CHAPTER 14

Common Property and Public Goods

In Chapter 13 we learned how incomplete property rights can lead to inefficiency. Here we will examine some important special cases. One is the theory of common property, which is property that has no owner. An example is a lake where anybody can fish and for which nobody has the authority to charge an admission fee. Another topic is the theory of public goods, which are goods that, once produced, are costlessly available for use by others. An example is a streetlight you install in front of your house, which illuminates your neighbor's properties for free.

Each of these theories is a topic in the theory of externalities. The user of a common property resource imposes a negative externality on other users, so that such property tends to be overused. The producer of a public good creates a positive externality, so that such goods tend to be underproduced. We will explore the nature of these problems and will examine some potential solutions as well.

14.1 The Tragedy of the Commons

The Springfield Aquarium

The small town of Springfield has a large city park that never gets crowded. Unfortunately, picnics in the park are pretty much the only recreational activity available in Springfield, and people have begun hankering to expand their options. Therefore, the town council wants to build an aquarium, financed by tax dollars and offering free admission. The aquarium will be small but excellent, and it is anticipated that it will always be crowded.

How much should the citizens of Springfield be willing to pay for their aquarium? That is, how much pleasure will the aquarium bring them? If Springfielders all have identical tastes, the remarkable answer is: Zero! If the aquarium costs so much as one penny to build, it is a bad idea.

How can this be true? To analyze the problem, we first measure the dollar value of a picnic in the park. Suppose that each picnic is worth $2. (Here is where we use the assumption that everyone's tastes are identical: We assume that the same $2 figure applies to everybody. Without this assumption, the analysis would be a bit more complicated.) Next we measure the dollar value of visiting the aquarium. Suppose that this value is $3.

Under these circumstances, aquarium visitors are happier than picnickers. The obvious consequence is that people start canceling their picnics and plan trips to the aquarium instead. As they do so, the aquarium becomes more crowded, and therefore less desirable. The value of a visit to the aquarium is now only $2.50.

You can probably foresee what comes next: Because the aquarium remains more desirable than the park, additional people skip the park and go to the aquarium. The crowds get even larger and the aquarium less desirable still. The process continues until an aquarium visit is worth only $2—neither more nor less than a picnic. But now the aquarium is worth nothing at all to the Springfielders. It makes them no more happy than a picnic, and picnics have always been available for free. Any resources spent to build the aquarium have been completely wasted.

Common property
Property without a well-defined owner.

Dissipation of rents or tragedy of the commons
The elimination of social gains due to overuse of common property.

Suppose that despite this argument, the aquarium gets built. Suppose also that two years later, a popular new television program about a school of Ninja Guppies inspires everyone in Springfield to learn more about fish. Does this increase the value of their aquarium? Unfortunately not. It certainly increases the value of *seeing the fish,* but it increases the size of the crowds as well. As before, the crowds must grow until an aquarium visit is no more fun than a picnic.

The aquarium is an example of **common property;** it has no owner and there are no restrictions on its use. Consequently, it is overused, to the point where it is of no value to anyone. All of the consumers' and producers' surpluses that the aquarium might have provided have vanished. Economists call this phenomenon the **dissipation of rents,** or, more poetically, the **tragedy of the commons.**

Dangerous Curve

An important assumption has been slipped under the rug. We have assumed that the value of a picnic in the park is $2 for everyone. In particular, we have assumed that a picnic on Sunday is worth the same amount to people who are still cleaning ants out of Saturday's picnic basket as it is to people who have not picnicked in a year. If we assume instead that the value of a picnic depends on how much recent picnicking you've done, then the analysis becomes substantially more complicated, but dissipated rents remain the dominant theme.

Admission Fees

What if the town decides to charge an aquarium admission fee of $1 per patron? The cost of a visit is now $3 (a forgone $2 picnic plus a $1 admission fee), and the size of the crowd readjusts downward so that the value of a visit is equal to the $3 cost. Aquarium-goers are still no happier than they were at the park.

Does this mean that the situation is no better than before? It does not mean that, and here is why: The revenue that the town collects is a social benefit that did not exist when the aquarium was free. All of that revenue is pure social gain, because it comes at nobody's expense: Those who pay the fee are fully compensated for it by the smaller crowds.

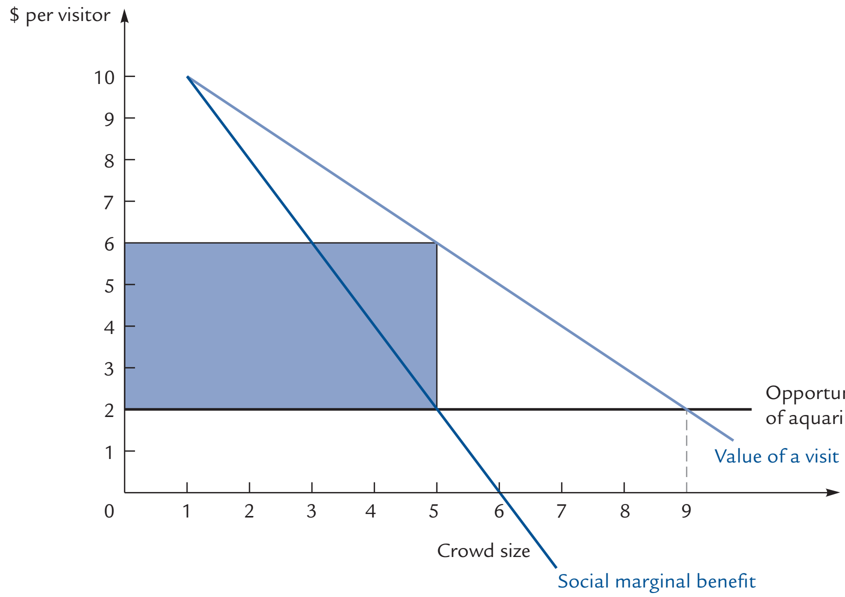
How can social gain be manufactured out of nothing at all? The answer is that each person who visits the aquarium imposes externalities on everyone whose elbows he jostles or whose view he obstructs. Because of these externalities, the free-admission equilibrium is inefficient. An admission fee acts as a Pigou tax that discourages overuse of the aquarium and increases the size of the social pie.

