Course Companion

AP Microeconomics

Every topic handout in one volume

全部专题讲义合集

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Basic Economic Concepts

AP Microeconomics

Scarcity



An outdoor market: markets allocate scarce resources among competing uses

You have one free evening before two exams. An extra hour on maths might raise your maths score a lot; the same hour on history might raise your history score a little. Spending the hour on one subject means not spending it on the other. Every person, firm and government faces this kind of choice all the time, and microeconomics is the study of how they make it.

Economics 经济学 begins with one stubborn fact: people's wants are effectively unlimited, but the **resources** 资源 to satisfy them are limited. This gap is **scarcity** 稀缺性, and it is why economics exists – if everything were free and endless, there would be nothing to decide.

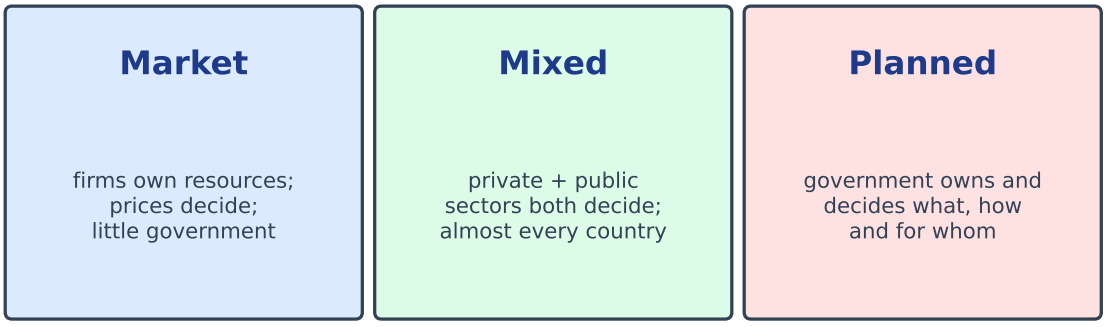
The resources (the **factors of production** 生产要素) are **land** (natural resources), **labor** 劳动 (human effort), **capital** 资本 (tools, machines, buildings), and **entrepreneurship** 企业家才能 (organizing the other three and taking risks). Because these are scarce, every economy must answer three questions: **what** to produce, **how** to produce it, and **for whom** to produce.

Scarcity forces **choice**, and every choice has an **opportunity cost** 机会成本 – the value of the next-best alternative you give up. This single idea runs through the whole course: the true cost of anything is what you sacrifice to get it, not just the money you pay.

Example. At constant rates, one worker can pack 30 boxes or deliver 12 orders per hour. One delivery's opportunity cost is $30/12 = 2.5$ boxes.

Resource Allocation and Economic Systems

An **economic system** 经济体制 is a society's way of answering the three questions.



Economic systems form a spectrum from a free market to full government planning

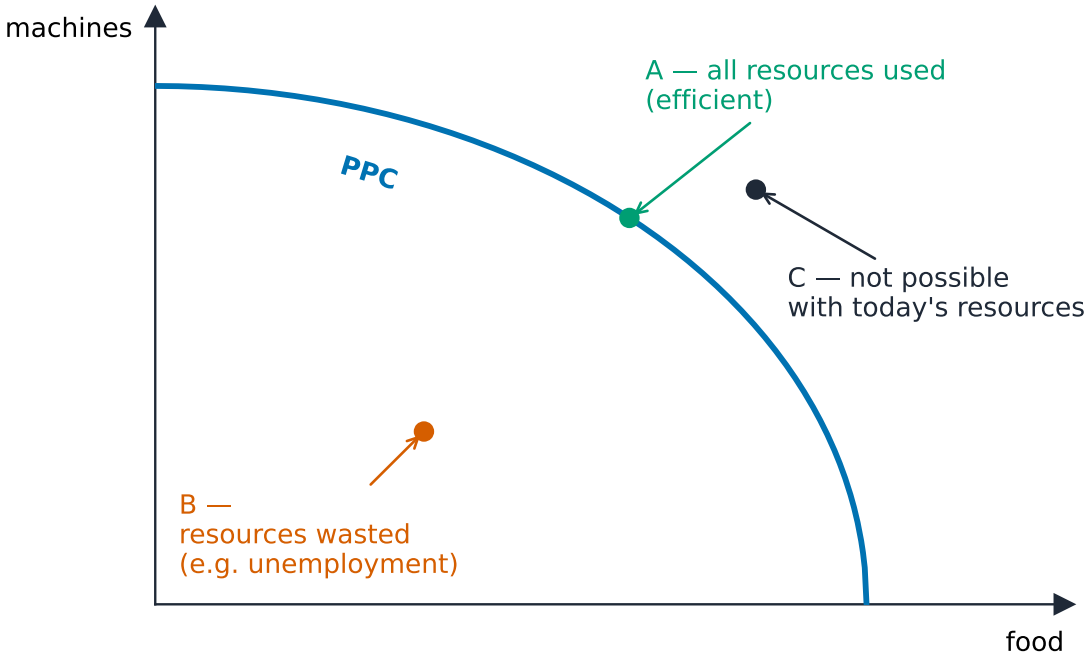
- In a **market economy** 市场经济, private buyers and sellers decide through prices; self-interest and competition coordinate them (the "invisible hand").
- In a **command economy** 计划经济, the government owns resources and plans production.
- Real economies are **mixed** 混合经济 – mostly markets, with government providing some goods and correcting problems.

For example, private canteens choosing menus and families buying at stated prices use a market mechanism. A public agency assigning menus and meals uses a command mechanism. Private sales plus publicly funded meals combine both. These examples illustrate allocation mechanisms, not a whole country's classification.

Prices carry information and **incentives** 激励. If demand for bread rises, a higher price can encourage a bakery to expand output, holding costs constant. This is not a guarantee of social efficiency: pollution or market power can weaken the outcome.

The Production Possibilities Curve

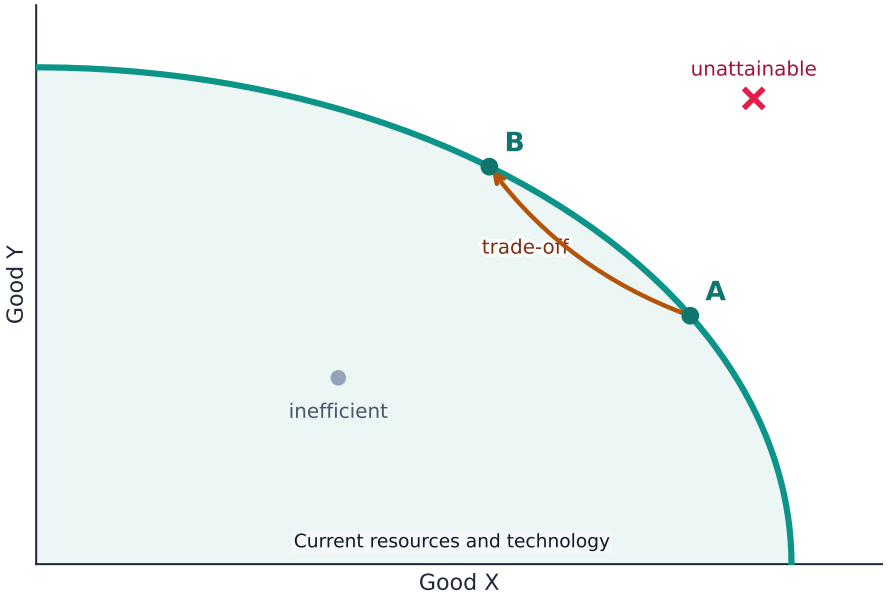
The **production possibilities curve (PPC)** 生产可能性曲线 shows the maximum combinations of two goods an economy can produce with its resources and technology fully and efficiently used.



Points on, inside, and outside the production possibilities curve

- Points **on** the curve are productively **efficient** 有效率; points **inside** are inefficient (wasted or unemployed resources); points **outside** are currently **unattainable** 无法实现.
- The PPC's downward slope shows **opportunity cost**: making more of one good means making less of the other. The **magnitude of the slope** gives the opportunity cost of the horizontal-axis good in units of the vertical-axis good. A negative slope does not mean a negative opportunity cost.
- A **bowed-out** (concave) PPC shows **increasing opportunity cost** – resources are not equally suited to both goods, so making more of one costs ever more of the other. A **straight-line** PPC means constant opportunity cost; a curve bowed toward the origin represents decreasing opportunity cost.
- **Economic growth** 经济增长 (more resources, better technology) shifts the frontier **outward**. A productivity gain in only one industry can pivot the frontier rather than expand both intercepts. Moving from inside to the existing frontier uses idle resources; it does not itself increase capacity.

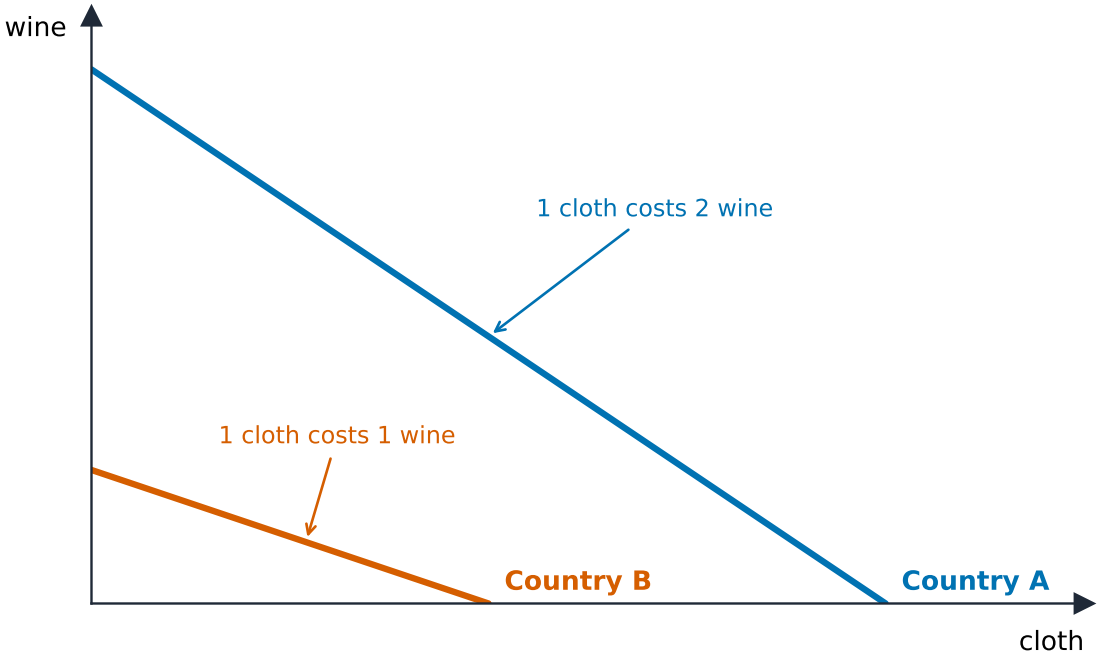
Worked example. Efficient combinations are A (100 wheat, 0 steel), B (80 wheat, 30 steel), and C (50 wheat, 50 steel). From A to B, steel's opportunity cost is wheat forgone divided by steel gained: $20/30 = 0.67$ wheat per steel. From B to C it rises to $30/20 = 1.5$. Resources differ in suitability. Being on the PPC shows productive efficiency, not which mix society prefers.



A production possibilities curve: efficient, inefficient, and unattainable points

Comparative Advantage and Gains from Trade

Two producers can both gain from trade by **specializing** 专业化.



Comparative advantage comes from differently-sloped production possibilities curves

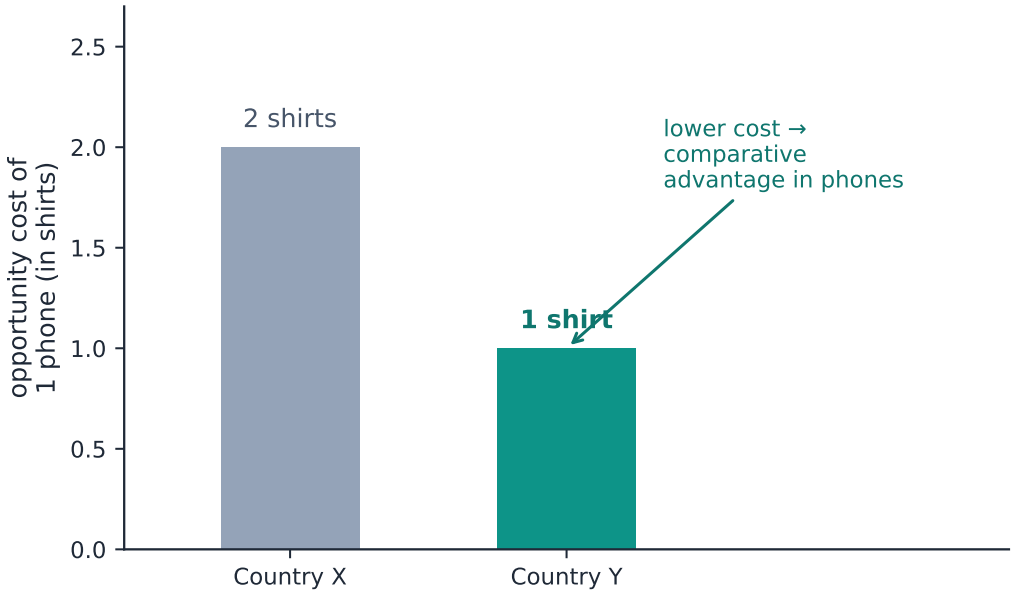
- A producer has an **absolute advantage** 绝对优势 in a good if it can make more of it with the same resources.
- A producer has a **comparative advantage** 比较优势 if it has the **lower opportunity cost** for that good. Comparative advantage – not absolute – determines who should specialize.
- Compute opportunity cost from output data: for each producer, one unit of good X costs (units of Y) ÷ (units of X). The producer who gives up less Y should make X.
- Both sides gain if they trade at a rate **between** their two opportunity costs – the **terms of trade** 贸易条件. With different opportunity costs and suitable terms of trade, specialization can expand consumption possibilities beyond each producer's own PPC. It does not shift that production frontier.

Output-table example. In one day X makes 10 phones **or** 20 shirts; Y makes 4 phones **or** 4 shirts. Assume constant opportunity costs. For a phone, X gives up $20/10 = 2$ shirts; Y gives up $4/4 = 1$ shirt. Y has comparative advantage in phones, X in shirts, even though X has absolute advantage in both. Trade one phone for 1.5 shirts: X saves 0.5 shirt compared with making the phone, and Y receives 0.5 shirt more than its cost. At an endpoint one producer is indifferent; equal costs leave no strictly beneficial interval in this model.

Input-table example. A needs 2 hours per phone and 1 hour per shirt; B needs 3 hours per phone and 6 hours per shirt. A phone's opportunity cost is hours per phone divided by hours per shirt: A gives up $2/1 = 2$ shirts, B only $3/6 = 0.5$. B has comparative advantage in phones although A needs fewer hours for both goods. Do not treat hours as output quantities.

Exam connection (AP 2023 Set 1, Q2a–c). Northland can make 100 bushels of wheat or 300 yards of cloth; Southland 100 or 50. One wheat costs 3 cloth in Northland and 0.5 in Southland. Trading 10 wheat for 20 cloth lies strictly between their costs of 5 and 30 cloth. If Southland's wheat maximum falls to 75 while cloth stays 50, its cloth cost becomes $75/50 = 1.5$ wheat. Northland's is still $100/300 = 1/3$, so Southland does not gain comparative advantage in cloth.

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Comparative advantage goes to the producer with the lower opportunity cost



Container shipping: comparative advantage and trade let countries specialise and gain

Cost-Benefit Analysis

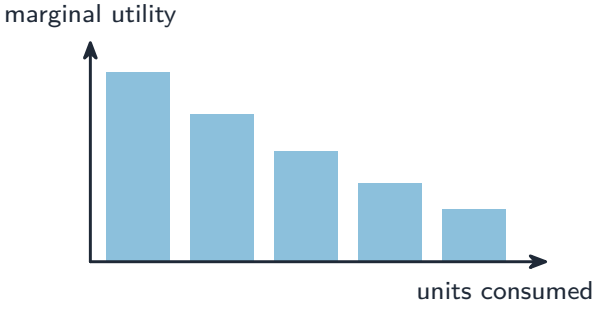
Rational decision-makers weigh **benefits against costs**. Compare feasible alternatives by net benefit (total benefit minus total cost), including opportunity cost. When a decision has increments, compare the extra benefit and cost of each increment. Money already spent and unrecoverable is a **sunk cost** 沉没成本 and should be **ignored** in decisions: only future costs and benefits matter.

Worked example (sunk cost). You paid $40 for a concert ticket, which cannot be refunded. On the night you feel ill and would enjoy staying home more than the concert. The $40 is gone whichever you choose, so it should not affect the decision: compare only the benefit of going with the benefit of staying home. "I already paid, so I must go" is the **sunk-cost fallacy**.

Explicit and implicit costs. The cost of a choice includes money paid (**explicit** costs) and the value of what you give up (**implicit** costs). A year of university costs its fees **plus** the wage you could have earned working that year.

Marginal Analysis and Consumer Choice

Most real decisions are not "all or nothing" but "a little more or a little less." **Marginal analysis** 边际分析 compares the **marginal benefit** 边际收益 (the benefit of one more unit) with the **marginal cost** 边际成本 (the cost of one more unit).



Each extra unit consumed gives less extra satisfaction (diminishing marginal utility)

- **Decision rule:** add a unit when its marginal benefit exceeds its marginal cost. A feasible interior optimum on smooth curves has **MB = MC**. Whole-unit tables may have no exact equality: choose the quantity with the greatest net benefit. A unit with equal MB and MC leaves net benefit unchanged.
- Consumers get **utility** 效用 (satisfaction) from goods, but each extra unit usually gives less added satisfaction – the **law of diminishing marginal utility** 边际效用递减法则.
- A consumer maximizes total utility by the **utility-maximizing rule**: spend so that the **marginal utility per dollar** is equal across all goods, $\frac{MU_x}{P_x} = \frac{MU_y}{P_y}$, subject to the budget. This equality describes a standard interior choice; with whole units, compare feasible combinations because exact equality may be impossible. With positive marginal utility and divisible goods, the budget is spent.

Whole-unit example. Four units give marginal benefits of 12, 9, 6 and 3 dollars; each costs 5 dollars. Their extra net benefits are 7, 4, 1 and -2 dollars. Cumulative net benefits are 7, 11, 12 and 10 dollars. Choose three units: the fourth reduces net

benefit, although no row has MB = MC.

Worked example (allocating time). Nirali's test scores rise with study hours as follows.

hour	1st	2nd	3rd	4th	5th
extra points in microeconomics	20	15	10	6	3
extra points in history	18	12	8	4	2

She has 5 hours. The second hour of history gains her 12 points; its opportunity cost is the best use she gives up – another hour of microeconomics. Taking hours one at a time in order of value: micro 20, history 18, micro 15, history 12, micro 10. So she should study **3 hours of microeconomics and 2 of history** for $20+15+10+18+12 = 75$ extra points. The last hours are worth 10 and 12 points; any switch loses points. If a sixth hour appears, it goes to whichever next hour is worth more: history's third hour (8) beats micro's fourth (6), so it goes to **history**. As she moves more of her 5 hours to history, the opportunity cost of each extra history hour **rises**: each one takes an hour from microeconomics, and the micro hours she gives up are worth more and more (10, then 15, then 20 points).

Unit	X	Y
1	20	28
2	16	24
3	12	16
4	8	8
5	4	-4
6	-2	-8

Consumer example (AP 2025 Set 2, Q3A–C). The table gives Lucy's marginal utility in utils. If both goods are free, choose 5 X and 4 Y: the next units add negative utility. Total utility from 2 X and 2 Y is $(20 + 16) + (28 + 24) = 88$ utils.

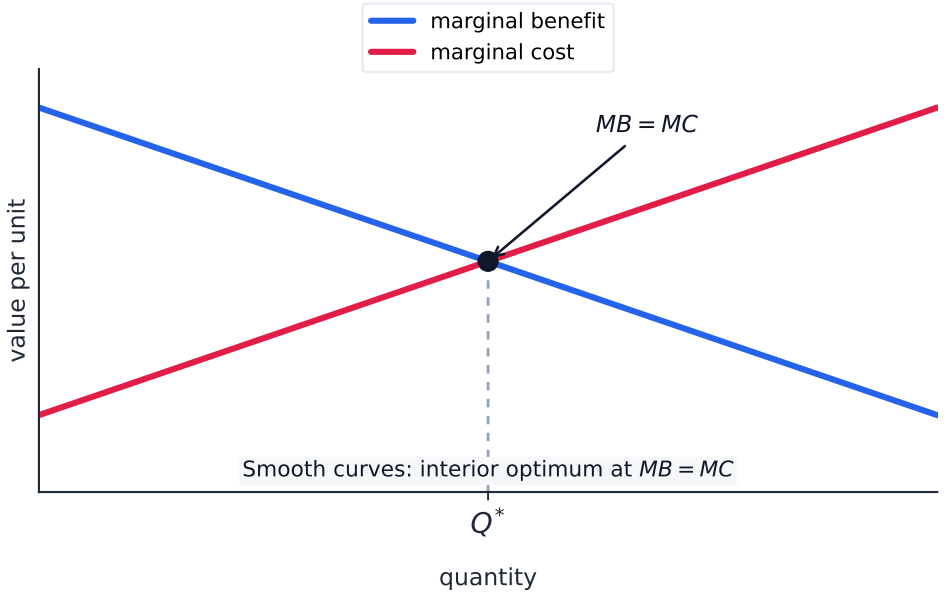
If X costs \$2, Y \$4, and the budget is \$20, buying 2 X leaves \$16 for 4 Y. The optimal combination is instead 4 X and 3 Y. The last units give $8/2 = 4$ and $16/4 = 4$ utils per dollar, and spending is $2(4) + 4(3) = 20$ dollars. Total utility is $56 + 68 = 124$ utils. Replacing two X with one Y loses $12 + 8 = 20$ utils and gains only 8. Replacing one Y with two X loses 16 and gains only $4 - 2 = 2$. Compare both marginal ratios and the budget.

Changes in income and prices. If Lucy's income **and** both prices double, nothing real has changed: she can buy exactly the same bundles, so her optimal choice stays the **same**. If her income falls with prices unchanged, she can no longer afford her old bundle and buys less (of normal goods).

Consumer surplus from a table. If Martha's marginal benefits from units of X are \$10, \$8, \$6, \$4 and \$2 and the price is \$2, she buys 5 units. Her consumer surplus is $(10 - 2) + (8 - 2) + (6 - 2) + (4 - 2) + (2 - 2) = 20$ dollars: the extra value she gets

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above what she pays, summed over the units.



Smooth interior case: net benefit is greatest where marginal benefit equals marginal cost

Exam tips

State the opportunity-cost units and compare both producers. Give a specific trade rate strictly between their costs. For consumer choice, check the budget and the last units bought. For marginal decisions, compare feasible net benefits; exact equality need not occur in a table.

Practice.

1. A firm has spent \$2 million developing a product. Finishing it would cost \$1 million more and bring in \$1.5 million. Should it finish? Why does the \$2 million not matter?
2. A worker can make 6 tables or 18 chairs a week. What is the opportunity cost of one table?
3. Using Nirali's table, what is the total gain from 2 hours of microeconomics and 3 hours of history? Why is it worse than her optimum?
4. $MU_x = 30$, $P_x = \$3$, $MU_y = 40$, $P_y = \$5$. Should the consumer buy more X or more Y with the next dollar?
5. Marginal benefits of 5 units are \$9, \$7, \$5, \$3, \$1, and each unit costs \$4. How many units maximise net benefit, and what is it?
6. Name the factor of production in each: a delivery van, a farmer's field, a nurse's work, the founder who starts a bakery.

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Answers.

1. Yes: the extra benefit ($1.5 million) exceeds the extra cost ($1 million). The $2 million is sunk – it is spent whatever the firm decides.
2. $\frac{18}{6} = 3$ chairs.
3. $20 + 15 + 18 + 12 + 8 = 73$ points, two fewer than 75: the third history hour (8) is worth less than the third micro hour (10).
4. X: $\frac{30}{3} = 10$ utils per dollar against $\frac{40}{5} = 8$ for Y.
5. Three units: net benefit $(9 - 4) + (7 - 4) + (5 - 4) = 9$ dollars; the fourth unit would lose $1.
6. Capital; land; labour; entrepreneurship.

