CHAPTER

3

The Theory of Environmental Externalities

Chapter 3 Focus Questions

- How can pollution and environmental damage be represented in economics?
- What economic policies can be instituted to respond to environmental problems?
- How and when can property rights be relied upon to solve environmental problems?

3.1 THE THEORY OF EXTERNALITIES

We saw in Chapter 1 that one of the core concepts of environmental economics is the theory of environmental externalities. Externalities were defined as impacts that affect the well-being of those outside of a market transaction. Externalities can be either positive or negative. The most common example of a **negative externality** is pollution. If markets operate without any regulation, the production decisions of companies will not account for the social and ecological damages of pollution. Consumers also typically will not limit their purchases because of pollution caused by the goods and services that they purchase. But it is important that economic analysis considers not just the ways markets impact buyers and sellers, but how markets affect all members of society. (It may also be relevant to consider impacts on non-human species and on ecosystems in general—this issue will be dealt later in this chapter and also in Chapters 6 and 7). So when we analyze the overall impacts of a market, we need to account for the damages from pollution.

negative externality negative impacts of a market transaction affecting those not involved in the transaction.

In some cases, a market transaction can generate a **positive externality** if it benefits those external to the market. An example of a positive externality is a landowner who buys and plants trees. In addition to benefits to the owner, the trees provide benefits to those who appreciate the scenery and to society as a whole because they absorb carbon dioxide and provide habitat for wildlife.

In a basic economic analysis of markets, demand and supply curves represent the costs and benefits of a transaction. A supply curve tells us the **marginal cost** of production—in other words, the costs of producing one more unit of a good or service. Meanwhile, a demand curve can also be considered a **marginal benefit** curve because it tells us the perceived benefits consumers obtain from consuming one additional unit. The intersection point of a demand and supply curve gives the **equilibrium price** at which supply and demand balance, as shown in Figure 3.1 for a hypothetical market for automobiles. This equilibrium (at a price of P_M and a quantity of Q_M) represents a situation of **economic efficiency** because it maximizes the total benefits from the market—but only if there are no externalities. (See Appendix 3.1 for an overview of supply, demand, equilibrium, and efficiency in markets.)

positive externality the positive impacts of a market transaction that affect those not involved in the transaction.

marginal cost the cost of producing or consuming one more unit of a good or service.

marginal benefit the benefit of producing or consuming one more unit of a good or service.

equilibrium price the market price where the quantity supplied equals the quantity demanded.

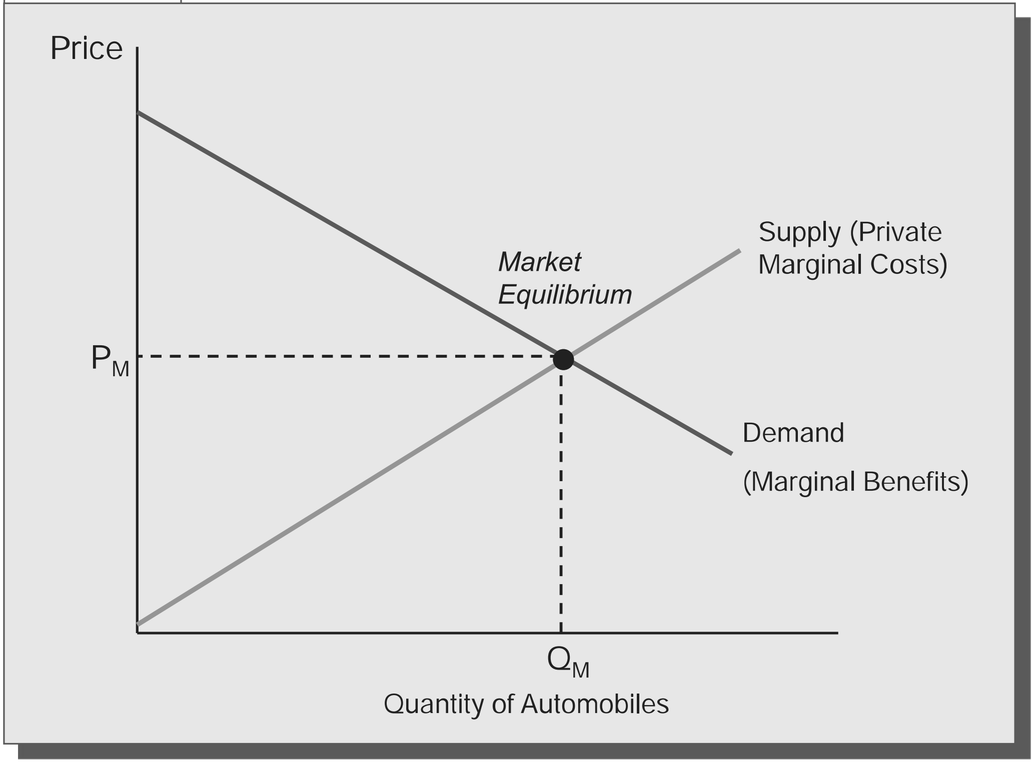
economic efficiency an allocation of resources that maximizes net social benefits; perfectly competitive markets in the absence of externalities are efficient.

Accounting for Environmental Costs

But this market equilibrium does not tell the whole story. The production and use of automobiles create numerous negative externalities. Automobiles are a major contributor to air pollution, including both local urban smog and regional problems such as acid rain. In addition, their emissions of carbon dioxide contribute to global warming. Automobile oil leaked from vehicles or disposed of improperly can pollute lakes, rivers, and groundwater. The production of automobiles involves the use of toxic materials that can be released to the environment as toxic wastes. The road system required for automobiles paves over many acres of wildlife habitat, and salt runoff from roads damages watersheds.

Where do these various costs appear in Figure 3.1? The answer is that they do not appear at all. Thus the market overestimates the net social benefits of automobiles because the costs

Figure 3.1 **The Market for Automobiles**



Note: Private marginal costs are the costs of production to private producers.

internalizing external costs/externalities using approaches such as taxation to incorporate external costs into market decisions.

external cost(s) a cost, not necessarily monetary, that is not reflected in a market transaction.

of the negative externalities are not considered. So we need to find ways of **internalizing externalities**—bringing the **external costs** into our market analysis.

The first problem in doing this is assigning a monetary value to environmental damages. How can we reduce the numerous environmental effects we have identified to a single monetary value? There is no clear-cut answer to this question. In some cases, economic damages are identifiable. For example, if road runoff pollutes a town's water supply, the cost of water treatment gives at least one estimate of environmental damages. However, this does not include less tangible factors such as damage to lake and river ecosystems.

If we can identify the health effects of air pollution, the resulting medical expenses will give us another monetary damage estimate, but this does not capture the aesthetic damage done by air pollution. Smoggy air limits visibility, which reduces people's well-being even if it does not have a measurable effect on their health. Issues such as these are difficult to compress into a monetary estimate. Yet if we do not assign a monetary value to environmental damages, the market implicitly assigns a value of zero, because none of these issues are directly reflected in consumer and producer decisions about automobiles. We will discuss the techniques economists use to value environmental impacts in more detail in Chapter 6.

Some economists have attempted to estimate the external costs of automobiles in monetary terms (see Box 3.1 and Table 3.1). Assuming we have a reasonable estimate of these external costs, how can these be added to our supply and demand analysis in Figure 3.1?

Box 3.1

THE EXTERNAL COSTS OF AUTOMOBILE USE

What are the external, or social, costs of motor vehicle use? Automobiles are considered to be the largest source of several major air pollutants including carbon monoxide and nitrogen oxides. According to the U.S. EPA, transportation accounts for about 13 percent of global greenhouse gas emissions.[1] The World Health Organization estimates that over one million deaths occur each year due to accidents on the world's roads.[2] Additional external costs include the destruction of natural habitats from building roads and parking lots, the disposal of vehicles and parts, military costs associated with securing petroleum supplies, and noise pollution.

Attempts to estimate the external costs of automobiles focus on developed countries. A 2007 article summarized the existing literature on automobile externalities in the United States[3] and presented a "best assessment" of automobile externalities per mile, divided into several categories as shown in Table 3.1. Converted to damages per gallon of gasoline, the damages are $2.10 per gallon. These estimates suggest that externalities from automobile use in the United States amount to about 3 percent of GDP.

A similar study was conducted in Europe in 2012.[4] The results of this study are also presented in terms of externality damages per mile in Table 3.1. Note that the final estimate, 9 cents per mile, is quite similar to the U.S. estimate. The European study estimates higher climate change damages but omits an estimate of congestion damages (which is close to half of total U.S. damages). The climate change estimate used in the U.S. is equivalent to a damage of $20 per ton of carbon emitted. We'll see in Chapter 13 that other estimates of climate damages are significantly higher.

A tax on gasoline is one way to internalize the external costs of automobile use, but as noted in the U.S., using a range of policy approaches is a more effective way to fully internalize all the costs associated with automobile use. For example, internalizing air pollution externalities should ideally be based on a vehicle's emissions level rather than gasoline consumption. The externalities associated with congestion could be internalized through congestion tolls that charge drivers on busy roads depending on the time of the day, using electronic sensors.