What is the best admission fee for the town to set? Because the only social gains in this situation are the revenues from the admission fee, the efficient fee is the one that maximizes those revenues. The socially optimal behavior for the town council is to behave like a profit-maximizing firm.

A Graphical Analysis

Exhibit 14.1 shows the value of an aquarium visit as a function of the crowd size. The first two columns in the table show that if only 1 person is present, he values his visit at $10; if 2 are present, they value their visits at $9 each, and so forth. If 10 are present, they value their

EXHIBIT **14.1** **The Dissipation of Rents**



Crowd Size	Value of a Visit	Total Value of Visits	Social Marginal Benefit
1	$10/visitor	$10	$10/visitor
2	9	18	8
3	8	24	6
4	7	28	4
5	6	30	2
6	5	30	0
7	4	28	−2
8	3	24	−4
9	2	18	−6
10	1	10	−8

Each visitor to the aquarium lowers the value of all other visitors' visits. Therefore, the social marginal benefit of adding a visitor is less than the value of his visit. If there is no admission fee, and the opportunity cost of a visit is $2, then 9 visitors enter, and there is no social gain. Rents are completely dissipated, and the aquarium is of no value to anybody.

If only 5 people come to the aquarium, each gains $4 (the $6 value of his visit minus his $2 opportunity cost). The social gain of $20, represented by the shaded area, is the largest possible. A $4 admission fee would ensure this optimal outcome.

visits at only $1 each. The numbers in the "value of a visit" column can also be thought of as the private marginal benefit that each new visitor gains from going to the aquarium.

The next column shows the total value of all aquarium visits. These numbers are constructed by multiplying the value of each visit times the size of the crowd. The final column shows the social marginal benefit due to each new visitor.

Notice that there is a discrepancy between private and social marginal benefits. For example, when the fourth visitor enters the aquarium, his private marginal benefit is $7 but the social marginal benefit is only $4. The $3 difference is accounted for by the externalities that his presence imposes on each of the first three visitors. The value of their visits is reduced by $1 apiece, from $8 to $7, for a total external cost of $3.

Exercise 14.1 When the sixth visitor enters, what is the difference between his private marginal benefit and the social marginal benefit? What accounts for the difference?

The marginal cost of adding a visitor is a picnic forgone, or $2. We will assume that it costs the town nothing to let the visitor walk through the aquarium, so that this $2 is both the private marginal cost and the full social marginal cost. In the absence of an admission fee, the crowd grows until the private marginal benefit is equal to the $2 private marginal cost. The crowd size is 9 and there is no social gain.

The social optimum is achieved when the *social* marginal benefit is equal to the $2 marginal cost, at a crowd size of 5. At this crowd size, the difference between private marginal benefit and social marginal benefit (i.e., the externality) is $6 − $2 = $4. Therefore, the optimum can be achieved by imposing a Pigou tax—that is, an admission fee—of $4. This raises the private cost of a visit to $2 + $4 = $6, and the crowd stops growing when it reaches its optimal size of 5. The social gain is the sum of the admission fees, or 5 × $4 = $20, which is represented by the shaded area in the exhibit.

To check that we really have achieved a social optimum, we can compute what would happen if the admission fee were something different. If the fee is $8, then the private cost of a trip to the aquarium is $2 + $8 = $10 per person, and only 1 visitor attends. The town collects a total of $8 in fees. If the fee is $7, the private cost is $9 per person, and 2 visitors attend. The town collects $18. Continuing in this way, we can generate a table:

Admission Fee	Crowd Size	Social Gain
$8	1	$8
7	2	14
6	3	18
5	4	20
4	5	20
3	6	18
2	7	14
1	8	8
0	9	0

Exercise 14.2 Check all of the entries in the table.

An examination of the table confirms that the $4 admission fee generates the largest possible social gain.

Throughout the analysis, we have treated crowding as something that *reduces the benefit* of visiting the aquarium. It would be equally correct to treat crowding as something that *increases the cost* of visiting the aquarium. Under the alternative analysis, the private and social marginal benefit curves would coincide, but the private and social marginal cost curves would diverge. For example, when the fifth person enters the aquarium, he lowers its value to the first four visitors by $1 each, so the social marginal cost of the fifth visitor is $6 ($2 private marginal cost plus $4 in externalities). The alternative analysis would result in a different graph, but the same numerical conclusions.

However, it is important not to double count. It is correct to count crowding as a reduction in benefit (as we have chosen to do in this text) or to count it as an increase in cost (as suggested in the preceding paragraph). It is *not* correct to treat it as both simultaneously.

Dangerous Curve

Property Rights

We have seen that if the Springfield aquarium were privately owned, all social gains would go to the owner in the form of entrance fees. To maximize these gains, the owner would set a $4 admission fee, ensuring the optimal crowd size of 5. Under private ownership, the socially efficient outcome is achieved automatically.

Indeed, any well-defined allocation of property rights leads to the socially efficient outcome. If it were feasible for visitors to demand compensation from others who jostled them or blocked their views, all of the externalities would be internalized and the crowd would adjust to its optimal size. In this scenario, property rights are allocated to some of the visitors rather than an aquarium owner. As always, it doesn't matter (for efficiency) who has the property rights as long as they are assigned and enforced.

But when there are no property rights at all—as when the town operates the aquarium and allows anyone to use it—we face the tragedy of the commons. In this example, rents are dissipated completely, and the aquarium might as well not exist.