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Supply and Demand

AP Microeconomics

Demand



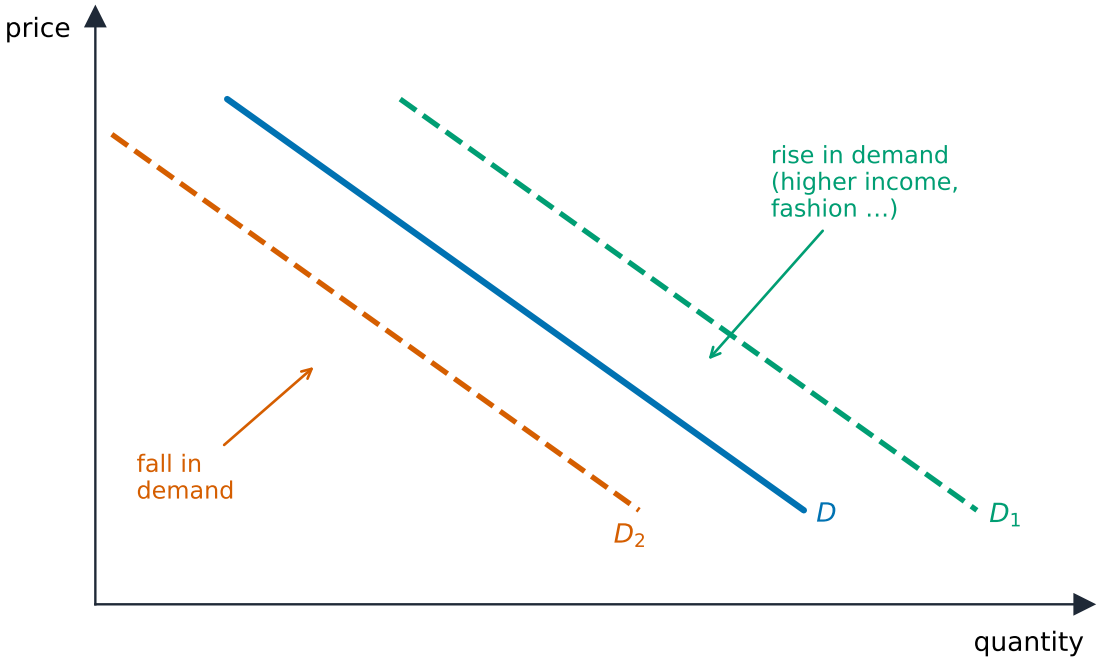
Shoppers in a market: demand shows how quantity demanded responds to price

When concert tickets for a popular tour go on sale, they sell out in minutes and then reappear on resale sites at several times the printed price. When a bumper harvest increases strawberry supply, strawberries become cheaper at the market, other things equal. Neither price is set by anyone in charge: both come from buyers and sellers responding to each other. This unit builds the model that explains them.

Well-defined **property rights** 产权 support exchange: owners can use, exclude others from, and trade their resources. Within that framework, the two forces are demand and supply.

Demand 需求 is the relationship between the price of a good and the quantity buyers are willing and able to buy. The **law of demand** 需求定律 says that, with other conditions held constant, price and quantity demanded move in **opposite** directions, so the demand curve slopes **downward**. Two reasons: the **substitution effect** 替代效应 (when a good gets pricier, buyers switch to alternatives) and the **income effect** 收入效应 (a higher price shrinks real purchasing power).

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The demand curve slopes down; income, tastes, and related prices shift it

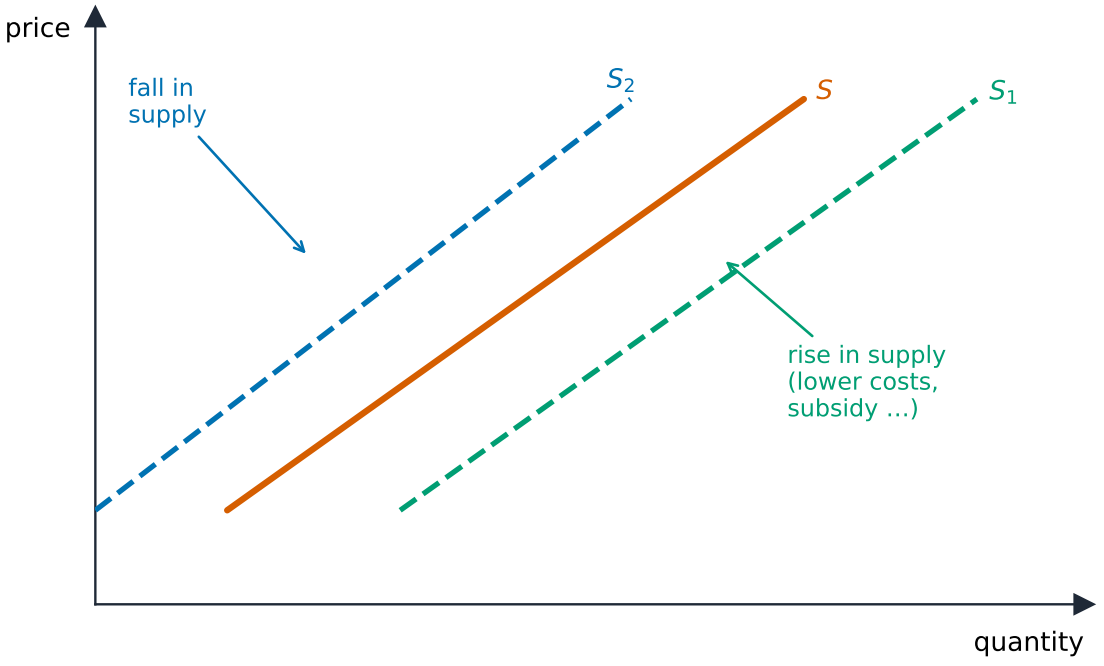
Distinguish a **change in quantity demanded** (a move *along* the curve, caused only by the good's **own price**) from a **change in demand** (a *shift* of the whole curve). Demand shifts with the **determinants** 决定因素, remembered as **TRIBE**:

- **T**astes/preferences,
- **R**elated goods – a rise in the price of a **substitute** 替代品 raises demand; a rise in the price of a **complement** 互补品 lowers it,
- **I**ncome – for a **normal good** 正常商品 more income raises demand; for an **inferior good** 低档商品 it lowers it,
- **B**uyers (number of consumers),
- **E**xpectations of future price or income.

The **market demand curve** is the **horizontal summation** 水平相加 of every individual buyer's demand curve – at each price, add up the quantities all buyers want. That is why more buyers (the **B** above) shifts the whole market curve to the right.

Supply

Supply 供给 is the relationship between price and the quantity sellers will offer. The **law of supply** 供给定律: with other conditions held constant, price and quantity supplied move in the **same** direction, so the supply curve slopes **upward** (higher prices cover higher marginal costs and reward more output).



The supply curve slopes up; costs, technology, tax, and subsidy shift it

Again separate a **change in quantity supplied** (movement along the curve, from the good's own price) from a **change in supply** (a shift). Supply shifts with **input prices**, **technology**, taxes and **subsidies** 补贴, **prices of other goods** a firm could make, **number of sellers**, and **expectations**. Just like demand, the **market supply curve** is the horizontal sum of individual firms' supply curves – add the quantities all firms offer at each price – so more sellers shifts market supply to the right.

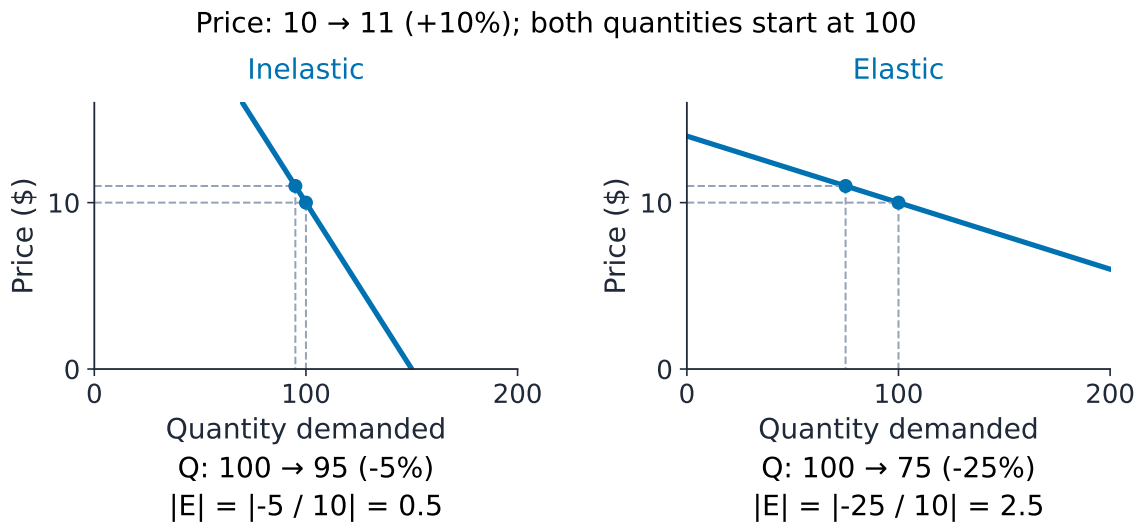
Exam skill: on the free-response section you must draw correctly labeled supply-and-demand graphs and shift the *right* curve in the *right* direction – decide first whether the event changes an "own price" (move along) or a determinant (shift).

Price Elasticity of Demand

Price elasticity of demand 需求价格弹性 measures how responsive quantity demanded is to a price change:

$$E_d = \left| \frac{\%\ \Delta \text{ quantity demanded}}{\%\ \Delta \text{ price}} \right|.$$

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Inelastic versus elastic demand: a small versus large response to a price change

- $E_d > 1$: **elastic** 富有弹性 (quantity responds strongly);
- $E_d < 1$: **inelastic** 缺乏弹性 (quantity barely responds);
- $E_d = 1$: **unit elastic**.

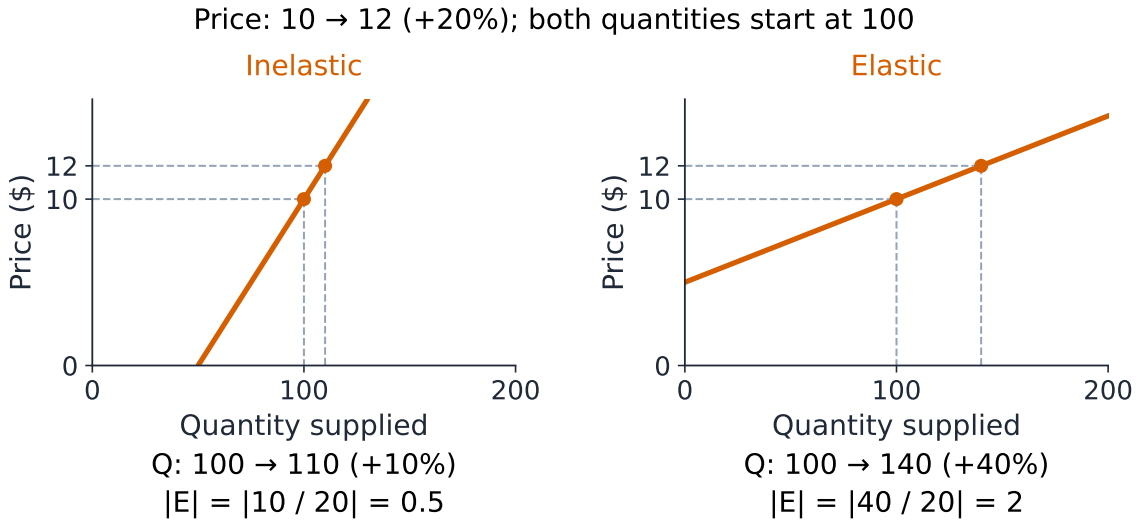
Demand is more elastic when there are more **substitutes**, the good is a **luxury**, it takes a large share of income, or buyers have **more time** to adjust. Elasticity links to **total revenue** 总收入 ($P \times Q$): if demand is elastic, a price cut *raises* revenue; if inelastic, a price cut *lowers* it. Elasticity compares **percentage changes**, not slope alone. Along a straight-line demand curve with positive intercepts, elasticity falls as you move down (elastic on top, inelastic at the bottom).

Worked example (percentage changes measured from the initial values). A price rise from \$10 to \$12 (a +20% change) cuts quantity demanded from 100 to 85 (a −15% change). Then $E_d = \left|\dfrac{-15\%}{20\%}\right| = 0.75 < 1$, so demand is **inelastic**. Because it is inelastic, the price rise *raises* total revenue: from $\$10 \times 100 = \$1000$ to $\$12 \times 85 = \$1020$.

Worked example (where demand is unit elastic). On the straight-line demand curve $P = 20 - Q$, total revenue $TR = PQ = (20 - Q)Q$ is largest at the **midpoint**, $Q = 10$, $P = \$10$, where $TR = \$100$. That is where demand is **unit elastic**. Above the midpoint (higher prices) demand is elastic, and a price cut raises revenue; below it demand is inelastic, and a price cut lowers revenue. A straight demand line has a constant slope but a changing elasticity.

Price Elasticity of Supply

Price elasticity of supply 供给价格弹性, $E_s = \dfrac{\%\ \Delta\ Q_s}{\%\ \Delta\ P}$, measures how responsive sellers are. Supply is more elastic when firms can adjust output easily: they have spare capacity, the good can be stored, or they have **more time** to change production. More time usually makes supply more elastic, but it does not fix a particular value.



The same price rise gives a small supply response when PES is below 1, a large one above 1

Worked supply comparison. Both firms start at price \$10 and quantity 100. Price rises to \$12, a 20% rise from the initial price. Firm A increases supply to 110 units, a 10% rise; firm B to 140, a 40% rise. Using these initial-value percentage changes:

$$E_{s,A} = \frac{\%\Delta Q_s}{\%\Delta P} = \frac{10}{20} = 0.5, \qquad E_{s,B} = \frac{40}{20} = 2.$$

Firm A has inelastic supply; firm B has elastic supply. Horizontal supply is perfectly elastic; vertical supply is perfectly inelastic.

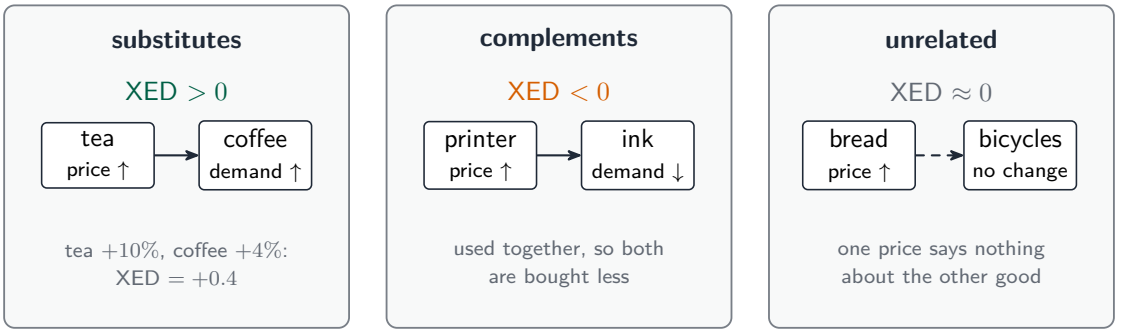
Other Elasticities

- **Cross-price elasticity** 交叉价格弹性 $= \dfrac{\%\ \Delta\ Q_x}{\%\ \Delta\ P_y}$: **positive** for substitutes, **negative** for complements – the sign tells you the relationship.
- **Income elasticity** 收入弹性 $= \dfrac{\%\ \Delta\ Q}{\%\ \Delta\ \text{income}}$: **positive** for normal goods (and > 1 for luxuries), **negative** for inferior goods.

Worked example. When the price of coffee rises 10%, the quantity of tea demanded rises 6%: cross-price elasticity $= \dfrac{+6\%}{+10\%} = +0.6$. The **positive** sign confirms coffee and tea are **substitutes**. If instead a 5% rise in incomes raised restaurant-meal demand 10%, income elasticity $= \dfrac{10\%}{5\%} = +2$ – a normal good, and a **luxury** since it exceeds 1.

Further practice and answers. Printer price rises 10% and ink quantity demanded falls 4%: $E_{ink,printer} = \frac{-4}{10} = -0.4$, so they are complements. Income rises 10% and bus-ticket quantity demanded falls 5%: $E_Y = \frac{-5}{10} = -0.5$, so bus travel is an inferior good **in this example**. Hold other determinants constant.

Official application: AP 2024 Set 1, Q1(e). Quinoa price rises 25%, its quantity demanded falls 5%, and tofu quantity demanded rises 10%. Own-price elasticity magnitude is $|E_d| = |-5/25| = 0.2$, so quinoa demand is inelastic. Cross-price elasticity is $E_{tofu,quinoa} = 10/25 = +0.4$, so the goods are substitutes. Neither value establishes whether tofu is normal or inferior; that requires an income change.

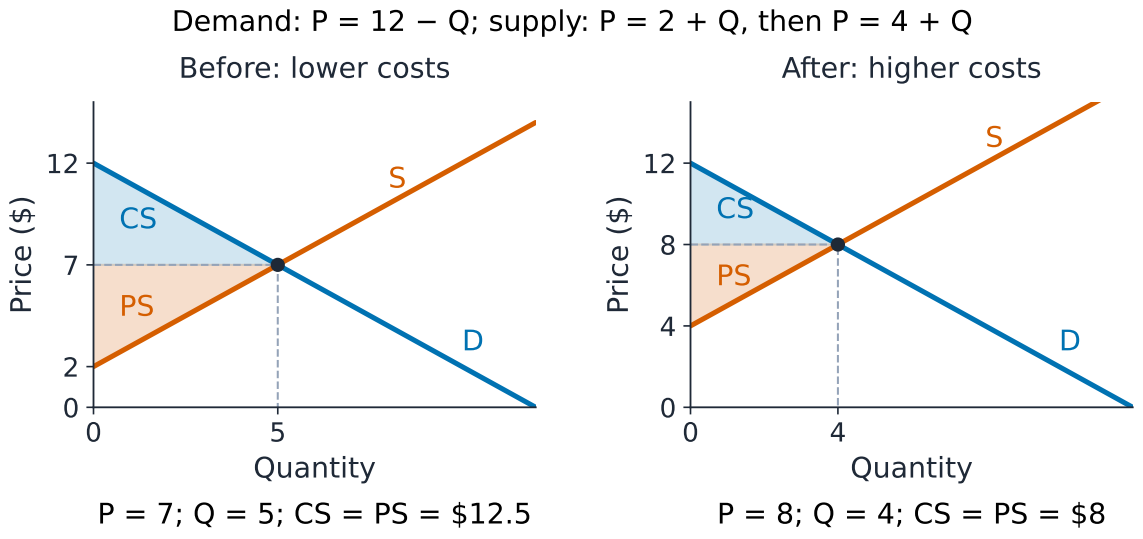


Cross elasticity: positive for substitutes, negative for complements

Exam skill: you are expected to compute an elasticity, classify it, and read a *sign* as evidence of substitute/complement or normal/inferior.

Market Equilibrium, Consumer Surplus, and Producer Surplus

Equilibrium 均衡 is where supply meets demand: the **equilibrium price** clears the market, so quantity demanded equals quantity supplied and there is no shortage or surplus.



Consumer surplus and producer surplus at the market equilibrium

- **Consumer surplus** 消费者剩余 is the area **below the demand curve and above the price** – the gap between what buyers would pay and what they do pay.
- **Producer surplus** 生产者剩余 is the area **above the supply curve and below the price** – the gap between the price and sellers' minimum acceptable price.
- Their sum is **total surplus** 总剩余, and a competitive equilibrium **maximizes** it when there are no market failures. Private benefits and costs must reflect social benefits and costs for this equilibrium to be **allocatively efficient** 配置有效率.



A fruit and vegetable stall: the photograph shows goods offered for sale, not an observed equilibrium

Worked market used below. Demand is $P_D = 20 - Q$ and supply is $P_S = 2 + Q$,

with price in dollars and quantity in units. Equilibrium requires equal demand and supply prices:

$$P_D = P_S, \quad 20 - Q = 2 + Q, \quad Q^* = 9, \quad P^* = \$11.$$

For these straight-line curves, use triangle areas:

$$CS = \tfrac{1}{2}Q^*(P_{D,0} - P^*) = \tfrac{1}{2}(9)(20 - 11) = \$40.50.$$

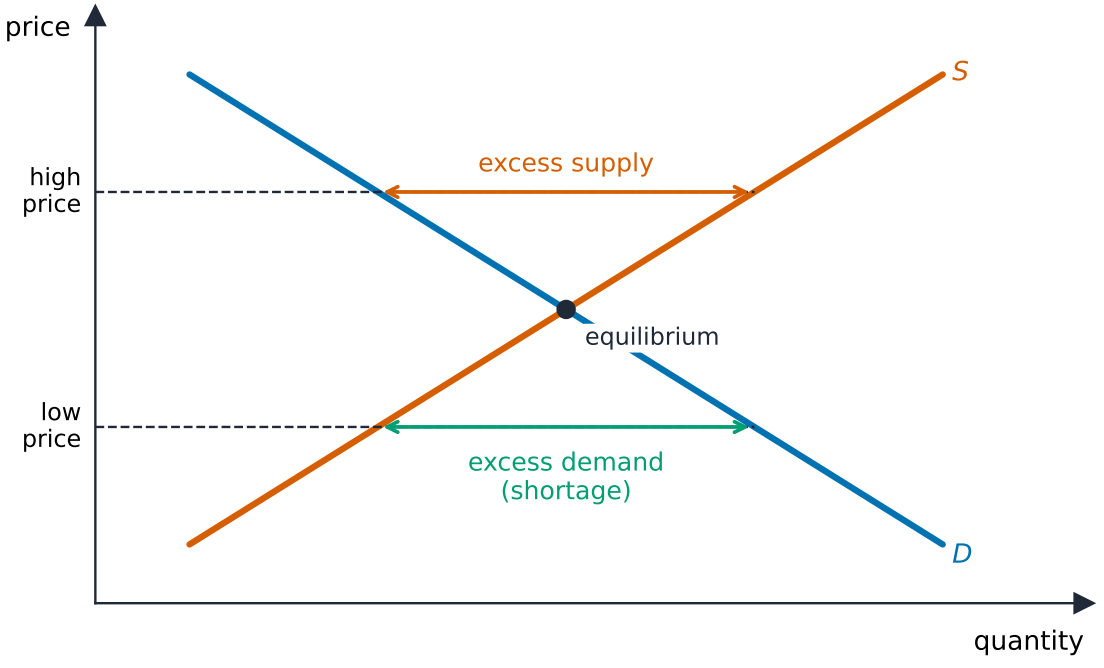
$$PS = \tfrac{1}{2}Q^*(P^* - P_{S,0}) = \tfrac{1}{2}(9)(11 - 2) = \$40.50.$$

$$TS = CS + PS = \$81.$$

Assume no external costs or benefits.

Market Disequilibrium and Changes in Equilibrium

Away from equilibrium the market self-corrects: above the equilibrium price there is a **surplus** 过剩 (excess supply) that pushes price down; below it a **shortage** 短缺 (excess demand) that pushes price up.