Table 3.1 **External Costs of Automobile Use, U.S. Cents per Mile, United States and Europe**

Cost Category	United States Estimate	Europe Estimate
Climate Change	0.3	3.3
Local Pollution (air and noise)	2.0	0.8
Accidents	3.0	3.7
Oil Dependency	0.6	Not estimated
Traffic Congestion	5.0	Not estimated
Other External Costs	Not estimated	1.2
Total	10.9	9.0

Sources: Parry *et al*., 2007; Becker *et al*., 2012.

Note: Original European estimates were in euros per kilometer. Conversion to cents per mile based on 2016 currency conversion rates.

social marginal cost curve the cost of providing one more unit of a good or service, considering both private production costs and externalities.

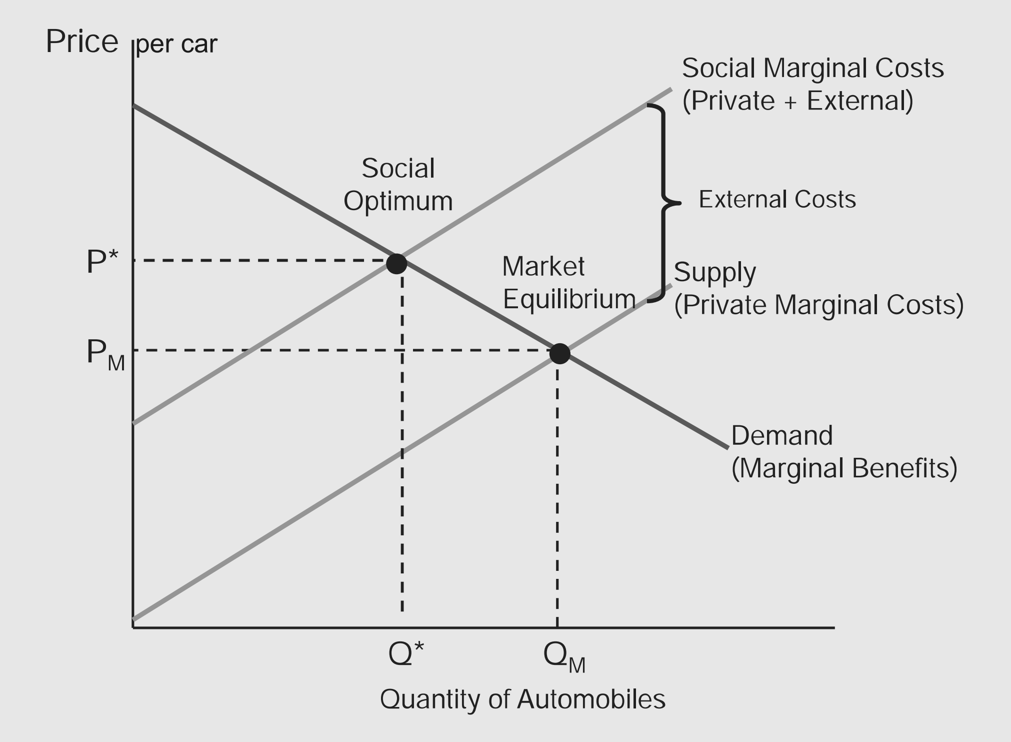
Recall that a supply curve tells us the marginal costs of producing a good or service. But in addition to the normal private production costs, such as the labor, steel, and electricity to produce a car, we now also need to consider the environmental costs—the costs of the negative externalities. So we can add the external costs to the production costs to obtain the total social costs of automobiles. This results in a new cost curve, which we call a **social marginal cost curve**. This is shown in Figure 3.2.

The social marginal cost curve is above the original market supply curve because it now includes the external costs. Note that the vertical distance between the two cost curves is our estimate of the external costs of each automobile, measured in dollars. In this simple case, we have assumed that the external costs of automobiles are constant. Thus the two curves are parallel. This is probably not the case in reality, as the external costs of automobiles can change depending on the number of automobiles produced. Specifically, the external costs of an additional automobile are likely to increase when more automobiles are produced as air pollution exceeds critical levels and congestion becomes more severe.

Considering Figure 3.2, is our market equilibrium still the economically efficient outcome? It is definitely not. To understand why, you can think of the decision to produce each automobile as depending on a comparison of the marginal costs to the marginal benefits. If the marginal benefit exceeds the marginal cost at a particular level of automobile production, considering all benefits and costs, then from the social perspective it makes sense to produce that automobile. But if the cost exceeds the benefit, then it does not make sense to produce that particular automobile.

So, in Figure 3.2 we see that it makes sense to produce the first automobile because the demand curve (reflecting the marginal benefits) is above the social marginal cost curve (reflecting the sum of the production and external costs). Even though the first automobile creates some negative externalities, the high marginal benefits justify producing that automobile. We

Figure 3.2 **The Market for Automobiles with Negative Externalities**



see that this is true for each automobile produced up to a quantity of $Q*$. At this point, the marginal benefits equal the social marginal costs. But then notice that for each automobile produced beyond $Q*$, the marginal social costs are actually above the marginal benefits. In other words, for each automobile produced above $Q*$, society is becoming worse off!

So, our unregulated market outcome, at Q_M, results in a level of automobile production that is too high. We should produce automobiles only as long as the marginal benefits are greater than the marginal social costs. Thus the optimal level of automobile production is $Q*$, not the market outcome of Q_M. Rather than producing the maximum benefits for society, the equilibrium outcome is inefficient in the presence of a negative externality. We can also see in Figure 3.2 that from the perspective of society, the market price of automobiles is too low—that is, it fails to reflect the true social costs of automobiles, including the environmental impacts. The **socially efficient** price for automobiles is higher, at $P*$. (See Appendix 3.2 for a more formal analysis of negative externalities.)

socially efficient a market situation in which net social benefits are maximized.

Internalizing Environmental Costs

What can we do to correct this inefficient market equilibrium? The solution to our problem lies in getting the price of automobiles "right." The market fails to send a signal to consumers or producers that further production past Q* is socially undesirable. While each automobile imposes a cost upon society, neither the consumers nor the producers pay this cost. So, we need to "internalize" the externality so that these costs now enter into the market decisions of consumers and producers.

The most common way to internalize a negative externality is to impose a tax. This approach is known as a **Pigovian tax**, after Arthur Pigou, a well-known British economist who published his *Economics of Welfare* in 1920. It is also known as the **polluter pays principle**, since those responsible for pollution pay for the damages they impose upon society.

Pigovian (pollution) tax a per-unit tax set equal to the external damage caused by an activity, such as a tax per ton of pollution emitted equal to the external damage of a ton of pollution.

polluter pays principle the view that those responsible for pollution should pay for the associated external costs, such as health costs and damage to wildlife habitats.

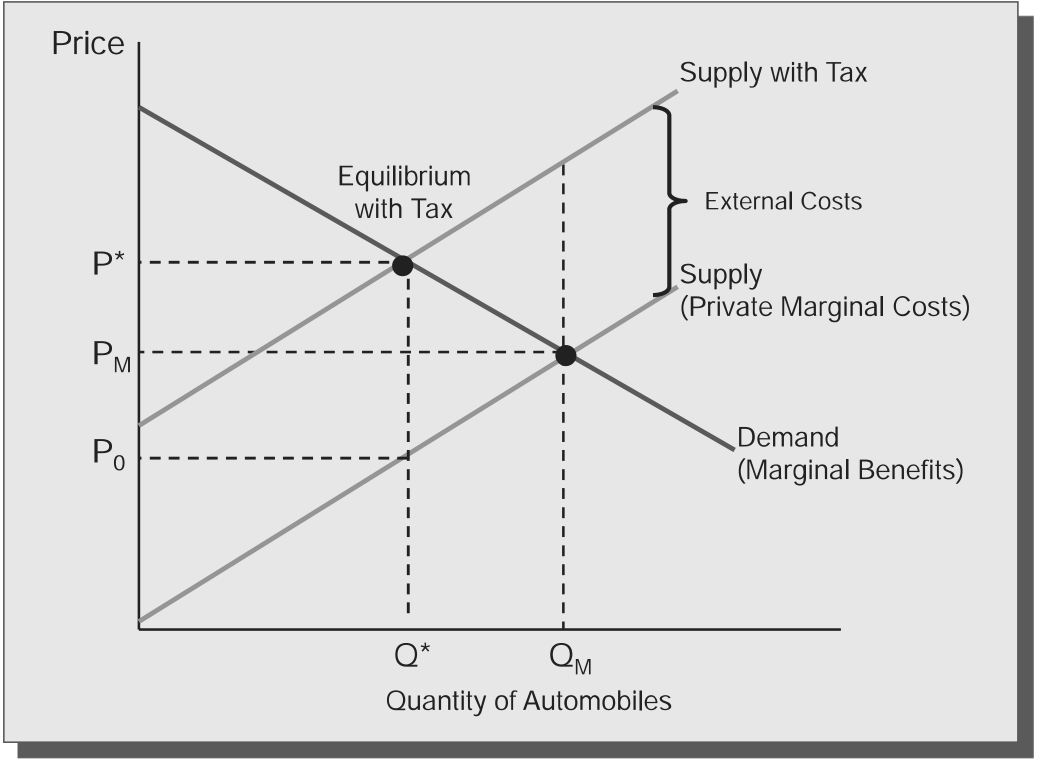
For simplicity, assume that the tax is paid by automobile manufacturers.[5] For each automobile produced, they must pay a set tax to the government. But what is the proper tax amount?

