Chapter 17
Property Rights, Externalities, Rivalries, and Exclusion

■ Chapter Outline

17.6 Rivalry and Exclusion
- Open-Access Common Property
  - Application: For Whom the Bridge Tolls
- Club Goods
- Public Goods
  - Free Riding
  - Application: Radiohead's Public Goods Experiment
  - Optimal Provision of a Public Good
  - Solved Problem 17.3
- Reducing Free Riding
- Valuing Public Goods
  - Application: What's Their Beef?

■ Teaching Tips

Students are often eager to discuss topics related to this chapter. Consumers are constantly confronted with environmental claims made by firms, public interest groups, and the government, but they do not have much information about how to react. If you like, you can cover portions of this chapter in the form of an introduction to Chapter 7 (Costs). While introducing cost in Chapter 7, you will need to note that social costs are excluded because the simple minimization model includes only private costs. You might take an extra 15 minutes at that time to talk about the existence of externalities, the problem of the commons, and the way the inclusion of these costs would affect the measurement of cost. You can also introduce the Coase theorem at the intuitive level. Because of the recent trend in firms being "green," many students have a fairly simplistic view of negative externalities. It is an important point that although competitive markets do produce excessive pollution, the optimal level of pollution is not zero.

It is also important for students to understand the international perspective as it relates to production externalities. Pollution standards vary greatly in different countries, which can create a competitive disadvantage for firms in environmentally conscious countries. If two firms from separate countries compete in the same world market, and have otherwise equal costs, the firm that faces the pollution tax is at a competitive disadvantage. This can be shown by simply comparing the pretax and posttax solutions in Figure 17.3 in the text. One of the reasons that NAFTA was so controversial was the claim that Mexico had a built-in cost advantage due to less stringent pollution standards.

When discussing the Coase theorem, you might ask the class whether they have rules in their dorms regarding property rights. For example, at most schools, property rights regarding noise pollution are determined by time of day. Between the hours of midnight and 8 A.M., individuals have the right to quiet. At all other times, individuals have the right to make noise. Although bribes for the right to either have noise or quiet are probably rare, without such rules, noisy and quiet individuals have no basis on which to negotiate a solution.

The problems of the commons and the markets for public goods are intuitive and do not take much time to cover. The lobster fishery application on the Web site makes the point well. If you discuss this example, you may find the table on the next page from Wilson (1977) useful in summarizing the effects of controlled access.

Table 17.1

Private Versus Common Property in Maine Lobster Fishers

	Private Ownership	Common
Weight per trap haul (kgm)	0.54	0.32
Number of lobster per trap haul	0.98	0.61
Weight per lobster (kgm)	0.55	0.53
Length of lobster (mm)	89.98	87.89
Avg. gross income of fishers ($)	22,929*	16,449

*Income of fishers in privately controlled areas was adjusted to remove the effect of higher prices in seasons in which their output remained high (while it fell off in the commons).

Source: Wilson, James A., "A Test of the Tragedy of the Commons," in Hardin, Barret, and John Baden, eds., *Managing the Commons.* San Francisco: W.H. Freeman, 1977, 96–111, especially Table 12.1.

This will also be a good point at which to discuss the problems of the 2010 BP oil spill. While information is not fully available at the time of writing of this manual, this issue involves problems of negative externalities, information, and common goods.

■ Additional Applications

Firms Aren't Green

Some firms claim they are environmentally aware. They may endorse the Valdez-CERES Principles, which require that a company "sell products that minimize adverse environmental impacts," or the Business Charter for Sustainable Development, which calls for firms "to modify their operations to prevent serious or irreversible environmental degradation." Are these firms just "talking green," or are they willing to raise production costs to improve environmental quality?

To answer this question, Lave and Matthews (1996) surveyed 54 large American companies that had expressed environmental concerns, such as by publishing an environmental report. They posed the following hypothetical situation:

A material used in one of your company's products is found to harm the environment. Another, nontoxic material is available that yields the same product quality but costs more than the original input.

Would the company switch to the nontoxic input?

Nearly half, 25, of the firms responded to the survey. Almost all firms were willing to switch if doing so would raise product cost by 0.01 percent; if, for example, switching raised a manufacturer's costs by $2 on a $20,000 car.

The willingness to switch fell off quickly, however, as the cost increased. Two-thirds claimed they would substitute if costs rose 0.1 percent; one-third if costs increased 1 percent; 8 percent (2 of the 25 firms) would substitute if costs rose 5 percent; and none of the companies would switch if the cost increased by more. Thus even among firms that profess to be green, few would be willing to take actions to protect the environment if the actions raised their costs and lowered their profits by more than 1 percent.

