EC 111: Principles of Microeconomics

Lecture Notes, Chapters 10–11: Externalities; Public Goods and Common Resources

Onur Altındağ
Bentley University

Fall 2026

10 Externalities

Chapter 7 showed that a competitive market maximizes total surplus: it makes every unit whose value to buyers is above its cost to sellers, and no others. That result has fine print. It assumes that the only people affected by a trade are the buyer and the seller. Often they are not. A factory's smoke reaches the neighbors; a flu shot protects the people around the person who gets it. When a trade affects people outside the market, the market quantity is no longer the best one. This chapter shows why, by how much, and what can be done about it. Chapter 11, in the second half of these notes, applies the same idea to goods that nobody can be made to pay for.

10.1 What an externality is

Definition 10.1 (Externality)**.** An **externality** is the uncompensated impact of one person's actions on the well-being of a bystander.

- A **negative externality** harms the bystander: factory smoke, drunk driving, a barking dog, a phone ringing in class.
- A **positive externality** helps the bystander: a vaccine, a restored historic building, research that other firms can copy, a neighbor's flower garden.

The key word is *uncompensated*. The factory does not pay the neighbors for the smoke, so it does not count the smoke as a cost when it decides how much to produce. The person who gets a flu shot is not paid by the people she protects, so she does not count their benefit when she decides whether to get it. Buyers and sellers look only at their own costs and benefits. As a result:

Key point

With a negative externality, the market produces **more** than the socially best quantity. With a positive externality, it produces **less**.

10.2 Negative externalities

10.2.1 The running market, now with pollution

We keep the market from Chapters 6, 7 and 9:

$$Q_d = 400 - P, \qquad Q_s = 3P.$$

The market clears at $P = \$100$ and $Q = 300$. Now suppose each unit produced releases smoke that does \$40 of damage to the people who live near the factory.

The supply curve measures the sellers' cost of each unit, the **private cost**. Society pays that cost plus the \$40 of damage. So the **social cost** of each unit is the private cost plus \$40: the social-cost curve is the supply curve shifted up by \$40 (Figure 1, left). Written as prices, the supply curve is $P = Q/3$ and the social-cost curve is $P = Q/3 + 40$.

Definition 10.2 (Social cost)**.** The **social cost** of a unit is the private cost to the producer plus the external cost to bystanders.

The best quantity for society, the **optimum**, makes every unit whose value to buyers is above its social cost. It is where the demand curve meets the social-cost curve:

$$400 - Q = \frac{Q}{3} + 40 \quad \Rightarrow \quad \frac{4Q}{3} = 360 \quad \Rightarrow \quad Q = 270.$$

At 270 units the last unit is worth $400 - 270 = \$130$ to buyers and costs society $90 + 40 = \$130$. The market makes 300 units, 30 too many.

10.2.2 The deadweight loss of the market outcome

Look at units 271 to 300. Buyers value them at \$130 down to \$100. Their social cost runs from \$130 up to \$140. Every one of them costs society more than it is worth. The total loss is the triangle between the social-cost curve and the demand curve, from 270 to 300 (Figure 1, left):

$$\text{DWL} = \tfrac{1}{2} \times 30 \times 40 = \$600.$$

Common mistake

The deadweight loss is not the whole \$40 times 300 units of damage. Some pollution is worth it: the first 270 units are worth more to buyers than they cost society, smoke included. The loss is only the damage from units that should not

have been made.

10.2.3 The fix: a corrective tax

The problem is that sellers do not feel the \$40. The fix is to make them feel it: a tax of \$40 per unit, the size of the external cost. This is called **internalizing** the externality.

Definition 10.3 (Internalizing an externality)**. Internalizing an externality** means changing incentives so that people take account of the external effects of their actions.

Definition 10.4 (Corrective tax)**.** A **corrective tax** (or **Pigovian tax**, after the economist Arthur Pigou) is a tax designed to make private decision makers take account of the social costs of a negative externality.