By forcing manufacturers to pay a tax for each automobile produced, we have essentially increased their marginal production costs. So, you can think of a tax as shifting the private marginal cost curve upward. The higher the tax, the more we would shift the cost curve upward. So, if we set the Pigovian tax exactly equal to the externality damage associated with each automobile, then the marginal cost of production would equal the social marginal cost curve in Figure 3.2. This is the "correct" tax amount—the tax per unit should equal the externality damage per unit.[6] In other words, those responsible for pollution should pay for the full social costs of their actions.

In Figure 3.3, the new supply curve with the tax is the same curve as the social marginal cost curve from Figure 3.2. It is the operative supply curve when producers decide how many automobiles to supply, because they now have to pay the tax in addition to their manufacturing costs.

The market will adjust to the Pigovian tax by shifting to a new equilibrium, with a higher price of $P*$ and a lower quantity of $Q*$. The tax has resulted in the optimal level of automobile production. In other words, automobiles are produced only to the point where the marginal benefits are equal to the social marginal costs. Also note that even though the tax was levied on producers, a portion of the tax is passed on to consumers in the form of a price increase for automobiles (from P_M to $P*$). This causes consumers to cut back their purchases from Q_M to $Q*$.

Figure 3.3 **Automobile Market with Pigovian Tax**



From the point of view of achieving the socially optimal equilibrium, this is a good result. Of course, neither producers nor consumers will like the tax, since consumers will pay a higher price and producers will have lower sales, but from a social point of view we can say that this new equilibrium is optimal because it accurately reflects the true social costs of automobiles.

Our story tells a convincing argument in favor of government regulation in the presence of negative externalities. The tax is an effective policy tool for reaching a more efficient outcome for society. But should the government always impose a tax to counter a negative externality? The production of virtually all good or services results in some pollution damages. So, it may seem as if the government should tax the vast majority of products on the basis of their environmental damage.

But two factors suggest we probably should not put a Pigovian tax on all products. First, recall that we need to estimate the tax amount in monetary terms, which requires economic research and analysis, perhaps along with toxicological and ecological studies. Some products cause relatively minimal environmental damages, and the small amount of taxes collected may not be worth the costs of estimating the "right" tax. Second, we need to consider the administrative costs of imposing and collecting the tax. Again, if a product does not cause much environmental damage, then these costs might outweigh the revenues we would collect.

Determining the appropriate tax on every individual product that causes environmental damage would be a monumental task. For example, we might impose a tax on shirts because the production process could involve growing cotton, using petroleum-based synthetics, applying potentially toxic dyes, and so on. But we would ideally need to set a different tax on shirts made with organic cotton, or those using recycled plastics, or even shirts of different sizes!

upstream tax a tax implemented as near as possible to the point of natural resource extraction.

Rather than looking at the final consumer product, economists generally recommend applying Pigovian taxes as far upstream in the production process as possible. An **upstream tax** is imposed at the level of the raw production inputs, such as the crude oil or cotton used to make a shirt. If we determine the appropriate Pigovian tax on cotton, then this cost will be reflected in the final selling price of the shirt based on how much cotton is used in production. We could focus our taxation efforts on those raw materials that cause the most widespread ecological damage. So, we might tax fossil fuels, various mineral inputs, and toxic chemicals. This limits the administrative complexity of tax collection and avoids the need for estimating the appropriate tax for a multitude of products.

The policy implications for a system of externality taxes on the extraction and processing of raw materials are significant. As discussed in Box 3.2, a 2013 study[7] estimated the global externalities generated from "primary" production industries (including agriculture, fishing, mining, power generation, and initial materials processing) to be $7.3 trillion, or 13 percent of world economic production. For comparison, the World Bank estimates current global tax revenues to be approximately 14 percent of world economic production.[8] Thus implementing a complete global system of Pigovian taxes would have dramatic implications for the world economy.

Box 3.2

ESTIMATING GLOBAL ENVIRONMENTAL EXTERNALITIES

While many studies have estimated externality damages for specific environmental impacts and in specific locations, few estimates are available regarding the global extent of externalities. A 2013 study by Trucost, an environmental consulting company, is perhaps the most comprehensive attempt to monetize global environmental externalities.[9] The research finds that in 2009 primary production and processing industries generated $7.3 trillion in unpriced externality damages, equivalent to 13 percent of world economic output. The breakdown of these damages is given in Table 3.2.

Table 3.2 **Global Environmental Externalities**

Impact Category	Damages
Land use	$1.8 trillion
Water consumption	$1.9 trillion
Greenhouse gases	$2.7 trillion
Air pollution	$0.5 trillion
Land and water pollution	$0.3 trillion
Waste generation	$0.05 trillion

Source: Trucost, 2013.

Among the most significant impacts are the damages from coal power generation in Eastern Asia and North America, cattle ranching and farming in South America, and wheat and rice farming in Southern Asia. An interesting component of the research is that it compares the externality damages generated by specific industries to total revenues. In many cases the externalities far exceed industry revenues, suggesting that these markets are highly inefficient. For example, coal power generation in North America causes $317 billion in environmental damages but generates only $247 billion in revenues. Rice farming in Northern Africa produces about $2 billion in revenues yet results in $84 billion in damages.

An earlier 2011 version of the research found that the world's largest 3,000 companies cause one-third of global environmental damages.[10] Further, these damages equate to 50 percent of these companies' combined earnings. The 2011 study also projects global externalities into the future under a business-as-usual scenario. It estimates that in 2050 global external costs will rise to 18 percent of world economic production, with over 70 percent of these damages due to greenhouse gas emissions. The study notes that the "failure to maintain natural capital, if uncorrected, will undermine economic growth over time."

Another issue related to our externality analysis is to explore how the tax burden is distributed between producers and consumers. Many noneconomists claim that any taxes are simply passed on to consumers in terms of higher prices. While it is true that the automobile tax raised prices, was the full cost passed on to consumers? The answer is no. Note that the tax per unit was the vertical difference between P_0 and P^* in Figure 3.3. But the price went up only by the difference between P_M and P^* (a smaller vertical distance in the graph). In this example, it seems that the tax burden was borne about equally by consumers and producers.

In some cases, the tax burden may fall more heavily on producers, while in other cases the burden may fall mostly on consumers. It depends on the **elasticities of supply and demand** with respect to price—how responsive supply and demand are to price changes. We discuss the topic of elasticities in more detail later in the text, including Appendix 3.1.

elasticity of supply the sensitivity of quantity supplied to prices; an elastic supply means that a proportional increase in prices results in a larger proportional change in quantity supplied; an inelastic supply means that a proportional increase in prices results in a small change.

elasticity of demand the sensitivity of quantity demanded to prices; an elastic demand means that a proportional increase in prices results in a larger proportional change in quantity demanded; an inelastic demand means that a proportional increase in prices results in a small change.

A final consideration is that a tax can fall disproportionately on certain income groups. One concern with most environmental taxes, such as taxes on fossil fuels, is that they hit low-income households the hardest. This is because the lower a household's income is, the more they tend to spend, as a share of their income, on fossil-fuel products, including gasoline and electricity. So we might wish to use some of the tax revenues to counteract the impact on low-income households, perhaps in the form of tax credits or rebates.

In practice, environmental policy often takes the form of other kinds of regulation besides taxes, such as, in the case of automobiles, fuel efficiency standards or mandated pollution control devices such as catalytic converters. These policies reduce fuel consumption and pollution without necessarily reducing the number of automobiles sold. They are also likely to drive up the purchase price of automobiles, so in this respect their effects are somewhat similar to a tax (although greater fuel efficiency reduces operating costs). We'll compare different pollution control policies in more detail in Chapter 8.

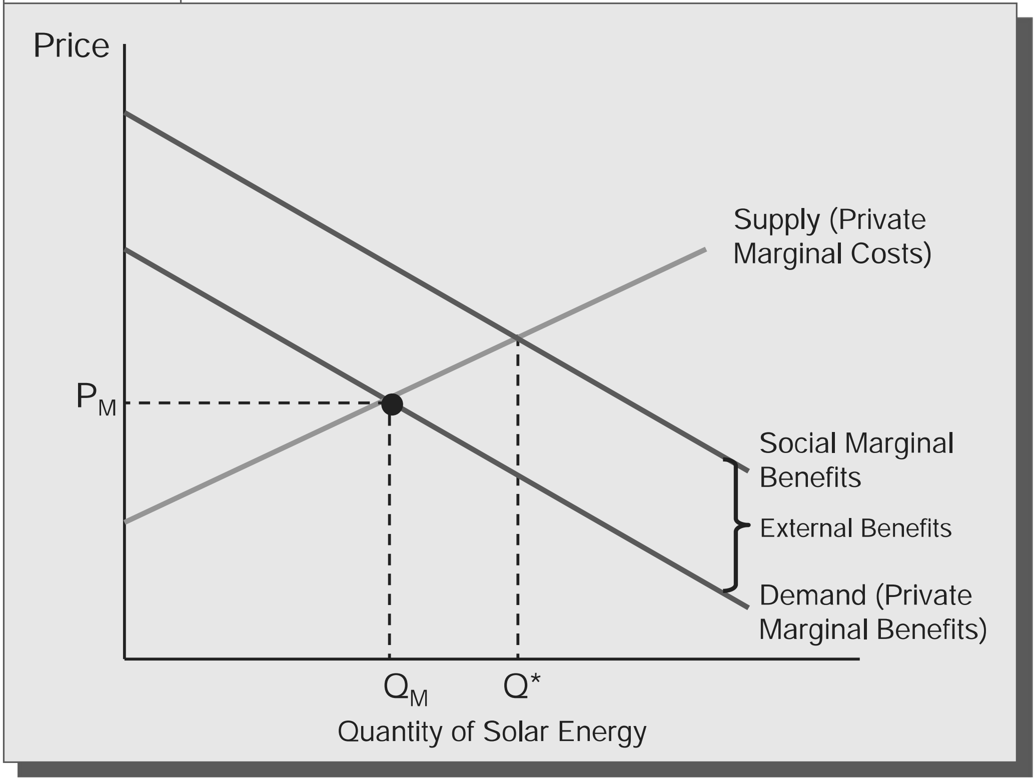
Positive Externalities

Just as it is in society's interest to internalize the social costs of pollution, it is also socially beneficial to internalize the social benefits of activities that generate positive externalities. As with a negative externality, an unregulated market will also fail to maximize social welfare in the presence of a positive externality. Similarly, a policy intervention will be required to reach the efficient outcome.