1. How would firm behavior change if consumers preferred "green" products over nongreen substitutes?

2. Should the government require firms to place environmental impact stickers on product labels?

Energy Saving[1]

"The United States Senate should reject 'energy rationing' amendments that would harm the U.S. economy," the United States Chamber of Commerce said.

In a letter sent to the U.S. Senate Tuesday morning, the Chamber announced its opposition the McCain-Lieberman and Bingaman amendments to the Energy Policy Act of 2005 (S. 10). Those amendments would establish mandatory cap-and-trade programs for greenhouse gas emissions.

"Such amendments will limit the sources of energy the nation can use, impose millions of dollars in new costs on businesses, and will cripple the economy," wrote Bruce Josten, the Chamber's executive vice president.

"Rather than engaging in the costly energy rationing scheme embodied in the McCain-Lieberman or Bingaman amendments, the Senate should let American technological ingenuity work as it has for decades improving environmental quality."

The Climate Stewardship Act, first introduced in the U.S. Senate in 2003 by John McCain (R-Ariz.) and Joe Lieberman (D-Conn.), was reintroduced in both chambers of Congress in February 2005.

The Chamber said it supports an alternative amendment expected to be introduced by Senators Chuck Hagel (R-Neb.) and Mark Pryor (D-Ark.), which would provide incentives (direct loans, loan guarantees, etc.) for reducing greenhouse gas emissions and also address international as well as national sources of emissions.

The goal, the chamber said, is to reduce greenhouse gas emissions without devastating the U.S. economy.

1. Using theory of externality, explain why the market alone is not enough to solve the greenhouse gas problem.
2. What is the fundamental difference between the energy rationing proposal and the one by Hagel and Pryor? (*Hint:* What is the difference in terms of incidence?)

■ Discussion Questions

1. What is the likely effect of a pollution tax on the mix of goods and services sold in the economy?
2. The EPA states that a nationwide ban on smoking in public places could save $39 to $72 billion per year and as many as 12,900 premature deaths annually. Discuss the pros and cons of such a policy.
3. Give an example of a positive externality that creates a problem for society. Would a market develop to eliminate the problem? Why or why not?
4. Serious, contagious illnesses spread throughout the population. Should vaccines be mandatory? What are the externalities to consider?
5. Is there too little or too much commercial fishing? Why? What regulations might reduce the problem?
6. List as many public goods as you can, and discuss why exclusion is impossible.
7. What should the government do if it does not have enough information to regulate pollution properly?

[1]Susan Jones, "U.S. Business Lobby Rejects 'Energy Rationing'," CNSNews.com, June 21, 2005.

8. What positive and negative externalities are created by airports? What would be the consequence of shifting away from air travel toward greater use of rail travel?

■ Additional Questions and Problems

1. Why would someone buy a home in a development that reduces individual freedom through the establishment of restrictive covenants such as no above-ground pools, restrictions on paint schemes, and limitations on allowable fence types?

2. Show, using a graph, that the more elastic the demand curve, the greater the social cost of ignoring a negative production externality.

3. Comment on the following: "All pollution should be eliminated."

4. Market supply in a competitive industry is $p = Q$. Demand is $p = 100 - Q$. Production creates pollution with a social cost of \$1 per unit of output. In response to environmentalists, the government creates a tax of \$2 per unit. Is overall welfare improved or reduced by the tax?

5. In Problem 4, would social welfare in the industry be larger or smaller if it were monopolized and the tax were dropped? Explain.

6. Explain how the Coase theorem would apply to a factory polluting a stream and a spring water producer located downstream.

7. Many lakes in the Adirondack State Park in New York are carefully managed. At some lakes, fines are levied for introducing nonintended fish into the lake. Why would such a rule exist?

8. White Mountain National Forest in New Hampshire is currently experimenting with use permits, whereby a person must pay for a parking sticker for the right to park his or her car at any of the trailheads for any length of time. Area residents, as well as many other park users, are furious. Others support the fees. Discuss these fees as they relate to the problem of the commons.

9. Choose a law designed to curb a negative externality related to driving. Explain the externality the law is designed to reduce, and discuss its effectiveness.