It Can Pay to Be Different

Consider again an aquarium with free admission. In our original analysis, we assumed that everyone values picnics at $2. Thus, we were implicitly assuming that everyone has identical tastes. Under this assumption, we discovered that the aquarium has no social value.

But now let us modify our assumption and suppose that tastes differ. Some Springfielders don't share their neighbors' enthusiasm for picnics; others are particularly keen on watching fish; still others are unusually serene about large crowds. Any of these people might have a positive preference for the aquarium over the park and can benefit from its presence. That benefit is a real social gain, and it means that the rents from the aquarium are not entirely dissipated.

Whether or not tastes differ, this much remains true: The marginal aquarium-goer is indifferent between the park and the aquarium. If he weren't, the crowd would grow and he wouldn't be marginal anymore. If everyone is identical to the fellow at the margin, then everyone shares his indifference and the aquarium is worthless. But if people are *not* all identical, the aquarium can yield positive social gains.

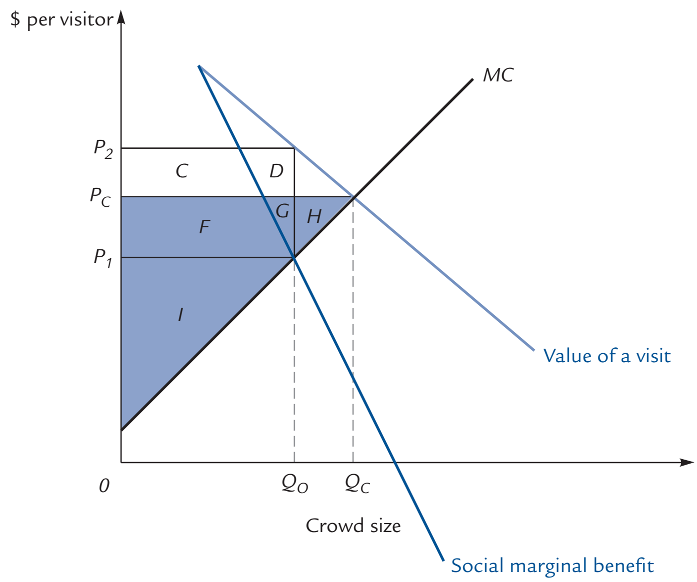
Unfortunately, even in this case the outcome is suboptimal. The crowd still grows until its marginal member has equated his private cost to his private benefit. That last entrant to the aquarium would be just as happy at the park, where he wouldn't be in other people's way. Moving him to the park would be a clear social improvement, but he has no incentive to move. An admission fee can provide the right incentive.

A Graphical Analysis

Suppose that people differ in their enjoyment of picnics, so that some face higher opportunity costs than others when they visit the aquarium. Then the marginal cost of adding a visitor is upward sloping, as in Exhibit 14.2. The reason for the upward slope is that the first visitor is the one with the lowest opportunity cost, the second has a slightly higher opportunity cost, and so on.

Visitors arrive until the marginal visitor is just indifferent between entering the aquarium and going to the park; this occurs at a quantity Q_C. The visitors earn a total surplus of $F + G + H + I$. (This area can be divided into rectangles, each representing the excess of a visitor's benefit, which is always P_C, over his opportunity cost.) There would be more surplus if visitors stopped arriving when the marginal cost of entry equaled the marginal social benefit, at quantity Q_O. Here the surplus is $C + D + F + G + I$. This optimum can be achieved via an admission fee of $P_2 - P_1$.

EXHIBIT 14.2 **Gains from an Aquarium Whose Visitors Are Not Identical**



The *MC* curve shows the cost of adding visitors to the aquarium. Visitors enter until the later entrant's visit has a value equal to his opportunity cost. This occurs at Q_C. Each visitor values his visit at P_C, and the total surplus is $F + G + H + I$. If it were possible to control entry, the optimal crowd size would be Q_O and surplus would be $C + D + F + G + I$. An admission fee of $P_2 - P_1$ yields this optimal outcome, with I going to visitors as surplus and $C + D + F + G$ going to the owner as revenue.

If the aquarium were run by a private competitor (competing with other aquariums), $P_2 - P_1$ is exactly the admission fee the owner would set. To discover this directly would require a little work, but we can jump to the conclusion because we know that competitive markets maximize social gains and that social gains are maximized by this admission fee. Under competition, then, the number of visitors is Q_O, the value of a visit is P_2, and the price of a visit is $P_2 - P_1$. Each visitor earns a surplus of P_1 minus his opportunity cost. The total surplus to visitors is area *I*. At the same time, the owner collects revenue equal to $C + D + F + G$. The social gain, consisting of visitors' surplus plus the owner's revenue, is $C + D + F + G + I$, the largest possible.

Common Property

Common property is overused. At a common-property aquarium, the crowds grow too large. Rents are dissipated. This much we have seen. But there are still other problems associated with common property. One problem is that nobody has any incentive to maintain or improve that which is commonly owned. Imagine a large forest where many people come to cut trees. There might very well be nobody with the incentive to plant and tend new trees, because the planter has no well-defined property rights. Thus, we have two separate problems: First, if loggers impose externalities on each other, there will be too many loggers. Second, if planters have no rights to the fruit of their labors, there will be too few planters.

The most frequently cited example of a common-property resource is a lake stocked with fish. This example is cited so frequently, in fact, that economists sometimes refer to any commonly owned property as a **fishery.** Here the dissipation of rents and the lack of maintenance can be especially acute, because a fish caught today is a fish that does not reproduce tomorrow. As a result, the fish can be overharvested to the point of extinction. The whaling industry presents an important instance (whales are not fish, but whaling is a fishery). The imminent extinction of various species is a direct result of the fact that nobody owns the whales. In the timber industry, by contrast, trees are constantly replenished precisely because they are owned.