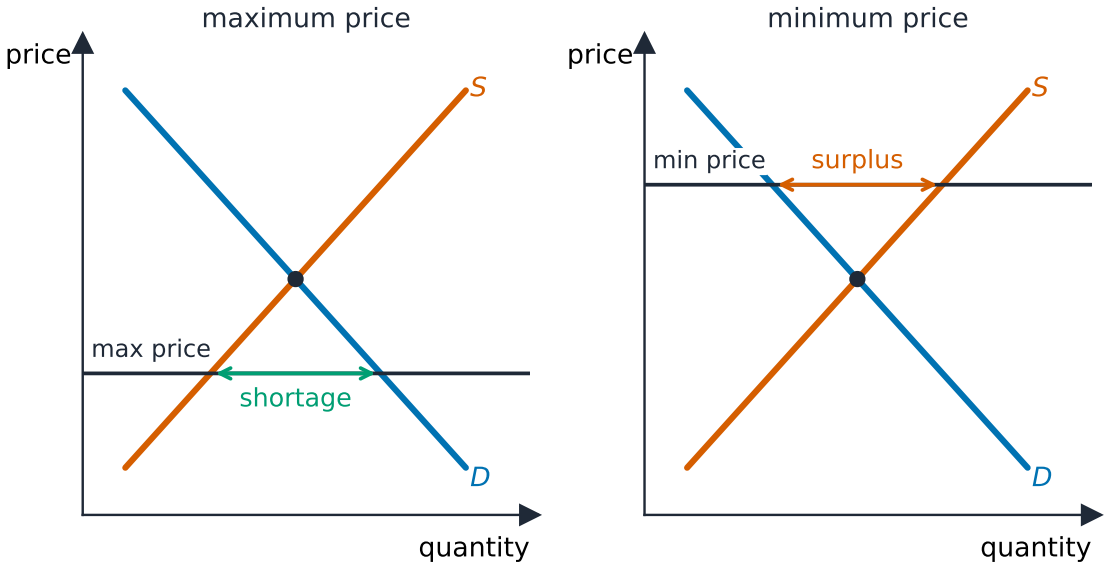
Above equilibrium there is excess supply; below it, excess demand

When a determinant shifts a curve, the equilibrium moves predictably. A **single** shift gives a definite result for both price and quantity. When **both** curves shift, one of price or quantity is **indeterminate** (depends on the relative sizes of the shifts) – a favorite exam trap. Work these out by drawing the shifts.

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The Effects of Government Intervention in Markets

Start with an initially efficient competitive market. Binding interventions can reduce total surplus; a policy correcting a market failure can instead improve social welfare (Unit 6).



A binding price ceiling causes a shortage; a binding price floor causes a surplus

- A **price ceiling** 价格上限 (a legal maximum, like rent control) below equilibrium causes a persistent **shortage**.
- A **price floor** 价格下限 (a legal minimum, like a minimum wage) above equilibrium causes a persistent **surplus**.
- A per-unit **excise tax** 消费税 on sellers shifts supply up by the tax; the burden (**tax incidence** 税收归宿) falls more heavily on whichever side is **more inelastic**.
- A per-unit producer **subsidy** shifts supply down, raising quantity.

Deadweight loss 无谓损失 is lost total surplus. In this initially efficient model, a tax prevents some beneficial trades; a subsidy can encourage units whose cost exceeds their benefit. A nonbinding price control has no effect on the market outcome.

Worked controls. Use $P_D = 20 - Q$ and $P_S = 2 + Q$, so the original equilibrium is $P^* = \$11$, $Q^* = 9$. At a ceiling of \$8:

$$Q_d = 20 - P = 20 - 8 = 12, \qquad Q_s = P - 2 = 8 - 2 = 6.$$

$$\text{Shortage} = Q_d - Q_s = 12 - 6 = 6 \text{ units}.$$

At most six units trade without other supply. At a floor of \$14, $Q_d = 6$ and $Q_s = 12$, so the surplus is six units; without government purchases, buyers take at most six units.

Non-binding controls. A ceiling of \$12 in this market lies **above** the equilibrium price of \$11, so it does not bind: the market still clears at \$11 and 9 units, with neither a shortage nor a surplus. A floor only binds when it is above equilibrium, and a ceiling only when it is below.

Worked output limit. If the government restricts output to 6 units, buyers value the sixth unit at $P_D = 20 - 6 = \$14$ while it costs $P_S = 2 + 6 = \$8$ to supply. The trades between 6 and 9 units are lost:

$$DWL = \tfrac{1}{2}(9-6)(14-8) = \$9.$$

Minimum wage. An effective (binding) minimum wage is a price floor in the **labour** market. At a wage above equilibrium, the quantity of labour supplied exceeds the quantity demanded: a **surplus of labour**, which is unemployment. The workers who keep jobs earn more; those who cannot find work earn nothing.

Worked tax. A \$4 tax per unit creates a wedge between the buyer price P_b and seller receipt P_s:

$$P_b = P_s + t, \qquad 20 - Q = 2 + Q + 4.$$

$$Q_t = 7, \qquad P_b = \$13, \qquad P_s = \$9.$$

Tax incidence. Buyers pay \$2 more and sellers receive \$2 less than before; the burden is equal for these symmetric schedules. Generally, the relatively more inelastic side bears more.

$$\text{Tax revenue} = tQ_t = 4(7) = \$28.$$

$$DWL = \tfrac{1}{2}t(Q^* - Q_t) = \tfrac{1}{2}(4)(9-7) = \$4.$$

Government revenue is a transfer, not the deadweight loss.

> **Worked example (who bears a tax?).** Demand for gasoline is less elastic than supply in this example: drivers cannot quickly change how far they travel. A \$2 tax on producers shifts supply up by \$2. Because buyers barely reduce their purchases, sellers can pass most of the tax on: the price buyers pay rises by **most** of the \$2, and the price sellers keep falls by little. The burden falls **more on buyers**. Tax revenue is the tax times the new quantity – on a graph, the rectangle between the buyer price and the seller price, out to the after-tax quantity.

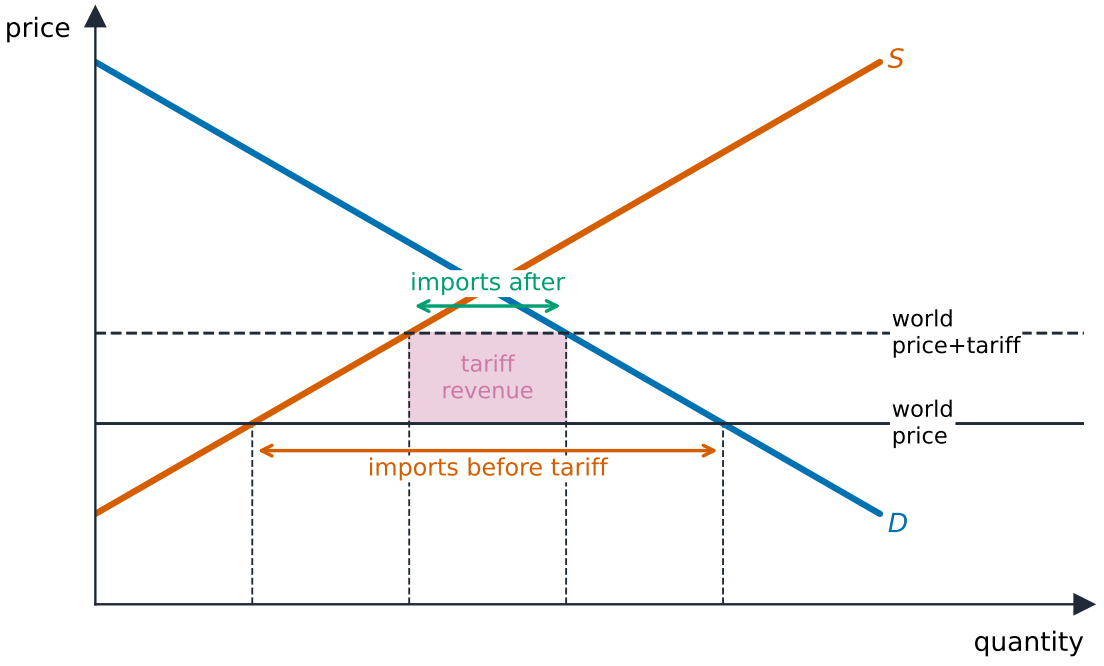
Exam skill: on a graph, be able to shade consumer surplus, producer surplus, government revenue from a tax, and deadweight loss, and say who bears the tax and why.

International Trade and Public Policy

In the competitive small-country model, the country takes the **world price** 世界价格 as given. Assume no external costs or benefits. Compare it with the domestic price before trade:

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- If the world price is **below** the domestic price, the country **imports** 进口 – consumers gain more than producers lose, so total surplus rises.
- If the world price is **above** the domestic price, the country **exports** 出口 – producers gain more than consumers lose.



A tariff raises quantity supplied, lowers quantity demanded, and reduces imports; neither domestic curve shifts

A binding **tariff** 关税 (import tax) or **quota** 配额 (import limit) raises domestic price and reduces total surplus in this model. Domestic curves do not shift.

Worked imports and tariff. Keep $P_D = 20 - Q$ and $P_S = 2 + Q$. The world price is \$6, below the \$11 no-trade equilibrium.

$$Q_d = 20 - P_w = 14, \quad Q_s = P_w - 2 = 4, \quad M = Q_d - Q_s = 10.$$

A \$2 tariff raises the domestic price to \$8; imports continue because this is below \$11.

$$Q_{d,t} = 20 - 8 = 12, \quad Q_{s,t} = 8 - 2 = 6, \quad M_t = 12 - 6 = 6.$$

$$\text{Tariff revenue} = tM_t = 2(6) = \$12.$$

The production and consumption distortions each lose a triangle of surplus:

$$DWL = \tfrac{1}{2}t[(Q_{s,t} - Q_s) + (Q_d - Q_{d,t})] = \tfrac{1}{2}(2)[(6-4) + (14-12)] = \$4.$$

These are conditional model results, not a claim that every real-world trade policy has the same welfare effect.

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Exam tips

- Separate a **movement along** a curve (own price) from a **shift** (a determinant); a single shift gives a definite result, a double shift leaves one variable indeterminate.
- Compute elasticity $E_d = |\%\Delta Q \div \%\Delta P|$; elastic ($> 1$) means a price cut raises total revenue, inelastic (< 1) lowers it.
- Read the sign of cross-price elasticity (substitutes $+$, complements $-$) and income elasticity (normal $+$, inferior $-$).
- Shade **consumer/producer surplus** and the **deadweight loss** from a tax or price control; incidence falls on the more **inelastic** side.
- A price ceiling below equilibrium causes a shortage; a price floor above causes a surplus.

Practice.

1. The price of a good falls from \$8 to \$6 and quantity demanded rises from 100 to 140. Is demand elastic or inelastic (percentage changes from the initial values)? What happens to total revenue?
2. Demand is $P = 30 - 2Q$. At what quantity is demand unit elastic?
3. With $P_D = 20 - Q$ and $P_S = 2 + Q$, is there a shortage or surplus with a price floor at \$16? With a ceiling at \$12?
4. With the same market, calculate producer surplus at equilibrium.
5. A \$6 per-unit tax is placed on the same market. Find the new quantity, the buyer and seller prices, the tax revenue and the deadweight loss.
6. Demand for cigarettes is very inelastic and less elastic than supply. Who bears most of a cigarette tax, and does the tax raise much revenue?

Answers.

1. $\%\Delta P = -25\%$, $\%\Delta Q = +40\%$, so $E_d = 1.6$: elastic. Total revenue rises from \$800 to \$840.
2. $TR = (30 - 2Q)Q$ is largest at $Q = 7.5$ (the midpoint, $P = \$15$).
3. Floor \$16 (above \$11): $Q_d = 4$, $Q_s = 14$, a surplus of 10. Ceiling \$12 (above \$11): not binding, neither.
4. $\frac{1}{2}(9)(11 - 2) = \$40.50$.
5. $20 - Q = 2 + Q + 6$ gives $Q = 6$, $P_b = \$14$, $P_s = \$8$; revenue $6 \times 6 = \$36$; $DWL = \frac{1}{2}(6)(9 - 6) = \$9$.
6. Buyers bear most of it because demand is less elastic than supply. Revenue equals the tax per unit times after-tax sales; its size still depends on the tax and quantity. Inelastic demand limits the quantity reduction and associated deadweight loss, other things equal.

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Production, Cost, and the Perfect Competition Model

AP Microeconomics

The Production Function



A steel plant: production functions and costs shape how firms supply goods

Why it matters. An Iowa corn farmer cannot choose the price of corn: thousands of farms grow the same crop, and the price is quoted every day on the Chicago futures market. What the farmer *can* choose is how many workers, machines and acres to use, and how much to grow. This unit builds the tools for that choice: how output responds to inputs, how costs follow, and when a firm should expand, shut down or leave the industry.

The **production function** 生产函数 links inputs to output. In the **short run** 短期 at least one input (usually **capital**) is **fixed** 固定; in the **long run** 长期 all inputs vary.

- **Total product** 总产量 is the total output.
- **Marginal product** 边际产量 (MP) is the extra output from one more unit of a variable input (usually labor): $MP = \dfrac{\Delta \text{ output}}{\Delta \text{ labor}}$.
- **Average product** 平均产量 is output per worker.

As you add workers to fixed capital, MP eventually falls – the **law of diminishing marginal returns** 边际收益递减法则. With a constant wage and labor as the only variable input, lower MP raises marginal cost. This relationship depends on input prices and the production conditions.



The production function turns inputs – labour and capital like this robot – into output

■ Worked example: one oven and four workers

The oven and technology stay fixed. All workers work equal daily hours. With 0, 1, 2, 3 and 4 workers, total product is 0, 10, 24, 33 and 39 loaves per day. First calculate each extra worker's contribution, then average output at three workers. $MP = \Delta TP/\Delta L$ gives 10, 14, 9 and 6 loaves per worker-day. The third worker starts diminishing marginal returns because MP falls from 14 to 9. Total output still rises from 24 to 33: positive but falling MP means less extra output, not falling output. $AP = TP/L = 33/3 = 11$ loaves per worker-day.

■ Use the production table to choose workers

Use the bakery's production data above. Price is \$8 per loaf and wage \$60 per worker-day. Labor is the only variable input; the oven's fixed cost is unavoidable today. Choices are zero through four workers.

Worker added	**1**	**2**	**3**	**4**
Extra loaves MP	10	14	9	6
Extra revenue P×MP	80	112	72	48
Extra labor cost	60	60	60	60
Extra profit	20	52	12	−12

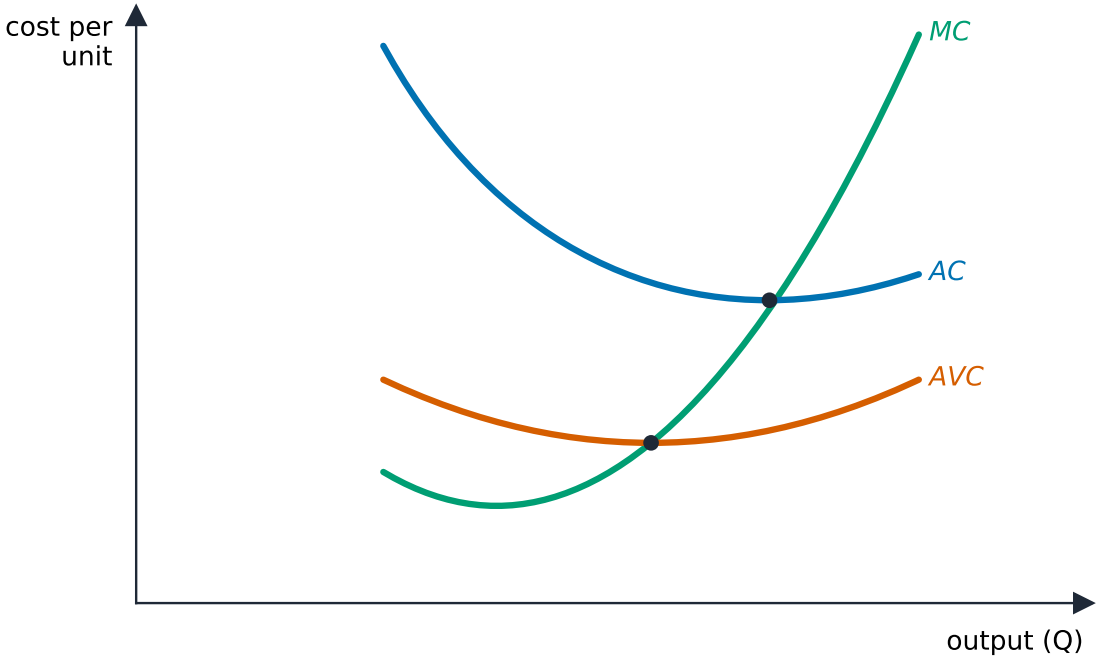
Money rows are dollars per day. Choose three workers: the third adds \$72 revenue for \$60 cost; the fourth lowers profit by \$12. The first three contribute \$84 toward unavoidable fixed cost and profit.

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Short-Run Production Costs

Costs split into **fixed** and **variable**:

- **Fixed cost** 固定成本 (FC) does not change with output (rent on the factory).
- **Variable cost** 可变成本 (VC) rises with output (materials, labor).
- **Total cost** 总成本 $TC = FC + VC$.



The short-run marginal, average, and average variable cost curves

The **per-unit** costs matter most:

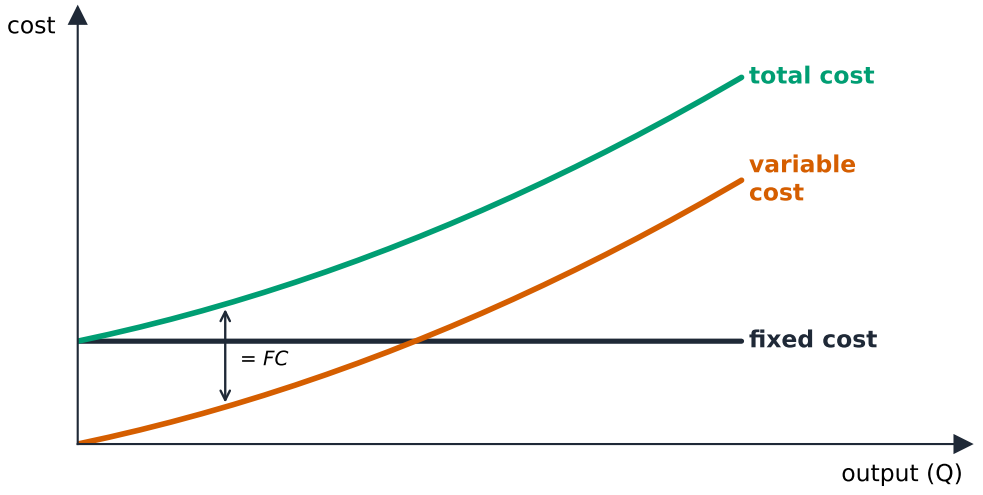
- **Average fixed cost** $AFC = FC/Q$ falls continuously (spreading fixed cost).
- **Average variable cost** $AVC = VC/Q$ and **average total cost** $ATC = TC/Q$ commonly have U-shaped curves in standard short-run diagrams; the shapes depend on production conditions.
- **Marginal cost** 边际成本 $MC = \dfrac{\Delta TC}{\Delta Q}$ is the cost of one more unit.

With constant wage w and labor as the only variable input, $MC = w/MP$: a lower MP raises MC. This is an inverse numerical relationship, not a literal reflection of graphs. **MC cuts both AVC and ATC at their minimum points** in the standard smooth cost model: when marginal is below average, average falls; when above, average rises.

Worked example. A firm has fixed cost $FC = \$100$. At $Q = 10$ its total cost is \$300, so variable cost is \$200: then $ATC = \frac{300}{10} = \$30$, $AVC = \frac{200}{10} = \$20$, and $AFC = \frac{100}{10} = \$10$ (note $AFC + AVC = ATC$). If raising output to $Q = 11$ pushes total cost to \$325, the marginal cost of that 11th unit is $\frac{\Delta TC}{\Delta Q} = \frac{325 - 300}{1} = \$25$.

Explain the cost change

In the cost example, the eleventh unit costs \$25, below the previous ATC of \$30. New $ATC = TC/Q = 325/11 \approx \$29.55$ per unit. At zero output the \$100 fixed cost remains, but average costs are undefined because their denominator is zero.



$TC = FC + VC$ · gap between TC and VC is FC

Fixed cost stays the same as output rises; variable cost rises; total cost is fixed plus variable, so the gap between total and variable cost is the fixed cost.

For the bakery above, assume each worker costs \$60 per day and labor is the only variable input. The second, third and fourth workers add 14, 9 and 6 loaves. Their extra cost per loaf is $MC = \Delta VC/\Delta Q = 60/14 \approx \$4.29$, $MC = 60/9 \approx \$6.67$, and $MC = 60/6 = \$10$. This shows why diminishing marginal returns raises MC when wage is unchanged.

If fixed rent alone rises by \$50, FC rises and ATC rises by $50/Q$ dollars per unit. AVC and MC stay unchanged: an extra unit does not add rent. If wage rises while productivity stays unchanged, variable cost, AVC, ATC and MC rise at positive output. Cost curves respond to the affected input; do not shift every curve automatically.

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Which cost curves move?

AP questions often change one cost and ask which curves shift. Ask one test: does the cost change with output? If not, MC cannot move.

Change	FC and AFC	AVC	ATC	MC
Lump-sum tax or licence fee rises	up	unchanged	up	unchanged
Lump-sum subsidy	down	unchanged	down	unchanged
Per-unit tax of $2	unchanged	up by $2	up by $2	up by $2
Wage rises (labor variable)	unchanged	up	up	up

A lump-sum change moves ATC but not MC, so a price-taking firm's profit-maximizing output does not change in the short run; only its profit does.

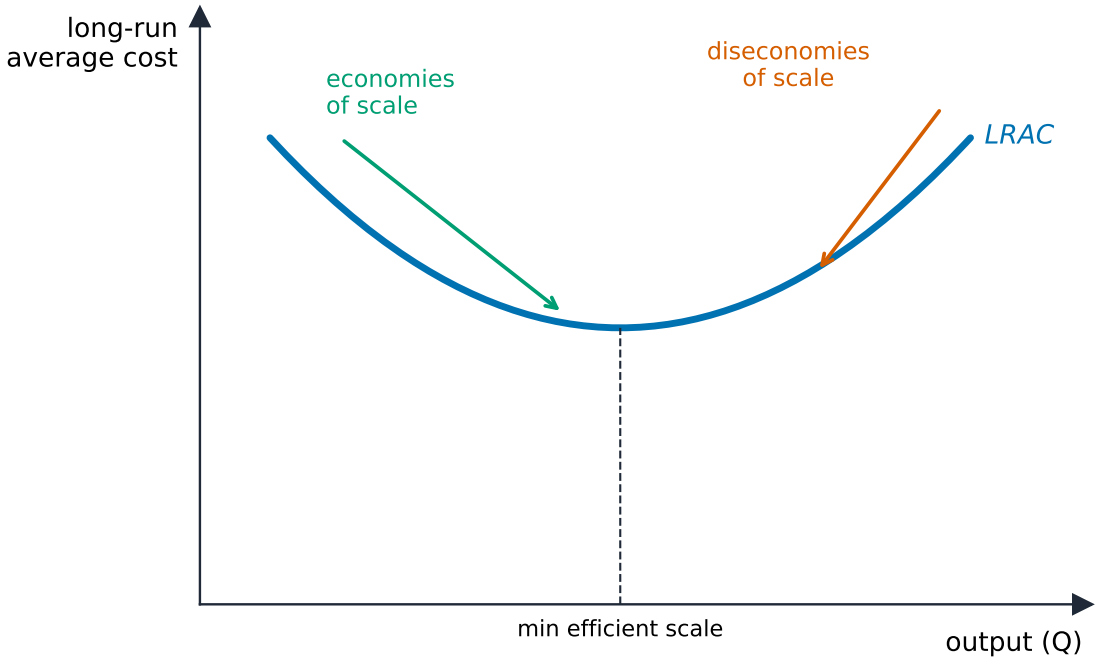
Long-Run Production Costs

In the long run all inputs – including plant size – can change, and all costs become variable. The **long-run average total cost (LRATC)** curve shows the lowest average cost attainable across plant choices:

- **Economies of scale** 规模经济: LRATC falls as output grows (bulk buying, specialization).
- Constant-cost range: LRATC is flat. At unchanged input prices, constant returns to scale can produce this pattern.
- **Diseconomies of scale** 规模不经济: LRATC rises (a firm too big to manage well).

Exam skill: know that "diminishing returns" is a **short-run** idea (one fixed input) while "economies of scale" is a **long-run** idea (all inputs vary) – examiners test the distinction.