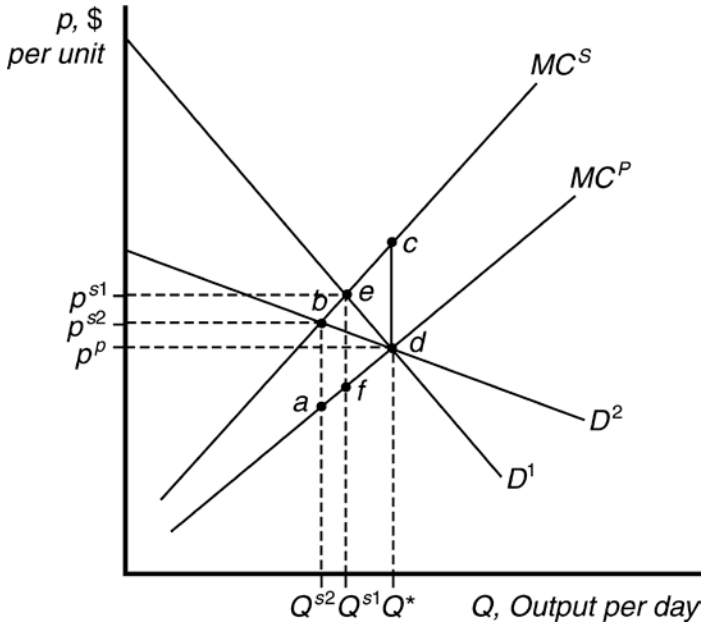
10. Explain why a lot of countries subsidize education. Try to relate this to the concept of externality.

11. The market demand curve of public goods is the vertical sum of private demand curves. What would the market demand curve of a public goods look like if the number of private demand curves gets sufficiently large? What is the economic implication?

■ Answers to Additional Questions and Problems

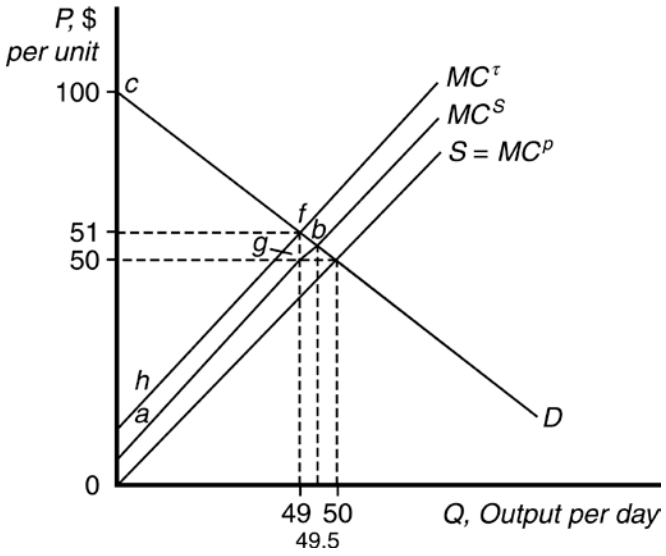
1. Restrictive covenants have a private cost, as they reduce personal freedom by constraining choices. However, there are social costs associated with having neighbors who make additions or alterations to their property that reduce the overall appearance of a neighborhood (and possibly property values). Homeowners will prefer restrictive covenants if their expected utility with the covenants exceeds that without the covenants. Such restrictions tend to increase the homogeneity of neighborhoods, as individuals with tastes and preferences that would be significantly constrained by the covenants are more likely to choose to live elsewhere.

2. In the graph, MC^P is the private marginal cost, and MC^S is the marginal social cost of production. Of the two demand curves shown, D^1 is less elastic. The cost of the externality with demand curve D^1 is *fecd*. The cost of the externality with demand curve D^2 is *abcd*. The cost of the externality is greater with this more elastic demand curve by area *abef*. The reason for the difference is the larger increase in output when social costs are ignored on the more elastic demand curve.

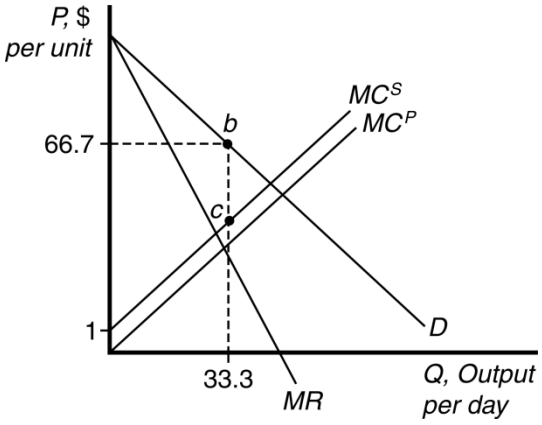


3. The elimination of all pollution is not possible. Even the elimination of all industrial pollution would mean the end of industrial production. Even the cleanest industries create some pollution. Spring water companies need to have containers to put their products in; woodworkers need to have tools to work with. The goal of policy should not be to eliminate pollution but to strike a balance between pollution abatement and forgone output. The difficulty in this process is the measurement of social cost.