A positive externality is an additional social benefit from a good or service beyond the private, or market, benefits. Because a demand curve tells us the private marginal benefits of a good or service, we can incorporate a positive externality into our analysis as an upward shift of the demand curve. This new curve represents the total social benefits of each unit.

Figure 3.4 shows the case of a good that generates a positive externality—solar panels. Each solar panel installed reduces emissions of carbon dioxide and other pollutants, and thus benefits society as a whole. The vertical distance between the market demand curve and the social marginal benefits curve is the positive externality per solar panel, measured in dollars. In this example, the social benefits are constant per panel, so the two benefit curves are parallel.

Figure 3.4 **The Market for Solar Energy with Positive Externalities**



The market equilibrium price is P_M, and quantity is Q_M. But notice in Figure 3.4 that between Q_M and $Q*$, marginal social benefits exceed the marginal costs. Thus the optimal level of solar energy is $Q*$, not Q_M. So we can increase net social benefits by increasing the production of solar energy.

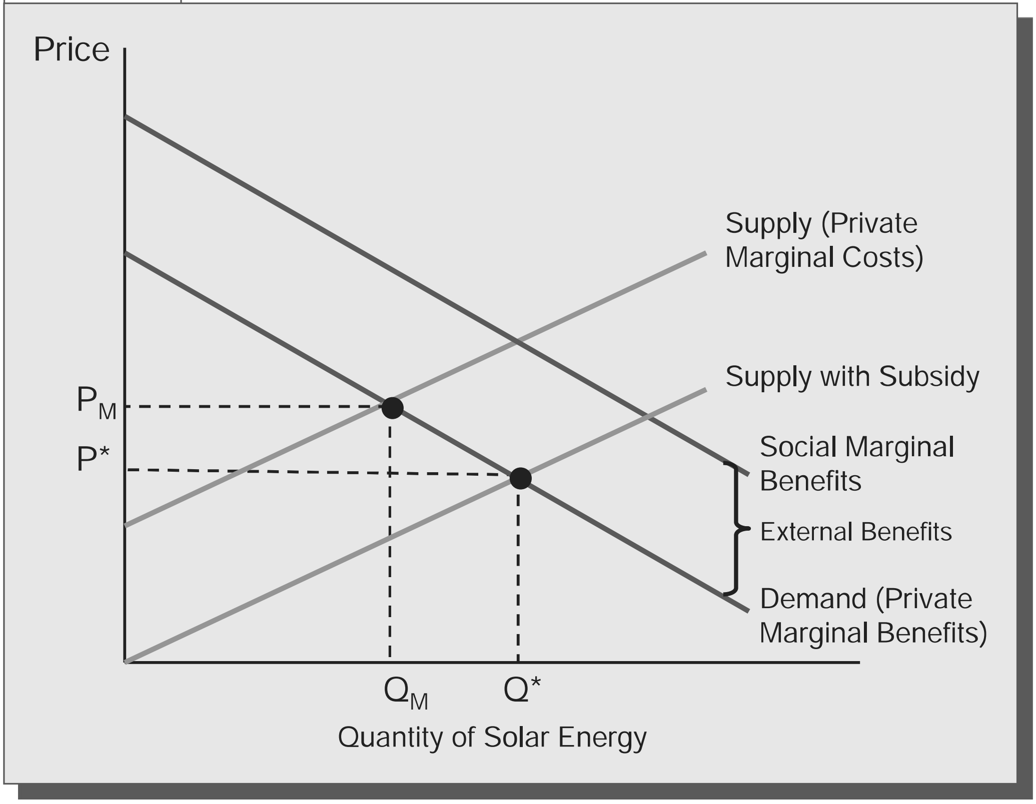
In the case of a positive externality, the most common policy to correct the market inefficiency is a subsidy. A **subsidy** is a payment to a producer to provide an incentive for it to produce more of a good or service. In some cases, subsidies are instead paid to consumers to encourage them to purchase particular goods and services.

subsidy government assistance to an industry or economic activity; subsidies can be direct, through financial assistance, or indirect, through other beneficial policies.

The way to illustrate a subsidy in our market analysis is to realize that a subsidy to providers effectively lowers the cost of producing something. So, a subsidy lowers the supply curve by the amount of the per-unit subsidy. In essence, a subsidy makes it cheaper to produce solar panels, because for every panel produced the manufacturer gets a payment from the government. The "correct" subsidy lowers the supply curve such that the new market equilibrium will be at $Q*$, which is the socially efficient level of production. This is illustrated in Figure 3.5, with equilibrium at the point where the supply curve with the subsidy intersects the market demand curve. The principle parallels the use of a tax to discourage economic activities that create negative externalities—except that in this case we want to encourage activities that have socially beneficial side effects. (See Appendix 3.2 for a more detailed analysis of positive externalities.)

The socially efficient equilibrium quantity Q* could also be achieved with a subsidy to consumers for buying solar panels, such as a tax credit. This would have the effect of shifting the demand curve up and to the right, leading to a higher market price but a lower effective price to consumers due to the subsidy, and the same equilibrium quantity as with a producer subsidy.

Figure 3.5 **The Market for Solar Energy with a Subsidy**



3.2 WELFARE ANALYSIS OF EXTERNALITIES

We can use a form of economic theory called **welfare analysis** to show in more detail why it is socially preferable to internalize externalities. The idea here is that *areas* on a supply and demand graph can be used to measure total benefits and costs. The area under the market demand curve shows the total benefit to consumers; the area under the market supply curve shows the total cost to producers. For each unit purchased, the demand curve shows the value of that unit to consumers.

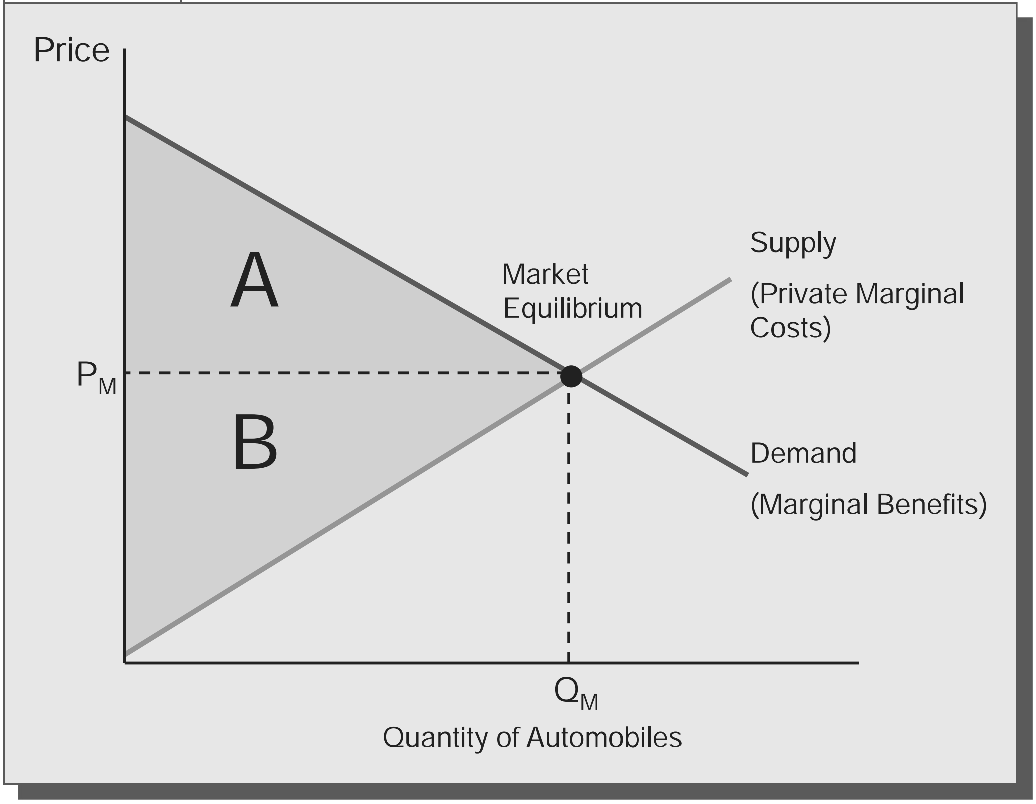
welfare analysis an economic tool that analyzes the total costs and benefits of alternative policies to different groups, such as producers and consumers.

