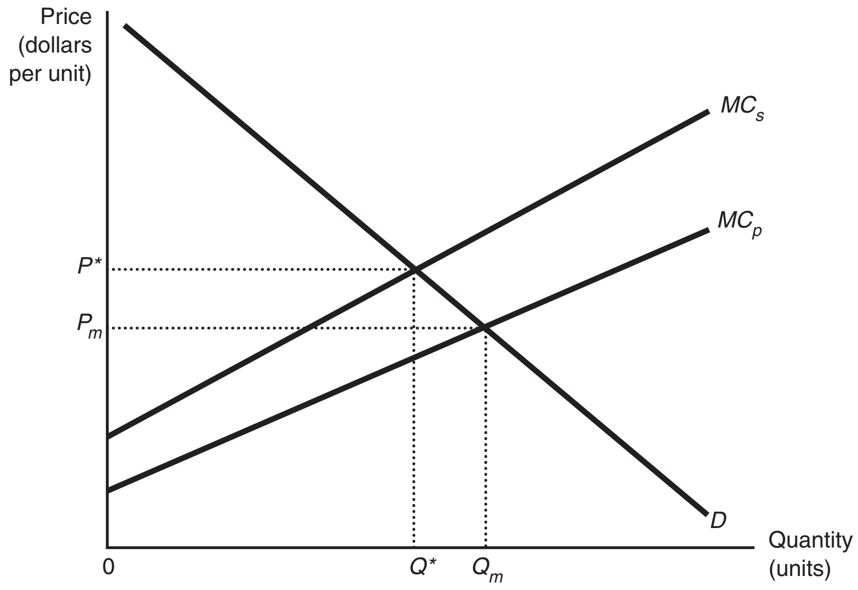
The effect of this external cost on the steel industry is illustrated in Figure 2.5, which shows the market for steel. Steel production inevitably involves producing pollution as well as steel. The demand for steel is shown by the demand curve D, and the private marginal cost of producing the steel (exclusive of pollution control and damage) is depicted as MC_p. Because society considers both the cost of pollution and the cost of producing the steel, the social marginal cost function (MC_s) includes both of these costs as well.

If the steel industry faced no outside control on its emission levels, it would seek to produce Q_m. That choice, in a competitive setting, would maximize its private producer surplus. But that is clearly not efficient, since the net benefit is maximized at Q^*, not Q_m.

With the help of Figure 2.5, we can draw a number of conclusions about market allocations of commodities causing pollution externalities:

1. The output of the commodity is too large.
2. Too much pollution is produced.

FIGURE 2.5 The Market for Steel



3. The prices of products responsible for pollution are too low.
4. As long as the costs are external, no incentives to search for ways to yield less pollution per unit of output are introduced by the market.
5. Recycling and reuse of the polluting substances are discouraged because release into the environment is so inefficiently cheap.

The effects of a market imperfection for one commodity end up affecting the demands for raw materials, labor, and so on. The ultimate effects are felt through the entire economy.

Types of Externalities

External effects, or externalities, can be positive or negative. Historically, the terms *external diseconomy* and *external economy* have been used to refer, respectively, to circumstances in which the affected party is damaged by or benefits from the externality. Clearly, the water pollution example represents an external diseconomy. External economies are not hard to find, however. Private individuals who preserve a particularly scenic area provide an external economy to all who pass. Generally, when external economies are present, the market will undersupply the resources.

One other distinction is important. One class of externalities, known as *pecuniary externalities*, does not present the same kinds of problems as pollution does. Pecuniary externalities arise when the external effect is transmitted through altered prices. Suppose that a new firm moves into an area and drives up the rental price of land. That increase creates a negative effect on all those paying rent and, therefore, is an external diseconomy.

This pecuniary diseconomy, however, does not cause a market failure because the resulting higher rents are reflecting the scarcity of land. The land market provides a mechanism by which the parties can bid for land; the resulting prices reflect the value of the land in its various uses. Without pecuniary externalities, the price signals would fail to sustain an efficient allocation.

The pollution example is *not* a pecuniary externality because the effect is not transmitted through prices. In this example, prices do not adjust to reflect the increasing waste load. The damage to the water resource is not reflected in the steel firm's costs. An essential feedback mechanism that is present for pecuniary externalities is not present for the pollution case.

The externalities concept is a broad one, covering a multitude of sources of market failure (Example 2.2 illustrates one). The next step is to investigate some specific circumstances that can give rise to externalities.

EXAMPLE 2.2

Shrimp Farming Externalities in Thailand

In the Tha Po village on the coast of Surat Thani Province in Thailand, more than half of the 1,100 hectares of mangrove swamps have been cleared for commercial shrimp farms. Although harvesting shrimp is a lucrative undertaking, mangroves serve as nurseries for fish and as barriers for storms and soil erosion. Following the destruction of the local mangroves, Tha Po villagers experienced a decline in fish catch and suffered storm damage and water pollution. Can market forces be trusted to strike the efficient balance between preservation and development for the remaining mangroves?

Calculations by economists Sathirathai and Barbier (2001) demonstrated that the value of the ecological services that would be lost from further destruction of the mangrove swamps exceeded the value of the shrimp farms that would take their place. Preservation of the remaining mangrove swamps would be the efficient choice.

Would a potential shrimp-farming entrepreneur make the efficient choice? Unfortunately, the answer is no. This study estimated the economic value of mangroves in terms of local use of forest resources, offshore fishery linkages, and coastal protection to be in the range of $27,264–$35,921 per hectare. In contrast, the economic returns to shrimp farming, once they are corrected for input subsidies and for the costs of water pollution, are only $194–$209 per hectare. However, as shrimp farmers are heavily subsidized and do not have to take into account the external costs of pollution, their financial returns are typically $7,706.95–$8,336.47 per hectare. In the absence of some sort of external control imposed by collective action, development would be the normal, if inefficient, result. The externalities associated with the ecological services provided by the mangroves support a biased decision that results in fewer social net benefits, but greater private net benefits.

Source: Suthawan Sathirathai and Edward B. Barbier. "Valuing Mangrove Conservation in Southern Thailand" CONTEMPORARY ECONOMIC POLICY, Vol. 19, No. 2 (April 2001), pp. 109–122.

Improperly Designed Property Rights Systems

Other Property Rights Regimes[2]

Private property is, of course, not the only possible way of defining entitlements to resource use. Other possibilities include state-property regimes (where the government owns and controls the property), common-property regimes (where the property is jointly owned and managed by a specified group of co-owners), and *res nullius* or open-access regimes (in which no one owns or exercises control over the resources). All of these create rather different incentives for resource use.