This is the \$40 tax we analyzed in Chapter 7. Buyers pay \$130, sellers keep \$90, and 270 units are sold: exactly the optimum. Tax revenue is $40 \times 270 = \$10{,}800$. Now count everyone, including the neighbors:

	No tax	\$40 tax
Consumer surplus	45,000	36,450
Producer surplus	15,000	12,150
Tax revenue	0	10,800
Smoke damage	$-12{,}000$	$-10{,}800$
Total surplus	48,000	48,600

Here CS $= \frac{1}{2} \times 270 \times (400 - 130)$, PS $= \frac{1}{2} \times 270 \times 90$, and the damage is \$40 times the units made.

Key point

In Chapter 7 the \$40 tax *cost* society \$600 of deadweight loss. With a \$40 external cost, the same tax *raises* total surplus by \$600. A tax that matches the external cost moves the market to the optimum and removes the deadweight loss instead of creating one.

10.3 Positive externalities

Now use the same curves for flu shots. A flu shot protects the person who gets it, and that private benefit is the demand curve. It also protects everyone she would otherwise infect, and suppose that benefit is worth \$40 per shot. The **social value** of a shot is the private value plus \$40: the demand curve shifted up by \$40, $P = 440 - Q$ (Figure 1, right).

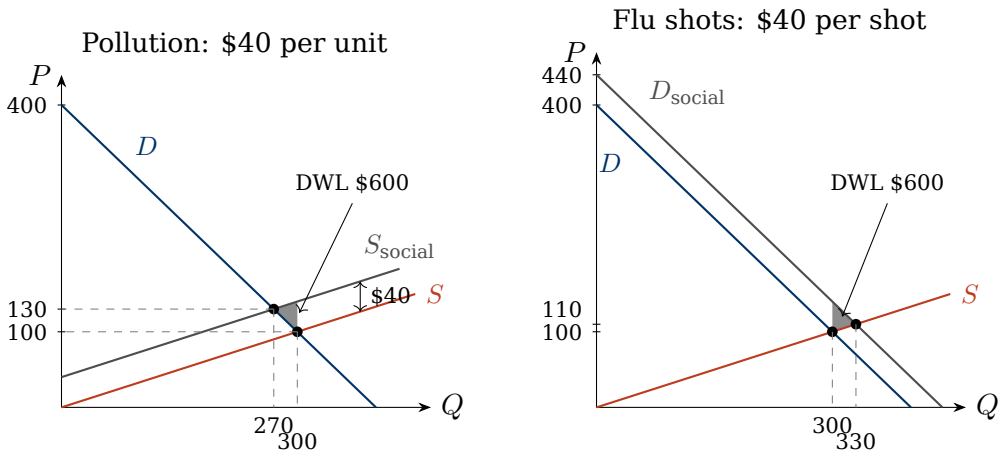


Figure 1: The running market $Q_d = 400 - P$, $Q_s = 3P$ with an externality of \$40 a unit. Left: a negative externality. The social-cost curve S_{social} lies \$40 above supply S, the private cost; the market makes 300, the optimum is 270, and the grey triangle is the \$600 deadweight loss. Right: a positive externality. The social-value curve D_{social} lies \$40 above demand D, the private value; the market makes 300, the optimum is 330, and the grey triangle is again \$600.

The optimum is where social value meets the supply curve:

$$440 - Q = \frac{Q}{3} \quad \Rightarrow \quad Q = 330.$$

The market makes 300 shots, 30 too few. Shots 301 to 330 are worth more to society than they cost to make, but the people who would get them do not count the protection they give others. The deadweight loss is again $\frac{1}{2} \times 30 \times 40 = \$600$.

The fix is the mirror image of the tax: a **corrective subsidy** of \$40 per shot. With a \$40 subsidy, buyers pay \$70, sellers receive \$110, and 330 shots are given ($400 - 70 = 330$ and $3 \times 110 = 330$).

Key point

Negative externality: social cost > private cost, the market makes too much, and a corrective tax fixes it. Positive externality: social value > private value, the market makes too little, and a corrective subsidy fixes it. In both cases the optimum is where social value meets social cost.

10.3.1 Spillovers from ideas and education

An important positive externality is the **technology spillover**: when one firm's research produces an idea, such as a better robot design, other firms can copy it. The inventing firm captures only part of the gain, so the market does too little research. Governments respond in three ways.

- **Industrial policy**: subsidize the industries thought to have the largest spillovers.

The difficulty is that spillovers are hard to measure, and every industry claims to have them.