Fishery
Common property.

It is interesting to contrast the fate of elephants with the fate of cattle. Elephants are hunted for their ivory and, like whales, face possible extinction. It is sometimes claimed that the world's demand for ivory is the source of the problem. But the world's demand for meat far exceeds its demand for ivory, and nobody worries that cattle might become extinct. The key difference is that elephants are common property, and cattle are not.

Optimal Activity Levels

Before we leave this subject, there is one further subtlety worth mentioning. There is a sense in which even an admission fee fails to completely alleviate the tragedy of the commons. The reason is this: Even though the admission fee can limit the number of entrants, it does nothing to limit people's activity after they have entered. Even at an aquarium where the crowd size is already optimal, there might be further social improvements if visitors could be induced to spend more time at the snack bar and less time standing in front of other visitors at the exhibits. To overcome this problem, the owner would have to be able to charge people separately for every activity that imposes externalities.

If you have ever been to Disneyland, you have directly observed this sort of inefficiency. There is a fee to enter the park, without which congestion would dissipate rents. But there are no fees for the individual rides, as a result of which people queue up for the popular rides without regard to the costs (in waiting time) that they are imposing on others.[1,2] The result can be waits of several hours, which would be alleviated by well-defined property rights.

Dangerous Curve

This is not a complete analysis of the problem. The next question to ask is: If the pricing system at Disneyland is so inefficient, why don't they change it? The same question occurs for ski-lift tickets: Why do resorts sell tickets on a daily basis rather than a per-ride basis, when the former creates long lines that skiers would be willing to pay to avoid? These questions are difficult, but they have been addressed.

Example-Splitting the Check

Suppose that you are eating dinner at a restaurant as part of a party of 10.[3] It comes time to decide whether to order dessert. You are surprised to discover that the dessert selections are very expensive, all priced at $10, whereas the most you would be willing to pay is $2. Of course, you choose to pass up dessert.

Now the waiter arrives at the table and announces that he forgot to keep separate checks and as a result will present one bill, which will be split 10 ways. Suddenly the dessert takes on the characteristics of common property: You can have it without paying the full cost. In fact, ordering a $10 dessert will raise everyone's bill, including your own, by only $1. You order dessert. This decision is individually optimal, regardless of what everyone else is doing.

Now, as it happens, everyone else at the table has the same preferences as you do and reasons in exactly the same way. Everyone orders dessert. You end up paying $10 (a $1 share of each of 10 desserts) and getting a dessert that you value at $2.

Perhaps this inefficient outcome should be referred to as the "tragedy of the compotes."

Exercise 14.3 Find a better pun.

Example-Bumblebees and Property Rights

Often, several species of bumblebees compete for nectar from the same flowers.[4] The nectar is a common-property resource, so each species has an incentive to extract more nectar than is optimal from the viewpoint of all the bees. A system of contracts limiting each species' harvesting would improve each species' welfare.

Evolution has provided an excellent substitute for such a system of contracts. In small locales only a few species of bees tend to be abundant, and these species tend to have tongues of widely varying lengths (typically, there are three species: one very

[1] As always, it doesn't matter who has these rights. If the park claimed them, it could set appropriate prices to discourage inefficient overuse of the rides. If the customers had well-defined, enforceable property rights, the people behind you in line could bribe you to leave, so that only those who valued the rides highly enough to justify the cost would remain.

[2] See R. Barro and P. Romer, "Ski-Lift Pricing, with Applications to Labor and Other Markets," *American Economic Review* 77 (1987): 875–890.

[3] This example is adapted from D. Weimer and A. Vining, *Policy Analysis: Concepts and Practice,* Chapter 3 (Englewood Cliffs, NJ: Prentice-Hall, 1989).

[4] This example is taken from the fascinating book *Bumblebee Economics* by Bernd Heinrich (Cambridge, MA: Harvard University Press, 1979).

short-tongued, one long-tongued, and one medium-tongued). These differences cause the bees to favor different flowers. Short-tongued bees cannot reach the nectar in flowers with deep corollas; on the other hand, a long tongue can be a clumsy liability on a short-corolla flower.

As a result, each species specializes in taking nectar from particular sorts of flowers. Tongue lengths allocate property rights, and the bees avoid dissipating rents from nectar, without which they could not survive.

14.2 Public Goods

A good is said to be a **public good** if one person's consumption increases the amount available to everybody. The most commonly cited example is national defense. An additional missile built to defend your house automatically defends your neighbor's houses as well. Police protection is another example, as are city parks, streetlights, and television programs (a program broadcast to your set is broadcast to other sets as well).

When called upon to make this definition more precise, economists define public goods in different ways. Some define a public good to be one that is **nonexcludable,** meaning that when one person consumes the good, there is no way to prevent others from consuming it as well. People define a public good to be one that is **nonrivalrous,** meaning that when one person consumes the good, it becomes possible to provide it to others at no additional cost. Yet other people define a public good to be one that is both nonrivalrous and nonexcludable simultaneously.

Common property, such as a fishery, is nonexcludable (anyone can use it) but not nonrivalrous (each fisherman reduces the number of fish available to others). Movie showings in uncrowded theaters are nonrivalrous (once the movie is being shown, it costs nothing to allow others to enter the theater) but not nonexcludable (theater owners can refuse admittance to anyone without a ticket). National defense, police protection, and uncrowded city parks are both nonexcludable and nonrivalrous.

Public good
A good where one person's consumption increases the consumption available for others.

Nonexcludable good
A good that, if consumed by one person, is automatically available to others.

Nonrivalrous good
A good that, if consumed by one person, can be provided to others at no additional cost.

Market failure
An occasion on which private markets fail to provide some good in socially efficient quantities.