State-property regimes exist not only in former communist countries, but also to varying degrees in virtually all countries of the world. Parks and forests, for example, are frequently owned and managed by the government in capitalist as well as in socialist nations. Problems with both efficiency and sustainability can arise in state-property regimes when the incentives of bureaucrats, who implement and/or make the rules for resource use, diverge from collective interests.

Common-property resources are those shared resources that are managed in common rather than privately. Entitlements to use common-property resources may be formal, protected by specific legal rules, or they may be informal, protected by tradition or custom. Common-property regimes exhibit varying degrees of efficiency and sustainability, depending on the rules that emerge from collective decision making. While some very successful examples of common-property regimes exist, unsuccessful examples are even more common.[3]

One successful example of a common-property regime involves the system of allocating grazing rights in Switzerland. Although agricultural land is normally treated as private property in Switzerland, grazing rights on the Alpine meadows have been treated as common property for centuries. Overgrazing is protected by specific rules, enacted by an association of users, which limit the amount of livestock permitted on the meadow. The families included on the membership list of the association have been stable over time as rights and responsibilities have passed from generation to generation. This stability has apparently facilitated reciprocity and trust, thereby providing a foundation for continued compliance with the rules.

Unfortunately, that kind of stability may be the exception rather than the rule, particularly in the face of heavy population pressure. The more common situation can be illustrated by the experience of Mawelle, a small fishing village in Sri Lanka. Initially, a complicated but effective rotating system of fishing rights was devised by villagers to assure equitable access to the best spots and best times while protecting the fish stocks. Over time, population pressure and the infusion of outsiders raised demand and undermined the collective cohesion sufficiently that the traditional rules became unenforceable, producing overexploitation of the resource and lower incomes for all the participants.

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[2]This section relies on the classification system presented in Bromley (1991).
[3]The two cases that follow, and many others, are discussed in Ostrom (1990).

Res nullius property resources, the main focus of this section, can be exploited on a first-come, first-served basis because no individual or group has the legal power to restrict access. *Open-access resources*, as we shall henceforth call them, have given rise to what has become known popularly as the "tragedy of the commons."

The problems created by open-access resources can be illustrated by recalling the fate of the American bison. Bison are an example of "common-pool" resources. *Common-pool resources* are shared resources characterized by nonexclusivity and divisibility. Nonexclusivity implies that resources can be exploited by anyone, while divisibility means that the capture of part of the resource by one group subtracts it from the amount available to the other groups. (Note the contrast between common-pool resources and public goods, the subject of the next section.) In the early history of the United States, bison were plentiful; unrestricted hunting access was not a problem. Frontier people who needed hides or meat could easily get whatever they needed; the aggressiveness of any one hunter did not affect the time and effort expended by other hunters. In the absence of scarcity, efficiency was not threatened by open access.

As the years slipped by, however, the demand for bison increased and scarcity became a factor. As the number of hunters increased, eventually every additional unit of hunting activity increased the amount of time and effort required to produce a given yield of bison.

Consider graphically how various property rights structures (and the resulting level of harvest) affect the scarcity rent (in this case, equivalent to the economic surplus received by consumers and producers), where the amount of rent is measured as the difference between the revenues received from the harvest minus the costs associates with producing that harvest. Figure 2.6 compares the revenue and costs for various levels of harvest. In the top panel the revenue is calculated by multiplying, for each level of hunting activity, the (assumed constant) price of bison by the amount harvested. The upward sloping total cost curve simply reflects that fact that increases in harvest effort result in higher costs. (Marginal cost is assumed to be constant for this example.)

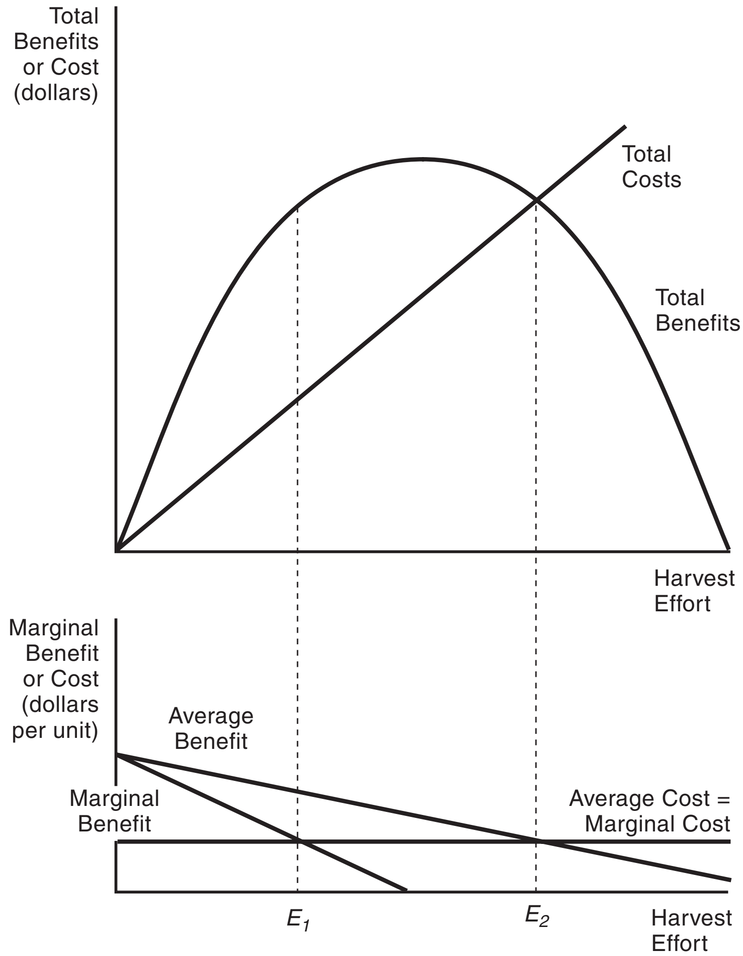
In terms of the top panel of Figure 2.6 the total surplus associated with any level of effort is measured as the vertical difference between the total revenue curve and the total cost curve for that level of harvest.

In the bottom panel the marginal revenue curve is downward sloping (despite the constant price) because as the amount of hunting effort increases, the resulting bison population size decreases. Smaller populations support smaller harvests per unit of effort expended.