- **Patents**: a property right to an invention for 20 years. The inventor keeps more of the gain, so firms do more research.
- **Subsidies for education**: an educated population makes better-informed voters, less crime and more new ideas. Public schools, state universities and Pell grants all subsidize education.

In class

Negative or positive externality? Does the market make too much or too little? (a) A loud motorcycle exhaust. (b) Planting a tree in your front yard. (c) Alcohol, given drunk driving. (d) A new open-source software library. (e) Antibiotics, given drug-resistant bacteria.

Answers. (a) Negative, too much. (b) Positive, too little. (c) Negative, too much. (d) Positive, too little. (e) Negative, too much: each use helps the patient but raises resistance for everyone else.

10.4 Public policies toward externalities

10.4.1 Command-and-control policies

Definition 10.5 (Command-and-control policy)**.** A **command-and-control policy** regulates behavior directly: it requires or forbids certain actions.

Examples are the Environmental Protection Agency's emission limits, rules that require a plant to install scrubbers, and the ban on dumping toxic waste. Regulation works well when the right answer is clear, such as zero for some toxic chemicals. Its weakness is that the regulator must know the details: which plants can cut pollution cheaply, and by how much. And a firm that meets the limit has no reason to cut any further.

10.4.2 Market-based policy 1: corrective taxes and subsidies

A corrective tax leaves the choice to the firm. A firm that can cut pollution cheaply cuts a lot to avoid the tax; a firm for which cutting is expensive cuts less and pays. The same reduction in pollution is reached at a lower total cost than under a uniform rule. And unlike most taxes, a corrective tax raises revenue while *removing* a deadweight loss rather than creating one.

Examples:

- **Gasoline.** Driving causes congestion, accidents and pollution. In the United States the gas tax is about 51 cents a gallon: 18.4 cents federal and about 33 cents state on average (EIA, 2025). It is much higher in Europe.

- **Alcohol and tobacco**: drunk driving and secondhand smoke.
- **A carbon tax**: a price on carbon dioxide emissions, paid in everything that uses fossil fuels. In surveys of leading economists by the IGM Forum, 98% agreed that a carbon tax is a less distorting way to raise revenue than an income tax of the same size, and 95% that it would cut emissions more cheaply than fuel-economy rules for cars. Few such taxes have passed: the cost is visible to every voter, while the benefit is spread across the world and over decades.

10.4.3 Market-based policy 2: tradable pollution permits

Three firms emit 90 tons of a pollutant. The government wants only 60 tons, so it gives each firm 20 permits, each allowing one ton. Each firm can cut pollution at a constant cost per ton:

	Firm A	Firm B	Firm C
Emissions today (tons)	30	40	20
Cost of cutting one ton	\$25	\$40	\$10

No trading. Each firm must get down to 20 tons. A cuts 10 tons (\$250), B cuts 20 tons (\$800), C cuts nothing. Total cost: **\$1,050**.

Trading allowed. C can cut a ton for \$10, while B would pay \$40. So C cuts all 20 of its tons (\$200) and sells its 20 permits to B, which then cuts nothing. A still cuts its 10 tons (\$250). Total cost: **\$450**. The permit price ends up between \$10 and \$25: high enough for C to sell, and low enough that A would rather cut its own 10 tons than sell permits.

Emissions are 60 tons either way, but trading saves \$600. The firms that can cut cheaply do the cutting, and both sides of each trade gain.

Key point

A corrective tax and tradable permits both make polluters pay to pollute, and both get a given reduction at the lowest cost. The tax sets the *price* of pollution and lets the market pick the quantity. Permits set the *quantity* and let the market pick the price.

The U.S. program of tradable permits for sulfur dioxide in the 1990s cut acid rain at far lower cost than expected. The European Union has run a carbon permit market since 2005.

Note

The efficient amount of pollution is not zero. Cutting pollution uses resources, and at some point the next ton cut costs more than the harm it does. The goal is to cut pollution until the cost of the last ton cut equals the harm it does.

10.5 Private solutions to externalities

Government action is not the only way to deal with an externality. People solve many externalities themselves:

- **Moral codes and social norms**: most people do not litter, even when no one is watching.
- **Charities**: the Sierra Club protects the environment; alumni donations fund scholarships, which have a positive externality.
- **Merging**: a beekeeper's bees pollinate the nearby apple orchard, and the orchard feeds the bees. If one firm runs both, it counts both benefits.
- **Contracts**: the orchard can pay the beekeeper to keep more bees.