Some Market Failures

A **market failure** occurs when private markets fail to provide some good in socially efficient quantities. Nonexcludable and nonrivalrous goods are particularly susceptible to market failures, for reasons we shall now explore.

Nonexcludability

In Section 14.1 we saw how nonexcludability (e.g., at an admission-free aquarium) can lead to inefficient crowding. Here we shall concentrate on a different form of inefficiency associated with nonexcludable goods: The market tends to undersupply them.

Suppose that it would cost $300 to install a streetlight that is worth $10 to each of 100 neighbors. The streetlight is socially desirable, but no individual is willing to pay for it. The neighborhood could take up a collection, asking everybody to contribute to a streetlight fund. If the fundraising drive is successful, the light gets built and everybody benefits. Nevertheless, people are not eager to contribute. Each reasons thus: "I'm not sure whether my neighbors are contributing generously, though I hope they are. But if they're not, my contribution probably won't be enough to get the light built. And if they are, the light will get built without my contribution. Either way, I see no point in contributing."

This free riding is an example of the Prisoner's Dilemma that we met in Chapter 11. Although it is rational behavior for each individual separately, it leads to a socially suboptimal outcome: The streetlight does not get built.

If streetlights were excludable, there would be no problem. The rule would simply be that if you don't contribute, you can't use the light. Unfortunately, there is no way to prevent people from making use of a streetlight once it is lit. This nonexcludability is the source of the free-riding problem.

Nonrivalry

Computer software is expensive to develop but cheap to reproduce. Indeed, copies of sophisticated software can be reproduced at a marginal cost very close to zero. Thus, software is an example of a nonrivalrous good.

What is the efficient price for a software package once it has been produced? The answer is zero. At any higher price, some people who want the software will decide not to buy it. Because it would cost nothing to make the software available to everybody, it is inefficient to deny it to anybody.

The same is true of seats in an uncrowded movie theater. If the $5 admission fee keeps people away, there is a pure social loss. It would cost the theater owner nothing to allow people to sit in the unused seats.

Unfortunately, if nonrivalrous goods were really priced at zero, nobody would produce them. The software manufacturers and theater owners must set positive prices for their goods or there will be no goods to sell. These nonzero prices mean that nonrivalrous goods, if they are produced at all, are produced in inefficiently small quantities.

The Provision of Public Goods

Because nonexcludable and nonrivalrous goods are supplied inadequately by the marketplace, they are often provided by the government. If it would cost $300 to build a streetlight that 100 neighbors value at $10 apiece, we have seen that the market can fail to provide the streetlight. A government, however, can assess a tax of $3 per neighbor and use the proceeds to build the light, yielding a clear gain in social welfare.

On the other hand, alternative mechanisms can sometimes accomplish the same job through the marketplace. In principle, an ambitious entrepreneur could buy all 100 houses in the neighborhood for their current market value, install the streetlight at a cost of $300, and then resell each house for $10 more than he paid for it—because we already know that a house near a streetlight is worth $10 more than a house that is in the dark at night.

For something as small as a streetlight, this kind of plan might be more trouble than it's worth—unless the entrepreneur already owns the houses. A builder who has just constructed a housing development will voluntarily install streetlights at his own expense if he thinks their value to potential buyers exceeds their cost. If the builder is a shrewd judge of preferences, he will provide such public goods in optimal quantities, without any need for the government to take action.

Example-Clean Air

Cleantown and Grimyville are identical in every way except for air quality. The Grimyville Steel Plant accounts for the difference.

People moving in from out of state can rent apartments in either Cleantown or Grimyville. Why does anyone choose Grimyville? For one reason and one only: The rents are lower. In fact, the rents are just enough lower so that people are indifferent between the two towns. If people weren't indifferent, there would be migration between the two towns and rents would adjust until people *were* indifferent.

Grimyville Steel is capable of producing clean air by installing filters in its smokestacks. The reason it doesn't do so is that clean air is nonexcludable; there is no way to make the beneficiaries pay for it. This is just the sort of transactions cost that we often encountered in Chapter 13.

Because the market does not provide clean air in adequate quantities, the Grimyville City Council has ordered Grimyville Steel to clean up its act under penalty of law. The results have been remarkable: Grimyville's air is now indistinguishable from Cleantown's.

Of course, Grimyville's rents are also now indistinguishable from Cleantown's. So who benefits from the clean air legislation? Certainly not the apartment dwellers. Originally, they had a choice between living in Grimyville and Cleantown, and between the two they were indifferent. Now they have a choice between living in two copies of Cleantown. This makes them no worse off than before, but no better off either.[5]

The only beneficiaries of the clean air legislation are the landlords of Grimyville, who collect all of the benefits in the form of higher rents. It is therefore very easy to determine whether the clean air legislation is efficient: If rents rise by more than the cleanup costs, then there is a net social gain; if they rise by less, there is a net social loss.

Now the question is: Could the landlords of Grimyville have taken up a collection on their own to bribe Grimyville Steel and make it stop polluting, or to clean up the air in some other way? Surely there would be a free-rider problem here, but not so intractable a free-rider problem as if all the citizens of Grimyville had been beneficiaries. If there are only half a dozen landlords in town, it is conceivable that they could formulate and enforce an agreement that would obligate all of them to contribute to the antipollution fund.

When the benefits of a public good are concentrated among a small number of people, there is a better chance that the good can be provided by coordinated action among the beneficiaries. The point of this example is that a good that at first appears to benefit a very large class (here, all of the residents of Grimyville) may in fact benefit only a much smaller class (here, the Grimyville landlords). In fact, whenever a public good increases the desirability of living in a certain area, its benefits tend to be captured completely by an increase in land values. If the number of landlords is small, the public good can frequently be provided by private action.