The efficient level of hunting activity in this model (E_1) maximizes the surplus. This can be seen graphically in two different ways. First, E_1 maximizes the vertical difference between the two curves in the top panel. Second, in the bottom panel E_1 is the level where the marginal revenue, which records the addition to the surplus from an additional unit of effort, crosses the marginal cost curve, which measures the reduction in the surplus due to the additional cost of expending that last unit of effort. These are simply two different (mathematically equivalent) ways to demonstrate the same outcome. (The curves in the bottom panel are derived from the curves in the top panel.)

With all hunters having completely unrestricted access to the bison, the resulting allocation would not be efficient. No individual hunter would have an incentive

FIGURE 2.6 Bison Harvesting



to protect scarcity rent by restricting hunting effort. Individual hunters, without exclusive rights, would exploit the resource until their total benefit equaled total cost, implying a level of effort equal to (E_2). Excessive exploitation of the herd occurs because individual hunters cannot appropriate the scarcity rent; therefore, they ignore it. One of the losses from further exploitation that could be avoided by exclusive owners—the loss of scarcity rent due to overexploitation—is not part of the decision-making process of open-access hunters.

Two characteristics of this formulation of the open-access allocation are worth noting: (1) In the presence of sufficient demand, unrestricted access will cause resources to be overexploited; (2) the scarcity rent is dissipated; no one is able to appropriate the rent, so it is lost.

Why does this happen? Unlimited access destroys the incentive to conserve. A hunter who can preclude others from hunting his stock has an incentive to keep the herd at an efficient level. This restraint results in lower costs in the form of less time and effort expended to produce a given yield of bison. On the other hand, a hunter exploiting an open-access resource would not have an incentive to conserve because the potential additional economic surplus derived from self-restraint would, to some extent, be captured by other hunters who simply kept harvesting. Thus, unrestricted access to resources promotes an inefficient allocation. As a result of excessive harvest and the loss of habitat as land was converted to farm and pasture, the Great Plains bison herds nearly became extinct (Lueck, 2002). Another example of open-access, fisheries, is the principal topic of Chapter 13.

Public Goods

Public goods, defined as those that exhibit both consumption indivisibilities and nonexcludability, present a particularly complex category of environmental resources. *Nonexcludability* refers to a circumstance where, once the resource is provided, even those who fail to pay for it cannot be excluded from enjoying the benefits it confers. Consumption is said to be *indivisible* when one person's consumption of a good does not diminish the amount available for others. Several common environmental resources are public goods, including not only the "charming landscape" referred to by Emerson, but also clean air, clean water, and biological diversity.[4]

Biological diversity includes two related concepts: (1) the amount of genetic variability among individuals within a single species, and (2) the number of species within a community of organisms. *Genetic diversity*, critical to species survival in the natural world, has also proved to be important in the development of new crops and livestock. It enhances the opportunities for crossbreeding and, thus, the development of superior strains. The availability of different strains was the key, for example, in developing new, disease-resistant barley.

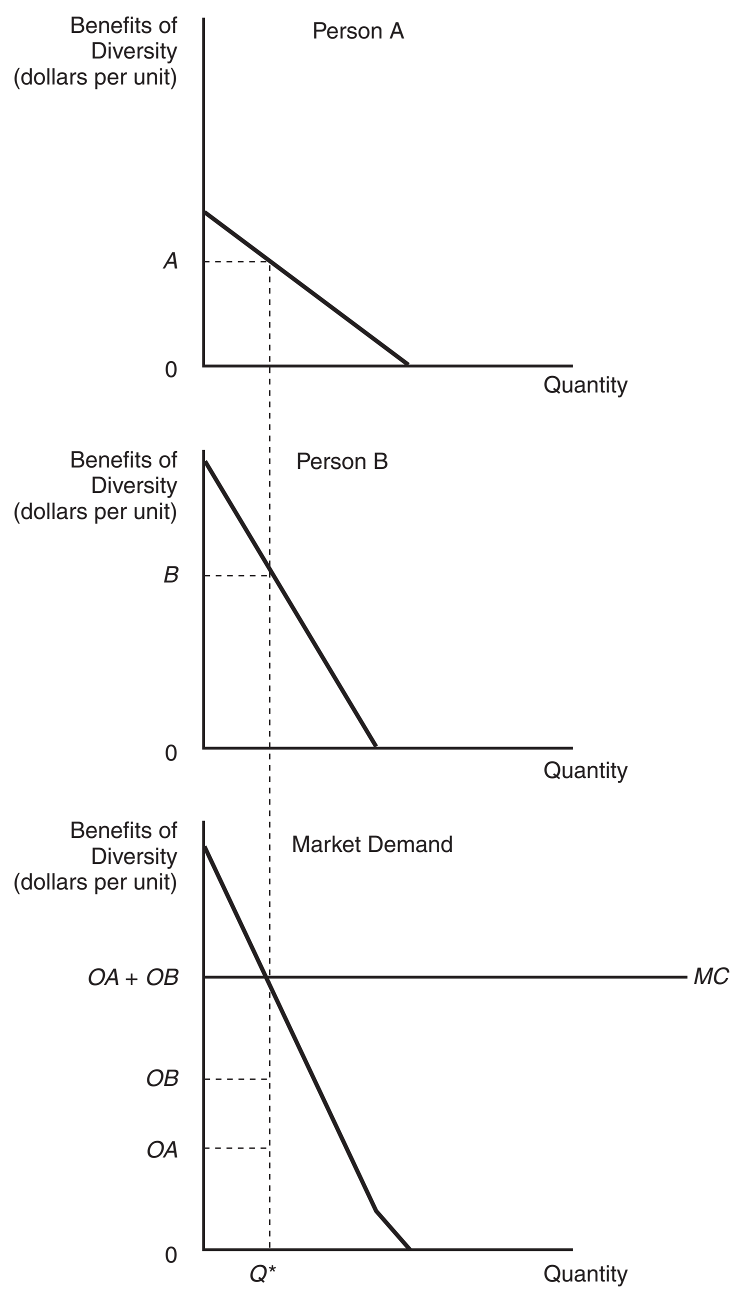
Because of the interdependence of species within ecological communities, any particular species may have a value to the community far beyond its intrinsic value. Certain species contribute balance and stability to their ecological communities by providing food sources or holding the population of the species in check.

The richness of diversity within and among species has provided new sources of food, energy, industrial chemicals, raw materials, and medicines. Yet, considerable evidence suggests that biological diversity is decreasing.