10.5.1 The Coase theorem

Definition 10.6 (Coase theorem)**.** The **Coase theorem** says that if private parties can bargain without cost over the allocation of resources, they can solve the problem of externalities on their own.

Example. Emily's dog barks. Owning the dog is worth $600 to her. The barking costs her neighbor Horace $900.

- **Emily has the right to keep the dog.** Horace can offer her any amount between $600 and $900 to give it up. Both are better off, so the dog goes.
- **Horace has the right to quiet.** Emily would have to pay Horace at least $900 to keep the dog, but it is worth only $600 to her. The dog goes.

Now suppose the barking costs Horace only $400. If Emily has the right, Horace will pay at most $400, less than the $600 she needs: the dog stays. If Horace has the right, Emily pays him something between $400 and $600 to keep it: the dog stays.

Key point

When bargaining is free, the efficient outcome happens whoever holds the legal right. The right decides only who pays whom.

10.5.2 Why private solutions often fail

Definition 10.7 (Transaction costs)**. Transaction costs** are the costs that parties incur in the process of agreeing to and following through on a bargain.

Bargaining is rarely free. Lawyers and time cost money. Each side may hold out for a better deal, and the bargain falls apart. Most important, when many people are affected, bargaining becomes impossible: one factory and 10,000 neighbors cannot all sit at one table, and each neighbor hopes the others will pay. Climate change affects billions of people, many not yet born; no private bargain can cover them. The Coase theorem works in small, clear cases. Large, diffuse cases need the government.

10.6 An exam-style problem

In class

$Q_d = 90 - P$, $Q_s = 2P$. Each unit causes \$15 of pollution damage to neighbors.

(a) Find the market price and quantity.
(b) Find the socially optimal quantity.
(c) Find the deadweight loss of the market outcome.
(d) Find the tax that reaches the optimum, the price buyers pay, the price sellers keep, and the tax revenue.

Answers. (a) $90 - P = 2P$: $P = \$30$, $Q = 60$. (b) The supply curve is $P = Q/2$, so social cost is $P = Q/2 + 15$. Setting $90 - Q = Q/2 + 15$ gives $Q = 50$. (c) At $Q = 60$ the last unit is worth \$30 to buyers and costs society $30 + 15 = \$45$. DWL $= \frac{1}{2} \times (60 - 50) \times 15 = \$75$. (d) A \$15 tax. Buyers pay $90 - 50 = \$40$; sellers keep \$25 (check: $2 \times 25 = 50$); revenue is $15 \times 50 = \$750$.

10.7 Summary

- An externality is the uncompensated effect of one person's action on a bystander. With a negative externality the market makes too much; with a positive one, too little.
- The optimum is where social value meets social cost. The deadweight loss of the market outcome is the triangle between the two, from the market quantity to the optimum.
- A corrective tax (or subsidy) equal to the external cost (or benefit) internalizes the externality, moves the market to the optimum and removes the deadweight loss.
- Command-and-control rules require or forbid actions. Market-based policies, corrective taxes and tradable permits, reach the same reduction at a lower cost, because the firms that can cut cheaply do the cutting. A tax sets the price of pollution; permits set the quantity.
- The Coase theorem: if bargaining is free, private parties reach the efficient outcome whoever holds the right. Transaction costs, holdouts and many parties often prevent it.

Exercises

Exercise 10.1. The market for a chemical is $Q_d = 150 - P$, $Q_s = 2P$. Making each unit causes \$30 of pollution damage.

(a) Find the market price and quantity, and the socially optimal quantity.
(b) Find the deadweight loss of the market outcome.
(c) What tax reaches the optimum? Find the price buyers pay, the price sellers keep and the tax revenue.

(d) Find consumer surplus, producer surplus, tax revenue and pollution damage with and without the tax. Check that total surplus rises by the deadweight loss you found in (b).

Exercise 10.2. Use the same curves, $Q_d = 150 - P$, $Q_s = 2P$, for home insulation. Each unit installed saves neighbors and the power grid \$15, a benefit the homeowner does not count.