4. Without government intervention, the equilibrium quantity is 50, price is $50, and total welfare is 2,450, which is consumer surplus plus producer surplus, less deadweight loss of $50. The socially optimal output level is 49.5. The socially optimal level of production results in total welfare ($CS + PS^S$) of 2,450.25, which is area *abc*. When the government imposes the tax, output falls below the socially optimal level. With the tax, consumer surplus plus producer surplus falls to 2,401 = cfh. Area gfb is the deadweight loss created by the excessive tax. The government collects $98 in tax revenue and $49 externality cost. Thus total welfare with the tax is 2,450, which is equal to total welfare without the tax.



5. If the industry were monopolized, total welfare would be area *abcd*, or 2,187.82, which is less than welfare with the tax.



6. Without the establishment of property rights, the factory and the spring water firm are unable to negotiate a solution. However, if property rights are established in either one's favor, bargaining may occur. For example, if the factory has the right to pollute the stream rather than internalize the waste at a cost of $1 million per year but the pollution costs the spring water firm $2 million per year, the spring water firm will be willing to pay the waste disposal costs for the factory, as they still end up $1 million better off. If the rights are reversed, then no bargaining occurs because it is cheaper for the factory to dispose of the waste at a cost of $1 million than to pay off the spring water firm for the right to pollute.

7. Some species of fish can establish large populations in lakes very quickly. Once they do, they consume food sources of the desirable fish (such as trout). Some also undesirable fish feed on the desirable fish themselves. Thus the introduction of these fish harms the intended fish populations and also creates a negative externality on the users of the waterway who enjoy fishing.

8. Most parks are public goods in that they are nonexclusionary in consumption. During the crowded summer hiking season, the parks may be overutilized. Crowds reduce the quality experience of all users, and additional park staff is needed to patrol common areas, watch for forest fires, clean up trash, and manage campgrounds. By creating the parking fee, use is reduced, lessening these problems. In addition, although they cannot prevent individuals from using the park without paying the fee (some may elect to bike or walk in), the fees that are collected can be used to pay for additional park staff.

9. There are many possible answers, including restrictions on blood alcohol levels, speed limits, and even stopping for traffic signals. In most cases, traffic laws are designed to reduce the possibility of injury to person and property. Damage to the driver represents private costs. Damage to other passengers, individuals in other cars, property, and pedestrians represents an external cost.

10. Education as a form of private investment in human capital will increase people's future earning potential. In addition to that, it makes those receiving it better citizens in various aspects. Hence education has a positive externality. Therefore, it is welfare-improving for the government to subsidize education.

11. As the number of people demanding a public goods gets larger, the market demand curve approaches a vertical line. It implies that the social demand for public goods will be invariant to the marginal cost of supplying those public goods.

■ Answers to Exercises in the Text

1.1 This is a selection rather than externality. The fact that my friends are heavier does not cause me to be heavier. This can be explained by the fact that people probably choose their friends from among those who look more like them.

1.2 The movies are not designed to impact people's productivity in any way—however, they did. The movie producers gained revenue but did not have to pay for the lost productivity that occurred when they premiered the movie at midnight. Since the cost of lost productivity was not borne by the entity that caused it, it is a negative externality.

1.3 An externality occurs when a person's well-being or a firm's production capability is directly affected by the actions of other consumers or firms rather than indirect through changes in prices. In this example, individuals sick with swine flu do not account for the effects of their actions on coworkers (and other students). In particular, if individuals sick with swine flu report for work (or attend school), then they risk infecting their peers. Prior to the law, the marginal private benefit of staying home if sick was less than the marginal social benefit. By essentially subsidizing staying at home if sick, the law raises the marginal private benefit of staying home if sick such that it is closer to (or perhaps equal) to the marginal social benefit.

1.4 In the presence of a positive externality, the competitive market results in a quantity that is too low (relative to the social optimum). In this instance, the competitive market results in a quantity of games with superstars that is less than at the social optimum because the private marginal cost of superstars is greater than the social marginal cost. To solve the problem of the externality, teams must internalize the externality. In this instance, that would be to capture the benefit that one provides to others. Specifically, teams with superstars could capture the benefit they provide other teams by having other teams subsidize the cost of superstars.

1.5 An externality occurs when a person's well-being or a firm's production capability is directly affected by the actions of other consumers or firms rather than indirectly through changes in prices. An externality that harms others is called a negative externality. A positive externality benefits others. Employees viewing the 2012 Olympics instead of working is a negative externality because the productivity losses are due to actions of other firms outside their markets.

2.1 Zero pollution is probably impossible to attain even if it were desirable. Any type of production results in some level of pollution (even spring water has to be delivered, which requires trucks). Thus no pollution means no production and the elimination of the consumer and producer surplus that it creates. The marginal cost of pollution elimination would be extremely high for the last units of pollution, and the marginal benefits would be very low.