This concept is illustrated in Figure 3.6, which presents a welfare analysis of the automobile market. Because the supply and demand curves, as noted above, show the *marginal* benefits and costs for each individual unit produced, the areas under these curves in effect sum up the *total* benefits and costs for all units produced. For consumers, total net benefits are called consumer surplus (area A)—representing the difference between their benefits from the consumption of automobiles, as shown by the demand curve, and the price they pay, as shown by the horizontal line at P_M. Producers gain a net benefit defined as producer surplus (area B)—the difference between their production costs, shown by the supply curve, and the price P_M that they receive. (Appendix 3.1 provides a background overview of market analysis, including a discussion of consumer and producer surplus.)

In the absence of externalities, the market equilibrium is economically efficient because it maximizes the net social benefit (areas A + B). But if we introduce externalities, the market equilibrium is no longer economically efficient.

We can define the net social benefits of the automobile market as the sum of consumer and producer surplus minus the externality damage. Thus net benefits equal the market

Figure 3.6 **Welfare Analysis of the Automobile Market**



benefits (areas A and B in Figure 3.6) minus negative externality damages. This is shown in Figure 3.7. Here we superimpose externality damages, shown by the area between the private marginal cost curve and the social marginal cost curve, on Figure 3.6. (Figure 3.7 is equivalent to Figure 3.2, showing negative externalities in exactly the way we did earlier, but it also shows the total external costs, equal to the dark gray area).

Note that the externality damages effectively offset parts of consumer and producer surplus. Net social welfare in the presence of the negative externality is (A' + B' – C), where C is just the triangular area to the right of Q^* marked by dashed lines. We have used the notation of A' and B' because these areas are smaller than areas A and B from Figure 3.6. A' and B' represent the areas of consumer and producer surplus that are not offset by subtracting the externality damage. But note that actual consumer and producer surplus are not lowered by the presence of the negative externality. Consumer surplus remains area A from Figure 3.6, and producer surplus remains area B. But parts of the benefits of A and B are offset by the social loss from pollution. In addition to these smaller areas of net benefits, area C represents a loss, because between Q^* and Q_M social marginal costs exceed marginal benefits (the demand curve).

Now consider the imposition of a Pigovian tax to internalize the externality. The tax will shift the equilibrium from Q_M to Q^*. We can prove that net social welfare has increased as a result of the tax by comparing the net welfare before the tax, area (A' + B' – C) from Figure 3.7, to net welfare in Figure 3.8. With price at P^* and quantity at Q^*, our new consumer surplus is A'' and producer surplus is B''. Note that the sum of A'' and B'' is the same as the sum of A' and B' from Figure 3.7—as we will see shortly, this point is critical to our analysis.

As we are only producing Q^* automobiles instead of Q_M, the externality damages are now area D, which is less than the externality damages from Figure 3.7. The per-unit tax is the vertical distance between the two supply curves. This tax is collected on a quantity of Q^* automobiles. Thus the total tax revenue is represented by area D. The tax revenue exactly

Figure 3.7 **Welfare Analysis of the Automobile Market with Externalities**

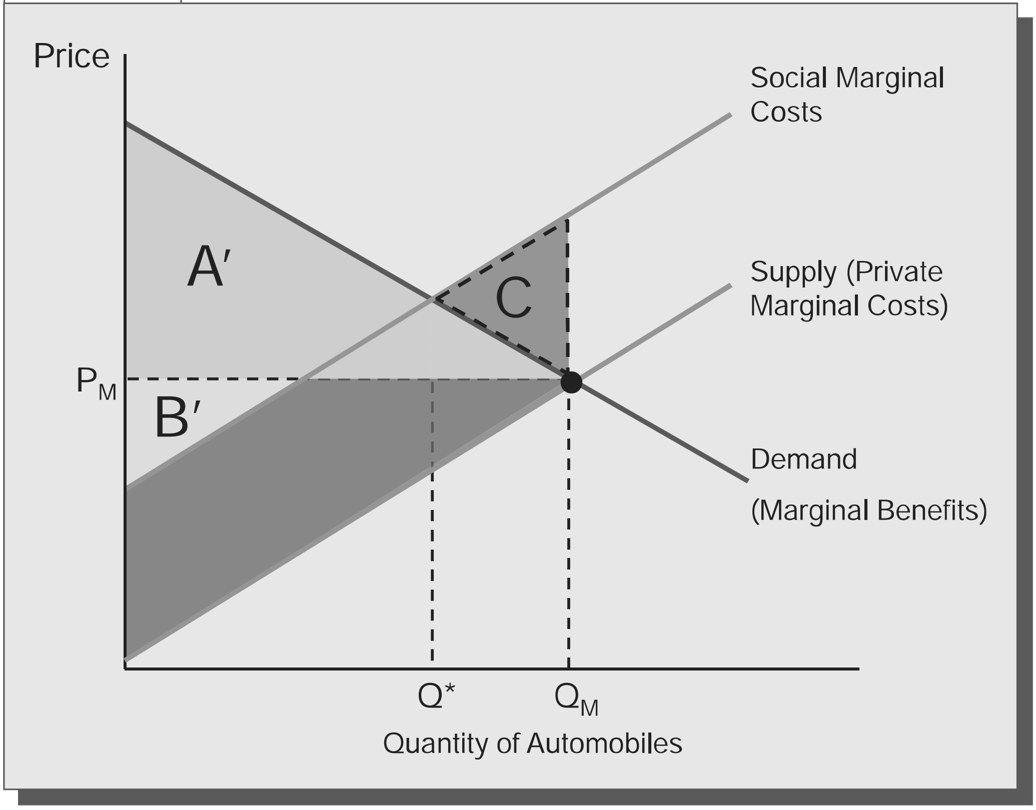
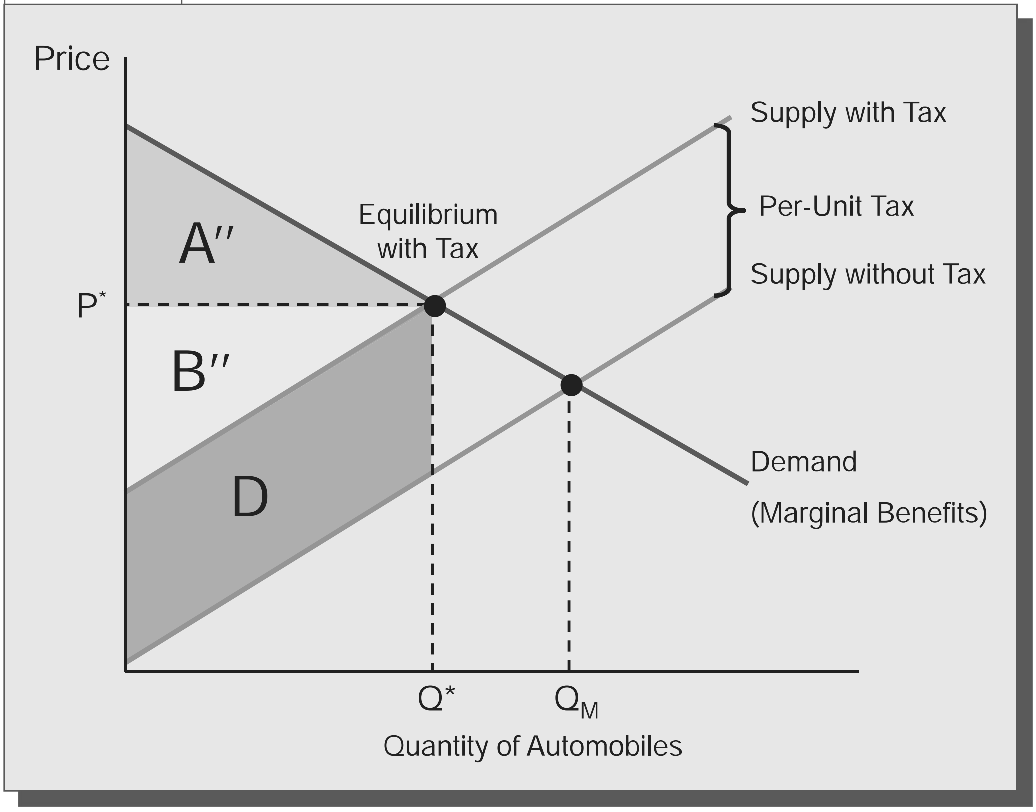


Figure 3.8 **The Welfare-Improving Effect of a Pigovian Tax**



equals the externality damages. In other words, the tax revenue is exactly sufficient to fully compensate society for the externality damages.

The net social welfare is the sum of consumer and producer surplus, minus the externality damages, plus the benefit of the tax revenue, or:

$$\begin{aligned} \textit{Net Social Welfare} &= A'' + B'' - D + D \\ &= A'' + B'' \end{aligned}$$

As we mentioned above, area (A'' + B'') equals area (A' + B'). Recall that net social welfare before the tax was (A' + B' – C). Now net social welfare is effectively (A' + B'). Net social welfare has increased as a result of the Pigovian tax by area C. Society is better off with the tax than without it!

A similar welfare analysis of a positive externality and the impacts of a subsidy can be used to show that a subsidy in the presence of a positive externality increases net social welfare. The analysis is a bit more complex and is presented in Appendix 3.2.