Can we rely on the private sector to produce the efficient amount of public goods, such as biological diversity? Unfortunately, the answer is no! Suppose that in response to diminishing ecological diversity we decide to take up a collection to provide some means of preserving endangered species. Would the collection yield

[4]Notice that public "bads," such as dirty air and dirty water, are also possible.

FIGURE 2.7 Efficient Provision of Public Goods



sufficient revenue to pay for an efficient level of ecological diversity? The general answer is no. Let's see why.

In Figure 2.7, individual demand curves for preserving biodiversity have been presented for two consumers A and B. The market demand curve is represented by the vertical summation of the two individual demand curves. A vertical summation is necessary because everyone can simultaneously consume the same amount of biological diversity. We are, therefore, able to determine the market demand by finding the sum of the amounts of money they would be willing to pay for that level of diversity.

What is the efficient level of diversity? It can be determined by a direct application of our definition of efficiency. The efficient allocation maximizes economic surplus, which is represented geometrically by the portion of the area under the market demand curve that lies above the constant marginal cost curve. The allocation that maximizes economic surplus is Q^*, the allocation where the demand curve crosses the marginal cost curve.

Why would a competitive market not be expected to supply the efficient level of this good? Since the two consumers get very different marginal willingness to pay from the efficient allocation of this good (*OA* versus *OB*), the efficient pricing system would require charging a different price to each consumer. Person *A* would pay *OA* and person *B* would pay *OB*. (Remember consumers tend to choose the level of the good that equates their marginal willingness to pay to the price they face.) Yet the producer would have no basis for figuring out how to differentiate the prices. In the absence of excludability, consumers are not likely choose to reveal the strength of their preference for this commodity. All consumers have an incentive to understate the strength of their preferences to try to shift more of the cost burden to the other consumers.

Therefore, inefficiency results because each person is able to become a free rider on the other's contribution. A *free rider* is someone who derives the value from a commodity without paying an efficient amount for its supply. Because of the consumption indivisibility and nonexcludability properties of the public good, consumers receive the value of any diversity purchased by other people. When this happens it tends to diminish incentives to contribute, and the contributions are not sufficiently large to finance the efficient amount of the public good; it would be undersupplied.

The privately supplied amount may not be zero, however. Some diversity would be privately supplied. Indeed, as suggested by Example 2.3, the privately supplied amount may be considerable.

Imperfect Market Structures

Environmental problems also occur when one of the participants in an exchange of property rights is able to exercise an inordinate amount of power over the outcome. This can occur, for example, when a product is sold by a single seller, or *monopoly*.

It is easy to show that monopolies violate our definition of *efficiency* in the goods market (see Figure 2.8). According to our definition of *static efficiency*, the efficient allocation would result when *OB* is supplied. This would yield consumer surplus represented by triangle *IGC and* producer surplus denoted by triangle *GCH*.

EXAMPLE 2.3

Public Goods Privately Provided: The Nature Conservancy

Can the demand for a public good such as biological diversity be observed in practice? Would the market respond to that demand? Apparently so, according to the existence of an organization called The Nature Conservancy.

The Nature Conservancy was born of an older organization called the Ecologist Union on September 11, 1950, for the purpose of establishing natural area reserves to aid in the preservation of areas, objects, and fauna and flora that have scientific, educational, or aesthetic significance. This organization purchases, or accepts as donations, land that has some unique ecological or aesthetic significance, to keep it from being used for other purposes. In so doing they preserve many species by preserving the habitat.

From humble beginnings, The Nature Conservancy has, as of 2010, been responsible for the preservation of 119 million acres of forests, marshes, prairies, mounds, and islands around the world. Additionally, The Nature Conservancy has protected 5,000 miles of rivers and operates over 100 marine conservation projects. These areas serve as home to rare and endangered species of wildlife and plants. The Conservancy owns and manages the largest privately owned nature preserve system in the world.

This approach has considerable merit. A private organization can move more rapidly than the public sector. Because it has a limited budget, The Nature Conservancy sets priorities and concentrates on acquiring the most ecologically unique areas. Yet the theory of public goods reminds us that if this were to be the sole approach to the preservation of biological diversity, it would preserve a smaller-than-efficient amount.

Source: The Nature Conservancy, http://nature.org/aboutus/.

The monopoly, however, would produce and sell *OA*, where marginal revenue equals marginal cost, and would charge price *OF*. At this point, although the producer's surplus (HFED) is maximized, the sum of consumer and producer surplus is clearly not, because this choice causes society to lose economic surplus equal to triangle *EDC*.[5] Monopolies supply an inefficiently small amount of the good.

Imperfect markets clearly play some role in environmental problems. For example, the major oil-exporting countries have formed a cartel, resulting in higher-than-normal prices and lower-than-normal production. A *cartel* is a collusive agreement among producers to restrict production and raise prices. This collusive agreement allows the group to act as a monopolist. The inefficiency in the goods market would normally be offset to some degree by the reduction in

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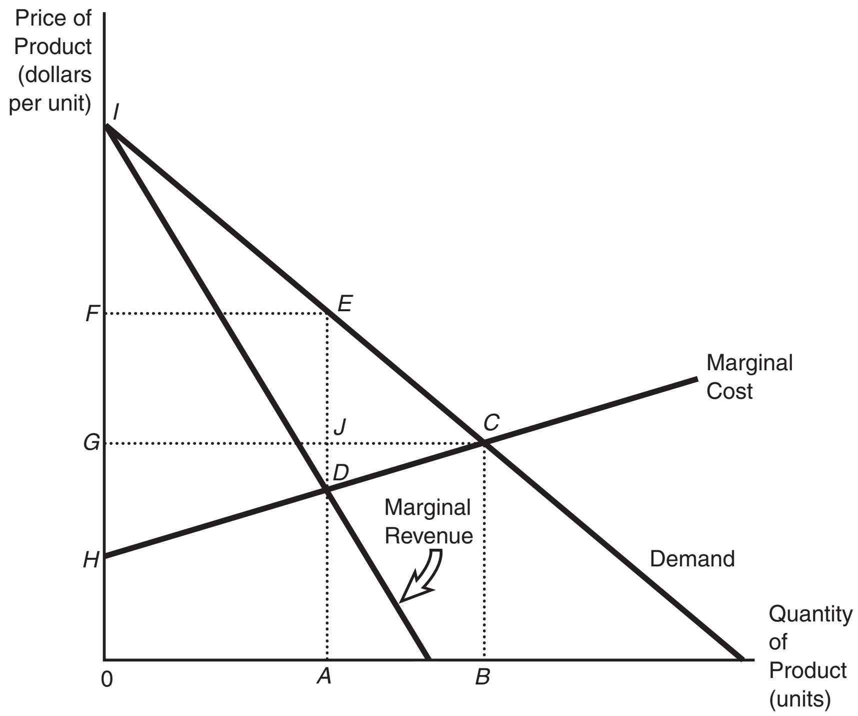
[5]Producers would lose area *JDC* compared to the efficient allocation, but they would gain area *FEJG*, which is much larger. Meanwhile, consumers would be worse off, because they lose area *FECJG*. Of these, *FEJG* is merely a transfer to the monopoly, whereas *EJC* is a pure loss to society. The total pure loss (*EDC*) is called a *deadweight loss*.