2.2 At the competitive market outcome, e_c is the quantity of paper produced. The cost of the externality is the vertical difference between the social marginal cost curve (MC^s) and the private marginal cost curve (MC^p). This is equal to the area $G + C + D + H +$ E. At the socially optimal outcome, e_s is the quantity of paper produced. The cost of the externality is $G + C$. Therefore, the additional externality cost from producing at the competitive equilibrium instead of the socially optimal outcome is $D + H + E$, which is the vertical difference between the social marginal cost curve and the private marginal cost curve for the units of paper produced between Q_s and Q_p.

2.3 The parameter A must be positive in order for gunk reduction to be beneficial, and α must be between zero and one in order for marginal benefits of gunk reduction to decline. If costs are increasing at an increasing rate, β must be greater than one.

2.4 To determine this level, set marginal benefit equal to marginal cost.

$$\alpha A H^{\alpha-1} = \beta H^{\beta-1}$$
$$H^{(\alpha-\beta)} = \beta/(\alpha A)$$
$$H = [\beta/(\alpha A)^{1/(\alpha-\beta)}$$

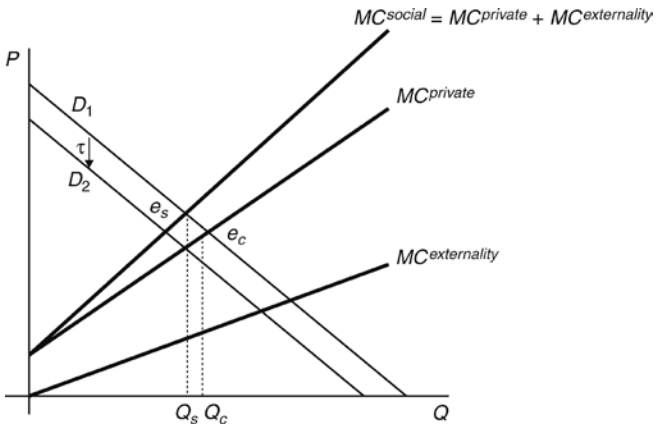
3.1 One alternative is a tax on the old bulbs that makes the cost of each bulb greater than the reservation price of consumers for the new bulbs. If the tax is used to pay for reduced energy consumption in other areas, it could be quite effective relative to a total ban and may allow people who truly prefer the old bulbs to continue to use them, albeit at a much higher cost. Another alternative is to increase energy costs so that the new bulbs are more cost efficient to consumers in a shorter period of time (since they use less energy.) The problem with the second suggestion is that it will affect all other energy uses—not just light bulbs.

3.2 If liquor creates a negative externality, then the competitive equilibrium will result in a quantity of liquor that is too high. The socially optimal quantity of liquor is where the social marginal cost of liquor equals the social marginal benefit from liquor. Thus, the regulatory agency should provide the number of liquor licenses that results in the socially optimal quantity of liquor.

Tighter liquor licensing restrictions would seem to reduce competition by reducing the number of liquor stores, blocking the entry of new liquor stores. This will raise liquor prices and might increase an existing liquor store's profits, particularly if the liquor store owner is allocated a license by the government at essentially no cost.

3.3 a. Yes, there is a negative externality.

b. For simplicity, assume that each motorcyclist rides without a helmet. As shown in the figure below, the social marginal cost curve is the sum of the private marginal cost and the marginal cost of the negative externality. If the government sets a no-helmet specific *t* tax $\tau = \boldsymbol{MC}^{externality}|_{Q=Q_S}$ as shown in the figure, then the socially desirable level of motorcycle sales will be achieved at Q_S.

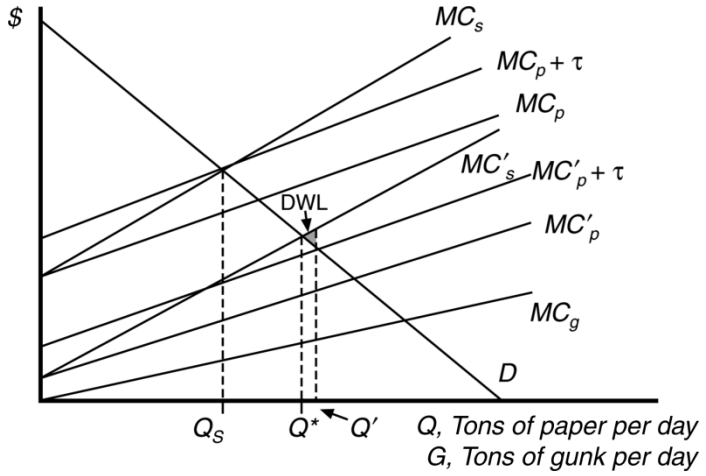


3.4 A specific tax of $84 per ton of output or per unit of emissions (gunk) leads to the social optimum.

3.5 In this market for paper, the competitive equilibrium is at e_c, where the private marginal cost curve and the demand curve intersect. The social optimum is at e_s, where the social marginal cost curve and the demand curve intersect. Too much paper is produced at the competitive equilibrium because paper producers to not account for the effect of their production on others (the negative externality from paper production). As a result, the social marginal cost is higher than the private marginal cost, and at e_c, deadweight loss equal to area *E* is created.