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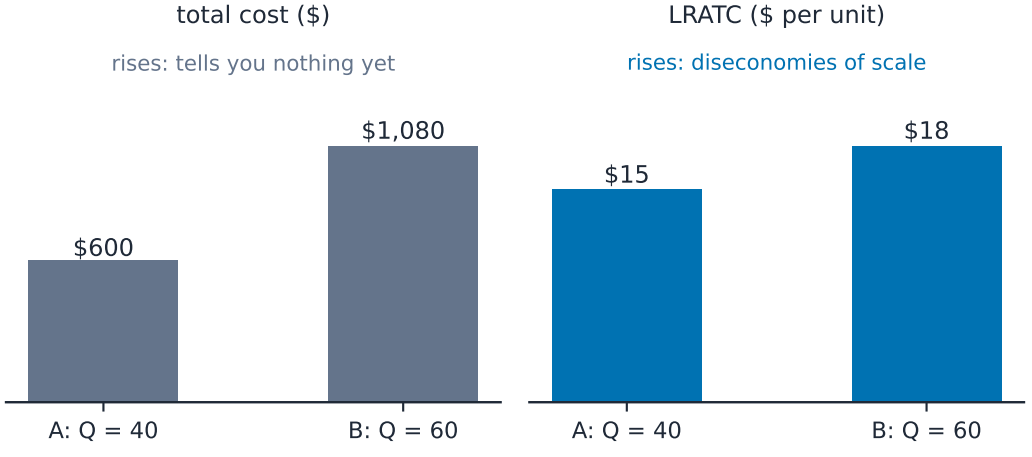


Economies and diseconomies of scale on the long-run average cost curve

■ Worked example: calculate before classifying

Two long-run plans can change all inputs. Plan A produces 40 units at total cost \$600; plan B produces 60 at total cost \$1080. Does higher total cost alone establish diseconomies?

$LRATC = TC/Q = 600/40 = \$15$ per unit for A; $LRATC = 1080/60 = \$18$ per unit for B. Rising average cost establishes diseconomies over this output range. Total cost can rise while average cost falls, so total cost alone is insufficient.



Classify by average cost: LRATC rises from 15to18, so diseconomies

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Physical returns to scale compares output after **all inputs** increase proportionately, with technology fixed. If every input doubles, more than double output means increasing returns, exactly double means constant returns, and less than double means decreasing returns. At unchanged input prices, increasing returns can lower average cost; input-price changes also affect cost. This differs from adding labor while holding an oven fixed.

Minimum efficient scale 最小有效规模 is the smallest output at minimum LRATC. When this scale is large relative to market demand, fewer firms can operate at that scale, helping explain market concentration. It does not by itself prove monopoly.

Types of Profit

Economists count all opportunity costs, including the owner's. **Explicit costs** 显性成本 are out-of-pocket payments; **implicit costs** 隐性成本 are the opportunity costs of owner-supplied resources, such as forgone salary and interest.

Accounting profit 会计利润 is revenue minus explicit costs. **Economic profit** 经济利润 also subtracts implicit costs. **Normal profit** 正常利润 means zero economic profit: every opportunity cost is covered. It can include positive accounting profit and income for the owner.

■ **Worked example: one year's shop accounts**

Revenue is \$200,000 and payments for rent, wages and materials are \$120,000. The owner gives up a \$70,000 salary and \$5,000 interest on savings invested in the shop. Treat these as all relevant costs over the same year. Calculate the two profits before reading the answers.

Accounting profit $= TR - EC = 200,000 - 120,000 = \$80,000$.

Implicit costs $= 70,000 + 5,000 = \$75,000$.

Economic profit $= TR - EC - IC = 200,000 - 120,000 - 75,000 = \$5,000$.

On these complete data, the business pays more than its next-best alternative. Positive accounting profit alone cannot establish that conclusion: with \$90,000 implicit costs, the same accounting profit would imply an economic loss of \$10,000. Short-run operation and long-run exit still require their own comparisons below.

Profit Maximization

For a smooth interior optimum, use $MR = MC$ with MC crossing MR from below. Compare feasible total profits and shutdown too. With discrete output, equality may never occur.

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■ **Worked example: choose the best operating output**

A price-taking firm can sell at \$8 per unit. All costs are economic costs. Its unavoidable fixed cost this period is \$32. For continuous output q, the cost model is:

$$TC = 32 + 2q + \tfrac{1}{2}q^2, \qquad VC = 2q + \tfrac{1}{2}q^2, \qquad MC = 2 + q.$$

This simple numerical model has $AVC = 2 + \frac{1}{2}q$, rising for positive output, rather than the U-shaped AVC in the earlier schematic. The marginal-versus-average logic still applies.

A price taker has $MR = P = 8$. Why use the marginal rule? Additional units before the crossing add more revenue than cost; beyond it, extra cost exceeds extra revenue.

$$MR = MC$$

$$8 = 2 + q$$

$$q = 8 - 2 = 6 \text{ units.}$$

Revenue is $TR = Pq = 8(6) = \$48$.

Variable cost is $VC = 2q + \frac{1}{2}q^2 = 2(6) + \frac{1}{2}(6)^2 = \$30$.

Economic profit is $\pi = TR - FC - VC = 48 - 32 - 30 = -\$14$. The best operating output makes a loss; that does not yet prove shutdown is preferable.

■ **Discrete choices: compare all feasible profits**

A different firm sells indivisible units at \$8 each. Its complete feasible outputs are 0, 1, 2, 3 and 4. Total costs are respectively \$10, \$14, \$19, \$26 and \$36. Calculate revenue and profit at each output.

$TR = Pq$ gives \$0, \$8, \$16, \$24 and \$32. $\pi = TR - TC$ gives −\$10, −\$6, −\$3, −\$2 and −\$4. Choose three units. The third unit adds \$8 revenue and \$7 cost; the fourth adds \$8 revenue and \$10 cost. No MR=MC equality is needed, and three units beat zero output despite making a loss.

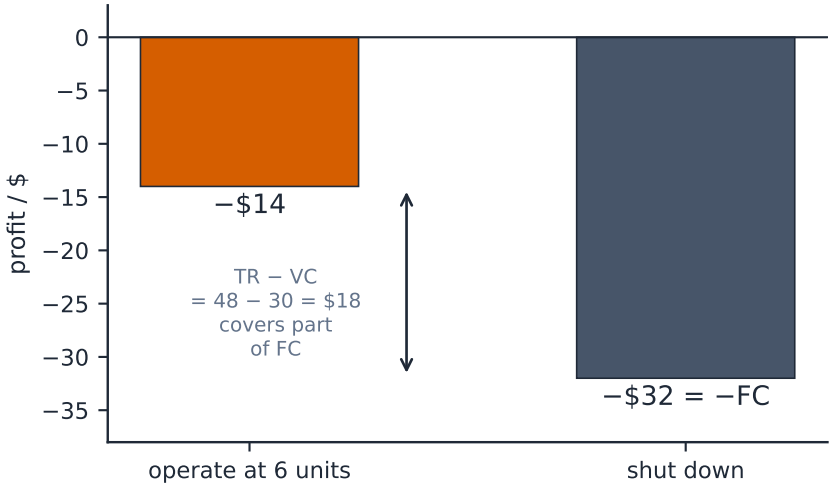
Deciding to Produce, Enter, or Exit

For a price taker, compare price with **average variable cost** at its best positive operating output. If $P > AVC$, revenue covers variable cost and contributes toward fixed cost; operating is preferable to shutdown when fixed cost is unavoidable. If $P < AVC$, shutdown is preferable. At $P = AVC$, the choices can give equal losses. In the standard cost model, the firm's short-run supply is the rising MC segment above minimum AVC, with zero supply below the shutdown price.

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■ **Worked decision: minimize the short-run loss**

For the continuous-output firm above, operating at six units gives a \$14 loss. Shutting down makes output and variable cost zero, but leaves \$32 fixed cost: $\pi = -FC = -\$32$. Operating reduces the loss by \$18 because $TR - VC = 48 - 30 = \$18$ contributes to fixed cost.



At a price of \$8 operating loses less than shutting down

At this output, $AVC = VC/q = 30/6 = \$5$ and $ATC = TC/q = 62/6 \approx \$10.33$. Price \$8 is below ATC but above AVC. A loss and a decision to operate can therefore coexist.

If price instead falls to \$1, every positive output has $TR = q < VC = 2q + \frac{1}{2}q^2$. No positive output covers variable cost. The firm shuts down and loses the unavoidable \$32.

For a separate boundary case, suppose the best positive output is five units at price \$4, with VC\$20 and unavoidable FC\$10. $TR = Pq = 4(5) = \$20 = VC$; operating profit is $\pi = 20 - 20 - 10 = -\$10$, equal to shutdown profit $\pi = -FC = -\$10$.

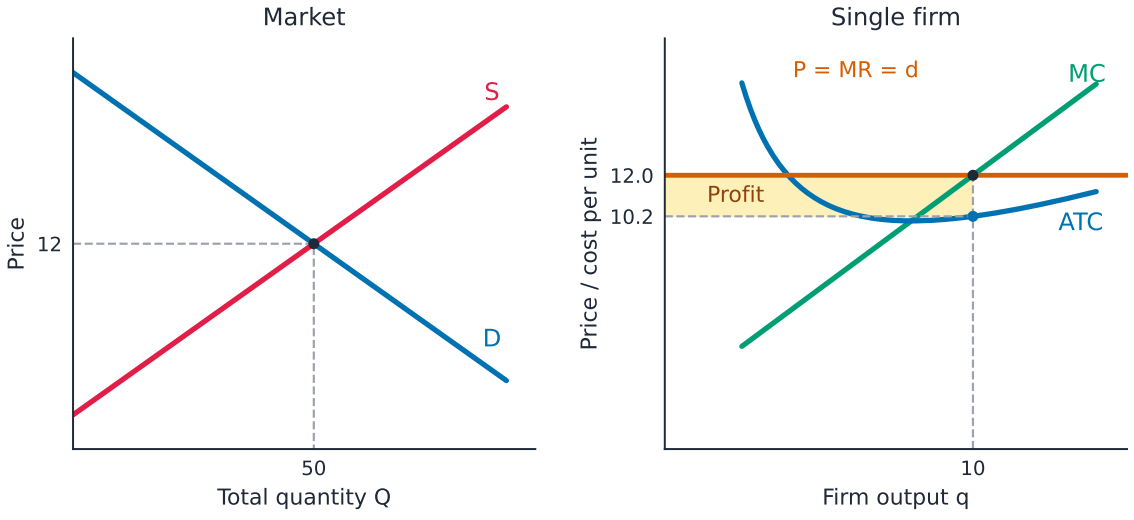
Entry 进入 and **exit** 退出 are long-run decisions. When commitments can change, expected continuing economic losses encourage exit and expected positive economic profit encourages entry if entry is free. A temporary loss does not alone establish that leaving the industry is best. Normal profit permits a firm to stay: its next-best resource uses are already compensated.

Perfect Competition

A **perfectly competitive** 完全竞争 market has many small firms, identical products, free entry and exit, and perfect information. Each firm is a **price taker** 价格接受者. Its horizontal demand curve is at the market price, with $P = MR = AR$. The whole market still has downward-sloping demand.

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If identical products remain available from other sellers at \$12, one tiny seller charging \$13 sells nothing and earns zero revenue. This conclusion depends on the ideal market assumptions; it is not a claim that any real business raising price loses all customers.



Market price becomes the firm's horizontal MR line; the profit rectangle uses ATC at the chosen output

■ Read the market and firm graphs separately

The market shown has inverse demand $P = 22 - 0.2Q$ and supply $P = 2 + 0.2Q$. Equality gives market quantity $Q = 50$ and price $P = 12$. Market quantity Q aggregates firms; individual output q uses a separate axis.

For the continuous-output firm, $MC = 2 + q = 12$ gives $q = 10$. $TC = 32 + 2(10) + \frac{1}{2}(10)^2 = \$102$, so $ATC = TC/q = 102/10 = \$10.20$. Profit is $\pi = (P - ATC)q = (12 - 10.2)10 = \$18$. Read ATC at ten units, not at its minimum eight-unit output. The graph's curves come from this same cost model; MC is already rising throughout its positive-output range.

■ One firm can earn profit, normal profit or a loss

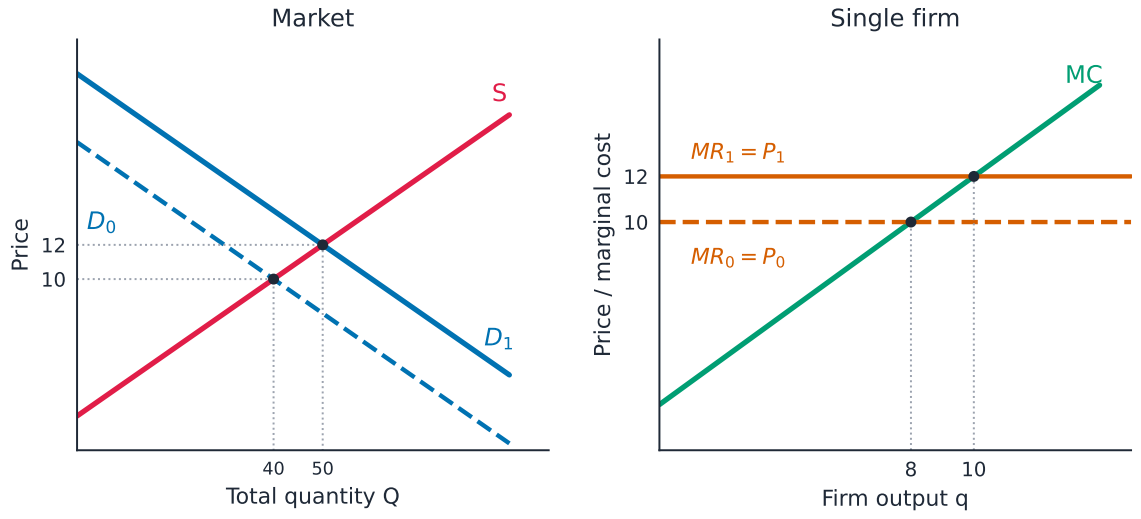
With the same cost model, price \$12 gives $q = 10$, TR\$120, TC\$102 and profit\$18. Price \$10 gives $q = 8$, TR\$80, TC\$80 and zero economic profit. Price \$8 gives $q = 6$, TR\$48, TC\$62 and loss\$14, with operation still preferable to shutdown. These are separate market-price cases, not choices the price-taking firm sets itself.

■ Demand shock and long-run entry

Suppose the market initially has demand $P = 18 - 0.2Q$ and supply $P = 2 + 0.2Q$, giving $Q = 40$ and $P = 10$. The typical firm produces eight units at minimum ATC and earns normal profit. A permanent increase in demand to $P = 22 - 0.2Q$ gives short-run $Q = 50$ and $P = 12$. Market demand shifts right; the firm's horizontal MR line rises. Its cost curves stay unchanged unless input costs or productivity change.

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Firm output rises from eight to ten and profit becomes \$18.



Market quantity rises from 40 to 50; the individual firm's output rises from 8 to 10 before entry

■ Entry in a constant-cost industry

In a **constant-cost industry** 成本不变行业, new firms can enter without changing input prices or firms' cost curves. Profit attracts entry, market supply shifts right, and long-run price returns to the unchanged minimum ATC of \$10. With the higher demand, market quantity becomes $Q = (22 - 10)/0.2 = 60$. Each typical firm returns to eight units. More firms can raise total market output while each incumbent makes less than at the short-run peak. The model treats entry continuously; these graph quantities are illustrative scales, not a literal count of firms.

After a demand fall, continuing losses encourage exit and supply shifts left. Adjustment takes time and relies on the entry/exit assumptions.

■ Industry costs can change as the market expands

Return to an initial price of \$10. Suppose higher demand and industry expansion leave the new minimum average cost at \$10 in industry A, \$11 in B and \$9 in C. With free entry and comparable firms, zero-economic-profit long-run prices are respectively \$10, \$11 and \$9. A is constant-cost. B is an **increasing-cost industry** 成本递增行业; C is a **decreasing-cost industry** 成本递减行业. Scarcer inputs can raise input prices as an industry expands; external economies can lower costs. This is different from a single firm's internal economies or diseconomies of scale. Do not promise that price always returns to its original level.

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■ Efficiency: two tests

Productively efficient 生产效率 output is at minimum ATC. **Allocatively efficient** 配置效率 output satisfies $P = MC$ when private marginal costs and benefits equal social ones. In the competitive long-run benchmark, operating firms satisfy $P = MC = \min ATC$ and earn normal profit. A short-run price-taking firm can satisfy $P = MC$ while producing away from minimum ATC.

Draw separate market and firm axes, label their different quantities, show the relevant demand/supply or MR/cost curves, and mark the profit/loss rectangle before explaining entry or exit. The 2024 Set 1 soybean task explicitly requires this graph sequence; the 2024 Set 2 production task requires output-based AFC/MC calculations and numerical diminishing-returns and scale explanations.

■ Worked example: a lump-sum subsidy in long-run equilibrium

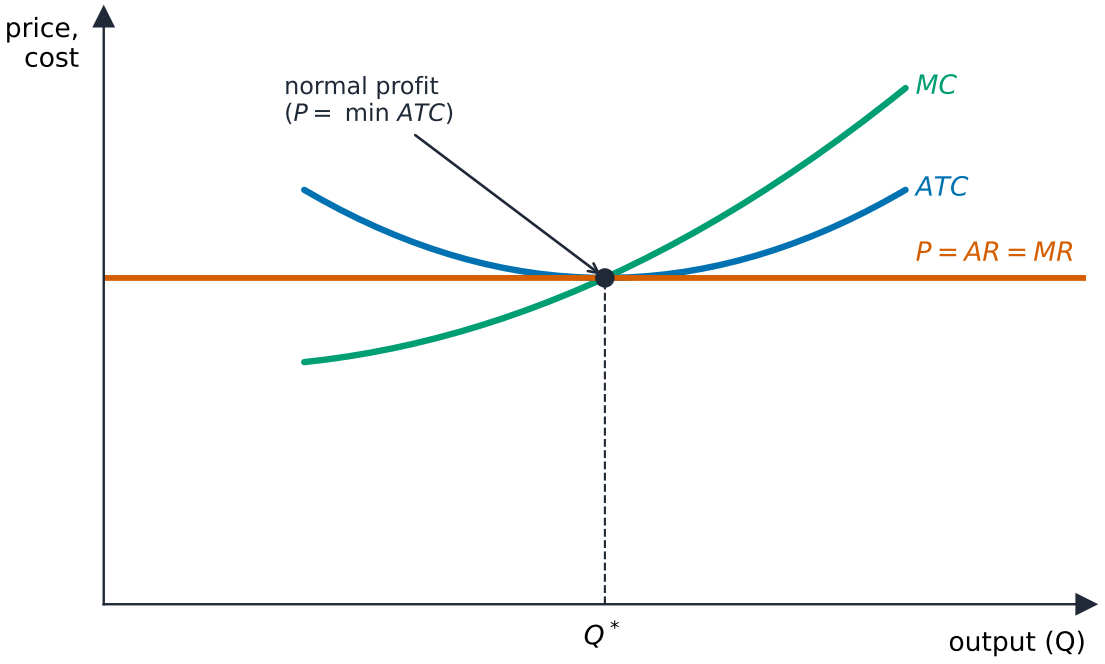
A constant-cost perfectly competitive industry is in long-run equilibrium. The government then gives every firm a lump-sum subsidy each year. State what happens to the typical firm's output and profit in the short run, and to market price, firm output and the number of firms in the long run.

Short run. The subsidy lowers FC, AFC and ATC, but MC is unchanged. Price is unchanged, so $P = MC$ gives the same output. ATC is now below price at that output, so the firm earns positive economic profit.

Long run. Profit attracts entry; market supply shifts right and price falls. Price stops at the new, lower minimum ATC. Since MC is unchanged and the lower ATC curve now meets MC further down MC, minimum ATC is at a **smaller** output. Each firm produces less, market quantity is larger, so there are **more firms**. Profit returns to zero.

A lump-sum tax works the other way: short-run losses with unchanged output, then exit, a higher long-run price, larger output per firm and fewer firms.

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Long-run competitive equilibrium: MC meets the horizontal price line at minimum ATC

Exam tips

- Show the formula, substitute the data, and give units. Separate total, average and marginal values.
- Label market and firm graphs separately; mark output, price and the profit or loss rectangle.
- State which inputs are fixed before explaining diminishing returns or returns to scale. Check shutdown separately from the best operating output.

Common mistakes.

- Blaming the upward slope of LRATC on diminishing marginal returns. Diminishing returns needs a fixed input, so it is short-run; rising LRATC is diseconomies of scale.
- Saying a firm should shut down because it makes a loss. The test is $P < AVC$, not $P < ATC$.
- Shifting MC after a lump-sum tax, fee or subsidy. Only per-unit costs move MC.
- Reading profit as $(P - \min ATC)q$. Use ATC at the chosen output.
- Drawing the firm's demand as downward sloping, or drawing the market and the firm on one graph with one quantity label.
- Claiming that market price rises when one competitive firm raises its price. That firm sells nothing; its total revenue falls to zero.

Practice.

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1. A workshop with one machine has total product 0, 12, 30, 42 and 48 units with 0, 1, 2, 3 and 4 workers. (a) Calculate the marginal product of each worker. (b) Which worker begins diminishing marginal returns? (c) Calculate average product with four workers.
2. A firm has fixed cost \$60. Total cost is \$160 at five units and \$186 at six units. Calculate (a) AVC at five units, (b) ATC at five units, (c) AFC at six units and (d) the marginal cost of the sixth unit.
3. A price-taking firm has $FC = \$20$, $VC = q + \frac{1}{2}q^2$ and $MC = 1 + q$. Price is \$9. (a) Find the profit-maximizing output. (b) Calculate economic profit. (c) If the industry has free entry, what happens to price in the long run, and why?
4. For the same firm, price falls to \$4. (a) Find the best positive output. (b) Should the firm operate or shut down in the short run? Show the comparison.
5. A constant-cost perfectly competitive industry is in long-run equilibrium when the government imposes a lump-sum tax on each firm. State the short-run effect on the typical firm's output and profit, and the long-run effect on market price, firm output and the number of firms.
6. Plan A produces 100 units at total cost \$2,000; plan B produces 200 units at total cost \$3,600. All inputs can vary. Does the firm experience economies or diseconomies of scale over this range? Show your work.
7. A competitive firm's ATC at its profit-maximizing output is \$15 and price is \$12. Average variable cost there is \$10. Is the firm earning a profit, a normal profit or a loss? Should it keep operating in the short run? What happens to the number of firms in the long run?

Answers.

1. (a) MP = 12, 18, 12, 6. (b) The third worker: MP falls from 18 to 12. (c) $AP = 48/4 = 12$ units per worker.
2. (a) $VC = 160 - 60 = 100$, so $AVC = 100/5 = \$20$. (b) $ATC = 160/5 = \$32$. (c) $AFC = 60/6 = \$10$. (d) $MC = 186 - 160 = \$26$.
3. (a) $9 = 1 + q$, so $q = 8$. (b) $TR = 72$, $VC = 8 + 32 = 40$, $\pi = 72 - 40 - 20 = \$12$. (c) Positive economic profit attracts entry; market supply shifts right and price falls until it equals minimum ATC, where profit is zero.
4. (a) $4 = 1 + q$, so $q = 3$. (b) $AVC = 1 + \frac{1}{2}(3) = \$2.50 < P = \$4$, so operate. Operating: $\pi = 12 - 7.5 - 20 = -\$15.50$; shutting down: $-\$20$. Operating loses \$4.50 less.
5. Short run: MC is unchanged, so output is unchanged; ATC rises, so the firm makes a loss. Long run: firms exit, supply shifts left and price rises to the new higher minimum ATC; that minimum is at a larger output, so each remaining firm produces more; there are fewer firms.
6. $LRATC_A = 2000/100 = \$20$; $LRATC_B = 3600/200 = \$18$. Average cost falls as output rises, so economies of scale.

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7. A loss, because $P < ATC$. Keep operating, because $P = \$12 > AVC = \$10$: revenue covers variable cost and part of fixed cost. In the long run, if losses continue, firms exit and the number of firms falls.

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Imperfect Competition

AP Microeconomics

Imperfect Competition and Market Power

Why it matters. While a new medicine is protected by a patent, one company sells it and can charge far more than it costs to make. When the patent expires, other firms sell identical copies, and the price usually falls a long way. The same pill, made in the same factories, sells at very different prices depending on how many sellers there are. This unit explains why market structure changes price, output and who gains.