FIGURE 2.8 Monopoly and Inefficiency



social costs caused by the lower levels of pollution resulting from the reduction in the combustion of oil. Debate 2.1 examines the pricing activities of OPEC and recent fluctuations in oil prices.

Government Failure

Market processes are not the only sources of inefficiency. Political processes are fully as culpable. As will become clear in the chapters that follow, some environmental problems have arisen from a failure of political, rather than economic, institutions. To complete our study of the ability of institutions to allocate environmental resources, we must understand this source of inefficiency as well.

Government failure shares with market failure the characteristic that improper incentives are the root of the problem. Special interest groups use the political process to engage in what has become known as *rent seeking*. Rent seeking is the use of resources in lobbying and other activities directed at securing protective legislation. Successful rent-seeking activity will increase the net benefits going to the special interest group, but it will also frequently lower the surplus to society as a whole. In these instances, it is a classic case of the aggressive pursuit of a larger slice of the pie leading to a smaller pie.

DEBATE 2.1

How Should OPEC Price Its Oil?

As a cartel, OPEC (Organization of Petroleum Exporting Countries) has considerable control over its output and, hence, prices. And as Figure 2.8 suggests, it could increase its profits by restricting supply, a tactic that would cause prices to rise above their competitive levels. By how much should prices be raised?

The profit-maximizing price will depend upon several factors, including the price elasticity of demand (to determine how much the quantity demanded will fall in response to the higher price), the price elasticity of supply for non-OPEC members (to determine how much added production should be expected from outside producers), and the propensity for cheating (members producing more than their assigned quotas). Gately (1995) has modeled these and other factors and concluded that OPEC's interests would be best served by a policy of moderate output growth, defined as growth at a rate no faster than world income growth.

As Gately points out, however, OPEC historically has not always exercised this degree of caution. In 1979–1980, succumbing to the lure of even higher prices, OPEC chose a price strategy that required substantial restrictions of cartel output. Not only did the price elasticities of demand and non-OPEC supply turn out to be much higher than anticipated by the cartel, but also the higher oil prices triggered a worldwide recession (which further lowered demand). OPEC lost not only revenue but also market share. Even for monopolies, the market imposes some discipline; the highest price is not always the best price.

Interestingly, since 1980, world oil markets have experienced increasing price volatility. Oil prices dropped as low as $10 per barrel in 1998 and rose above $30 per barrel in 2000 (then considered a huge price swing). In 2008, oil prices rose to over $138 per barrel! Kohl (2002) analyzes OPEC's behavior during the period of 1998–2001. He notes that OPEC has consistently had trouble with member compliance and with the non-OPEC competitive fringe (e.g., Norway, Mexico, and Russia). He notes that compliance with production quotas has been best during periods of high demand or when the quotas are set above production capacity.

High demand has been the recent situation. With surging demand in China and the United States, oil prices have risen dramatically. Will higher prices induce sufficient reductions in consumption to moderate OPEC power? Stay tuned.

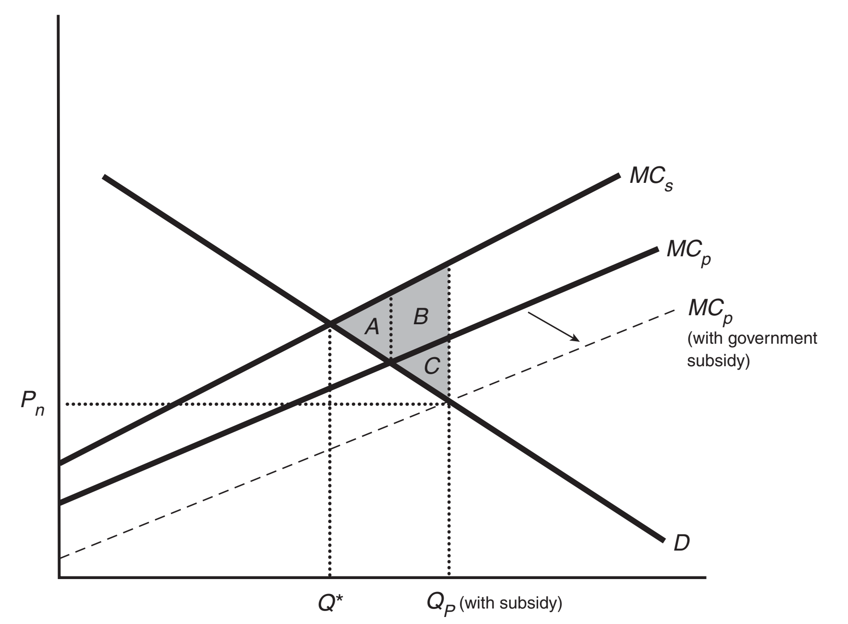
Sources: Dermot Gately. "Strategies for OPEC's Pricing and Output Decisions." ENERGY JOURNAL, Vol. 16, No. 3 (1995), pp. 1–38; Wilfrid L. Kohl, "OPEC Behavior, 1998–2001." QUARTERLY REVIEW OF ECONOMICS AND FINANCE, Vol. 42 (2002), pp. 209–233; and "OPEC Finds Price Range to Live With." THE NEW YORK TIMES, December 6, 2007.

Why don't the losers rise up to protect their interests? One main reason is voter ignorance. It is economically rational for voters to remain ignorant on many issues simply because of the high cost of keeping informed and the low probability that any single vote will be decisive. In addition, it is difficult for diffuse groups of individuals, each of whom is affected only to a small degree, to organize a coherent, unified opposition. Successful opposition is, in a sense, a public good, with its attendant tendency for free riding on the opposition of others. Opposition to special interests would normally be underfunded.