The Role of Government

When the benefits of a public good are widespread, private mechanisms can break down and the government plays a role as provider. Governments provide national defense and police services because such goods are nonexcludable. A private army or police force cannot charge for its services and protect only those who pay; an aggressor or criminal deterred is as much a benefit to those who don't contribute as to those who do.

[5] This analysis assumes that everyone's tastes are identical. Without this assumption the analysis is slightly subtler. This theme is taken up in the problems at the end of the chapter.

There is, however, a crucial difficulty. How can the government determine when it is optimal to purchase a public good? Suppose that some neighbors believe that the streetlight would be a net benefit to the neighborhood and others don't. One possibility is to conduct a vote on the matter. However, a disadvantage of voting is that it does not allow people to register the strengths of their preferences. If 19 people each value the light at $1 apiece and if one person would be willing to pay $40 to prevent its construction, an election will lead to an overwhelming victory for installing the light, even though installing it is socially undesirable.

Another possibility is for the government to ask people not just whether they want the light, but how much it is worth to them to either have it or not have it. This has the disadvantage that people will find it in their interest to exaggerate their preferences. If you want the light at all, you might as well claim that it is worth $1 million to you, just to increase the chance of its being built.

In order to create appropriate incentives, the government might say that your share of the tax burden for installing the streetlight will be proportional to its value to you. This makes it costly to exaggerate the value and discourages overstatements. Unfortunately, it encourages dishonesty of another sort. People will tend to understate their personal valuations so as to shift the tax burden to their neighbors. With everybody understating, there may be a false appearance of insufficient demand to justify installing the lamp.

In order for the government to provide public goods in appropriate quantities, it must find ways of gathering information that is initially available only to private individuals with no incentives to reveal it. One possible source of such information is the price of private goods that are similar in nature to the public good being contemplated. For example, suppose that the good under consideration is a dam that will make water available to surrounding farmland. If the farmers are currently purchasing water through a private mechanism, the price of that water is a good indication of its value to farmers.

The more common situation, however, is one in which no such easily observable good exists. The surprising fact is that in such a case it is often possible, by the clever structuring of incentives, to induce people to reveal their true demand for a public good.

Before describing such a mechanism, we present as puzzles two other situations in which there exist surprising mechanisms to elicit the revelation of privately held information. In each case try to figure out the scheme that works before looking at the answer later in this section.

Puzzle No. 1: In Joseph Conrad's novel *Typhoon,* each of 200 men on a ship has stored several years' wages in his own personal strongbox. The ship encounters bad weather, the boxes are smashed, and all the coins are mixed together. The captain gathers up all the coins and wants to return them to the men, giving each the number of coins to which he is rightfully entitled. Each man knows how many coins were his, but nobody knows how many belong to anybody else. Obviously, each man, if asked, will exaggerate his fair share. How can the coins be returned to their owners?[6]

Puzzle No. 2: Property taxes are levied in proportion to the value of people's homes. Ideally, each individual would be taxed a given fraction of the valuation that he personally places on his house. In practice, this is assumed to be equal to the market value of

[6] The analogy between this problem and the theory of public goods was suggested by Gene Mumy in "A Superior Solution to Captain MacWhirr's Problem," *Journal of Political Economy* 89 (1981). The solution he proposed was substantially more complicated (though identical in spirit) to the one that we will give.

similar houses. Because no two houses are alike, taxing agencies devote considerable resources to examining individual houses and assessing their values. Homeowners often protest these assessments, leading to costly disputes. How can the tax collector costlessly determine the true value of an individual house (keeping in mind that only the owner himself is initially in possession of this information)?

In interpreting Puzzle No. 2, keep in mind that the value a homeowner places on his home might be very different from its market value.

Dangerous Curve

Schemes for Eliciting Information

The town of Springfield is thinking of installing a streetlight, and the local newspaper has been lobbying for it very hard. Mayor June is interested to know just how much Ed the Editor really values a streetlight and doesn't trust him to tell the truth if he is asked outright. So the mayor has thought of a tricky plan.

Using his pocket calculator, the mayor has generated a random number X, which is recorded in a sealed envelope. He has walked into Ed's office and laid down some terms: "Ed, I want you to tell me how much you really value that streetlight. Whatever answer you give me I will call E. If my secret number X is less than E, I will build the streetlight and I will raise your taxes by X to pay for it. (The mayor has total control of the tax laws in Springfield.) But if X is more than E, then I'm going to forget all about this streetlight thing and leave your taxes as they are."

Now Ed actually values the streetlight at \$47. Because he'll have to pay X in taxes to build it, Ed is thinking "If X is less than \$47, this streetlight is a good deal for me and I hope it gets built. But if X is more than \$47, I hope we can forget all about this streetlight thing."

If you compare the mayor's offer with Ed's silent calculation, you will discover something remarkable: If Ed tells the truth, so that $E = \$47$, then he is certain to get the outcome he prefers. Faced with the mayor's terms, Ed will choose to tell the truth and the mayor will learn the streetlight's true value.

Reaching the Efficient Outcome

It is not only Ed's opinion that interests the mayor. What the mayor really wants to know is whether it would be efficient to build the streetlight. The light would cost \$300 and it would benefit five people, one of whom is Ed. The problem is to simultaneously discover how much each of the five values the streetlight and to build it only if the sum of those values exceeds \$300.

Here is the mayor's plan. Instead of walking into Ed's office with a secret number in his pocket, he asks each of the five (Al, Barb, Cassie, Dale, and Ed) to write down an assessment of the streetlight's value. The mayor plans to call these numbers A, B, C, D, and E. He announces to Ed (in advance): "After the envelopes are opened I am going to compare your number E with the number $X = 300 - A - B - C - D$. If X is less than E, I will build the streetlight and charge you X. Otherwise, I will forget about the streetlight."