Optimal Pollution

Our analysis of negative externalities reveals an idea that may seem paradoxical—the concept of **optimal pollution**. Note that even after imposing an externality tax, society is still left with pollution damages of area D in Figure 3.8. According to our analysis, this is the "optimal" amount of pollution based on current production costs and technologies. But you might object—Isn't the optimal level of pollution *zero*?

optimal level of pollution the pollution level that maximizes net social benefits.

The economist's answer would be that the only way to achieve zero pollution is to have zero production. If we want to produce virtually any manufactured good, some pollution will result. We as a society must decide what level of pollution we are willing to accept. Of course, we can strive to reduce this level over time, especially through pollution-reducing technology, but as long as we have production we will have to determine an "optimal" pollution level.

Some people remain uneasy with the concept of optimal pollution. Note, for example, that if the demand for automobiles increases, the demand curve will shift to the right and the "optimal" pollution level will increase. This suggests that as global demand for automobiles rises steadily, ever-rising levels of pollution will, in some sense, be acceptable. We might choose instead to set a maximum level of acceptable pollution based on health and ecological considerations, rather than economic analysis. In fact, the main federal air pollution law in the United States, the Clean Air Act, sets pollution standards based on scientific data on health impacts, explicitly ruling out economic considerations in setting standards.

The question of overall limits on pollution levels can be related to the notion of economic scale that we discussed in Chapter 1. Ecological economists would tend to favor reliance upon something other than economics to determine the overall scale of allowable negative externalities, even if Pigovian taxes are used to control externalities at the individual market level. We discuss pollution policies and the concepts of optimal pollution, overall limits on pollution, and policies to "green" the economy, in more detail in Chapters 8 and 14.

3.3 PROPERTY RIGHTS AND THE ENVIRONMENT

The idea of a Pigovian tax, which forces polluters to pay for the cost of their social and environmental damages, is intuitively appealing. Implicit in the imposition of a Pigovian tax is the idea that society has a legitimate right to be compensated for any pollution damages. Many people would contend that this is an appropriate allocation of rights. In other words, society has a right to clean air, but polluters do not have a right to emit whatever they want into the atmosphere.

In other cases, the appropriate allocation of rights may be less clear cut. Suppose a farmer drains a wetland on his property to create a field suitable for growing crops. His downstream neighbor complains that without the wetland to absorb heavy rainfall, her land now floods, damaging her crops. Should the first farmer be obliged to pay the second the value of any crop damages? Or does he have the right to do what he wants on his own land?

We can see that this is an issue not just of externalities but also of the nature of property rights. Does the ownership of land include a right to drain wetlands on that land? Or is this right separate, subject to control by the community or other property owners?

The property rights in this case could be allocated in one of two ways. Suppose we say that the first farmer (call him Albert) *does* have the right to drain the wetland on his land. Assume that the net value of crops grown on this drained wetland is $5,000. Further, let's suppose that the second farmer (call her Betty) would suffer crop losses of $8,000 if the land were drained. We also assume that both Albert and Betty have accurate information regarding their potential costs and benefits. Even though Albert has the right to drain the wetland, Betty could potentially pay Albert not to drain it. Specifically, she would be willing to pay Albert up to $8,000 to keep the wetland intact, because that is the value of the damage she would suffer if Albert exercises his right to drain it. Meanwhile, Albert would be willing to accept any amount higher than $5,000, because that is what he stands to gain by draining the wetland.

Between $5,000 and $8,000 lies sufficient negotiation space for Albert and Betty to reach an agreement that satisfies both of them. Let's say that Albert accepts an offer of $6,000 from Betty to keep the wetland intact. He gains $1,000 relative to what he would have made by draining the wetland. Betty is not happy about paying $6,000, but she is better off than she would be if the wetland was drained and she lost $8,000. In effect, Betty purchases the right to say how the wetland will be used (without having to purchase the land).

Society can also assign the relevant right to Betty, by passing a law stating that no one can drain a wetland without the agreement of any affected parties downstream. In that case, Albert would have to reach an agreement with Betty before he could drain the wetland. With the crop values that we have assumed, the same result will be reached—the wetland will not be drained, because the value of doing so to Albert ($5,000) is not enough to compensate Betty for her loss. Betty will demand at least $8,000 to grant her permission, and this price is too high for Albert. So, regardless of who holds the property rights, the same outcome is achieved—the wetland is not drained.

Now suppose that a new gourmet crop item becomes popular, a crop that grows well on former swampland and would bring Albert $12,000 in profit. A deal is now possible—Albert can pay Betty, say, $10,000 for the right to drain the swamp and earn $12,000 from the new crop, netting $2,000 profit for himself and leaving Betty $2,000 better off as well.

Note that Albert could offer Betty an amount lower than $10,000. In theory, Betty would accept any payment greater than $8,000. But Albert would be willing to pay up to $12,000 for the right to drain the swamp. The actual price Albert would pay depends on the bargaining abilities of the two parties.

The principle at issue in this simple example has come to be known as the **Coase theorem**, after Ronald Coase, a Nobel prize–winning economist who discussed similar examples of property rights and externalities in his 1960 article "The Problem of Social Cost."[11] The Coase theorem states that if property rights are well defined, and there are no **transaction costs**, an efficient

Coase theorem the proposition that if property rights are well defined and there are no transactions costs, an efficient allocation of resources will result even if externalities exist.

transaction costs costs associated with a market transaction or negotiation, such as legal and administrative costs to transfer property or to bring disputing parties together.

allocation of resources will result even if there are externalities. Transaction costs are costs involved in reaching and implementing an agreement, which can include costs of obtaining information (such as surveying the land), time and effort spent in negotiations, and costs of enforcing the agreement. In the case of Albert and Betty, these costs should be low, because they need only to reach an understanding about the amount of compensation, although legal costs may be involved in formalizing an agreement.

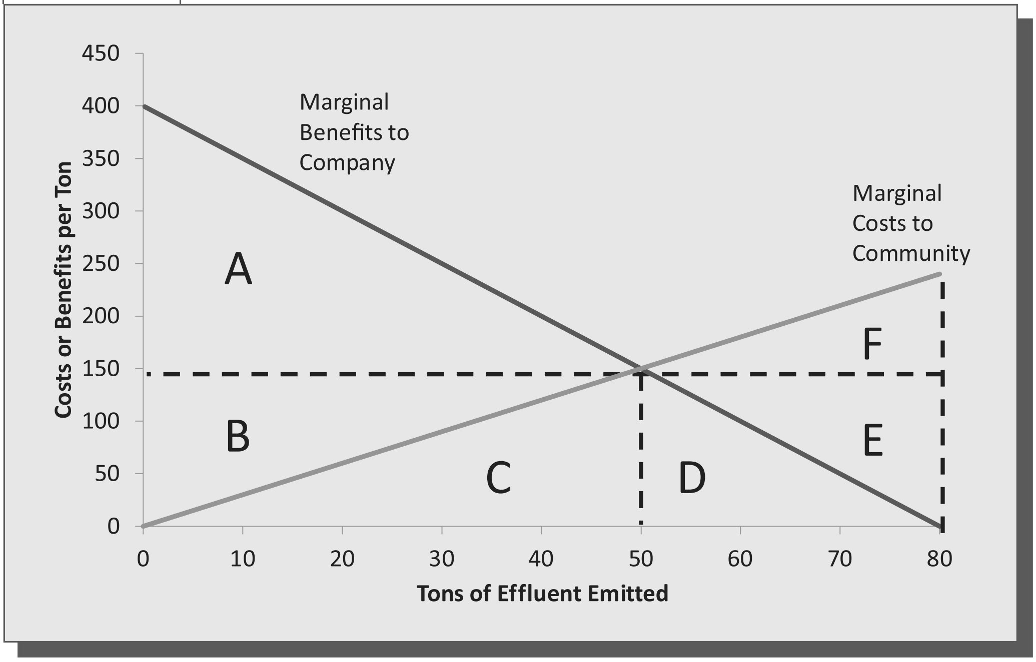
Through negotiations, the two parties will balance the external costs against the economic benefits of a given action (in this case, draining the wetland). In the example above, the external costs were $8,000. It is not worth incurring these costs for an economic benefit of $5,000, but an economic benefit of $12,000 makes it worthwhile. Regardless of which farmer is assigned the property right, the "efficient" result will occur through negotiation.

An Illustration of the Coase Theorem

We can illustrate the Coase theorem graphically, by showing the marginal benefits and marginal costs of an economic activity that generates an externality. Suppose, for example, a factory emits effluent into a river, polluting the water supply of a downstream community. The factory is currently emitting 80 tons of effluent. If the factory were forced to reduce effluent to zero, it would have to abandon a valuable production line. Thus, we can say that the factory realizes marginal benefits from emitting pollution, and the community pays marginal costs as a result of the damage to their water supply. We can arrive at a reasonable quantitative estimate of these external costs by estimating the costs of water treatment. Both marginal costs and marginal benefits are shown in Figure 3.9.

What is the optimal solution? The emission of 80 tons of pollution clearly imposes high marginal costs on the community, while bringing the company hardly any marginal benefits for the last few tons of pollution. This is "too much" pollution. But suppose that emissions were limited to 50 tons. Marginal benefits to the company would then be equal to marginal costs to the community. A further limitation to, say, 20 tons, would result in high additional losses to the company while bringing only low additional benefits to the community.