A car maker can offer a different design from its rivals. A **patent** 专利 can stop rivals from copying a product. These are possible sources of **market power** 市场势力: some ability to choose price, subject to buyers' demand. A large factory alone does not prove that the firm has market power. We must identify the market, **substitutes** 替代品 and entry conditions.



A car assembly line: scale alone does not show whether buyers have close substitutes

In an **imperfectly competitive** 不完全竞争 product market, the firm faces downward-sloping demand. Under **uniform pricing** 统一定价, every buyer pays the same price. To sell more, the firm cuts the price of all units. The revenue lost on earlier units makes **marginal revenue** 边际收入 lower than price. This statement concerns uniform pricing; perfect price discrimination works differently.

> **Worked example: extra revenue.** Demand is $P = 110 - Q$, with price in dollars per unit and Q in units per period. At $Q = 1$, $P = \$109$; at $Q = 2$, $P = \$108$.

$$TR = P \times Q = \$109 \times 1 = \$109$$

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$$TR = P \times Q = \$108 \times 2 = \$216$$

$$MR = \Delta TR/\Delta Q = (\$216 - \$109)/(2 - 1) = \$107 \text{ per unit}$$

The extra unit brings \$108, but the price cut loses \$1 on the first unit. Net extra revenue is \$107, below the new price. For this linear demand, the continuous marginal revenue curve is $MR = 110 - 2Q$: the same intercept and twice the slope. The discrete second-unit revenue is measured over an interval; do not substitute $Q = 2$ into the continuous curve and expect the interval average.



Market structures range from perfect competition to monopoly

Structure	Sellers and product	Entry
Perfect competition 完全竞争	Many; identical product	Free
Monopolistic competition	Many; different products	Easy
Oligopoly	Few major sellers	Barriers
Monopoly	One seller; no close substitutes	Barriers

The spectrum is a guide, not evidence that every industry fits perfectly. **Barriers to entry** 进入壁垒 include patents, control of key resources and large **economies of scale** 规模经济. They can protect **economic profit** 经济利润; they do not guarantee it. **Monopsony** 买方垄断 is buyer power and belongs to factor-market analysis in Unit 5.

Monopoly

A **monopoly** 垄断 is one seller of a product with no close substitutes, protected by entry barriers. It chooses quantity using marginal revenue and **marginal cost** 边际成本, then reads the price buyers will pay from demand. It cannot choose any price and quantity independently.

One model for output, profit and welfare. Demand is $P = 110 - Q$, $MR = 110 - 2Q$, and $MC = 20 + Q$. Total cost is $TC = 600 + 20Q + 0.5Q^2$, so $ATC = 600/Q + 20 + 0.5Q$. Money is in dollars; output is units per period. **Fixed cost** 固定成本 \$600 is unavoidable this period. There are no external costs or benefits. The rising MC crosses falling MR, so their intersection is the profit maximum for this model.

$$MR = MC \quad \Rightarrow \quad 110 - 2Q = 20 + Q$$

$$Q_M = (110 - 20)/3 = 30 \text{ units}$$

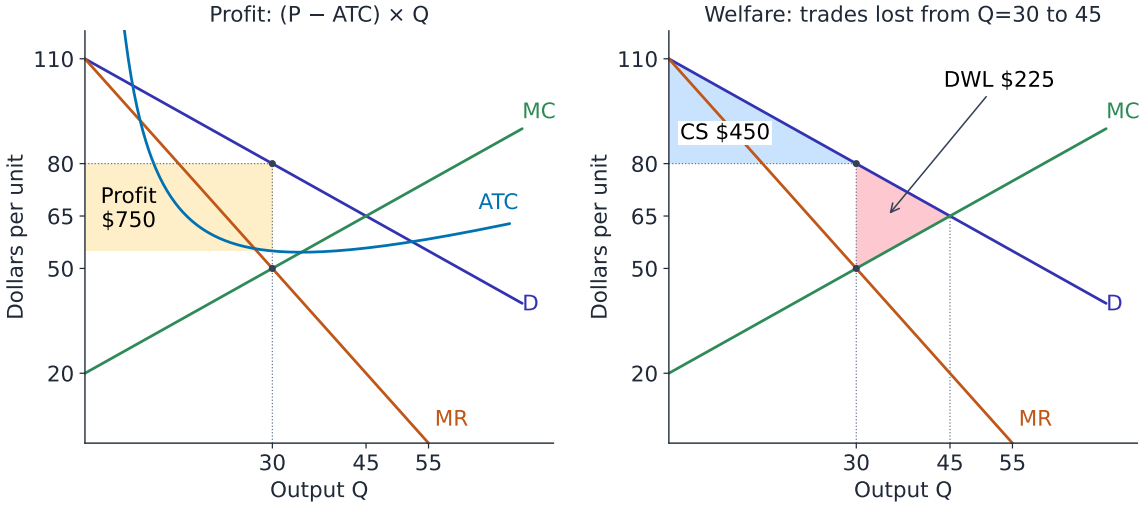
$$P_M = 110 - Q_M = 110 - 30 = \$80 \text{ per unit}$$

Profit needs average total cost, not marginal cost. Read **average total cost** 平均总成本 (ATC) at the chosen output, rather than its minimum unless those happen to coincide.

$$ATC = 600/Q + 20 + 0.5Q = 600/30 + 20 + 0.5(30) = \$55 \text{ per unit}$$

$$\pi = (P - ATC)Q = (80 - 55) \times 30 = \$750$$

Here $P - MC = 80 - 50 = \$30$, while $P - ATC = 80 - 55 = \$25$. Profit is the rectangle of height $P - ATC$ and width Q_M, not a rectangle using MC. A price–MC gap alone does not tell us total profit.



Left: profit uses ATC. Right: welfare uses demand and MC. These are different areas.

Consumer surplus and deadweight loss. **Consumer surplus** 消费者剩余 is buyers' **willingness to pay** 支付意愿 above the uniform price. Efficient output equates demand (marginal benefit) to MC, given the no-externality assumption.

$$CS = \tfrac{1}{2}(P_{\text{intercept}} - P_M)Q_M = \tfrac{1}{2}(110 - 80) \times 30 = \$450$$

$$P = MC \quad \Rightarrow \quad 110 - Q = 20 + Q$$

$$Q_E = (110 - 20)/2 = 45 \text{ units}$$

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$$DWL = \tfrac{1}{2}(Q_E - Q_M)(P_M - MC_M) = \tfrac{1}{2}(45-30)(80-50) = \$225$$

Deadweight loss 无谓损失 is lost gains from trades between 30 and 45 units. For these units buyers' willingness to pay exceeds MC, but a uniform-price monopolist does not sell them. The \$30 price–MC gap is the triangle's height, not its area. The triangle formula applies here because both curves are straight lines.

Producer surplus 生产者剩余 is revenue less **variable cost** 可变成本; economic profit also subtracts fixed cost. In this model:

$$VC = 20Q + 0.5Q^2 = 20(30) + 0.5(30)^2 = \$1,050$$

$$PS = TR - VC = 80(30) - 1,050 = \$1,350$$

$$\pi = PS - FC = 1,350 - 600 = \$750$$

Profit is not the same as producer surplus when fixed cost is positive. Adding CS and PS gives **total surplus** 总剩余 of \$1,800; the \$225 loss is surplus that no buyer or seller receives.

A monopoly can make a loss. Raise this model's fixed cost to \$1,500, leaving demand, MR and MC unchanged. Its profit-maximizing output is still 30 and price still \$80.

$$ATC = 1,500/Q + 20 + 0.5Q = 1,500/30 + 20 + 0.5(30) = \$85$$

$$\pi = (P - ATC)Q = (80 - 85) \times 30 = -\$150$$

It still operates this period because revenue \$2,400 covers variable cost \$1,050 and contributes to unavoidable fixed cost. Barriers stop entry; they do not create enough demand to guarantee profit.

Revenue maximization is a different objective. For the original model, total revenue is maximized where MR reaches zero:

$$MR = 0 \quad \Rightarrow \quad 110 - 2Q = 0$$

$$Q_R = 110/2 = 55 \text{ units}; \qquad P_R = 110 - Q_R = \$55$$

Demand is **unit elastic** 单位弹性 at this revenue maximum. Above it on the linear demand curve demand is **elastic** 富有弹性 and MR positive; below it demand is **inelastic** 缺乏弹性 and MR negative. With positive MC, profit maximization occurs

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in the elastic portion, at a smaller output than revenue maximization. Do not label the MR-zero quantity as the profit maximum.

Changing entry conditions. If a patent expires and close substitutes enter, demand facing the original firm becomes more elastic. This is a statement about that firm's demand, not a claim that total market demand must fall by the same amount.

> **Worked example: patent expiry and surplus.** A drug monopolist sells 30 units at \$80. After the patent expires, a rival sells an identical drug and the market price falls to \$65 with 45 units sold in total. *Consumer surplus* rises: buyers already in the market pay \$15 less, and new buyers whose willingness to pay lies between \$65 and \$80 now buy. The original firm's *producer surplus* falls: it loses some customers and earns less on each unit it still sells. Part of the old profit becomes consumer surplus, and the old deadweight loss shrinks.

■ Natural monopoly and regulation

A **natural monopoly** 自然垄断 occurs when one firm can supply the market at lower average cost than multiple firms: long-run average cost falls across the relevant market demand.



A utility plant: investigate costs and substitutes before calling its market a natural monopoly

Use a separate simplified utility model: $TC = 1,200 + 20Q$, $MC = 20$, $ATC = 1,200/Q + 20$, demand $P = 100 - Q$. Treat this as its relevant long-run cost schedule. Fixed network cost makes average cost fall as output expands.

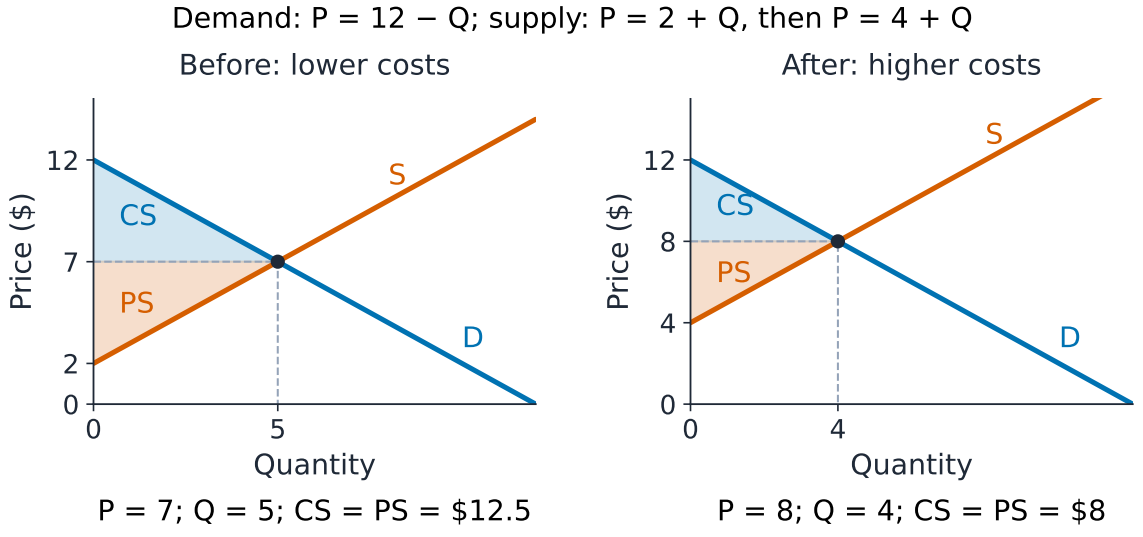
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Pricing rule	Output Q	Price	ATC	Economic profit
Unregulated MR=MC	40	\$60	\$50	\$400
Marginal-cost pricing	80	\$20	\$35	−\$1,200
Fair-return P=ATC	60	\$40	\$40	\$0

At $P = MC = \$20$, efficient output is 80, but price does not cover average cost. The loss is $\$1,200$, requiring a **subsidy** 补贴 or another funding method if supply continues. Fair-return pricing at the larger-output demand–ATC intersection covers costs, including normal return, but output 60 remains below efficient output 80. $P = ATC$ does not mean **productive efficiency** 生产效率: ATC is still falling. **Antitrust** 反垄断 policy addresses competition and entry; natural-monopoly price **regulation** 管制 is a distinct policy choice.

Price Discrimination

Price discrimination 价格歧视 means different prices for the same good that are not explained by differences in supply cost. The seller needs market power, a way to identify willingness to pay, and limits on **resale** 转售. A cheaper student ticket with the same seat and service is a possible example; a higher price for a more costly premium service alone is not proof.



Consumer surplus is the area below demand and above the price; producer surplus is the area above supply and below the price.

Test the conditions. A cinema can check student identification and make tickets personal. It can keep the lower-price group separate. If discounted tickets can be freely resold, buyers can avoid the higher price and the separation breaks down. Differences in demand elasticity can support group pricing; student discounts do not reveal every buyer's exact willingness to pay.

Under **perfect price discrimination**, each unit sells for its buyer's maximum willingness to pay. There is no uniform price cut on earlier units, so marginal revenue for the next unit follows demand. With no externalities, the firm sells all units for which willingness to pay covers MC.

For the original monopoly model, set demand equal to MC: $110 - Q = 20 + Q$, giving $Q = 45$ and the lowest price $P = 110 - 45 = \$65$. Earlier units sell at higher prices along demand. Consumer surplus becomes zero because each buyer pays their maximum willingness to pay; the \$225 deadweight loss disappears. Producer surplus is now the whole triangle between demand and MC, from zero to 45 units.

$$PS = \tfrac{1}{2}(P_{\text{intercept}} - MC_{\text{intercept}})Q_E = \tfrac{1}{2}(110 - 20) \times 45 = \$2,025$$

$$\pi = PS - FC = 2,025 - 600 = \$1,425$$

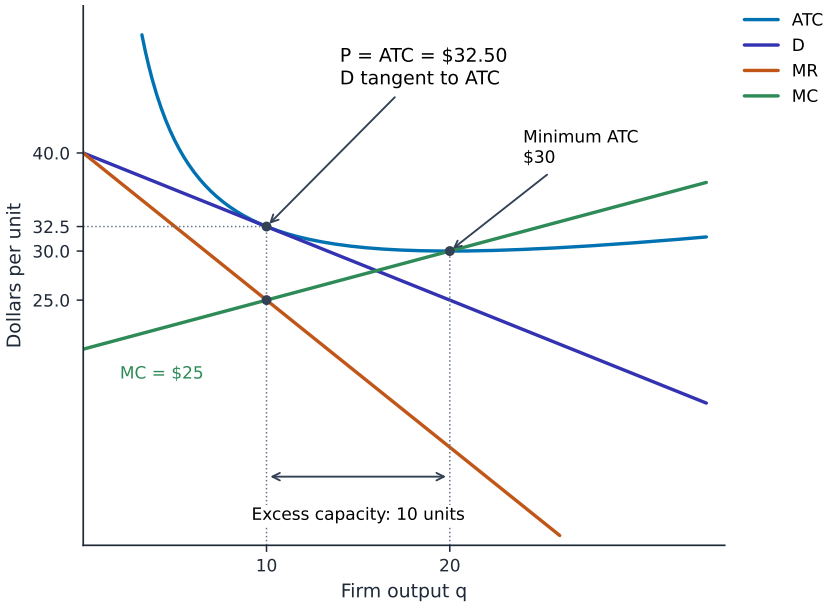
Capturing consumer surplus is not the same as making every dollar of revenue profit.

Monopolistic Competition

Monopolistic competition 垄断竞争 has many firms selling **differentiated** 差异化 products, with easy entry and exit. A restaurant can offer different food or service from its neighbours, so its own demand slopes down. Advertising and product design are forms of **non-price competition** 非价格竞争.

In the short run, choose output where MR crosses MC, then read price and ATC at that output. Profit, loss or zero economic profit are all possible. Positive economic profit attracts entry. More substitutes reduce demand facing each existing firm and tend to make it more elastic. Losses lead to exit, increasing demand for remaining firms. In the long-run model, this process ends at zero economic profit: demand is **tangent** 相切 to ATC at the MR=MC output.

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Demand touches ATC at q=10; minimum ATC occurs at q=20. Zero profit does not remove the price–MC gap.

Read the long-run graph. The firm produces 10 units at $P = ATC = \$32.50$. MC there is \$25. Minimum ATC is \$30 at 20 units.

$$\pi = (P - ATC)q = (32.50 - 32.50) \times 10 = \$0$$

$$\text{Excess capacity} = q_{\min ATC} - q_{\text{actual}} = 20 - 10 = 10 \text{ units}$$

Excess capacity 过剩产能 means producing below the quantity that minimizes ATC, not necessarily shelves of unsold stock. The firm is not productively efficient and, with no externalities, $P > MC$ means **allocative inefficiency** 配置无效率. Zero economic profit includes a normal return; it does not mean owners receive no income. Product variety is a benefit outside these simple cost-efficiency comparisons.

For a reproducible graph, $D : P = 40 - 0.75q$, $MR = 40 - 1.5q$, $MC = 20 + 0.5q$, $ATC = 100/q + 20 + 0.25q$. At $q = 10$, MR=MC=25 and demand touches ATC at 32.50. MC crosses minimum ATC at $q = 20$. Do not draw D tangent at minimum ATC while also showing a downward-sloping firm demand and MR=MC to its left.

Oligopoly and Game Theory

An **oligopoly** 寡头垄断 has a few major sellers and entry barriers. Firms are **interdependent** 相互依存: each firm's profit depends on its own decision and rivals' decisions. **Game theory** 博弈论 studies such choices. **Colluding** 勾结 means cooperating to raise joint profit; **cartels** 卡特尔 coordinate members' prices or output.

A member may gain from cheating, but this incentive does not prove every cartel immediately collapses.

A **payoff matrix** 收益矩阵 shows the result of every combination of choices. In the following games, firms choose independently and simultaneously, know the table, and do not cooperate. Entries are profits in millions of dollars, with A first and B second. Compare only the deciding firm's payoff, holding the other firm's choice fixed.

■ Game 1: cooperation and individual incentives

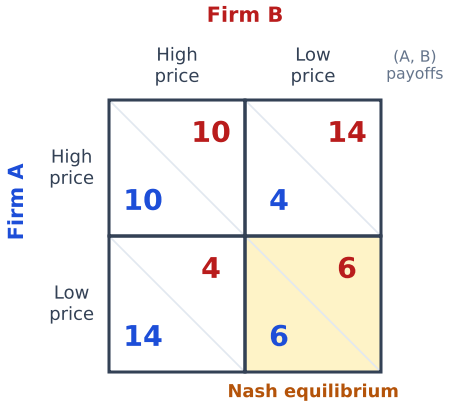
A's choice	B: High price	B: Low price
High price	(10, 10)	(4, 14)
Low price	(14, 4)	(6, 6)

Try first. Does A prefer Low for each possible B choice? Check B separately. Can either firm gain by switching alone from (Low, Low)? Which combination maximizes combined profit?

A **dominant strategy** 优势策略 is better regardless of the rival's choice. For A, if B chooses High, Low gives 14 rather than 10. If B chooses Low, Low gives 6 rather than 4. Thus Low is A's dominant strategy. For B, if A chooses High, Low gives 14 rather than 10; if A chooses Low, Low gives 6 rather than 4. Low is also B's dominant strategy.

At (Low, Low), A switching alone gets 4 instead of 6; B switching alone also gets 4 instead of 6. Neither benefits. This is a **Nash equilibrium** 纳什均衡. Both would prefer (High, High), which gives 10 each and combined profit 20. But at that cooperative outcome each can raise its own profit to 14 by switching alone. This is a **prisoners' dilemma** 囚徒困境. The largest total payoff is not automatically a Nash equilibrium.

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A prisoners' dilemma: each firm's dominant strategy is Low, giving the Nash equilibrium

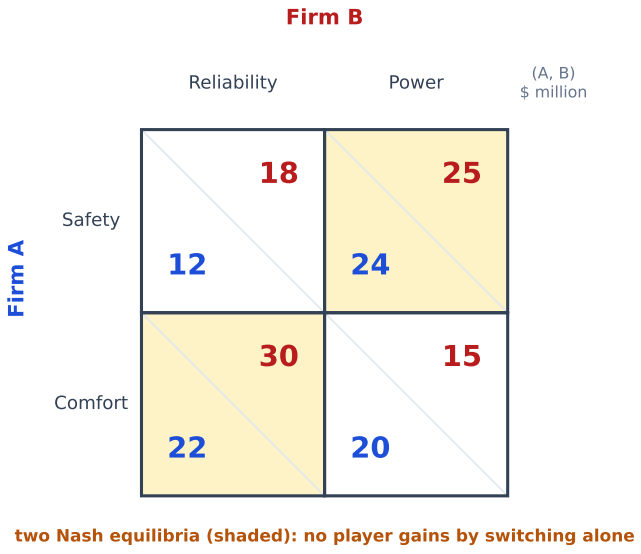
■ Game 2: a Nash equilibrium without A having a dominant strategy

A's choice	B: Reliability	B: Power
Safety	(12, 18)	(24, 25)
Comfort	(22, 30)	(20, 15)

These are new illustrative numbers, not a copied past-paper table. If B chooses Reliability, A prefers Comfort: 22>12. If B chooses Power, A prefers Safety: 24>20. A has no dominant strategy. B also has no dominant strategy: Power gives 25>18 when A chooses Safety, but Reliability gives 30>15 when A chooses Comfort.

Check both players at each outcome. (Safety, Power) is Nash: A switching gets 20 instead of 24, B switching gets 18 instead of 25. (Comfort, Reliability) is also Nash: A switching gets 12 instead of 22, B switching gets 15 instead of 30. The other cells each allow a profitable switch. A game can therefore have more than one pure-strategy Nash equilibrium even though neither player has a dominant strategy. Mixed strategies are outside this unit.

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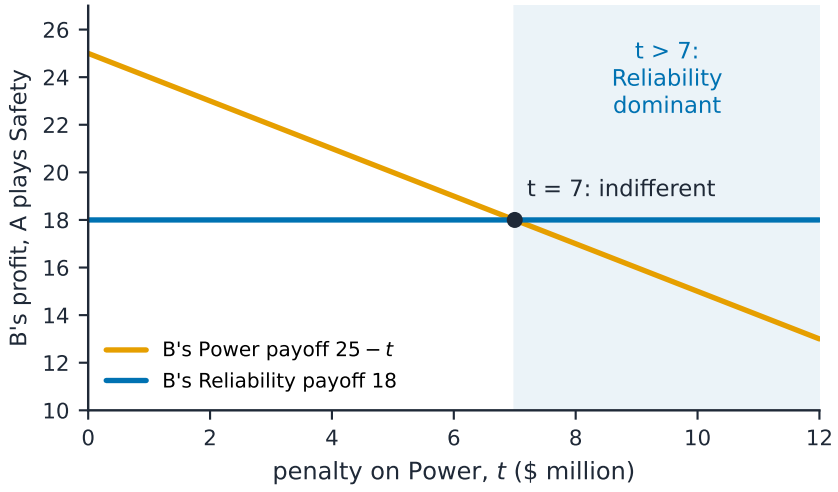


Game 2 has two Nash equilibria although neither firm has a dominant strategy

Change an incentive. Reduce B's profit from choosing Power by \$10 million in both Power cells. These become (24, 15) and (20, 5); A's payoffs and the Reliability column stay unchanged. B now prefers Reliability for either A choice: 18>15 and 30>5. A's **best response** 最优反应 is Comfort, so the unique Nash equilibrium becomes (Comfort, Reliability), paying (22, 30).