Rent seeking can take many forms. Producers can seek protection from competitive pressures brought by imports or can seek price floors to hold prices above their efficient levels. Consumer groups can seek price ceilings or special subsidies to transfer part of their costs to the general body of taxpayers. Rent seeking is not the only source of inefficient government policy. Sometimes governments act without full information and establish policies that are ultimately very inefficient. For example, as we will discuss in Chapter 17, one technological strategy chosen by the government to control motor vehicle pollution involved adding the chemical substance MTBE to gasoline. Designed to promote cleaner combustion, this additive turned out to create a substantial water pollution problem.

Governments may also pursue social policy objectives that have the side effect of causing an environmental inefficiency. For example, looking back at Figure 2.5, suppose that the government, for reasons of national security, decides to subsidize the production of steel. Figure 2.9 illustrates the outcome. The private marginal cost curve shifts down and to the right causing a further increase in production, lower prices, and even more pollution produced. Thus, the subsidy moves us even further away from where surplus is maximized at Q^*. The shaded triangle A shows the deadweight loss (inefficiency) without the subsidy. With the subsidy, the deadweight loss grows to areas $A + B + C$. This social policy has the side effect of increasing an environmental inefficiency. In another example, in Chapter 7, we shall see how the desire to hold down natural gas prices for consumers led to massive

FIGURE 2.9 The Market for Steel Revisited



shortages. These examples provide a direct challenge to the presumption that more direct intervention by the government automatically leads to either greater efficiency or greater sustainability.

These cases illustrate the general economic premise that environmental problems arise because of a divergence between individual and collective objectives. This is a powerful explanatory device because not only does it suggest why these problems arise, but also it suggests how they might be resolved—by realigning individual incentives to make them compatible with collective objectives. As self-evident as this approach may be, it is controversial. The controversy involves whether the problem is our improper values or the improper translation of our quite proper values into action.

Economists have always been reluctant to argue that values of consumers are warped, because that would necessitate dictating the "correct" set of values. Both capitalism and democracy are based on the presumption that the majority knows what it is doing, whether it is casting ballots for representatives or dollar votes for goods and services.

The Pursuit of Efficiency

We have seen that environmental problems arise when property rights are ill defined, and when these rights are exchanged under something other than competitive conditions. We can now use our definition of efficiency to explore possible remedies, such as private negotiation, judicial remedies, and regulation by the legislative and executive branches of government.

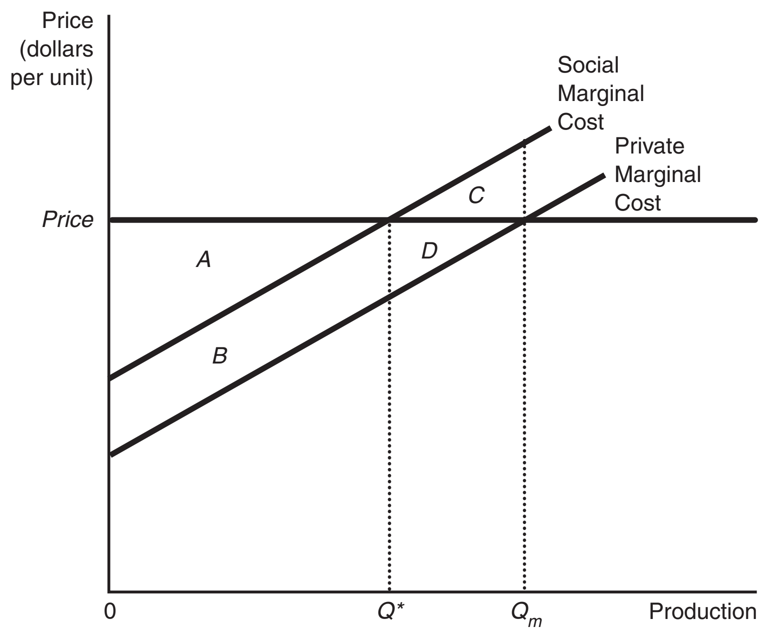
Private Resolution through Negotiation

The simplest means to restore efficiency occurs when the number of affected parties is small, making negotiation feasible. Suppose, for example, we return to the case used earlier in this chapter to illustrate an externality—the conflict between the polluting steel company and the downstream resort.

Figure 2.10 reveals the answer. If the resort offers a bribe of $C + D$, they would experience damage reduction from the decrease in production from Q_m to Q^*. Let's assume that the bribe is equal to this amount. Would the steel company be willing to reduce production to the desired level? If they refused the bribe, their producer surplus would be $A + B + D$. If they accepted the bribe, their producer surplus would be $A + B$ plus the bribe, so their total return would be $A + B + C + D$. Clearly, they are better off by C if they accept the bribe. Society as a whole is better off by amount C as well since the economic surplus from Q_m is $A - C$ and the economic surplus for Q^* is A.

Our discussion of individual negotiations raises two questions: (1) Should the property right always belong to the party who gained or seized it first (in this case the steel company)? (2) How can environmental risks be handled when prior negotiation is clearly impractical? These questions are routinely answered by the court system.

FIGURE 2.10 Efficient Output with Pollution Damage



The Courts: Property Rules and Liability Rules

The court system can respond to environmental conflicts by imposing either property rules or liability rules. Property rules specify the initial allocation of the entitlement. The entitlements at conflict in our example are, on one hand, the right to add waste products to the river and, on the other, the right to an attractive river. In applying property rules, the court merely decides which right is preeminent and places an injunction against violating that right. The injunction is removed only upon obtaining the consent of the party whose right was violated. Consent is usually obtained in return for an out-of-court monetary settlement.

Note that in the absence of a court decision, the entitlement is naturally allocated to the party that can most easily seize it. In our example, the natural allocation would give the entitlement to the steel company. The courts must decide whether to overturn this natural allocation.

How would they decide? And what difference would their decision make? The answers may surprise you.

In a classic article, economist Ronald Coase (1960) held that as long as negotiation costs are negligible and affected consumers can negotiate freely with each other (when the number of affected parties is small), the court could allocate the entitlement to *either* party, and an efficient allocation would result. The only effect of the court's decision would be to change the distribution of surplus among the affected parties. This remarkable conclusion has come to be known as the Coase theorem.