A price floor at p_s will restrict output to Q_s, which is the social optimum, eliminating the deadweight loss. (A price ceiling at p_s would still allow the market to be at the competitive equilibrium because the competitive equilibrium price, p_c, is below the ceiling.)

3.6 When the marginal private cost of output falls, output increases (as does the quantity of gunk produced). If the tax remains unchanged at \$84, as shown by the dashed line in the figure, it is not high enough to decrease the firm's output to the socially optimal level. The new output level is Q', which is greater than the optimal output Q^*. Thus, although consumer surplus increases because the price falls, there is a deadweight loss associated with the excess production beyond the socially optimal level.



3.7 a. The unregulated equilibrium ($MC^P = p$) is $Q = 60$, $p = 140$.

b. The socially optimal equilibrium ($MC^S = MC^P + MC^g = p$) is $Q = 40$, $p = 160$.

c. A specific tax of \$40 per unit results in this outcome. With the tax, $MC^P = 120 + Q$.

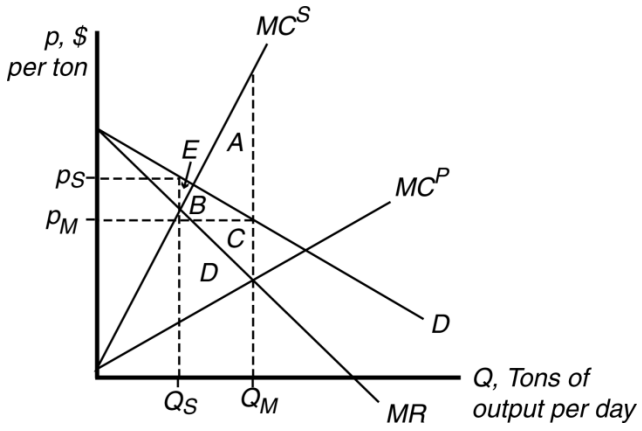
3.8 The fleet operators would recover only half the cost of conversion. Assuming the cost of cleaner fuels is no less than the cost of gasoline, there is no incentive for fleet operators to make the change.

3.9 If a government has sufficient knowledge about pollution damage, the demand curve, costs, and the production technology, it can force a competitive market to produce the social optimum. The government might control pollution directly by restricting the amount of pollution that firms may produce (with an emissions standard) or by taxing them for pollution they create (with an emissions tax). With the emissions fee, the government can achieve the social optimum by taxing output or the amount of pollution produced. With an emissions standard, the government can achieve the social optimum by forcing the optimal quantity of pollution or output.

Unfortunately, the government usually does not know enough to regulate optimally. To set quantity restrictions on output optimally, the government must know how the marginal social cost curve, the demand curve, and pollution vary with output. Whether it is optimal to use fees or standards depends on the government's degree of uncertainty and the shape of the marginal benefit and marginal costs curves for pollution abatement.

3.10 The government uses its expected marginal benefit curve to set a standard at S or a fee at f. If the true marginal benefit curve is MB^1, the optimal standard is S_1 and the optimal fee is f_1. The deadweight loss from setting either the fee or the standard too high is the same, DWL_1. Similarly, if the true marginal benefit curve is MB^2, both the fee and the standard are set too low, but both have the same deadweight loss, DWL_2. Thus the deadweight loss from a mistaken belief about the marginal benefit does not depend on whether the government uses a fee or a standard. When the government sets an emissions fee or standard, the amount of gunk actually produced depends only on the marginal cost of abatement and not on the marginal benefit. Because the standard and fee lead to the same level of abatement at e, they cause the same deadweight loss.

4.1 When the tax is imposed, price increases from p_M to p_S. Although prices are increased, a deadweight loss of area E results. Area $A + B + C + D$ is the reduction in social cost due to the tax, resulting in a net increase in social welfare.



4.2 a. The unregulated monopoly output is the same as the socially optimal output. $Q = 40$, $p = 160$.

b. The monopolist is already producing the socially optimal output level and, thus, does not require regulation.