This is just like the mayor's earlier plan except that the unknown random number X from the mayor's calculator is replaced by the unknown number $X = 300 - A - B - C - D$. Just as before, Ed is induced to tell the truth.

At the same time, the mayor tells Dale that he will decide whether to build the light by comparing Dale's number D with the number $300 - A - B - C - E$. If $300 - A - B - C - E < D$, the mayor will build and charge Dale $300 - A - B - C - E$; otherwise, he will do nothing. Dale, like Ed, is induced to tell the truth.

The mayor makes similar announcements to Cassie, Barb, and Al. In Cassie's case he says he will make a decision by comparing $300 - A - B - D - E$ with C; this leads Cassie to tell the truth, and similarly for Barb and Al.

Now the mayor has made a lot of apparently contradictory promises, but fortunately the contradictions are only apparent. He has told Ed that he will build if and only if $300 - A - B - C - D < E$; he has told Dale that he will build if and only if $300 - A - B - C - E < D$, and so forth. A small amount of algebra reveals that each of these conditions is equivalent to the single condition $A + B + C + D + E > 300$. Therefore, all of the promises are equivalent and can be kept simultaneously.

And something even more wonderful is true: The streetlight gets built if and only if it is efficient. The inequality $A + B + C + D + E > 300$ says precisely that the light's benefits exceed its costs; and this is precisely the circumstance in which the light gets built.

Clarke tax

A tax designed to elicit information about the demand for public goods.

The mayor's tax plan is an example of a **Clarke tax.** The only problem with the Clarke tax is that if the light *does* get built, the mayor has made some promises about how much he will tax everybody, and there is no reason why the tax revenue should happen to just cover the $300 cost of the light: It could turn out to be either too high or too low. Thus, the mayor must be prepared either to turn a profit for the city treasury or to finance the light partly out of city coffers if that becomes necessary. If he is willing to do so, he can simultaneously elicit full information from everybody and guarantee an efficient outcome.

Solutions to Puzzles

The mayor's cleverness solves a problem that initially appears insoluble. Here are some clever solutions to the puzzles from earlier in this chapter.

Solution to Puzzle No. 1: The captain can ask each man to write down the number of coins he started with. He announces that the numbers will be added up and that if the sum does not match exactly the total number of actual coins, all of the coins will be tossed overboard.

Solution to Puzzle No. 2: Ask each homeowner what his house is worth to him. The values will be made public, and each owner will be required to sell to anyone who offers him more than the stated value of his house. No truthful owner can be hurt by this scheme; he can only be forced to sell to someone he would be willing to sell to anyway.

Summary

Commonly owned property is an important source of externalities. There is no way to limit use of the property in order to avoid problems of congestion. Also, there is no incentive to improve the property itself. If all users of the property are identical, then rents will be dissipated completely. This is because people continue to use the property until everyone is indifferent regarding its existence. An owner—any owner—will improve social welfare by setting entry fees that discourage overuse and also perhaps by improving the property.

If users of the property vary in their tastes or opportunity costs, then rents are partially, but not completely, dissipated in the absence of ownership.

Because public goods present incentives for free riding, they represent a type of externality. Because individuals will purchase less than the optimal quantity of public goods, public goods are often provided by the government. This makes it desirable for the government to be able to elicit information about how much people value public goods, which presents a problem in view of individuals' incentives to be untruthful. A number of clever schemes have been devised for eliciting truthful responses in a variety of circumstances.

Review Questions

R1. What is the dissipation of rents? Under what circumstances are rents dissipated completely? Under what circumstances are they dissipated partially? Why?

R2. What is a nonrivalrous good? What is a nonexcludable good?

R3. Describe a mechanism that would induce each party to reveal how much he privately values a certain public good.

Numerical Exercises

N1. Each potential user of the Phoenix River Bridge is willing to pay up to \$299 per crossing, provided there are no other cars to slow him down. When there are more cars, willingness to pay goes down. Specifically, when there are N cars per day on the bridge, each user is willing to pay up to ($\$300 - N^2$) to cross.

- **a.** In terms of N, what is the social gain from the existence of the bridge?
- **b.** If there is no bridge toll, how many people cross per day and what is the social gain?
- **c.** What is the optimal number of bridge crossings per day? (To answer this question, you will need either some calculus or some patience with trial and error.)
- **d.** If there is a bridge toll of $\$T$, how many people cross per day? (Answer in terms of T.)
- **e.** What is the optimal bridge toll? How much social gain results when this toll is set? Who gets the benefits?

N2. Let A be the value of a visit to the aquarium and let η be the elasticity of A with respect to the number of visitors. (That is, η is the elasticity of the lightly colored curve in Exhibit 13.1.) Show that the optimal admission fee is $A|\eta|$.

Problem Set

1. A fisherman at Hardin Lake can catch 20 fish per day, provided he has the lake to himself. Two fishermen can catch 19 fish apiece per day, and three can catch 18 fish apiece per day. Other numbers are given by the table:

Number of Fishermen	Fish per Day per Fisherman
1	20
2	19
3	18
4	17
5	15
6	13
7	10
8	7

The opportunity cost of a day at the lake is 7 fish (i.e., the alternative activity is as valuable as 7 fish).

a. How many fishermen come to the lake? How many fish do they catch? What is the social gain from the existence of the lake?

b. What is the optimal number of fishermen at the lake? What is the social gain if this optimum is achieved?

c. What entrance fee leads to the optimal outcome?

2. Happy, Grumpy, Dopey, Sleepy, Sneezy, Doc, and Bashful are miners, who have nothing to do with their time but to go mining. There are no other miners in the vicinity. Each miner can dig in either of two mines. The number of gold nuggets that a miner can find in a day depends both on which mine he is working and how many other miners are present in that mine, as indicated by the following chart:

Number of Miners	Nuggets per day in Mine A	Nuggets per day in Mine B
1	20	30
2	18	27
3	16	24
4	14	21
5	12	18
6	10	15
7	8	12

a. If entry to the mines is free, how many miners work in each mine?

b. At the social optimum, how many miners would work in each mine?

c. What system of entry fees to the mines could bring about that social optimum?

d. Suppose that both mines are owned by a wicked queen who can set entry fees. What fees would she set?