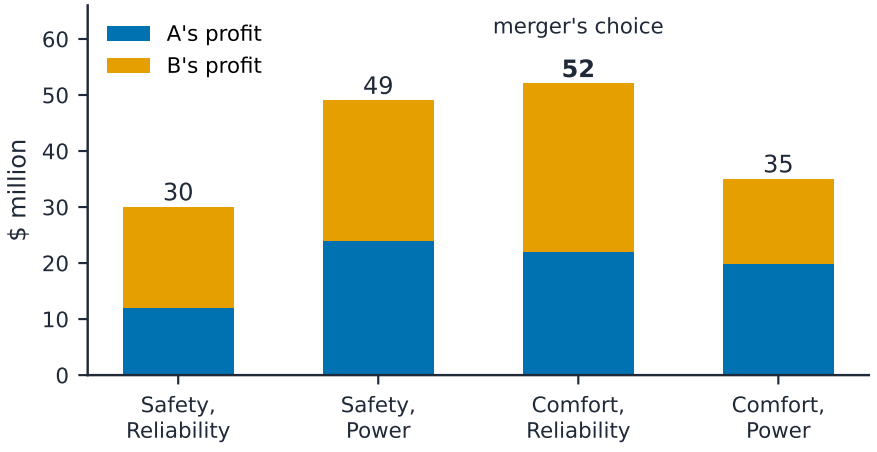
■ Incentive threshold and joint profit

Let the Power penalty be t. For Reliability to be strictly dominant for B, it must beat Power in both rows: $18 > 25 - t$ requires $t > 7$, and $30 > 15 - t$ requires $t > -15$. A nonnegative penalty must therefore exceed \$7 million. At exactly 7, B is indifferent in the Safety row; that is not strict dominance. If restricted to whole millions, 8 is the smallest sufficient penalty.



The penalty must exceed \$7 million before Reliability beats Power in the Safety row

A **merger** 合并 maximizing combined profit in the original Game 2 chooses (Comfort, Reliability): $22 + 30 = \$52$ million. The other totals are 30, 49 and 35. Always use the original or changed table specified by the question.



A merger looks at the total in each cell: Comfort with Reliability gives \$52 million

Worked FRQ: Monopoly and Government Policy

This long free-response question uses the monopoly model above: demand $P = 110 - Q$, $MR = 110 - 2Q$, $MC = 20 + Q$, $ATC = 600/Q + 20 + 0.5Q$.

(a) Draw a correctly labeled graph for the monopoly. Show the profit-maximizing quantity Q_M and price P_M, and shade the profit. Label the axes "Price" and "Quantity". Draw D, MR (below D, twice as steep), an upward-sloping MC and a U-shaped ATC. Mark Q_M where MR = MC (30 units), go **up to demand**

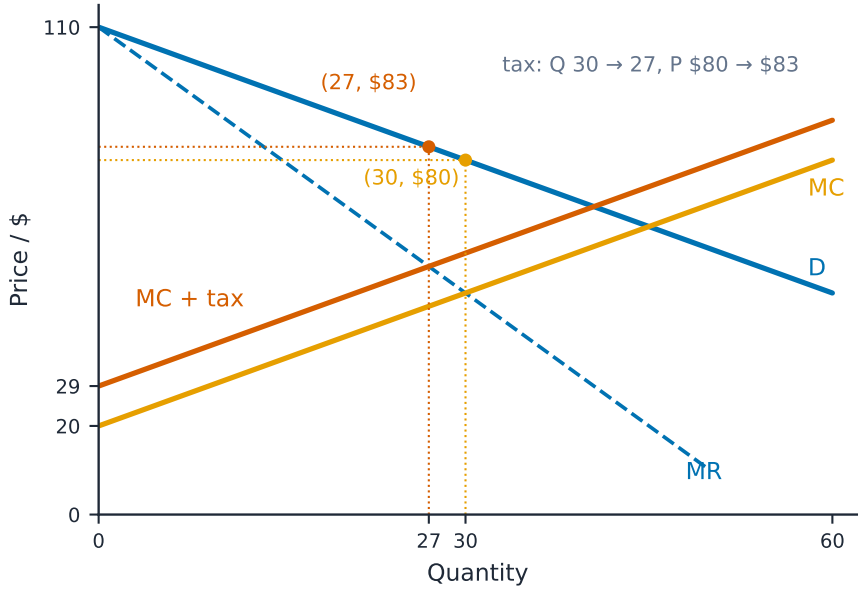
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for P_M (\$80), and shade the rectangle between P_M and ATC at Q_M (\$55): profit $= (80 - 55) \times 30 = \$750$.

(b) Is the monopoly allocatively efficient at Q_M? Explain. No. At 30 units $P = \$80$ but $MC = \$50$: buyers value the last unit more than it costs to make, so more output would add to total surplus. Allocative efficiency needs $P = MC$, which here is 45 units.

(c) The government charges the firm a lump-sum tax of \$300. What happens to Q_M, P_M and profit? A lump-sum tax is a fixed cost: it raises ATC but not MC. MR and MC do not change, so Q_M stays 30 and P_M stays \$80. Profit falls by the tax to $750 - 300 = \$450$. (ATC at 30 rises by $300/30 = \$10$, to \$65.)

(d) Instead, the government charges a per-unit tax of \$9. Calculate the new quantity and price, and state what happens to deadweight loss. A per-unit tax raises MC by \$9: $MC = 29 + Q$. Set $MR = MC$: $110 - 2Q = 29 + Q$, so $Q = 27$ and $P = 110 - 27 = \$83$. Output falls further below the efficient 45 units, so deadweight loss **increases**. Consumers pay \$3 more; the firm absorbs the other \$6 of the tax.



A per-unit tax raises MC: output falls to 27 and price rises to \$83

(e) Instead, the government sets a maximum price equal to the allocatively efficient price. Calculate that price and the new quantity. What happens to deadweight loss? Efficient output is where $P = MC$: $110 - Q = 20 + Q$, so $Q = 45$ and $P = \$65$. With a price ceiling of \$65, the firm's MR is \$65 for every unit up to 45 (it can sell up to 45 units at that price), so it produces where $65 = MC$: 45 units. Deadweight loss falls to **zero**. The firm still makes a profit: $ATC = 600/45 + 20 + 22.5 \approx \$55.83$, so profit $\approx (65 - 55.83) \times 45 \approx \$412.50$.

(f) Without any policy, what is the largest output at which the firm would

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earn zero economic profit? Label it Q_Z. Zero economic profit needs $P = ATC$, so find where demand meets ATC. $110-Q = 600/Q+20+0.5Q$ gives $1.5Q^2-90Q+600 = 0$, or $Q^2 - 60Q + 400 = 0$. The roots are $Q \approx 7.6$ and $Q \approx 52.4$. The **largest** is $Q_Z \approx 52.4$ units, to the right of Q_M, where demand cuts ATC from above. On the graph, mark the second crossing of D and ATC.

Scoring traps: reading price from MR instead of demand; shading profit with MC instead of ATC; saying a lump-sum tax changes output; forgetting that a price ceiling makes MR flat up to the demand curve.

Exam tips

- For a uniform-price monopoly, label D, MR, MC and ATC; find MR=MC, then read price on D and ATC at the same output. Shade profit separately from CS and DWL.
- Revenue maximization uses MR=0. Perfect price discrimination uses demand=MC to find the final unit and its lowest price.
- Zero long-run economic profit in monopolistic competition means P=ATC, not P=MC or minimum ATC.
- In a payoff matrix, show both comparisons for dominance and each player's possible unilateral switch for Nash. Recheck every changed payoff before finding a new equilibrium.

Practice.

1. A monopolist faces demand $P = 100 - 2Q$, so $MR = 100 - 4Q$. Marginal cost is constant at \$20 and fixed cost is \$200. Calculate (a) the profit-maximizing quantity and price, (b) economic profit, (c) consumer surplus, (d) deadweight loss, (e) the revenue-maximizing quantity and price.
2. The same monopolist can now perfectly price discriminate. Calculate its quantity, consumer surplus and economic profit.
3. Instead, the government places a per-unit tax of \$8 on the uniform-price monopolist in question 1. Find the new quantity and price. How much of the tax do buyers pay per unit?
4. A monopolistically competitive restaurant earns positive economic profit in the short run. State what happens in the long run to the demand it faces, its economic profit and whether it produces at minimum ATC.
5. Two firms each choose Advertise or Don't advertise. Payoffs are daily profits in dollars, (Firm A, Firm B).

	B: Advertise	**B: Don't advertise**
A: Advertise	(40, 40)	(70, 20)
A: Don't advertise	(20, 70)	(60, 60)

(a) Does Firm A have a dominant strategy? (b) Identify the Nash equilibrium. (c)

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Which pair of actions maximizes combined profit? Does either firm have an incentive to cheat on it? (d) The town now pays \$25 per day to any firm that does not advertise. Find the new Nash equilibrium.

Answers.

1. (a) $100 - 4Q = 20$, so $Q = 20$ and $P = 100 - 2(20) = \$60$. (b) $\pi = TR - TC = 1200 - (200 + 400) = \$600$. (c) $CS = \frac{1}{2}(100 - 60)(20) = \$400$. (d) Efficient output: $100 - 2Q = 20$, $Q = 40$; $DWL = \frac{1}{2}(60 - 20)(40 - 20) = \$400$. (e) $MR = 0$ gives $Q = 25$, $P = \$50$.
2. Demand meets MC at $Q = 40$. CS is zero. $\pi = \frac{1}{2}(100-20)(40)-200 = 1600-200 = \$1,400$.
3. $MC = 28$: $100 - 4Q = 28$ gives $Q = 18$, $P = 100 - 36 = \$64$. Buyers pay \$4 of the \$8 tax.
4. Profit attracts entry; demand facing the restaurant falls (shifts left) and becomes more elastic. Economic profit falls to zero ($P = ATC$, where demand is tangent to ATC). It produces less than the output at minimum ATC (excess capacity), so it is not productively efficient.
5. (a) Yes, Advertise: $40 > 20$ if B advertises and $70 > 60$ if B does not. (b) (Advertise, Advertise), with \$40 each; B's payoffs are symmetric. (c) (Don't, Don't) gives \$120 in total. Yes: either firm can switch to Advertise and earn \$70 instead of \$60. (d) Don't advertise now pays A \$45 or \$85. Since $45 > 40$ and $85 > 70$, Don't advertise is dominant for each firm. The new Nash equilibrium is (Don't, Don't), with \$85 each.

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Factor Markets

AP Microeconomics

Introduction to Factor Markets

Why it matters. In 2021 and 2022, many American hospitals paid temporary "travel nurses" two or three times their usual pay. Nothing about a nurse's work had changed. What changed was the value of an extra nurse to a hospital full of patients, and how many nurses were willing to work. Wages are prices too, set in markets for workers. This unit explains how firms decide how many workers to hire and what happens when one employer dominates a labour market.

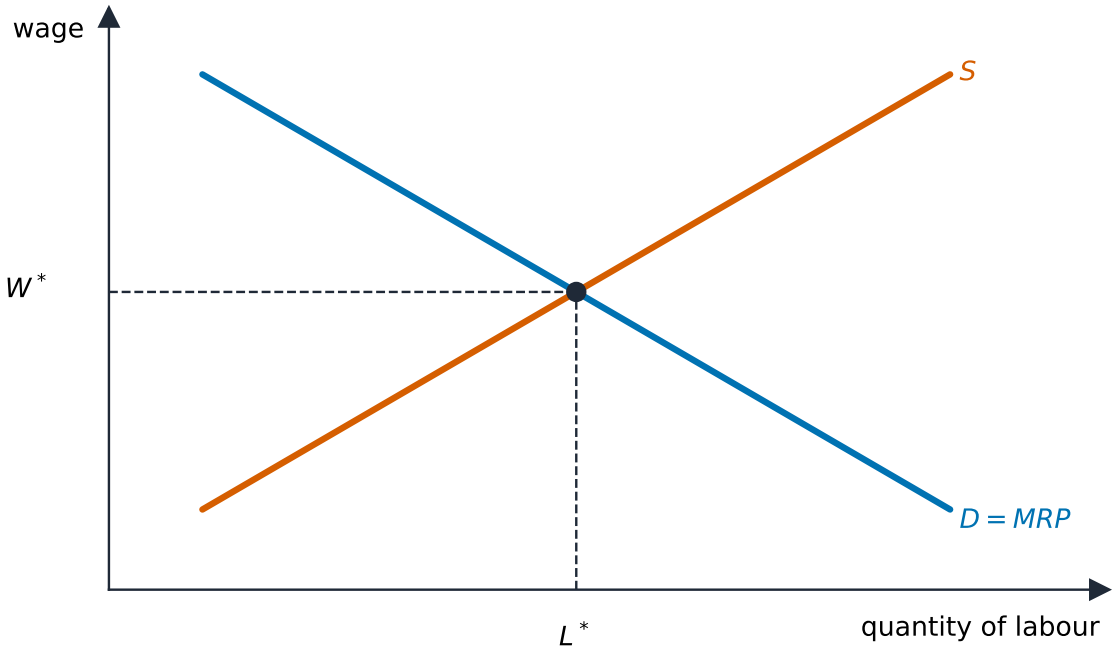
A bakery sells bread but buys flour and hires workers. The bread market concerns its output; the labour market concerns an input. In a **factor market** 要素市场, firms demand the services of **factors of production** 生产要素: **labour** 劳动, **land** 土地 and **capital** 资本. In the basic **circular-flow model** 循环流动模型, **households** 家庭 supply factors and receive **wages** 工资, **rent** 租金 and other factor income. Workers are not products that the firm owns.



A garment factory: firms demand workers' services to produce output

Demand for an input is **derived demand** 派生需求: firms want the revenue its output brings. If customers want more bread and its price rises, a worker's extra loaves may bring more **revenue** 收入. More valuable output can increase labour demand, with **productivity** 生产率 and other conditions unchanged.

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A competitive labour market sets the wage where labour demand meets labour supply

A change in the wage itself is a movement along labour demand or supply. A change in output price, worker productivity or the availability of workers shifts a curve. Keep the labour market, the firm's hiring decision and the product market distinct.

Changes in Factor Demand and Factor Supply

Labour demand. A higher output price in a competitive product market raises the revenue from each extra unit of output. Better training or complementary equipment can raise workers' marginal product. Both can shift labour demand right, holding other conditions constant. Technology that replaces workers can instead reduce demand for a particular job.

A cheaper **substitute** 替代品 input, such as a robot, has two possible effects. Substitution toward robots can reduce labour use for a given output. Lower production cost can also expand output and increase demand for workers. The net effect needs evidence; do not assume every cheaper machine raises or lowers labour demand.

Labour supply. More qualified workers, training that allows entry into an occupation, or immigration can shift supply right. Better wages in other available jobs can shift supply left for this occupation. Working conditions, preferences and the availability of alternatives matter. A higher wage in this occupation alone changes quantity supplied along the existing curve.

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■ One competitive market

Write demand as $w = 70 - L$ and supply as $w = 10 + L$. Wage w is dollars per labour unit per period; L is market labour in those units. Equating demand and supply:

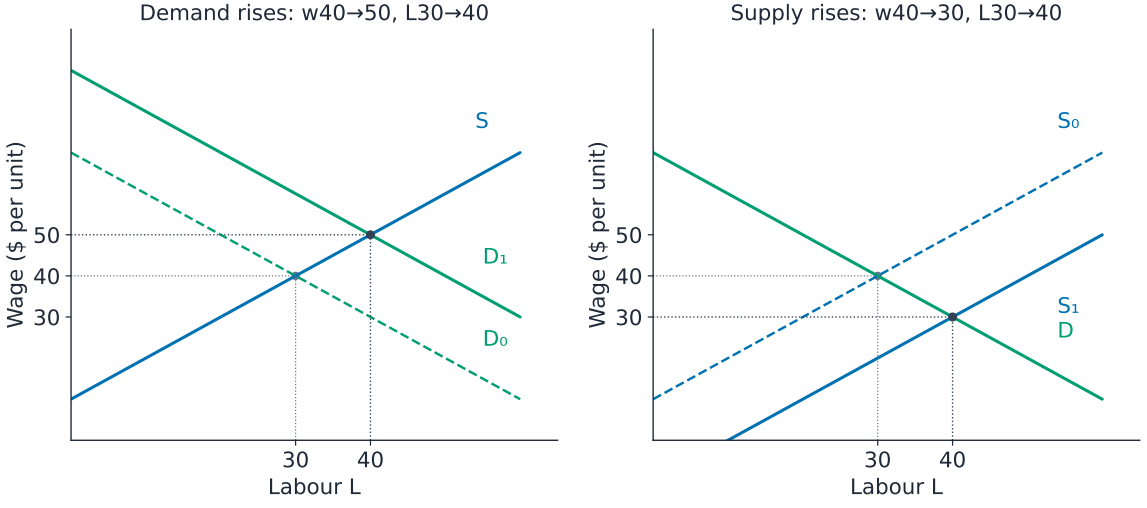
$$70 - L = 10 + L \quad \Rightarrow \quad L = (70 - 10)/2 = 30$$

$$w = 10 + L = 10 + 30 = \$40$$

Now compare two separate changes from that baseline.

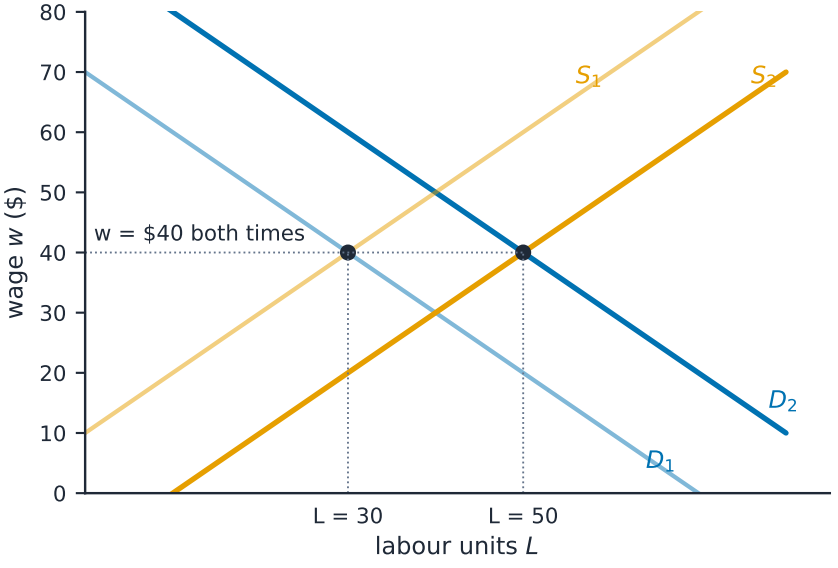
Change	New equation	Labour L	Wage w
Higher labour demand	Demand: w=90−L	40	$50
More available workers	Supply: w=−10+L	40	$30

For higher demand, $90 - L = 10 + L$ gives $L = 40$, then $w = 50$. For higher supply, $70 - L = -10 + L$ gives $L = 40$, then $w = 30$. The new supply equation is used only in the relevant nonnegative-wage range. Both changes raise **employment** 就业, but their wage effects differ.



Each panel starts at L=30, w=$40. Demand rises on the left; supply rises on the right.

If demand and supply both shift right, employment rises in the standard model, but the wage change depends on their relative shifts. Here, shifting demand to $90 - L$ and supply to $-10 + L$ gives $L = 50$, $w = 40$. Wage staying unchanged is one possible outcome, not a general rule.



Both curves shift right by the same amount: employment rises to 50, the wage stays $40

Profit-Maximizing Behavior in Perfectly Competitive Factor Markets

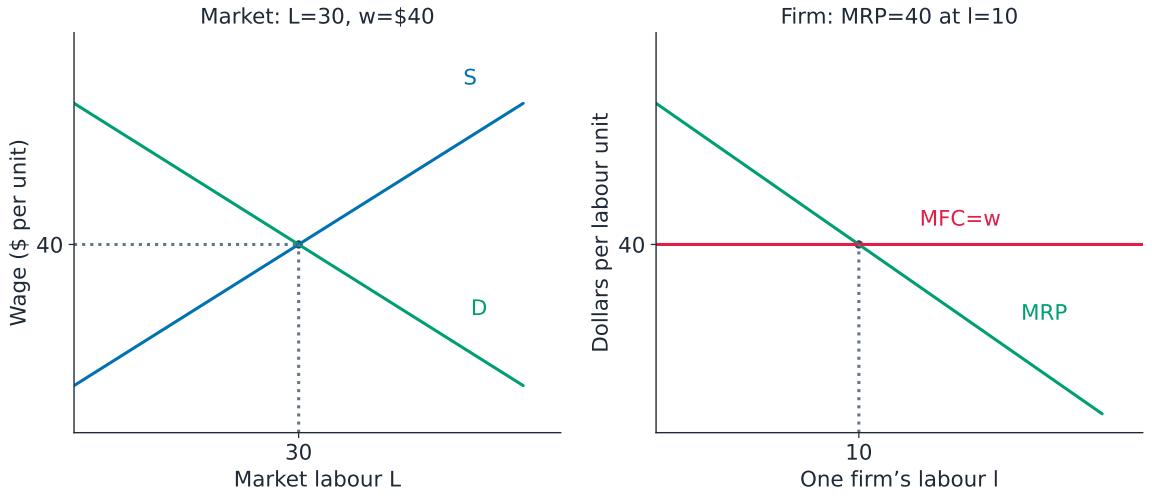
A firm compares extra revenue with extra labour cost. **Marginal revenue product** 边际收益产品 is extra revenue per extra labour unit: $MRP = \Delta TR/\Delta L$.

At the margin, $MRP = MP_L \times MR$. Only in a **perfectly competitive** 完全竞争 **product** market does $MR = P$, allowing $MRP = MP_L \times P$. Being a **wage taker** 工资接受者 in the labour market does not prove the firm is a **price taker** 价格接受者 for its output.

For example, if **marginal product** 边际产量 is 5 units and **marginal revenue** 边际收入 is \$6 per unit, MRP is $5 \times \$6 = \$30$ per labour unit. An output price of \$10 would give **value of marginal product** 边际产品价值 \$50, but would not make MRP \$50 when MR is \$6. At a marginal labour cost of \$40, this extra labour is not profitable.

Marginal factor cost 边际要素成本 (MFC) is the extra total input cost divided by the extra input hired. In a perfectly competitive labour market, a small firm can hire at the market wage without raising it, so its MFC equals that wage and is horizontal. In a smooth model with falling MRP and a suitable crossing, the firm chooses $MRP = MFC$. With whole workers, compare the last worker included and the next excluded; exact equality is not required.

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Market labour L is different from one firm's labour l. The firm takes the market wage; its labour supply is horizontal.

The market above sets $w = \$40$. One firm's MRP is $70 - 3l$. Its hiring decision is:

$$MRP = w \quad \Rightarrow \quad 70 - 3l = 40$$

$$l = (70 - 40)/3 = 10 \text{ labour units}$$

Three identical firms of this type would together demand $L = 30$ at that wage. Do not draw the upward-sloping market supply curve as a small wage-taking firm's supply curve.

■ Hiring whole workers from a production table

Use a separate bakery case. Bread sells in a competitive product market for \$5 per loaf. Workers have equal daily hours and each costs \$25 per day. Labour is the only **variable input** 可变投入; daily **fixed cost** 固定成本 is \$30.

Workers L	**0**	**1**	**2**	**3**	**4**	**5**
Loaves per day Q	0	8	18	24	28	30
MP: extra loaves	–	8	10	6	4	2
MRP: extra revenue	–	\$40	\$50	\$30	\$20	\$10

Try first. Calculate worker 2's MRP. Identify where diminishing marginal returns begin. Choose workers at wage \$25, and calculate profit. Then consider a higher fixed cost of \$80.

$$MP_2 = \Delta Q/\Delta L = (18 - 8)/(2 - 1) = 10 \text{ loaves per worker-day}$$

$$MRP_2 = MP_2 \times P = 10 \times \$5 = \$50 \text{ per worker-day}$$

Diminishing marginal returns 边际报酬递减 begin with worker 3: MP falls from 10 to 6. MRP first rises from 40 to 50, then falls. Do not claim MRP must fall from the first worker in every table.

Hire 3 workers: the third adds \$30 revenue at \$25 cost, raising profit by \$5. The fourth adds only \$20 revenue at \$25 cost, reducing profit by \$5. No worker has MRP exactly equal to the wage; 3 is still optimal.

$$TR = PQ = \$5 \times 24 = \$120 \text{ per day}$$

$$TVC = wL = \$25 \times 3 = \$75 \text{ per day}$$

$$\pi = TR - TVC - TFC = 120 - 75 - 30 = \$15 \text{ per day}$$

If fixed cost rises to \$80, hiring remains 3 because MRP and MFC do not change. Profit becomes $120 - 75 - 80 = -\$35$. Operating contributes \$45 toward unavoidable fixed cost; not operating would lose \$80 this day. A lower profit alone does not change the short-run marginal hiring comparison.