5.1 According to the Coase Theorem, a polluter and its victim can achieve the optimal levels of pollution if property rights are clearly defined and they can practically bargain. A lack of clearly defined property rights is the root of the externality problem. For Coase bargaining to work, it does not matter who gets the property rights, although who gets the property rights affects how they split the joint profit. However, parties may not be able to bargain successfully when transaction costs are high (the costs of getting the parties together may be high), when the parties engage in strategic bargaining behavior (such as bluffing), and when the parties lack information about the costs or benefits of reducing pollution.

5.2 If there were no market for any of the city's garbage, it would all represent a negative externality at a cost of $125 per ton. Because farmers are willing to take some of the garbage at a reduced rate, the cost of the externality is reduced. The garbage taken by the farmers represents a positive externality, as it helps others in the agriculture market. The fact that they consume the garbage means that it is beneficial for them to do so at current prices (which are negative). If the market was not used, the farmers would have to retrieve the garbage after it had been disposed of at full price—a less efficient solution.

5.3 a. The minimum price that the traveler can offer the family not to travel in first class is \$500 – \$300 = \$200.

b. Any price between \$200 and \$600 is mutually agreeable.

c. At price \$200, both are indifferent.

6.1 Rivalry means that only one person can consume the good: The good is used up in consumption so it is depletable. Exclusion means that others can be prevented from consuming the good. Private goods have the properties of rivalry and exclusion. Open-access common property has rivalry but no exclusion. Public goods have no rivalry, with some having exclusion and some having no exclusion.

Three goods that are not clearly private goods, open-access common property, public goods with exclusion, or public goods without exclusion are a concert in an auditorium, a pool at a country club, and a textbook.

Many goods differ in the degree to which they have rivalry and exclusion. A concert in an auditorium that is not filled has elements of both a private good (exclusion) and a public good (no rivalry). Although the marginal cost of providing the concert to one more person is zero, as long as attendance is less than the seating capacity of the auditorium, adding another person creates congestion or other externalities that harm concertgoers once the concert hall is filled. Similarly, a pool at a country club doesn't inflict extra costs until members start getting in each other's way. Many goods are hybrids, with properties of both private and public goods. A textbook is often viewed as a private good; however, the information in it is a public good.

6.2 Yes. My use of the bridge creates negative externality for others by creating congestion. A toll can internalize the negative externality.

6.3 Pure public goods have two important characteristics. They are nonrival in consumption, as are broadcast and cable television, and they are nonexcludable. While broadcast television is nonexcludable, consumers can be excluded from cable television. Therefore, cable television is a public good and broadcast television is a pure public good. Broadcast television is privately provided (in the United States) to solve the free rider problem. Commercials allow for payment for services given that the services are provided without exclusion.

6.4 Suppose the average value of fishing is a decreasing function of number of fish caught. In order to maximize private value, each boat continues fishing up to the point where marginal value (price in a competitive market) is equal to marginal cost; that is, as long as there is positive net gain, the fishing will continue. However, the socially optimum number of fish caught occurs where marginal value is equal to marginal social cost, which is likely to be higher than marginal private cost, thus we get the overfishing. Any tax on each fish caught that increases marginal cost reduces overfishing. However, the tax on the boat is a fixed cost and does not reduce the amount of fishing by each boat. Taxing each boat could affect the amount of fishing only if it forces some boats to go out of business, thus reducing the amount of fishing.

6.5 The value of crossing the bridge depends on the number of cars on the bridge (in the following, n is the number of cars on the bridge):

$V_A = 4$, if $n \le 60$; 3, if $60 < n \le 120$; 2, if $120 < n \le 180$; 1, if $n > 180$.

$V_B = 3$, if $n \le 60$; 2, if $60 < n \le 120$; 1, if $120 < n \le 180$; 0, if $n > 180$.

$V_C = 2$, if $n \le 60$; 1, if $60 < n \le 120$; 0, if $120 < n \le 180$; -1, if $n > 180$.

$V_D = 1$, if $n \le 60$; 0, if $60 < n \le 120$; -1, if $120 < n \le 180$; -2, if $n > 180$.

a. If the cost of crossing is zero, all groups will cross the bridge. This is because each group does not take into account the negative externality it creates for others.

b. If only cars in Group A pass the bridge, the total utility is 240. If Group B also passes the bridge, the value will be $60 \times 3 + 60 \times 2 = 300$. If Group C also passes the bridge, the total value will be $60 \times 2 + 60 \times 1 + 60 \times 0 = 180$. With the addition of Group D, the total value is $60 \times 1 + 60 \times 0 + 60 \times -1 + 60 \times -2 = -120$. The total utility is maximized when 120 (Groups A and B) pass the bridge.