Why is this so? In Figure 2.10, we showed that if the steel company has the property right, it is in the resort's interest to offer a bribe that results in the desired level of output. Suppose, now, that the resort has the property right instead. To pollute in this case, the steel company must bribe the resort. Suppose it could pollute only if it compensated the resort for all damages. (In other words, it would agree to pay the difference between the two marginal cost curves up to the level of output actually chosen.) As long as this compensation was required, the steel company would choose to produce Q^* since that is the level at which its producer's surplus maximized. (Note that, due to the compensation, the curve the steel company uses to calculate its producer surplus is now the higher marginal cost curve.)

The difference between these different ways of allocating property rights lies in how the cost of obtaining the efficient level of output is shared between the parties. When the property right is assigned to the steel company, the cost is borne by the resort (part of the cost is the damage and part is the bribe to reduce the level of damage). When the property right is assigned to the resort, the cost is borne by the steel company (it now must compensate for all damage). In either case, the efficient level of production results. The Coase theorem shows that the very existence of an inefficiency triggers pressures for improvements. Furthermore, the existence of this pressure does not depend on the assignment of property rights.

This is an important point. As we shall see in succeeding chapters, private efforts triggered by inefficiency can frequently prevent the worst excesses of environmental degradation. Yet the importance of this theorem should not be overstated. Both theoretical and practical objections can be raised. The chief theoretical qualification concerns the assumption that wealth effects do not matter. The decision to confer the property right on a particular party results in a transfer of wealth to that party. This transfer might shift the demand curve for either steel or resorts out, as long as higher incomes result in greater demand. Whenever wealth effects are significant, the type of property rule issued by the court affects the outcome.

Wealth effects normally are small, so the zero-wealth-effect assumption is probably not a fatal flaw. Some serious practical flaws, however, do mar the usefulness of the Coase theorem. The first involves the incentives for polluting that result when the property right is assigned to the polluter. Since pollution would become a profitable activity with this assignment, other polluters might be encouraged to increase production and pollution in order to earn the bribes. That certainly would not be efficient.

Negotiation is also difficult to apply when the number of people affected by the pollution is large. You may have already noticed that in the presence of several affected parties, pollution reduction is a public good. The free-rider problem would make it difficult for the group to act cohesively and effectively for the restoration of efficiency.

When individual negotiation is not practical for one reason or another, the courts can turn to liability rules. These are rules that award monetary damages, after the fact, to the injured party. The amount of the award is designed to correspond to the amount of damage inflicted. Thus, returning to Figure 2.10, a liability rule would force the steel company to compensate the resort for all damages incurred. In this case, it could choose any production level it wanted, but it would have to pay the resort an amount of money equal to the area between the two marginal cost curves from the origin to the chosen level of output. In this case the steel plant would maximize its producer's surplus by choosing Q^*. (Why wouldn't the steel plant choose to produce more than that? Why wouldn't the steel plant choose to produce less than that?)

The moral of this story is that appropriately designed liability rules can also correct inefficiencies by forcing those who cause damage to bear the cost of that damage. Internalizing previously external costs causes profit-maximizing decisions to be compatible with efficiency.

Liability rules are interesting from an economics point of view because early decisions create precedents for later ones. Imagine, for example, how the incentives to prevent oil spills facing an oil company are transformed once it has a legal obligation to clean up after an oil spill and to compensate fishermen for reduced catches. It quickly becomes evident that in this situation accident prevention can become cheaper than retrospectively dealing with the damage once it has occurred.

This approach, however, also has its limitations. It relies on a case-by-case determination based on the unique circumstances for each case. Administratively, such a determination is very expensive. Expenses, such as court time, lawyers' fees, and so on, fall into a category called *transaction costs* by economists. In the present context, these are the administrative costs incurred in attempting to correct the inefficiency. When the number of parties involved in a dispute is large and the circumstances are common, we are tempted to correct the inefficiency by statutes or regulations rather than court decisions.

Legislative and Executive Regulation

These remedies can take several forms. The legislature could dictate that no one produce more steel or pollution than Q^*. This dictum might then be backed up with sufficiently large jail sentences or fines to deter potential violators. Alternatively, the legislature could impose a tax on steel or on pollution. A per-unit tax equal to the vertical distance between the two marginal cost curves would work (see Figure 2.10).

Legislatures could also establish rules to permit greater flexibility and yet reduce damage. For example, zoning laws might establish separate areas for steel plants and resorts. This approach assumes that the damage can be substantially reduced by keeping nonconforming uses apart.

They could also require the installation of particular pollution control equipment (as when catalytic converters were required on automobiles), or deny the use of a particular production ingredient (as when lead was removed from gasoline). In other words, they can regulate outputs, inputs, production processes, emissions, and even the location of production in their attempt to produce an efficient outcome. In subsequent chapters, we shall examine the various options policy-makers have not only to show how they can modify environmentally destructive behavior, but also to establish the degree to which they can promote efficiency.

Bribes are, of course, not the only means victims have at their disposal for lowering pollution. When the victims also consume the products produced by the polluters, consumer boycotts are possible. When the victims are employed by the polluter producer, strikes or other forms of labor resistance are possible.

An Efficient Role for Government

While the economic approach suggests that government action could well be used to restore efficiency, it also suggests that inefficiency is not a sufficient condition to justify government intervention. Any corrective mechanism involves transaction costs. If these transaction costs are high enough, and the surplus to be derived from correcting the inefficiency small enough, then it is best simply to live with the inefficiency.

Consider, for example, the pollution problem. Wood-burning stoves, which were widely used for cooking and heat in the late 1800s in the United States, were sources of pollution, but because of the enormous capacity of the air to absorb the emissions, no regulation resulted. More recently, however, the resurgence of demand for wood-burning stoves, precipitated in part by high oil prices, has resulted in strict regulations for wood-burning stove emissions because the population density is so much higher.

As society has evolved, the scale of economic activity and the resulting emissions have increased. Cities are experiencing severe problems from air and water pollutants because of the clustering of activities. Both the expansion and the clustering have increased the amount of emissions per unit volume of air or water. As a result, pollutant concentrations have caused perceptible problems with human health, vegetation growth, and aesthetics.

Historically, as incomes have risen, the demand for leisure activities has also risen. Many of these leisure activities, such as canoeing and backpacking, take place in unique, pristine environmental areas. With the number of these areas declining as a result of conversion to other uses, the value of remaining areas has increased. Thus, the value derived from protecting some areas have risen over time until they have exceeded the transaction costs of protecting them from pollution and/or development.