Figure 3.9 **Application of the Coase Theorem**



The efficient or "optimal" solution, therefore, is at a level of pollution of 50 tons. At this level, the extra benefit to the company from production just balances the extra cost imposed on the community through pollution.[12]

The Coase theorem states that this solution can be achieved by assigning the pollution rights *either* to the company *or* to the community. Suppose first that the community has the right to say how much pollution can be emitted. You might initially think that it would not allow the company to emit any pollution. But notice in Figure 3.9 that the company would be willing to pay the community up to about $400 for the right to emit the first ton of pollution. Meanwhile, the damages to the community from the first ton of pollution are quite small, only a few dollars. So, there is a significant opportunity for a successful agreement in which the company would pay the community in order to be able to emit the first ton of pollution.

Note that this process of successful negotiation would continue as long as the marginal benefits to the company exceed the marginal damages to the community. However, the space for successful negotiation gradually declines as we move rightward on the graph. For example, after the company has already purchased the right to emit 40 tons of pollution, its marginal benefits of pollution have fallen to $200 per ton, while the marginal costs to the community have risen to $120 per ton. There is still some negotiating room for a payment that the community will accept, but not as much as when pollution was zero. Eventually, we reach a point, at 50 tons of pollution, where the company cannot offer the community enough to allow it to pollute any further. So, once the marginal benefits to the company equal the marginal costs to the community, we reach the optimal level of pollution. If there is any further pollution, the marginal costs would exceed the marginal benefits.

At this level, the marginal benefits to the company and marginal costs to the community are both equal to $150. The company will not be willing to pay any higher price than $150 for the fiftieth unit of pollution, and the community will not be willing to accept any lower price.

We can analyze the effects of this outcome using welfare analysis (as explained above, and in more detail in Appendices 3.1 and 3.2). For example, in Figure 3.9, area C represents the total costs of pollution damage at 50 tons of emissions. This area is $3,750 (using the formula for the area of a triangle, in this case 50 * 150 * ½).

If we assume that all rights to pollute sold for the same price of $150, then the community receives a total payment of $7,500 (area B + C). The total costs of pollution to the community are $3,750 (area C). So the community comes out ahead, with a net gain of $3,750.

What about the company? In purchasing the right to pollute 50 tons, it gains areas (A + B + C) in total benefits, or $13,750. But it has to pay the community $7,500 for the right to pollute 50 tons (area B + C). So the company comes out ahead by $6,250 (equal to area A), compared with not polluting at all. Considering the gains to both the company and the community, the total social welfare gain following the negotiation process is $10,000 ($3,750 + $6,250), as detailed in Table 3.3.

What if we instead assume that the company has the right to pollute as much as it wants? In this case, we start off with the firm emitting 80 tons of pollutants—gaining the maximum possible amount of benefits from polluting. Total benefits to the company would be areas (A + B + C + D), or $16,000. The total damage to the community would be areas (C + D + E + F), or $9,600. Thus total social benefits at 80 tons of pollution, prior to any negotiations, would be $16,000 − $9,600 = $6,400.

But notice that the company receives very small marginal benefits for the last ton emitted, just a few dollars. Meanwhile, the community suffered damages from the eightieth ton of $240. So, the community could pay the company to reduce its pollution, as there is a significant negotiation space where both parties could benefit. Again, the final outcome would be 50 tons of pollution, with the community paying the company $150 per ton for pollution reduction.

Table 3.3 **Distribution of Benefits and Losses with Different Property Rights and Negotiation**

		If Community Holds Rights		If Company Holds Rights
Gain/loss to community	+	$7,500 payment	–	$4,500 payment
	–	$3,750 environmental costs	–	$3,750 environmental costs
	+	$3,750	–	$8,250
Gain/loss to company	+	$13,750 total benefits	+	$13,750 total benefits
	–	$7,500 payment	+	$4,500 payment
	+	$6,250	+	$18,250
Total social gain	+	$10,000	+	$10,000

In this case, the company receives the financial benefits from its remaining 50 tons of pollution, or areas (A + B + C), which equal $13,750 as shown in Table 3.3. Assuming that all rights are negotiated for a price of $150 per ton, it also receives a payment of $4,500 from the community (areas D + E), for total benefits of $18,250. Note that this is higher than the $16,000 benefit it obtained from maximum pollution prior to negotiations.

The community suffers remaining damages of area C, or $3,750. It also pays the company $4,500. So its total losses are now $8,250—not a great outcome for the community, but better than its initial losses of $9,600. Note that overall net social benefits are now $18,250 – $8,250 = $10,000—the same exact outcome in terms of social benefits that we obtained when the community held the property rights.

This more formal demonstration of the Coase theorem shows that the efficient solution is reached regardless of the assignment of the property right governing pollution. Provided that right is clearly defined, the party that values it most highly will acquire it, with the result that the external costs of pollution and the economic benefits of production are balanced through the marketplace.

Note, however, that who receives the right makes a big difference in the distribution of gains and losses between the two parties (see Table 3.3). The net social benefit from production is the same in both cases, equal to area (A + B), or $10,000. But in one case, this benefit is divided between the community and the company. In the other case, the community has a net loss while the company has a large net gain.

By redistributing the right to pollute, or to control pollution, we make one party $12,000 better off and the other $12,000 worse off (to confirm this, compare the final positions of the community and the company under the two different rights allocations). The different assignments of rights are equivalent in terms of efficiency, because the final result balances marginal benefits and marginal costs, but they clearly differ in terms of equity, or social justice.

A Practical Application

An example of environmental protection using Coase theorem principles is New York City's Watershed Land Acquisition Program. The city must provide clean water to its 8.4 million residents. This can be done through building filtration plants, but the cost of building these plants can be avoided through watershed protection. By preserving land around the main water supplies for the city, the quality of the water can be maintained at a level that does not require filtration. The watersheds are located upstate, on lands not currently owned by the city. According to the U.S. Environmental Protection Agency:

> The Watershed Land Acquisition Program is a key element in the City's long-term strategy to preserve environmentally sensitive lands in its upstate watersheds. Land acquisition is a critical element of the City's ability to obtain filtration avoidance. Through this program, New York City has committed to soliciting a minimum of 355,050 acres of land over a ten-year period. The goal of the Program is for the City to acquire, from willing sellers, fee title to or conservation easements on real property determined to be water quality sensitive, undeveloped land. The land will be bought at fair market value prices and property taxes will be paid by the City. No property will be acquired by eminent domain.[13]

As in our Coase theorem example, all the transactions here are voluntary, based on private property rights. The power of eminent domain, by which a government can compel a property owner to give up land in return for compensation (see Box 3.3), is not used. New York City has made the determination that it is less expensive to pay private property owners for conservation easements, which restrict the uses of the land, or to purchase the land outright, than to construct filtration plants. This market-based solution appears to be both environmentally effective and economically efficient.

Limitations of the Coase Theorem

According to the Coase Theorem, the clear assignment of property rights appears to promise efficient solutions to problems involving externalities. In theory, if we could clearly assign property rights to *all* environmental externalities, further government intervention would not be required. Individuals and business firms would negotiate all pollution control and other environmental issues among themselves after it was clear who had the "right to pollute" or the "right to be free from pollution." Through this process, fully efficient solutions to the problem of externalities could be achieved.

This is the theoretical basis behind the idea of **free market environmentalism**. In effect, by setting up a system of property rights to the environment, this approach seeks to bring the environment into the marketplace, allowing the free market to handle issues of resource use and pollution regulation as interested parties negotiate their own solutions, without government regulation.

free market environmentalism the view that a more complete system of property rights and expanded use of market mechanisms is the best approach to solving issues of resource use and pollution control.

As we will see in dealing with specific examples in future chapters, this approach may have potential in particular cases, especially in areas like water rights. But it also has crucial limitations. What are some of the problems in simply assigning property rights and letting unregulated markets address environmental and resource problems?

We mentioned above that the Coase theorem assumes there are no transaction costs preventing efficient negotiation. In the examples that we have used, there are only two parties negotiating. What happens if, for example, 50 downstream communities are affected by pollution from a factory's effluent? The process of negotiating effluent limits will be very cumbersome, perhaps impossible. This problem would be even worse if there were several factories instead of just one. Thus, the efficient outcome may not be reachable because of significant transaction costs.

Box 3.3

PROPERTY RIGHTS AND ENVIRONMENTAL REGULATION

Under the principle of eminent domain, governments are permitted to appropriate private property for public purposes. However, the Fifth Amendment of the U.S. Constitution requires that the property owner be fairly compensated. Specifically, the Fifth Amendment concludes with the statement "nor shall private property be taken for public use, without just compensation."

An action by a government that deprives someone of his or her property rights is referred to as a "takings." In cases in which the property owner is deprived of all property rights, the Constitution clearly orders full compensation. For example, if a state government decides to build a highway through a parcel of private property, the landowner must be paid the fair market value of the property.

A more ambiguous situation arises when actions by a government limit the uses of property and, consequently, reduce the value of property. Instances of government regulations reducing the value of private property are often called "regulatory takings." For example, if a new law is created that regulates timber harvesting and reduces the value of private forests, are the landowners entitled to compensation under the Fifth Amendment?

The most notable case concerning a regulatory taking is *Lucas v. South Carolina Coastal Council*. David Lucas, a real estate developer, purchased two oceanfront lots in 1986 and planned to construct vacation homes. However, in 1988 the South Carolina state legislature enacted the Beachfront Management Act, which prohibited Lucas from building any permanent structures on the property. Lucas filed suit claiming that the legislation had deprived him of all "economically viable use" of his property.