6.6 The sink and the dishes are both a form of public good for those who live in the house. If there were no one else there who might clean up, each individual would benefit from cleaning up the mess. However, the possibility that the other person might do the dishes makes it seem that an optimal strategy is to simply leave dishes and wait for the other person to do them. Unfortunately, they have the same dominant strategy, and the dishes accumulate. As with Table 17.4 and the example of the security guard, each benefits the most by letting the other bear the cost.

6.7 As noted in the text, textbooks are typically owned by individuals, making them private goods, but the information in the books is public. Although copyright laws create a mechanism for exclusion, they do not cover all forms of communication (e.g., a lecture on the material in the book). Thus the books create a positive externality and are underprovided if priced as pure private goods.

6.8 As stated before, pure public goods have two important characteristics. They are nonrival in consumption, and they are nonexcludable. The vaccination is not nonrival, and it is excludible. Therefore, it is not a public good. However, it has positive externality, and the government should subsidize it or provide it for free.

6.9 Since the marginal benefit is significantly higher than marginal cost, the industry advertising is actually not optimal.

6.10 At the market price of guard service of $10 per hour, the TV store will hire four guards and the ice-cream store will hire none. Now with a $2 per hour subsidy from the mall owner, the private price of the TV store will be $8 per hour. Subsequently, the TV store will hire 5 guards, which makes the social marginal benefit equal to social marginal cost and therefore achieves the socially optimal outcome.

6.11 To find the social demand for the service, add the demand curves vertically (you must solve for p first). Individual inverted demands are $p = (-a_1/b_1) + (1/b_1)q$, and $p = (-a_2/b_2) + (1/b_2)q$. When added, the resulting curve will be nonlinear unless the demand curves have the same horizontal axis intercept. Note that $b_1, b_2 < 0$. For the solution below, assume that $a_1/b_1 < a_2/b_2$.

$$p = (-a_1/b_1 - a_2/b_2) + (1/b_1 + 1/b_2)\, q \quad \text{if} \quad q < a_1$$
$$p = (-a_2/b_2) + (1/b_2)q \quad \text{if} \quad q > a_1$$

6.12 The optimal provision of a public good for two individuals can be calculated as

$$\frac{\dfrac{\partial U_1}{\partial G}}{\dfrac{\partial U_1}{\partial P_1}} + \frac{\dfrac{\partial U_2}{\partial G}}{\dfrac{\partial U_2}{\partial P_2}} = 1.$$

For each consumer,

$$\frac{\partial U_i}{\partial P_i} = 1,$$

So the condition

$$\frac{\dfrac{\partial U_1}{\partial G}}{\dfrac{\partial U_1}{\partial P_1}} + \frac{\dfrac{\partial U_2}{\partial G}}{\dfrac{\partial U_2}{\partial P_2}} = 1$$

can be rewritten as

$$\frac{\partial U_1}{\partial G} + \frac{\partial U_2}{\partial G} = 1.$$

Since $\dfrac{\partial U_1}{\partial G} = \dfrac{\partial U_1(G)}{\partial G}$ and $\dfrac{\partial U_2}{\partial G} = \dfrac{\partial U_2(G)}{\partial G}$,

$$\frac{\partial U_1(G)}{\partial G} + \frac{\partial U_2(G)}{\partial G} = 1.$$

This shows the optimal provision of the public good is unique and independent of P_1 and P_2.

6.13 In Nash equilibrium, each person maximizes her utility taking the number of hours the other works as given. Taking the partial derivative of U_A with respect to t_A and putting it equal to zero we get $24t_A + t_B = 552$. Taking the partial derivative of U_B with respect to t_B and putting it equal to zero we get $24t_B + t_A = 552$. Solving these two equations we get $t_A = t_B = 22.08$.

To find the number of hours that maximizes the sum of utilities, we take the partial derivative of the sum, once with respect to t_A and once with respect to t_B, and put them equal to zero. We get the two equations, $47t_A + t_B = 1{,}104$ and $t_A + 47t_B = 1{,}104$. Solving these two equations we get $t_A = t_B = 23$. Therefore Anna and Bess, while maximizing their utilities, would ride free.

7.1 There are several ways to demonstrate that welfare can go up despite the pollution. For example, one could redraw panel (b) with flatter supply curves so that Area *C* became smaller than *A* (Area *A* remains unchanged). Similarly, if the marginal pollution harm is very small, then we are very close to the no-distortion case, so that welfare will increase.

7.2 Going from no trade to free trade, consumers gain areas *B* and *C,* while domestic firms lose *B.* Thus, if consumers give firms an amount between *B* and *B* + *C,* both groups will be better off than with no trade.