The level and concentration of economic activity, having increased pollution problems and driven up the demand for clean air and pristine areas, have created the preconditions for government action. Can government respond or will rent seeking prevent efficient political solutions? We devote much of this book to searching for the answer to that question.

Summary

How producers and consumers use the resources making up the environmental asset depends on the nature of the entitlements embodied in the property rights governing resource use. When property rights systems are exclusive, transferable, and enforceable, the owner of a resource has a powerful incentive to use that resource efficiently, since the failure to do so results in a personal loss.

The economic system will not always sustain efficient allocations, however. Specific circumstances that could lead to inefficient allocations include externalities; improperly defined property rights systems (such as open-access resources and public goods); and imperfect markets for trading the property rights to the resources (monopoly). When these circumstances arise, market allocations do not maximize the surplus.

Due to rent-seeking behavior by special interest groups or the less-than-perfect implementation of efficient plans, the political system can produce inefficiencies as well. Voter ignorance on many issues, coupled with the public-good nature of any results of political activity, tends to create a situation in which maximizing an individual's private surplus (through lobbying, for example) can be at the expense of a lower economic surplus for all consumers and producers.

The efficiency criterion can be used to assist in the identification of circumstances in which our political and economic institutions lead us astray. It can also assist in the search for remedies by facilitating the design of regulatory, judicial, or legislative solutions.

Discussion Questions

1. In a well-known legal case, *Miller v. Schoene* (287 U.S. 272), a classic conflict of property rights was featured. Red cedar trees, used only for ornamental purposes, carried a disease that could destroy apple orchards within a radius of two miles. There was no known way of curing the disease except by destroying the cedar trees or by ensuring that apple orchards were at least two miles away from the cedar trees. Apply the Coase theorem to this situation. Does it make any difference to the outcome whether the cedar tree owners are entitled to retain their trees or the apple growers are entitled to be free of them? Why or why not?
2. In primitive societies, the entitlements to use land were frequently possessory rights rather than ownership rights. Those on the land could use it as they wished, but they could not transfer it to anyone else. One could acquire a new plot by simply occupying and using it, leaving the old plot available for someone else. Would this type of entitlement system cause more or less incentive to conserve the land than an ownership entitlement? Why? Would a possessory entitlement system be more efficient in a modern society or a primitive society? Why?

Self-Test Exercises

1. Suppose the state is trying to decide how many miles of a very scenic river it should preserve. There are 100 people in the community, each of whom has an identical inverse demand function given by $P = 10 - 1.0q$, where q is the number of miles preserved and P is the per-mile price he or she is willing to pay for q miles of preserved river. (a) If the marginal cost of preservation is \$500 per mile, how many miles would be preserved in an efficient allocation? (b) How large is the economic surplus?
2. Suppose the market demand function (expressed in dollars) for a normal product is $P = 80 - q$, and the marginal cost (in dollars) of producing it is $MC = 1q$, where P is the price of the product and q is the quantity demanded and/or supplied.
   a. How much would be supplied by a competitive market?
   b. Compute the consumer surplus and producer surplus. Show that their sum is maximized.
   c. Compute the consumer surplus and the producer surplus assuming this same product was supplied by a monopoly. (*Hint*: The marginal revenue curve has twice the slope of the demand curve.)
   d. Show that when this market is controlled by a monopoly, producer surplus is larger, consumer surplus is smaller, and the sum of the two surpluses is smaller than when the market is controlled by competitive industry.
3. Suppose you were asked to comment on a proposed policy to control oil spills. Since the average cost of an oil spill has been computed as \$*X*, the proposed policy would require any firm responsible for a spill immediately to pay the government \$*X*. Is this likely to result in the efficient amount of precaution against oil spills? Why or why not?
4. "In environmental liability cases, courts have some discretion regarding the magnitude of compensation polluters should be forced to pay for the environmental incidents they cause. In general, however, the larger the required payments the better." Discuss.
5. Label each of the following propositions as descriptive or normative and defend your choice:
   a. Energy efficiency programs would create jobs.
   b. Money spent on protecting endangered species is wasted.
   c. To survive our fisheries must be privatized.
   d. Raising transport costs lowers suburban land values.
   e. Birth control programs are counterproductive.
6. Identify whether each of the following resource categories is a public good, a common-pool resource, or neither and defend your answer:
   a. A pod of whales in the ocean to whale hunters.
   b. A pod of whales in the ocean to whale watchers.
   c. The benefits from reductions of greenhouse gas emissions.
   d. Water from a town well that excludes nonresidents.
   e. Bottled water.

Further Reading

Bromley, Daniel W. *Environment and Economy: Property Rights and Public Policy* (Oxford: Basil Blackwell, Inc., 1991). A detailed exploration of the property rights approach to environmental problems.

Bromley, Daniel W., ed. *Making the Commons Work: Theory, Practice and Policy* (San Francisco: ICS Press, 1992). An excellent collection of 13 essays exploring various formal and informal approaches to controlling the use of common-property resources.

Lueck, Dean. "The Extermination and Conservation of the American Bison," *Journal of Legal Studies* Vol 31(S2) (1989): s609–2652. A fascinating look at the role property rights played in the fate of the American bison.

Ostrom, Elinor, Thomas Dietz, Nives Dolsak, Paul Stern, Susan Stonich, and Elke U. Weber, eds. *The Drama of the Commons* (Washington, DC: National Academy Press, 2002). A compilation of articles and papers on common pool resources.

Ostrom, Elinor. *Crafting Institutions for Self-Governing Irrigation Systems* (San Francisco: ICS Press, 1992). Argues that common-pool problems are sometimes solved by voluntary organizations, rather than by a coercive state; among the cases considered are communal tenure in meadows and forests, irrigation communities, and fisheries.

Sandler, Todd. *Collective Action: Theory and Applications* (Ann Arbor: University of Michigan, 1992). A formal examination of the forces behind collective action's failures and successes.

Stavins, Robert N. "Harnessing Market Forces to Protect the Environment," *Environment* Vol. 31 (1989): 4–7, 28–35. An excellent, nontechnical review of the many ways in which the creative use of economic policies can produce superior environmental outcomes.

Stavins, Robert. *The Economics of the Environment: Selected Readings*, 5th ed. (New York: W.W. Norton and Company, 2005). A carefully selected collection of readings that would complement this text.

Additional References and Historically Significant References are available on this book's Companion Website:
http://www.pearsonhighered.com/tietenberg/