(a) Is the externality positive or negative? Does the market install too much or too little?
(b) Find the socially optimal quantity and the deadweight loss of the market outcome.
(c) What policy reaches the optimum? Find the price homeowners pay, the price installers receive, and the cost to the government.

Exercise 10.3. Two plants each emit 50 tons of a pollutant. Plant X can cut emissions at \$20 a ton; plant Y at \$50 a ton. The government wants total emissions of 60 tons.

(a) The government orders each plant to cut 20 tons. What is the total cost?
(b) Instead it gives each plant 30 permits and allows trading. Who cuts, who buys permits, and what is the total cost?
(c) Between what prices will a permit sell? If it sells for \$35, how much does each plant gain from trading?

Exercise 10.4. A chicken farm's smell costs the family next door \$3,000 a year. The farm could install filters that remove the smell for \$2,000 a year.

(a) The farm has the right to smell. What happens, and who pays?
(b) The family has the right to clean air. What happens, and who pays?
(c) Instead the smell costs each of 200 nearby families \$15 a year. Is a private bargain still likely? Why or why not?

Answers to exercises

Exercise 10.1. (a) $150 - P = 2P$: $P = \$50$, $Q = 100$. Supply is $P = Q/2$, so social cost is $P = Q/2 + 30$; $150 - Q = Q/2 + 30$ gives $Q = 80$. (b) DWL $= \frac{1}{2} \times (100 - 80) \times 30 = \$300$. (c) A \$30 tax per unit. Buyers pay $150 - 80 = \$70$, sellers keep \$40 ($2 \times 40 = 80$), revenue $= 30 \times 80 = \$2{,}400$. (d) No tax: CS $= \frac{1}{2} \times 100 \times 100 = 5{,}000$, PS $= \frac{1}{2} \times 100 \times 50 = 2{,}500$, damage $= 30 \times 100 = 3{,}000$, TS $= 4{,}500$. Tax: CS $= \frac{1}{2} \times 80 \times 80 = 3{,}200$, PS $= \frac{1}{2} \times 80 \times 40 = 1{,}600$, revenue $2{,}400$, damage $30 \times 80 = 2{,}400$, TS $= 4{,}800$. Total surplus rises by \$300.

Exercise 10.2. (a) Positive; the market installs too little. (b) Social value is $P = 165 - Q$; $165 - Q = Q/2$ gives $Q = 110$, against 100 in the market. DWL $= \frac{1}{2} \times 10 \times 15 = \$75$. (c) A \$15 subsidy per unit. Homeowners pay $150 - 110 = \$40$, installers receive \$55 ($2 \times 55 = 110$), and the subsidy costs $15 \times 110 = \$1{,}650$.

Exercise 10.3. (a) X: $20 \times 20 = \$400$; Y: $20 \times 50 = \$1{,}000$; total \$1,400. (b) X cuts 40 tons, emits 10, and sells its 20 spare permits to Y; Y cuts nothing and emits 50 with 50 permits. Total emissions 60; total cost $40 \times 20 = \$800$, \$600 less. (c) Between \$20

(X will not sell for less than its cost of cutting a ton) and \$50 (Y will not pay more than its own cost of cutting). At \$35, X receives $20 \times 35 = \$700$ for 20 extra tons that cost it \$400: it gains \$300. Y pays \$700 instead of spending \$1,000 to cut 20 tons: it gains \$300. The two gains add up to the \$600 saved.

Exercise 10.4. (a) The family pays the farm between \$2,000 and \$3,000 to install the filters, and the filters go in. (b) The farm would have to pay the family at least \$3,000 to keep smelling; filters cost only \$2,000, so it installs them at its own cost. The filters go in either way; only who pays changes. (c) Unlikely. The 200 families must agree among themselves on how much each contributes, and each hopes the others will pay (a free-rider problem). These transaction costs can block a bargain worth \$3,000 to them in total; a rule or a tax may be needed.

11 Public Goods and Common Resources

Some goods are enjoyed by people who never pay for them: a fireworks display, national defense, a clean lake. Markets work by charging a price, so when nobody can be charged, the market fails. This chapter sorts goods by two properties and shows which kinds the market handles badly.

11.1 The different kinds of goods

Definition 11.1 (Excludability and rivalry)**.** A good is **excludable** if people can be prevented from using it. A good is **rival in consumption** if one person's use reduces what is left for others.