A trial court ruled in Lucas's favor, concluding that the legislation had rendered his property "valueless" and awarded him $1.2 million in damages. However, the South Carolina Supreme Court reversed this decision. It ruled that further construction in the area posed a significant threat to a public resource and asserted that in cases in which a regulation is intended to prevent "harmful or noxious uses" of private property, no compensation is required.

The case was appealed to the U.S. Supreme Court. Although the Supreme Court overturned the state court ruling, ruling in favor of Lucas, it delineated a distinction between total and partial takings. Compensation is necessary only in cases of total takings—when a regulation deprives a property owner of "all economically beneficial uses." If a regulation merely reduces a property's value, then compensation is not required.

In essence, this ruling represented a victory for environmental regulation because cases of total takings are rare. Partial takings as a result of government regulations, however, are common. A requirement of compensation for partial takings would have created a legal and technical morass that would render many environmental laws ineffective. Still, partial takings can result in significant costs to individuals, and the debate continues over equity when private costs are necessary to achieve the public good. Legal cases since *Lucas* have affirmed the "total takings" principle with slight variations, with the Supreme Court, for example, ruling in *Palazzolo v. Rhode Island* (2001) that compensation was required in a case where virtually all uses of land had been prohibited, even if the land retained some small amount of value.

Sources: Ausness, 1995; Hollingsworth, 1994; Johnson, 1994; Eagle, 2009.

Free-Rider and Holdout Effects

Another problem may arise with a large number of affected communities. Suppose that we assign the factory the right to pollute. The communities can then offer compensation for reducing pollution. But which community will pay what share? Unless all 50 can agree, it might prove impossible to make a specific offer to the company. No single community, or group of communities, is likely to step forward to pay the whole bill. In fact, there is likely to be a tendency to hang back, waiting for other communities to "buy off" the factory—and thus gain pollution control benefits for free. This barrier to successful negotiations is known as the **free-rider effect**, in which there is a tendency not to pay one's share of the costs but still attempt to receive the benefits.

A similar problem arises if the communities are given the "right to be free from pollution" and the factory must compensate them for any pollution emitted. Who will determine which community gets how much compensation? Because all are situated on the same river, any single community can exercise a kind of veto power. Suppose that 49 communities have hammered out an agreement with the company on permissible pollution levels and compensation. The fiftieth community can demand a much higher rate of compensation, for if it withholds consent, the entire agreement will fail, and the company will be restricted to zero pollution (i.e., forced to shut down). This parallel to the free-rider effect is known as the **holdout effect**.

free-rider effect the incentive for people to avoid paying for a resource when the benefits they obtain from the resource are unaffected by whether they pay; results in the undersupply of public goods.

holdout effect the ability of a single entity to hinder a multiparty agreement by making disproportionate demands.

When large numbers of parties are affected, the Coase theorem generally cannot be applied. In this case, some form of government intervention is required, such as regulation or a Pigovian tax. The state or federal government could set a standard for a water-borne effluent or a tax per unit of effluent. This would not be a pure market solution (although a tax does have its impact through market processes) because government officials must decide on the strictness of regulation or the level of tax.

Issues of Equity and Distribution

Other lines of criticism of the Coase theorem concern its effects on equity. Suppose that in our original example the community suffering from pollution is a low-income community. Even if the water pollution is causing serious health impacts, which could be valued at many millions of dollars, the community may simply be unable to "buy off" the polluter. In this case, the market solution is clearly not independent of the assignment of property rights. Pollution levels will be significantly higher if the right to pollute is assigned to the company.

It is also possible that, even if the right is assigned to the community, poor communities will accept location of toxic waste dumps and other polluting facilities out of a desperate need for compensatory funds. While this is apparently consistent with the Coase theorem (it is a voluntary transaction), many people believe that communities should not be forced to trade the health of their residents for needed funds. An important criticism of free market environmentalism is that under a pure market system, poorer communities and individuals will generally bear the heaviest burden of environmental costs (see Box 3.4).

A similar issue relates to preservation of open space. Wealthy communities can afford to buy up open space for preservation, while poor communities cannot. If communities are allowed to use zoning to preserve wetlands and natural areas, poor communities, too, will be able to protect their environment, because passing a zoning regulation has zero cost other than for enforcement.

Box 3.4
ENVIRONMENTAL JUSTICE

As defined by the U.S. Environmental Protection Agency, "**Environmental justice** is the fair treatment and meaningful involvement of all people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies."

Issues of environmental injustice concern both economic status and also political power. Low-income communities and minorities often lack the political clout to affect decision-making at the local and state level, and as a result, many decisions can be made without having their best interests in mind. The result can be that the poorest parts of the population end up carrying the highest environmental burden.

This was the case in Flint, Michigan, where a crisis of water contamination arose when officials decided to switch the city's water source from the Detroit Water and Sewerage Department water to the Flint River in April 2014. The explicit goal was to save millions of dollars for the municipal budget of Flint, which was on the brink of financial collapse. The corrosive Flint River water was not treated properly, causing lead from aging pipes to leach into the water supply, resulting in highly elevated levels of this heavy metal neurotoxin.

In Flint, between 6,000 and 12,000 children have been exposed to drinking water with dangerously elevated levels of lead, and they may experience a range of serious health problems. Flint is a low-income community, 84 percent black, and the agonizingly slow government response to the crisis was widely considered as a prime example of environmental racism and injustice.

Sources: U.S. Environmental Protection Agency, https://www.epa.gov/environmentaljustice; John Eligon, "A Question of Environmental Racism in Flint". *New York Times*, Jan. 21, 2016.

environmental justice the fair treatment of people regardless of race, color, national origin, or income, with respect to the development, implementation, and enforcement of environmental laws, regulations, and policies.

Another point to note in considering the limitations of the Coase theorem is the issue of environmental impacts on nonhuman life forms and ecological systems. Our examples so far have assumed that environmental damage affects specific individuals or businesses. What about environmental damage that affects no individual directly but threatens plant or animal species with extinction? What if a certain pesticide is harmless to humans but lethal to birds? Who will step into the marketplace to defend the preservation of nonhuman species? No individual or business firm is likely to do so, except on a relatively small scale.

Consider, for example, the activities of a group like the Nature Conservancy, which buys up ecologically valuable tracts of land in order to preserve them. Here is an example of an organization that *is* prepared to pay to save the environment. But its purchases can reach only a tiny proportion of the natural areas threatened with destruction through development, intensive farming, and other economic activities. In the "dollar vote" marketplace, purely ecological interests will almost always lose out to economic interests. Ecological economists seek ways to ensure that the value of these interests are adequately expressed, either in monetary or ethical terms.

We should also note that property rights are typically limited to the current generation. What about the rights of the next generation? Many environmental issues have long-term implications. Rights to nonrenewable resources can be assigned today, but those resources will be used up at some time in the future. Ecosystems destruction and species loss today will have implications for all future generations. The important issue of resource allocation over time is addressed in Chapter 5. Long-term environmental impacts are also vital to the analysis of fisheries, forests, water (dealt with in Chapters 18, 19, and 20) and climate change (presented in Chapters 12 and 13).

In some cases, property rights are simply inappropriate tools for dealing with environmental problems. It may be impossible, for example, to establish property rights to the atmosphere or to the open ocean. When we confront problems such as global warming, ocean pollution, the decline of fish stocks, or endangered species, we find that the system of private property rights, which has evolved as a basis for economic systems, cannot be fully extended to ecosystems. It may be possible to use market transactions, such as tradable permits for air emissions or fishing rights, but these only apply to a limited subset of ecosystem functions. In many cases, some other techniques of economic analysis will be helpful in considering the interaction between human economic activity and aspects of the broader ecosystem. We consider some of these analyses next in Chapter 4.

Summary

Many economic activities have significant external effects—impacts on people who are not directly involved in the activity. Pollution from automobile use is an example. The costs of these external impacts are not reflected in the market price, leading to an excessive production of goods with negative externalities and an economically inefficient outcome.

One approach to pollution control is to internalize external costs using a tax or other market-based instrument that requires producers and consumers of the polluting good to take these costs into account. In general, the use of such a tax will raise the price and reduce the quantity produced of the good, thereby also reducing pollution. In so doing, it shifts the market equilibrium to a socially more desirable result. In theory, a tax that exactly reflects external costs could achieve a social optimum, but it is often difficult to establish a proper valuation for negative externalities.

Not all externalities are negative. Positive externalities result when economic activities bring benefits to others not directly involved in the transaction. Preservation of open land benefits those who live nearby directly, often raising their property values. The use of solar energy benefits society as it reduces pollution levels. When a positive externality exists, there is an economic case for a subsidy to increase the market provision of the good.

An alternative to the use of a tax is the assignment of property rights to externalities. If there is a clear legal right either to emit a certain amount of pollution or to prevent others from emitting pollution, a market in "rights to pollute" can develop according to the Coase theorem. However, this solution depends on the ability of firms and individuals to trade these pollution rights with relatively low transaction costs. Where large numbers of people are affected, or where the environmental damages are not easy to define in monetary terms, this approach is not effective. It also raises significant questions of equity, because under a market system the poor generally bear a heavier burden of pollution.

Key Terms and Concepts

Coase theorem

economic efficiency

elasticities of supply and demand

equilibrium price

external costs

free market environmentalism

free-rider effect

holdout effect

internalizing externalities

marginal benefit