Equality case. At wage \$30, hiring either 2 or 3 gives the same profit: $5(18) - 30(2) - 30 = 0$ and $5(24) - 30(3) - 30 = 0$. The third worker adds no net profit. Equality can mean indifference, rather than a uniquely required worker count.

> **Worked example: the lowest output price that justifies a worker.** A firm sells in a perfectly competitive product market and pays a market wage of \$24. The third worker adds 6 units of output. What is the lowest output price at which the firm hires the third worker?

The third worker is hired if $MRP \geq w$, and here $MRP = MP \times P$:

$$6 \times P \geq 24 \quad \Rightarrow \quad P \geq 24/6 = \$4 \text{ per unit}$$

At any price of \$4 or more, the third worker adds at least as much revenue as cost.

> **Worked example: a change in the product market.** The government gives buyers of guava a per-unit subsidy. Demand for guava rises, so the market price of guava rises. A guava farm that takes the price sees each worker's output become more valuable: $MRP = MP \times P$ rises at every quantity of labour, so its MRP (labour demand) curve shifts right. At an unchanged market wage it hires more workers. The subsidy is paid to consumers, but it reaches the labour market through derived demand.

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A car assembly line: labour and capital can be combined in different ways

■ The least-cost input combination

A **least-cost combination** 最低成本组合 produces a chosen output at the lowest possible cost. Compare marginal product per dollar spent on each input. With divisible inputs, an interior least-cost combination equates MP_L/w and MP_K/r, where r is the rental cost per capital unit. Constraints can prevent exact equality.

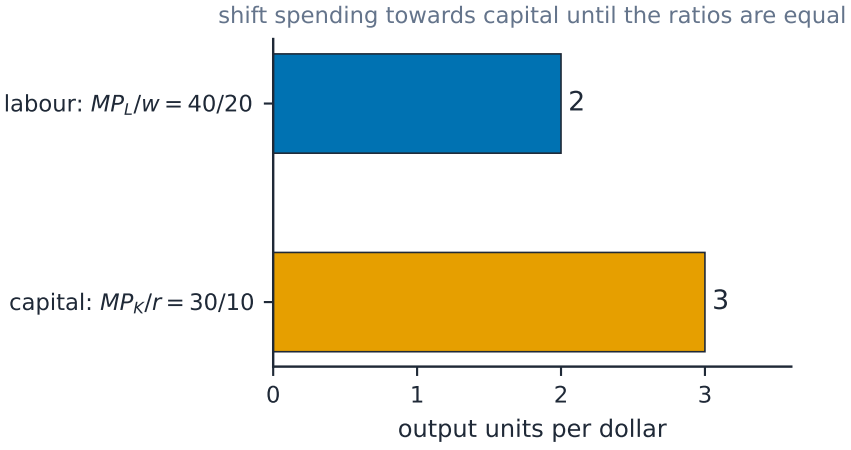
Suppose $MP_L = 40$, $w = \$20$, $MP_K = 30$ and $r = \$10$:

$$MP_L/w = 40/20 = 2 \text{ output units per dollar}$$

$$MP_K/r = 30/10 = 3 \text{ output units per dollar}$$

Capital gives more extra output per dollar at this combination. Shift spending toward capital and away from labour. For a small \$10 transfer, assuming these marginal products remain constant over that change, removing half a labour unit loses 20 output units; adding one capital unit gains 30. Net output rises by 10 at the same cost. Alternatively, less spending can maintain the original output. Recalculate as marginal products change.

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Capital gives 3 units per dollar, labour 2: shift spending towards capital

This is **cost minimization** 成本最小化 for a chosen output. It does not by itself prove the chosen output maximizes profit; that also needs revenue information.

> **Worked example: find the missing wage.** A firm uses the least-cost combination of labour and capital. It rents capital at \$500 per unit, and the last unit of capital has a marginal product of 2,500 units. The last worker's marginal product is 200 units. What wage must the firm be paying?

$$\frac{MP_K}{r} = \frac{2500}{500} = 5 \text{ units per dollar}$$

$$\frac{MP_L}{w} = 5 \quad \Rightarrow \quad w = \frac{200}{5} = \$40$$

At least cost, the last dollar spent on each input must buy the same extra output.

Monopsonistic Markets

A **monopsony** 买方垄断 has one buyer in the relevant factor market. Consider a uniform-wage employer with supply $w = 10 + L$. Attracting more labour requires raising the wage for all equally paid labour units, not just the new unit.

The **wage bill** 工资总额 is $wL = (10+L)L$. In the continuous model, $MFC = 10+2L$, above supply for positive employment.

Discrete wage-bill illustration. At $L = 2$, wage is \$12 and the bill is \$24. At $L = 3$, wage is \$13 and the bill is \$39.

$$\Delta\text{wage bill} = 13(3) - 12(2) = \$15$$

That extra unit costs \$13 for the new hire plus a \$1 raise for each of two existing units. This finite-interval cost is not the continuous MFC evaluated at the interval's endpoint.

Let MRP be $70 - L$. Choose labour using the rising MFC and falling MRP:

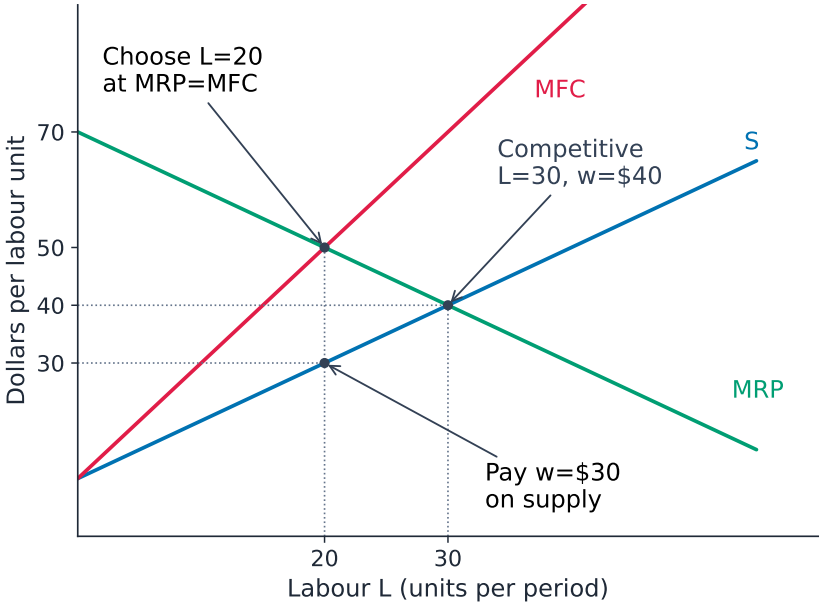
$$MRP = MFC \quad \Rightarrow \quad 70 - L = 10 + 2L$$

$$L_M = (70 - 10)/3 = 20 \text{ labour units}$$

$$w_M = 10 + L_M = 10 + 20 = \$30 \text{ per labour unit}$$

$$\text{Wage bill} = w_M L_M = 30 \times 20 = \$600 \text{ per period}$$

MFC at this output is $10 + 2(20) = \$50$, not the wage \$30. Pay the wage read from supply, not from the MFC–MRP intersection.



Employment is chosen at MRP=MFC; the paid wage is read down on supply. Competition instead equates labour demand and supply.

Using the same supply and MRP as the competitive benchmark, $70 - L = 10 + L$ gives $L_C = 30$, $w_C = \$40$. The uniform-wage monopsony therefore hires fewer units at a lower wage. This comparison holds the underlying curves constant; it is not a comparison of unrelated towns or occupations.

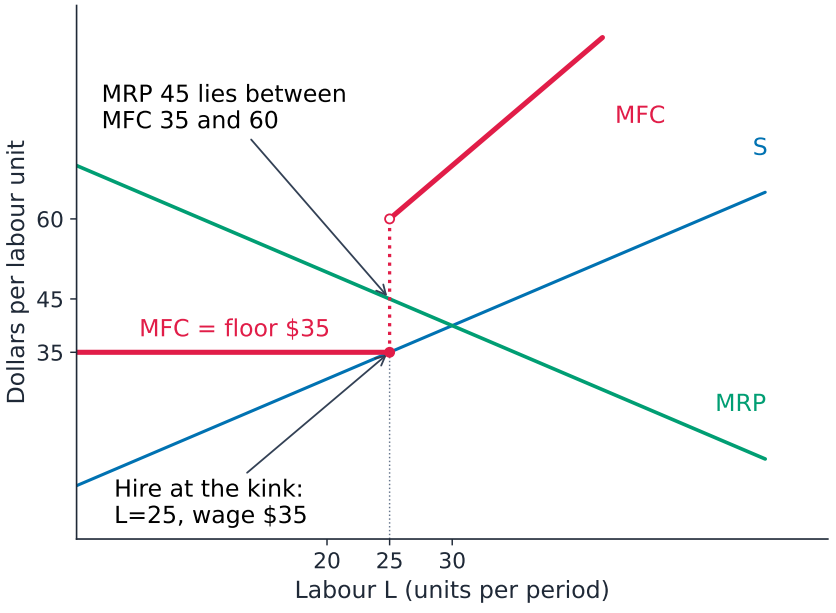
Higher product demand. Suppose stronger demand raises output price or marginal revenue and shifts MRP to $85 - L$, with labour supply unchanged. Then $85 - L = 10 + 2L$ gives $L = 25$, wage \$35 and MFC \$60. The firm moves up the unchanged MFC curve; MFC of its last hired unit rises from \$50 to \$60. This is not a labour-supply shift.

■ Minimum wages: the level matters

A **minimum wage** 最低工资 is a legal floor on the wage. Return to the original monopsony MRP $70 - L$ and supply $10 + L$. Assume an enforced uniform wage floor, no other hiring costs and the same worker productivity.

Wage floor	Labour hired	Wage paid	Wage bill
None	20	\$30	\$600
\$35	25	\$35	\$875
\$40	30	\$40	\$1,200
\$55	15	\$55	\$825

A floor of \$35**.** Supply at that wage is $L_S = 35 - 10 = 25$. Up to 25 units, the employer can add labour at marginal cost \$35 without raising the wage of existing workers. Beyond 25, attracting additional labour requires a wage above the floor for everyone, so MFC jumps to the original $10 + 2L$ branch. At 25, MRP is \$45, between MFC just below the kink (\$35) and just above it (\$60). Profit rises up to 25 units and falls beyond it: hire 25, paying $35(25) = \$875$. There is no smooth MRP=MFC equality at the optimum kink.



The flat MFC segment ends at available labour 25. Extending it forever would give the wrong hiring choice.

A floor of \$40**.** Supply is 30; MRP there also equals \$40. Hiring reaches the competitive benchmark, 30 units, and the wage bill is $40(30) = \$1,200$.

A high floor of \$55**.** Labour available is 45, but demand at a marginal cost of \$55 is only 15: $70 - L = 55$ gives $L = 15$. The bill is $55(15) = \$825$. Employment falls below the unregulated monopsony level of 20. A wage floor does not always raise monopsony

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employment.

In a competitive market with the same underlying curves, a floor above equilibrium \$40 creates excess labour supply. At \$55, supply is 45 and demand 15, a gap of 30 labour units. The monopsony result and the competitive result follow from different starting rules; do not apply a universal slogan about minimum wages.

Exam tips

- State which market is competitive. Use MRP=MP×MR generally; use product price only when MR=P.
- For a worker table, calculate changes in output, value them, and compare the last included and next excluded worker with MFC. Exact equality may not exist.
- Distinguish market labour supply from a wage-taking firm's horizontal labour supply. In monopsony, choose labour at MRP=MFC but read the wage on supply.
- Rebuild the relevant MFC schedule under a wage floor. Check availability and kinks before solving an equality, then calculate wage bill as wage times labour actually hired.

Common mistakes.

- Reading the monopsony wage from the MFC curve. Hire where MRP = MFC, then go **down** to the supply curve for the wage.
- Drawing a wage-taking firm's labour supply as upward sloping. It is horizontal at the market wage, and MFC equals the wage.
- Saying a higher fixed cost reduces hiring. Fixed cost changes neither MRP nor MFC.
- Using $MRP = MP \times P$ for a firm that is not a price taker in its product market. Use $MP \times MR$.
- Mixing up market labour supply shifts with a single firm's hiring. A smaller supply of workers raises the market wage; each wage-taking firm then moves up its MRP curve and hires fewer workers.

Practice.

1. A firm sells output for \$4 per unit in a perfectly competitive market and hires workers at a market wage of \$18. Total product with 1 to 5 workers is 8, 15, 20, 23 and 25 units. Fixed cost is \$20. (a) Calculate the MRP of the second worker. (b) How many workers does the firm hire? Explain with marginal analysis. (c) Calculate economic profit. (d) What is the lowest output price at which the fourth worker would be hired?
2. At its current input mix, a firm has $MP_L = 30$ at a wage of \$15 and $MP_K = 50$ at a rental price of \$20. Is it using the least-cost combination? If not, which input should it use more of?
3. A monopsony faces labour supply $w = 5 + L$, so $MFC = 5 + 2L$, and its MRP is $50 - L$. (a) Find the number of workers it hires and the wage it pays. (b) Find

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the competitive wage and employment with the same curves. (c) The government sets a minimum wage of \$25. How many workers are hired, and what is the wage bill?

4. A new law requires every parking attendant to buy an insurance policy at the worker's own expense. What happens to the market wage of parking attendants, and to the number hired by a typical wage-taking firm in the short run? Explain.
5. Demand for bottled water rises. A water firm sells in a perfectly competitive product market and hires in a perfectly competitive labour market. What happens to its demand for labour? Explain.

Answers.

1. (a) $MP = 15 - 8 = 7$, so $MRP = 7 \times 4 = \$28$. (b) MRP is \$32, \$28, \$20, \$12 and \$8. Hire 3: the third worker adds $\$20 > \$18$, but the fourth adds only $\$12 < \$18$. (c) $\pi = 4(20) - 18(3) - 20 = 80 - 54 - 20 = \$6$. (d) $MP_4 = 3$, so $3P \geq 18$ gives $P \geq \$6$.
2. No. $MP_L/w = 30/15 = 2$ but $MP_K/r = 50/20 = 2.5$. The last dollar on capital buys more output, so use more capital and less labour.
3. (a) $50 - L = 5 + 2L$ gives $L = 15$ and $w = 5 + 15 = \$20$. (b) $50 - L = 5 + L$ gives $L = 22.5$ and $w = \$27.50$. (c) At \$25, supply is $25 - 5 = 20$ workers, and MRP at 20 is $\$30 \geq \$25$, so the firm hires 20 (at the kink). Wage bill $= 25 \times 20 = \$500$. Employment rises from 15 to 20.
4. Working as an attendant becomes less attractive, so market labour supply shifts left and the market wage rises. The typical firm takes the higher wage and hires fewer workers, moving up its unchanged MRP curve.
5. It increases. Higher demand raises the price of bottled water, so each worker's $MRP = MP \times P$ rises. Labour demand is derived from product demand.

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Market Failure and the Role of Government

AP Microeconomics

Socially Efficient and Inefficient Market Outcomes

Why it matters. In July 2021 China opened a national carbon-emissions trading market, starting with coal- and gas-fired power plants. Each plant must hold permits for the carbon dioxide it emits, so polluting now has a price. Why should a government put a price on smoke? Because without one, power plants and their customers ignore a cost borne by everyone else. This unit asks when free markets get quantities wrong, and which policies fix the problem rather than make it worse.



Identify who bears the damage and why the firm's private calculation may omit it. The photograph alone does not establish the size of the cost or the efficient output.

A factory can make a profit while its smoke harms nearby residents. The buyers and sellers may choose well for themselves but leave out a cost paid by someone else. To judge the outcome, ask whose benefits and costs the decision includes.

An **allocation** 配置 is **socially efficient** 社会有效率 when it maximizes total economic surplus, including external benefits and costs. In the standard smooth model, choose the quantity where **marginal social benefit** 边际社会收益 (MSB) equals **marginal social cost** 边际社会成本 (MSC). Below that quantity, another unit adds more benefit than cost; above it, another unit costs more than its benefit.

Market failure 市场失灵 occurs when private incentives lead to an inefficient allocation. Competition alone does not guarantee efficiency: the private and social values must also coincide. With external effects, consumer surplus plus producer surplus alone is not total social surplus. Include the external effects and, when evaluating a

tax or **subsidy** 补贴, government revenue or spending. Transfers are not automatically resource losses.

Efficiency concerns the size of total net benefits. It does not say that the resulting distribution is fair. A change in tastes or real resource costs can change the efficient quantity; a different quantity from yesterday is not automatically a market failure.

Externalities

An **externality** 外部性 is an uncompensated cost or benefit affecting a **third party** 第三方 outside the market **transaction** 交易. Private decision-makers may leave it out. A higher price paid by another buyer is not, by itself, the external cost illustrated by pollution.



Cigarettes can create external costs through smoke affecting other people. A smoker's own health loss is a private cost, not automatically an externality.

A **negative externality** 负外部性 can arise in production or consumption. For polluting production, MSC = MPC + marginal external cost. With no external consumption effect, MSB = MPB. A **positive externality** 正外部性 from vaccination can instead make MSB greater than MPB while MSC = MPC. Identify the affected side before drawing the social curve; not every externality belongs on the cost side.

■ Pollution: private output versus efficient output

Consider a competitive chemical market. All quantities are units per period and all marginal values are dollars per unit. Demand is MPB = MSB = 100 − Q; supply is MPC = 20 + Q. Each unit causes an external cost of \$20, so MSC = 40 + Q.

Private choice. Buyers and sellers equate their private values:

$$MPB = MPC \quad \Rightarrow \quad 100 - Q = 20 + Q$$

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$$Q_m = (100 - 20)/2 = 40 \text{ units per period}$$

$$P_m = 100 - Q_m = 100 - 40 = \$60 \text{ per unit}$$

Social choice. Include the pollution cost:

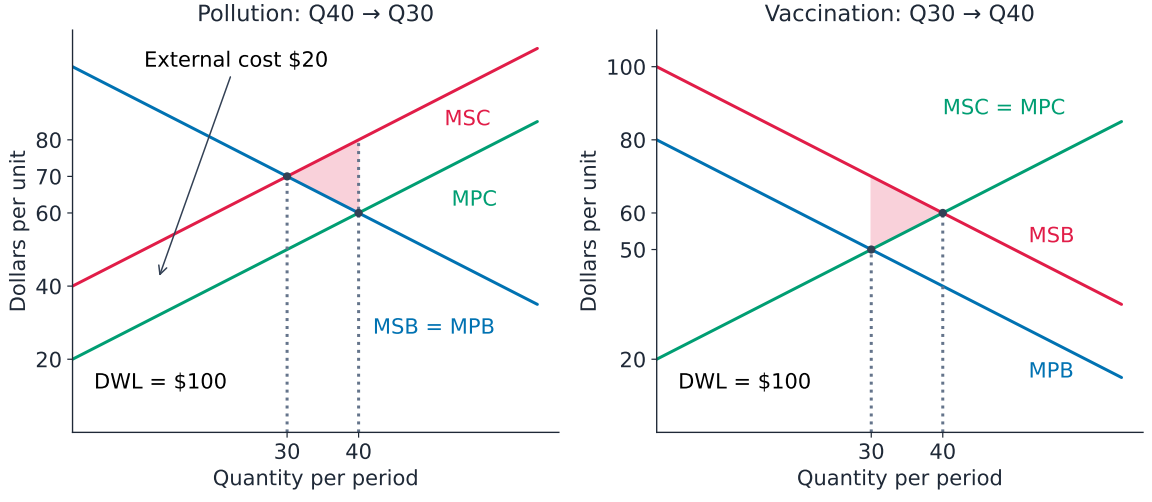
$$MSB = MSC \quad \Rightarrow \quad 100 - Q = 40 + Q$$

$$Q^* = (100 - 40)/2 = 30 \text{ units per period}$$

At Q = 30 both social marginal values are \$70. The market produces ten units too many. At Q = 40, MSC is \$80 but MSB is only \$60. The loss is the area between social cost and social benefit over the extra units, not the entire pollution bill:

$$DWL = \tfrac{1}{2}(Q_m - Q^*)[MSC(Q_m) - MSB(Q_m)]$$

$$DWL = \tfrac{1}{2}(40 - 30)(80 - 60) = \$100 \text{ per period}$$

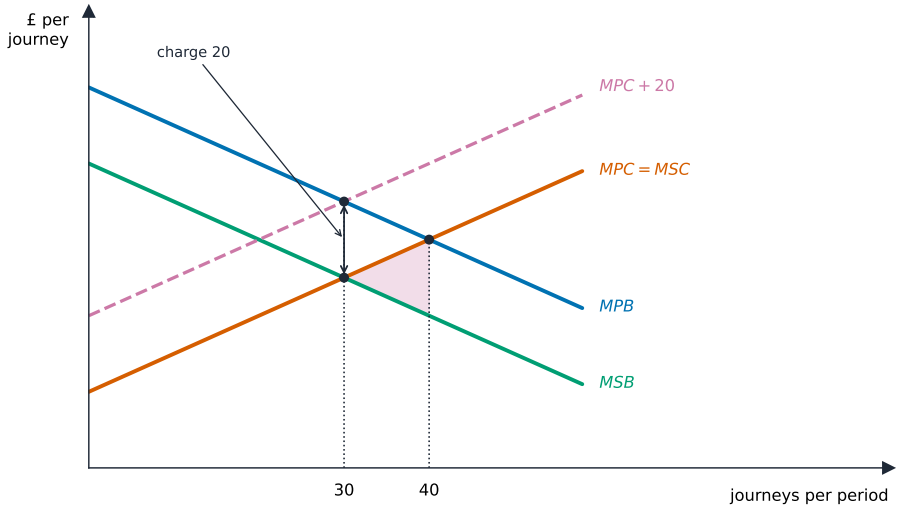


Left: pollution raises social cost above private cost. Right: an external vaccination benefit raises social benefit above private benefit. Both diagrams use the numerical cases in this handout.

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A corrective tax changes incentives

A **Pigovian tax** 庇古税 equal to marginal external cost at the efficient quantity can make the private choice match the social choice, under the stated model assumptions. Here a \$20 **per-unit tax** 从量税 raises the effective supply price from 20 + Q to 40 + Q:



Private choice: 40; efficient quantity: 30
Harm is counted once: $MSB = MPB - 20$

Private choice gives 40 journeys. Including the external harm gives 30. A 20-pound charge raises private marginal journey cost and reaches 30 in this model; the charge is a transfer, not an extra 20 pounds of real resource cost per journey.

$$100 - Q = 20 + Q + 20 \quad \Rightarrow \quad Q_t = 30$$

$$P_b = 100 - Q_t = 100 - 30 = \$70 \text{ per unit}$$

$$P_s = P_b - t = 70 - 20 = \$50 \text{ per unit}$$

$$R = tQ_t = 20(30) = \$600 \text{ per period}$$

Buyers pay \$70 and sellers keep \$50; the legal payer need not bear the whole burden. Pollution still occurs: external harm is 20(30) = \$600 per period. The tax does not remove every harmful unit. It removes units whose social cost exceeds social benefit.

Before tax, CS = \$800 and PS = \$800, but harm is \$800: social net benefit is \$800. After tax, CS = \$450, PS = \$450 and revenue is \$600, while harm is \$600: social net benefit is \$900. The gain is the \$100 **deadweight loss** 无谓损失 removed. Counting

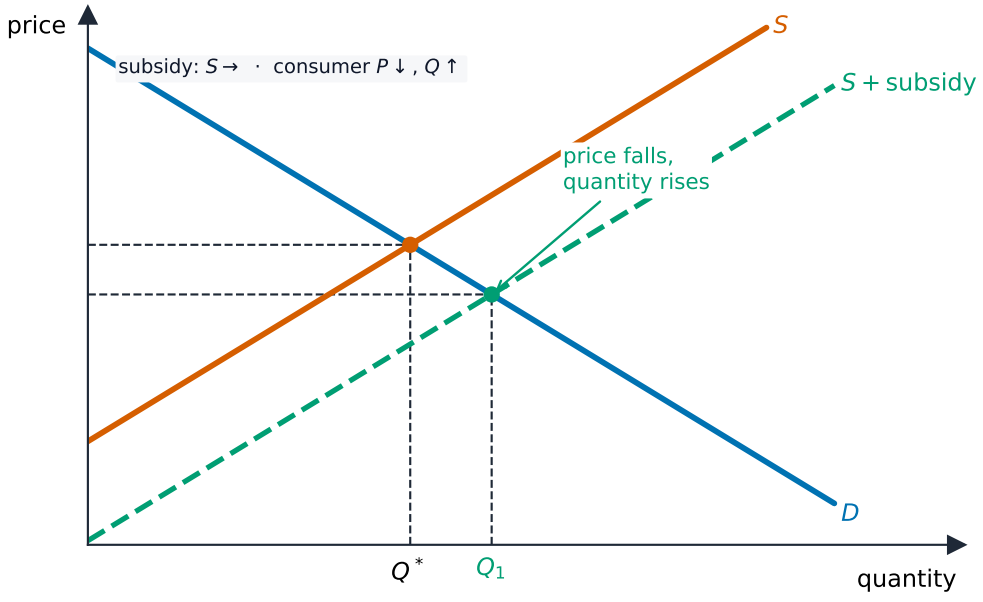
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the tax payment as both a cost and government revenue would count the same transfer twice.