The two properties give four kinds of goods:

	Rival	**Not rival**
Excludable	**Private goods** ice cream, clothes a congested toll road	**Club goods** Netflix, fire protection an uncongested toll road
Not excludable	**Common resources** ocean fish, clean air a congested free road	**Public goods** national defense, fireworks an uncongested free road

- **Private goods** are excludable and rival. The supply-and-demand model of earlier chapters is about these, and markets handle them well.
- **Public goods** are neither excludable nor rival.
- **Common resources** are rival but not excludable.
- **Club goods** are excludable but not rival. A firm that sells a club good often has market power (Chapter 16).

The same good can move between boxes. A road is a public good when it is empty and a common resource at rush hour; add a toll and it becomes a club good or a private good.

Key point

The bottom row of the table has no price: people cannot be made to pay. That is an externality problem. The market makes too little of a public good and uses up too much of a common resource.

11.2 Public goods

11.2.1 The free-rider problem

A town of 400 people could put on a Fourth of July fireworks show. It costs $2,000, and each resident values it at $15. The total value is $400 \times 15 = \$6{,}000$, more than the $2,000 cost, so the show should happen.

Could a private firm put it on? It would have to sell tickets, but everyone in town can see the fireworks whether or not they paid. Few people buy a ticket, so the firm cannot cover its cost and the show does not happen.

Definition 11.2 (Free rider)**.** A **free rider** is a person who receives the benefit of a good but avoids paying for it.

The town government can fix this: a $5 tax on each resident raises the $2,000, and every resident is $15 - 5 = \$10$ better off. The free-rider problem is a positive externality: when I pay for fireworks, my neighbors benefit too, and I do not count their benefit.

Not everything the government provides is a public good. A school is excludable and rival: it can turn students away, and a crowded classroom leaves less attention for each student. Governments provide schools for other reasons, such as the positive externality of education.

11.2.2 Some important public goods

- **National defense.** No one can be excluded from it, and protecting one more person does not reduce anyone else's protection. The United States spends about 3% of GDP on it.
- **Basic research.** General knowledge, such as a mathematical theorem or a fact about cell biology, can be used by anyone. Governments fund it through the National Institutes of Health and the National Science Foundation. Applied research, which leads to a specific product, is protected by patents instead.
- **Fighting poverty.** Many people would like to live in a society with less poverty. Private charity has a free-rider problem: each donor's gift benefits everyone who cares about poverty. Government programs fund the fight through taxes.

11.2.3 Are lighthouses public goods?

A lighthouse is the textbook public good: a ship cannot be stopped from seeing the light, and one ship's use does not dim it for others. Lighthouses are usually run by governments. In 19th-century England, though, some lighthouses were private. The owner charged the nearby port, not the ships, and if the port did not pay, the owner turned the light off. That made the light excludable. Whether a good is public depends on the circumstances, and above all on whether people can be excluded.

11.2.4 Cost–benefit analysis

Definition 11.3 (Cost–benefit analysis)**.** A **cost–benefit analysis** is a study that compares the costs and benefits to society of providing a public good.

Deciding how much of a public good to provide is hard because there is no price to show what people value. Surveys are one approach, but people overstate how much they want something they will not have to pay for directly.

Many public projects save lives, so cost–benefit analysis needs a value for a human life. Economists estimate it from the extra wages people demand for risky jobs. The answer is about **$10 million** per statistical life: if workers accept a 1-in-10,000 risk of death for $1,000 more a year, the implied value is $\$1{,}000 \times 10{,}000 = \$10$ million.

Example. A stoplight costs $40,000 over its life. It lowers the chance of a fatal accident at the corner by half a percentage point. The expected benefit is $0.005 \times \$10$ million $= \$50{,}000$, more than the cost, so the town should build it. The same reasoning applies to airbags, food inspection and highway guardrails.

11.3 Common resources

11.3.1 The tragedy of the commons

In a medieval town every family can graze its sheep on the town green for free. Each extra sheep is a gain to its owner, but it eats grass that the other families' sheep would have eaten. No family counts that cost, so they graze too many sheep, and in the end the grass is gone and the town loses its sheep.

Definition 11.4 (Tragedy of the commons)**.** The **tragedy of the commons** is a parable that shows why common resources are used more than is desirable from the standpoint of society as a whole.