3. Two roads go from Hereville to Thereville. One road is very wide and can easily accommodate all the traffic that would ever want to use it, but it is in poor repair and unpleasant to drive on. The other road is in excellent repair and goes through the most scenic areas, but it has only one lane in each direction and easily becomes congested.

a. Explain why, if there are sufficiently many drivers, both roads will be equally pleasant to drive on.

b. How do the private marginal benefits compare for a driver entering the wide road and a driver entering the narrow road? How do the marginal social benefits compare?

c. In view of your answer to part (b), could a social planner reallocate one car in order to make a welfare improvement?

d. How much further reallocation would the planner want to make? How could the same thing be accomplished without a planner?

4. A race of dwarfs lived near a forest where apple trees grew wild. Any dwarf who wanted to could enter the forest and pick apples for himself and his family. One day a giant came, claimed the forest for himself, and began charging the dwarfs for the right to pick apples.

a. Suppose that dwarfs can pick fewer apples when the forest is more crowded. Draw a graph with "Number of dwarfs in the forest" on the horizontal axis and "Apples per dwarf" on the vertical. Draw a curve representing the number of apples picked per dwarf and a curve representing each dwarf's marginal contribution to the apple harvest. Explain intuitively why the latter curve lies below the former.

b. Suppose that all dwarfs have the same opportunity cost to enter the forest. Show on your graph how many dwarfs enter the forest before the giant arrives and how many enter after the giant arrives. Show the giant's revenue.

c. Now drop the assumption that all dwarfs have the same opportunity cost, and assume that some dwarfs' time is more valuable than others'. On the graph you drew for part (a), add the upward-sloping curve that shows the marginal cost of adding dwarfs to the forest. Show the number of dwarfs that enter. Show the producers' surplus that the dwarfs earn as apple-pickers.

d. Continuing to use your graph from part (c), show the optimal number of dwarfs in the forest. Show the entrance fee that achieves this optimal number. Explain why this is the entrance fee that a competitive giant would set.

e. Can the dwarfs be made better off as a result of the giant's arrival and the entry fee? What about society as a whole (consisting of the dwarfs plus the giant)?

f. (This is a difficult problem.) Assuming straight-line curves, and assuming that the giant sets a monopoly price to enter the forest, show that the monopolized forest is more socially efficient than the common-property forest if and only if the "marginal apple harvest" curve is steeper than the dwarfs' marginal cost curve.

5. **True or False:** A communally owned lake is more valuable in a town where everybody is an excellent fisherman than in a town where people vary widely in their fishing ability.

6. Suppose that the town of Springfield establishes an aquarium with free admission and that all residents of Springfield are identical. **True or False:** If the population of Springfield is sufficiently small, not all rents will be dissipated.

7. Rollo's Roller Rink is located in a town where everyone is identical. Rollo's is subject to crowding and becomes less pleasant when it is crowded. **True or False:** If Rollo is a monopolist, he will charge exactly the same price as he would under competition.

8. Which of the following are nonexcludable? Nonrivalrous? Both? Neither?

a. Network TV programming

b. Cable TV programming

c. Textbooks

d. Statues in the park
e. Water fountains in the park

9. A public radio station soliciting donations argued that its listeners would be irrational not to contribute. "Unless our fund drive is successful," they warned, "we will have to go off the air. Surely you get at least $20 worth of pleasure from listening to our station over the course of a year. Make your $20 pledge now to protect your own self-interest." Comment.

10. Most of the people living on the north side of Boomtown are apartment dwellers who commute into the center of town every day to go to work. The city is considering building a new subway line between the north side and the center of town. **True or False:** Because the landlords all live on the south side of town, and the employers are all in the center of town, all of the benefits from the new subway will go to the working people on the north side of town.

11. Cleantown and Grimyville are identical except for the inferior air quality in Grimyville. All potential residents have identical tastes. Apartments in Cleantown rent for $300 per month. The cost of breathing Grimyville air is $100 per month. The quantity of apartments in each town is fixed.

    a. Explain why the demand curve for Grimyville apartments is flat at a price of $200 per month. Draw the supply and demand curves for Grimyville apartments and show the consumers' and producers' surpluses.
    b. Suppose that the air in Grimyville is brought up to Cleantown standards. Show the effects of this change on your graph. Show the increase in social gain. Who benefits from the clean air?

12. In the preceding problem, drop the assumption that everyone is identical. Some hate pollution more than others do. The one person in Grimyville who hates pollution the most considers the cost of breathing it to be $100 per month.

    a. Explain why the demand curve for Grimyville apartments is downward sloping. At what price does it cross the supply curve? Draw the supply and demand curves for Grimyville apartments and show the consumers' and producers' surpluses.
    b. Suppose that the air in Grimyville is brought up to Cleantown standards. Show the effects of this change on your graph. Show the increase in social gain. Who benefits from the clean air? Who loses from it?

13. Suppose that you want to sell your car to one of several people and that you decide to auction it off. You are curious to know the highest price that each of the potential buyers would be willing to pay for the car. You ask each to submit a sealed bid, announcing that the car will go to the high bidder but that he will be charged the amount of the second-highest bid. Will the submitted bids be truthful? Why or why not?

14. (This is a difficult problem.) A factory that emits noxious smoke is located near a small cluster of homes. It is up to you to decide whether the factory will have to install pollution-control equipment. A key variable in your decision is the extent of the cost imposed on the homeowners. How can you discover this cost?