A tax on output and a charge on emissions are different tools. If a firm can clean each unit, an emissions charge also rewards cleaner production. When harm changes with output, use marginal harm at the efficient quantity rather than an arbitrary average cost. Missing information, other market failures and enforcement costs can affect policy performance.

■ Vaccination: a subsidy versus a price ceiling

Now use a separate competitive market with MPB = 80 − Q, MPC = MSC = 20 + Q and a marginal external benefit of \$20. Then MSB = 100 − Q. The private equilibrium is Q = 30 and P = \$50; the efficient quantity is Q = 40, where MSB = MSC = \$60. Lost external benefits cause underproduction.



This separate model uses demand P=12−Q, original supply P=2.5+Q and a producer subsidy 2.4 per unit. The new buyer price is 6.05; the producer receives 8.45 including the subsidy.

$$DWL = \tfrac{1}{2}(Q^* - Q_m)(MSB - MPB) = \tfrac{1}{2}(40 - 30)(20) = \$100$$

A consumer subsidy of \$20 makes the producer receive \$20 more than the buyer pays:

$$MPB + 20 = MPC \quad \Rightarrow \quad 80 - Q + 20 = 20 + Q$$

$$Q_{sub} = (100 - 20)/2 = 40 \text{ units per period}$$

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$$P_s = 20 + Q_{sub} = 20 + 40 = \$60 \text{ per unit}$$

$$P_b = P_s - s = 60 - 20 = \$40 \text{ per unit}$$

$$G = sQ_{sub} = 20(40) = \$800 \text{ per period}$$

The subsidy expands quantity to the efficient level in this model; its fiscal cost is not the same as deadweight loss. Increased product demand can also raise firms' demand for labour through MRP, as in Unit 5.

Try a different policy. A legal **price ceiling** 价格上限 of \$40 gives private quantity demanded 40 but quantity supplied only 20. Without government supply or another arrangement, only 20 units can be exchanged. A lower legal price does not automatically deliver the efficient 40 units. The ceiling and the subsidy have different effects on sellers' incentives.

And a price floor? A **price floor** 价格下限 of \$55 in the same market raises the price buyers pay. Quantity demanded is $80 - 55 = 25$, below the private equilibrium of 30. Output moves further from the efficient 40, so deadweight loss grows. A floor cannot correct underproduction caused by an external benefit: the problem is that buyers value the good too little, and a higher price makes them buy even less.

■ When buyers underestimate harm

Some harm falls on the buyer later, but the buyer underestimates it when choosing. Sugary drinks are an example if consumers underestimate the long-run health damage. Demand reflects the *perceived* benefit, so the MSB curve, which counts the true harm, lies **below** demand (MPB). With $MPB = 90 - Q$, a true harm of \$10 per drink that buyers ignore, and $MPC = MSC = 10 + Q$:

$$\text{Market: } 90 - Q = 10 + Q \quad \Rightarrow \quad Q_m = 40$$

$$\text{Social: } 80 - Q = 10 + Q \quad \Rightarrow \quad Q^* = 35$$

$$DWL = \tfrac{1}{2}(40 - 35)(10) = \$25$$

The graph looks like a negative consumption externality: draw MSB below MPB, label Q_m where MPB meets MSC, and Q^* where MSB meets MSC. A per-unit tax of \$10 is one correction.

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Other ways to address external effects

Regulation can restrict emissions or require equipment; **tradable permits** 可交易排放许可 cap **emissions** 排放 and allow trading. A well-designed trading system can move **abatement** 减排 toward firms that can clean at lower marginal cost, but the cap, monitoring and market conditions matter. Public provision can also increase access to a service with external benefits.

The **Coase theorem** 科斯定理 describes how bargaining can reach an efficient allocation when **property rights** 产权 are clear and **transaction costs** 交易成本 do not prevent agreement. The allocation of rights affects who pays whom; it need not determine the efficient activity level under these assumptions. Many affected residents, costly information or difficulty enforcing an agreement can prevent this result.



An extra driver can delay other road users. The external effect is that added delay, not every minute of the driver's own journey.

Public and Private Goods

Rivalry 竞争性 asks whether one person's use reduces what is available to others. **Excludability** 排他性 asks whether non-payers can be kept out. Classify the service at the relevant capacity and under its actual access rules.

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Exam: classify by rivalry × excludability — free-rider problem only for non-excludable goods

Rivalry and excludability give four types of good: private, club, common resource, and public.

Example	Rival?	Excludable?	Category
A sandwich	Yes	Yes	Private
A noncongested paid stream	No	Yes	Club
Open-access ocean fish	Yes	No	Common resource
A nonexcludable warning signal	No	No	Public

A **private good** 私人物品 is rival and excludable. A **public good** 公共物品 is non-rival and non-excludable. People can **free-ride** 搭便车 when they enjoy a benefit without paying for it, weakening incentives for voluntary financing. Some public goods can still be supported by donations or other arrangements; "everyone refuses to pay" is not a definition.

One warning project. A neighbourhood signal costs \$50. Three households value that single project at \$30, \$20 and \$10. The total benefit is \$60, greater than its cost, but each household values it less than paying the full \$50 alone. Collective finance could support a worthwhile project that individual purchasing might not provide. This is an incentive problem, not evidence that the signal has no value.

Common resources 公共资源 are rival and non-excludable. Each fisher gains from an extra catch but can leave less stock for others. The **tragedy of the commons** 公地悲剧 describes inefficient overuse under such open-access incentives. Access rights, **quotas** 配额 or community rules may change those incentives. "Common" does not mean that every shared resource is inevitably destroyed.

Government can supply a private good free at the point of use. A school place still uses scarce classroom capacity and access can be controlled. Public funding is not the

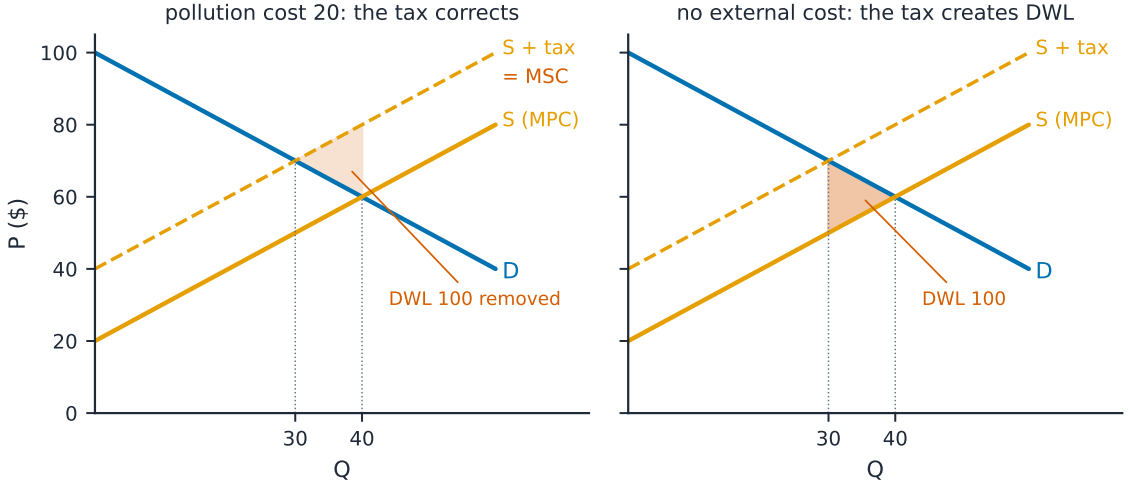
same as the economic definition of a public good.

The Effects of Government Intervention in Different Market Structures

Start with the market failure and the changed incentive. The same instrument can improve or worsen allocation depending on the initial conditions.

■ The same tax can have different welfare effects

Return to demand 100 − Q and private supply 20 + Q. With pollution cost 20, a tax 20 corrects overproduction and removes DWL100. With no external effects instead, the original Q40 is already efficient. The same tax 20 reduces output to Q30 and creates DWL100. A tax does not always create an additional efficiency loss; identify the starting social curves.



One tax, two outcomes: it depends on where the social curves start

A **lump-sum tax** 定额税 is a fixed charge, so it does not change marginal cost or marginal revenue. For a firm that continues operating at an interior optimum, its short-run profit-maximizing quantity and price stay the same while profit falls. A **lump-sum subsidy** 定额补贴 raises profit without directly changing marginal incentives. Participation, entry and exit can change; the statement is not a promise of unchanged industry output forever. Changes in demand or MR can also change output even when MC stays fixed.

■ A tax on a polluting monopoly

A per-unit tax equal to marginal external cost corrects a **competitive** market. A monopoly is different, because it already restricts output. Suppose demand is $P = 100 - Q$, $MR = 100 - 2Q$, private marginal cost is a constant \$20 and each unit causes \$20 of pollution, so $MSC = \$40$.

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$$\text{Monopoly: } 100 - 2Q = 20 \quad \Rightarrow \quad Q_M = 40,\ P_M = \$60$$

$$\text{Social: } 100 - Q = 40 \quad \Rightarrow \quad Q^* = 60$$

Despite the pollution, the monopoly produces **too little**: $40 < 60$. Deadweight loss is $\frac{1}{2}(60 - 40)(60 - 40) = \$200$.

A \$20 per-unit tax raises the monopoly's MC to \$40: $100 - 2Q = 40$ gives $Q = 30$ and $P = \$70$. Output moves further below 60, and deadweight loss rises to $\frac{1}{2}(60 - 30)(70 - 40) = \$450$. The tax that fixes a competitive market makes this monopoly outcome worse. Always compare the firm's actual output with the social optimum before choosing the direction of policy.

■ Regulating a natural monopoly

Use the separate network example from Unit 4: demand P = 100 − Q, MR = 100 − 2Q, total cost TC = 1200 + 20Q, and MC = \$20. ATC = 1200/Q + 20 declines over the relevant demand range, making one producer potentially cheaper than dividing output among firms: a **natural monopoly** 自然垄断.

Policy	Quantity	Price	Economic profit
Unregulated	40	\$60	\$400
Fair-return price	60	\$40	\$0
Marginal-cost price	80	\$20	−\$1,200

The unregulated firm sets MR = MC, then reads price from demand. Fair-return pricing sets P = ATC and allows zero economic profit, but Q60 is below the efficient Q80. Its DWL is \$200, compared with \$800 under unregulated monopoly. Zero profit does not mean full efficiency.

Check whether a ceiling binds. Demand and ATC also meet at Q20/P80 in this model, but a ceiling of \$80 is above the unregulated price \$60. It leaves the firm at Q40/P60. Fair-return regulation here uses the binding ceiling \$40: the firm can sell up to 60 units at that price, and each extra unit costs only \$20, so it expands to Q60. This choice covers total cost. An arbitrary intersection of demand and ATC is not enough to establish the regulated choice.

Compare marginal and fixed policies. At unregulated Q40 the firm earns \$400. A fixed tax 400 reduces profit to zero while leaving the interior operating choice Q40/P60 unchanged. A per-unit tax 10 instead raises effective MC to 30:

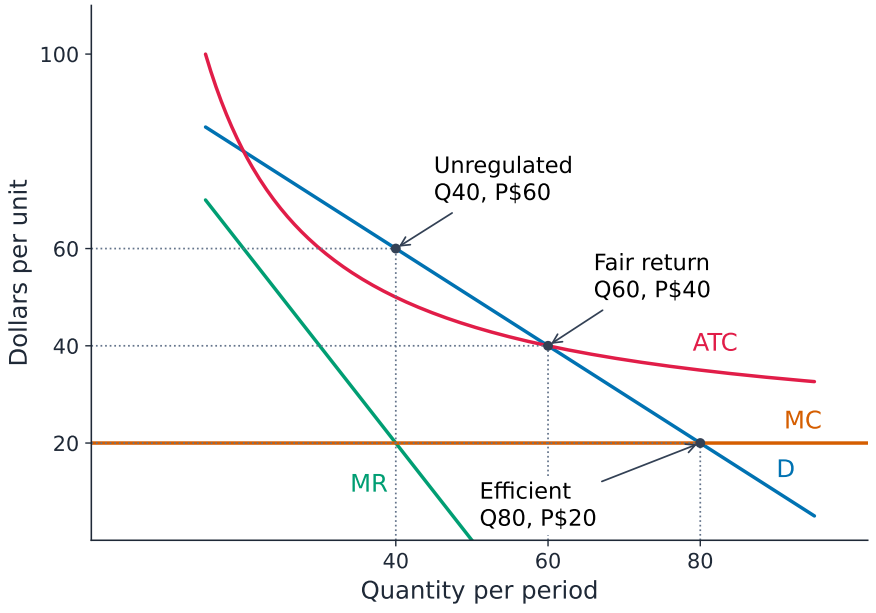
$$MR = MC + t \quad \Rightarrow \quad 100 - 2Q = 20 + 10$$

$$Q_t = (100 - 30)/2 = 35 \text{ units per period}$$

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$$P_t = 100 - Q_t = 100 - 35 = \$65 \text{ per unit}$$

A per-unit subsidy 10 lowers effective MC to 10 and gives Q45/P55. Its profit includes the subsidy; it is \$825, not just sales revenue minus original cost. Output rises, but is still below efficient Q80. A subsidy to a monopolist is not the same model as the earlier subsidy in a competitive vaccination market.



At Q80, marginal-cost pricing gives revenue 1600 and total cost 2800, leaving a 1200 funding gap. Fair-return pricing at Q60 covers total cost but leaves underproduction.

At marginal-cost pricing, revenue is \$1600 and cost is \$2800, so a fixed subsidy of \$1200 covers the loss. Funding and administrative costs still need evaluation. A ceiling changes the firm's feasible revenue schedule; do not keep using the unregulated MR curve as if nothing had changed.

Antitrust laws 反垄断法 aim to limit anticompetitive mergers and collusion and make markets more competitive. More firms do not automatically guarantee a net gain when economies of scale are large. Evaluate the changed incentives and real costs rather than assuming every intervention succeeds.

Inequality

Income distribution 收入分配 describes how an income flow is shared over a stated period. Wealth is a stock of assets minus liabilities at a date. High current income does not necessarily imply high accumulated wealth. Inequality compares shares; poverty concerns a living-standard threshold, so one is not a complete measure of the other.

The **Lorenz curve** 洛伦兹曲线 shows cumulative income share against cumulative population share, ordered from lowest to highest income. The equality line gives every

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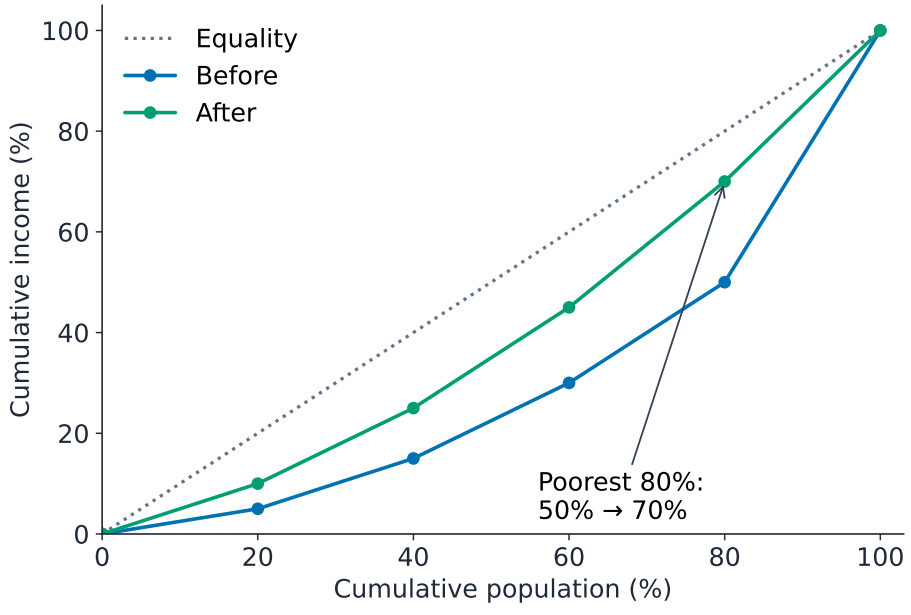
population share the same income share. A curve farther below it indicates more inequality when the curves do not cross. A **Gini coefficient** 基尼系数 summarizes inequality: zero indicates equality; values closer to one indicate more inequality under the usual nonnegative-income convention. Compare the same population and income definition.

■ Read complete distributions

These are illustrative shares for five equally sized groups, ordered by income. The second distribution represents a possible outcome after taxes and transfers, not a forecast that every policy produces it.

Group, lowest to highest	Before	After
First fifth	5%	10%
Second fifth	10%	15%
Third fifth	15%	20%
Fourth fifth	20%	25%
Fifth fifth	50%	30%

Before, the poorest 40% receive 15% of income; after, they receive 25%. The corresponding poorest 80% shares are 50% and 70%. The after curve is everywhere above the before curve except at the endpoints, so the after distribution is less unequal. Do not infer an exact Gini coefficient from only a bottom and top share. AP requires interpreting these measures, not drawing Lorenz curves or calculating Gini coefficients.



The after-transfer curve lies closer to equality at every interior plotted population share. The diagram teaches interpretation; no Gini calculation is required.

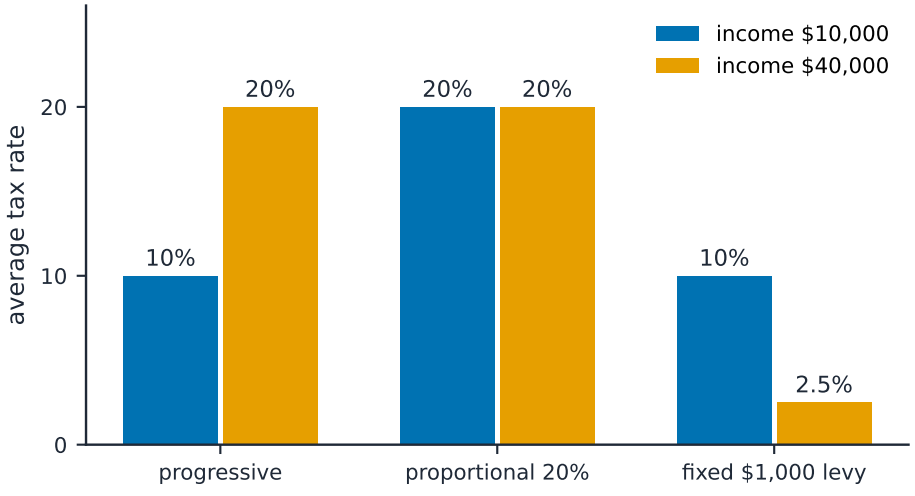
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Taxes, access and incentives

Human capital 人力资本 includes education and skills. Inheritance, social networks, discrimination, access to finance, mobility and bargaining power can also affect income and wealth. Do not assume pay differences always measure productivity or rank one source as the largest without evidence.

Compare average tax rates

Progressive taxes 累进税 take a higher average share as income rises. For incomes \$10,000 and \$40,000, taxes \$1,000 and \$8,000 give average rates 10% and 20%. A proportional 20% tax takes the same average share. A fixed \$1,000 levy takes 10% from the lower income but 2.5% from the higher income, making its average burden regressive. A higher absolute tax payment alone does not prove progression, and marginal tax brackets are not rates applied to every dollar of income.



Judge a tax by its average rate as income rises, not by the amount paid

Transfer payments 转移支付 change disposable income without being payment for current production, for example a household cash benefit. Taxes and transfers can alter measured inequality; compare distributions using the same definitions before and after.

The **efficiency–equity trade-off** 效率与公平权衡 is a possible tension, not a fixed law. Some designs reduce incentives to work or invest. Others improve health, education or access to jobs and may increase both opportunity and productivity. Evaluate a particular policy's incentives, funding and effects.

Exam tips

- Identify the third-party effect and the correct private and social curves.
- Calculate DWL over inefficient units; distinguish harm, transfers and fiscal cost.
- Check buyer and seller prices and the quantity actually supplied under a ceiling.
- Distinguish fixed charges from marginal incentives, and zero profit from efficiency.
- Classify goods by rivalry and excludability, not their funding.
- Compare complete income distributions; do not infer Gini from one or two shares.

Common mistakes.

- Drawing a negative externality with MSC **below** MPC, or a positive externality with MSB **below** MPB. External costs add to private cost; external benefits add to private benefit.
- Shading deadweight loss between the wrong curves. It is the triangle between MSB and MSC from the market quantity to the efficient quantity.
- Saying a lump-sum tax corrects an externality. It changes no marginal cost, so quantity does not change in the short run.
- Assuming a per-unit tax equal to MEC always helps. For a monopoly that already underproduces, it can increase deadweight loss.
- Calling a good "public" because the government provides it. Classify by rivalry and excludability.

Practice.

1. In a competitive market, demand is $P = 120 - Q$ and marginal private cost is $P = 20 + Q$. Production causes a constant marginal external cost of \$20. (a) Find the market quantity and price. (b) Find the socially optimal quantity. (c) Calculate deadweight loss at the market quantity. (d) What per-unit tax achieves the optimum?
2. In another competitive market, marginal private benefit is $P = 60 - Q$, marginal cost is $P = 10 + Q$ (no external cost), and each unit gives others a benefit of \$10. (a) Identify the market failure. (b) Find the market and socially optimal quantities. (c) What per-unit subsidy achieves the optimum? (d) Instead, the government sets a price floor at \$40. Does this correct the market failure? Explain with numbers.
3. A monopolist faces demand $P = 80 - Q$ and $MR = 80 - 2Q$. Marginal private cost is a constant \$20 and marginal external cost is \$10. (a) Find the monopoly quantity and the socially optimal quantity. (b) The government imposes a \$10 per-unit tax. Find the new monopoly quantity. Does deadweight loss increase or decrease?
4. For each good, state whether it is rival and whether it is excludable, then classify it: (a) a city fireworks show seen from public streets; (b) a fishing ground in international waters; (c) a sandwich.

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5. A family earning \$20,000 pays \$2,000 in a tax; a family earning \$100,000 pays \$8,000. Is the tax progressive, proportional or regressive? Show the average tax rates.

Answers.

1. (a) $120-Q = 20+Q$, so $Q = 50$ and $P = \$70$. (b) $MSC = 40+Q$: $120-Q = 40+Q$ gives $Q^* = 40$. (c) $DWL = \frac{1}{2}(50-40)(20) = \$100$. (d) A per-unit tax of \$20, equal to the marginal external cost.
2. (a) A positive externality: MSB is above MPB, so the market underproduces. (b) Market: $60 - Q = 10 + Q$ gives $Q = 25$. Social: $70 - Q = 10 + Q$ gives $Q^* = 30$. (c) A per-unit subsidy of \$10. (d) No. At \$40 quantity demanded is $60 - 40 = 20$, below the market's 25 and further from 30, so deadweight loss increases.
3. (a) $80 - 2Q = 20$ gives $Q_M = 30$. Social: $80 - Q = 30$ gives $Q^* = 50$. (b) $80 - 2Q = 30$ gives $Q = 25$. Output moves further below 50, so deadweight loss increases.
4. (a) Non-rival and non-excludable: a public good. (b) Rival and non-excludable: a common resource. (c) Rival and excludable: a private good.
5. Average rates are $2000/20000 = 10\%$ and $8000/100000 = 8\%$. The rate falls as income rises, so the tax is regressive.

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