This is a negative externality again: each user ignores the cost his use imposes on the others. The fixes are the ones from Chapter 10: limit the number of sheep per family, tax each sheep, auction a limited number of grazing permits, or divide the land among the families and make it private property.

Common resources today include ocean fish, groundwater, clean air and congested roads.

11.3.2 Why the cow is not extinct

Bison numbered in the tens of millions in 1800; by 1890 fewer than 1,000 were left. Elephants have been hunted for their ivory, and their numbers fell sharply. Cows, which are also valuable, have never been in danger. The difference is ownership: each cow has an owner who gains from keeping the herd healthy and growing. Wild bison and elephants belonged to no one, so each hunter took as many as he could. Some African countries, including Namibia and Zimbabwe, now let villages earn money from the elephants on their land, through tourism and hunting licenses, and the villages now have a reason to protect them.

11.3.3 Congested roads

A free road at rush hour is a common resource: each car slows every other car, and no driver counts that cost. **Congestion pricing** charges a toll that is highest when the road is most crowded. Singapore, London (2003) and Stockholm (2006) use it, and in an IGM survey 98% of leading economists agreed that more congestion charges, with other taxes cut, would leave people better off.

New York started congestion pricing on January 5, 2025: a car entering Manhattan below 60th Street at peak hours pays $9. In the first year, according to the MTA, about 73,000 fewer vehicles a day entered the zone (11% fewer), peak crossing times fell, and the charge raised about $550 million for public transit. Drivers who still drive pay more but move faster; drivers who switch to transit lose the option they preferred at a zero price; transit riders gain from the revenue.

11.4 Summary

- Goods differ in whether they are excludable and whether they are rival: private goods, club goods, public goods, common resources.
- Public goods are neither excludable nor rival. Free riders make the market provide too little; governments provide them and use cost–benefit analysis to decide how much.
- Common resources are rival but not excludable. Each user ignores the cost to others, so they are used too much: the tragedy of the commons.
- The fixes are regulation, a price (a tax, permits, congestion pricing) or property rights.

Exercises

Exercise 11.1. For each good, is it excludable? Rival? Which of the four kinds is it? (a) A city park on a quiet weekday. (b) Fish in a public lake. (c) A pay-per-view boxing stream. (d) A tornado siren. (e) A hamburger. (f) A crowded ski slope that sells lift tickets. (g) Wikipedia.

Exercise 11.2. A town of 1,000 people considers a mosquito-spraying program that costs $20,000. Six hundred residents value it at $30 each; the other 400 value it at $10 each.

(a) Should the program be carried out? Why would a private firm fail to provide it?
(b) The town pays for it with an equal tax on every resident. How large is the tax? Who gains and who loses, and by how much in total?

Exercise 11.3. A guardrail on a mountain road costs $300,000 over its life. Engineers estimate it lowers the chance of a fatal accident on the road by 2 percentage points over that time. Use a value of $10 million per statistical life.

(a) Should the state build it?
(b) The guardrail would also prevent injuries worth $150,000. Does the answer change?

Answers to exercises

Exercise 11.1. (a) Not excludable, not rival: a public good (it becomes a common resource when crowded). (b) Not excludable, rival: a common resource. (c) Excludable, not rival: a club good. (d) Not excludable, not rival: a public good. (e) Excludable, rival: a private good. (f) Excludable, rival (crowding): a private good. (g) Not excludable, not rival: a public good. It is provided by donations, and like other charities it faces free riders: most readers never give.

Exercise 11.2. (a) Yes: the total value is $600 \times 30 + 400 \times 10 = \$22{,}000 > \$20{,}000$. A firm cannot spray only the yards of people who paid, so residents free ride and too few pay. (b) A tax of $20 each. The 600 high-value residents gain $30 - 20 = \$10$ each ($6,000); the 400 others lose $20 - 10 = \$10$ each ($4,000). The town gains $2,000 in total, but not everyone is better off.

Exercise 11.3. (a) Expected benefit $= 0.02 \times \$10$ million $= \$200{,}000 < \$300{,}000$: do not build. (b) The benefit becomes $200{,}000 + 150{,}000 = \$350{,}000 > \$300{,}000$: build it.