ECONOMICS MASTERCLASS

UNIT 2

Supply, Demand, and Market Equilibrium

How buyers and sellers arrive at a price, and what moves it



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By the end of this unit, I should be able to answer these questions:

- Why does the price of a good rise when demand increases and supply stays the same, and why does the quantity rise with it?
- What is the difference between a change in demand and a change in the quantity demanded, and how do I draw each?
- How do I find the equilibrium price and quantity from two straight-line equations, and what do I check afterwards?
- When a government taxes petrol, who pays the tax in the end, and what decides the split between buyers and sellers?
- What happens in a market when the government sets a maximum price below the equilibrium price, and who gains?
- Why are some things not allowed to have a price at all, and what does a market designer do instead?

On most mornings at Toyosu market in Tokyo, buyers walk along rows of frozen tuna, shine a torch on a small cut of flesh near each tail, and decide what each fish is worth to them. A few minutes later an auctioneer sells the fish one by one to the highest bidder. Nobody in the hall fixes the price in advance, yet by the end of the auction every fish has one, and the prices reflect how many fish arrived that night and how many restaurants want them. This unit explains how the same thing happens in every market, with two curves and the point where they cross, and what moves that point when a frost, a tax, or a law hits the market.

1 What a market is

A **market** is the set of buyers and sellers of one good, together with the way they meet and trade. The Toyosu hall is a market; so are a website on which used phones are sold, the Chicago exchange on which wheat is traded, and the petrol stations of a country, whose owners never meet but watch each other's prices. The good can be a thing, a service, or the use of something for a while, such as a flat rented by the month.

The model of this unit describes a **competitive market**, which is a market with four properties. They are assumptions, and the later units relax every one of them.

1. There are many buyers and many sellers, each so small that no single one can move the price. Every participant is a **price taker**, for whom the price is a fact to react to, as the weather is for a farmer. Unit 5 studies markets in which one or a few sellers set the price.

2. The good is standardized, so that a buyer does not care which seller it comes from. Wheat of a given grade satisfies this; haircuts do not.
3. Sellers can enter and leave the market freely. Unit 4 shows what this does to prices in the long run.
4. Buyers and sellers know the price and the quality of what is traded. Unit 6 looks at markets in which one side knows more than the other.

Few real markets fit all four points exactly; coffee, wheat, crude oil, and shares of large companies come close, while flats, cars, and labour fit less well. The model is useful anyway, because it isolates one mechanism, the balancing of what buyers want against what sellers offer, which is at work in every market.

2 Demand and supply

2.1 Demand

The **quantity demanded** of a good is the amount buyers are willing and able to buy at a given price during a given interval, such as a year. It is a flow, an amount per period rather than a stock lying in a warehouse, so it always carries a time, such as million bags per year. A list of the quantities demanded at a range of prices is a **demand schedule**, and the same list drawn as a line is the **demand curve**, written D in the diagrams.

For example, the demand for coffee in the world market can be approximated, around the prices seen in 2019 and 2020, by the straight line

$$Q_{\mathrm{d}} = 260 - 30P,$$

with P in US dollars per kilogram of green beans (the unroasted beans in which coffee is traded in bulk) and Q_{d} in million bags of 60 kilograms per year. At a price of \$3 per kilogram the world buys 170 million bags, at \$4 only 140 million bags. The line is a line of best fit, chosen for the examples of this unit; the real relation is neither straight nor fixed, but near the prices that actually occurred it is a fair description.

The curve slopes downwards because, as the price rises, some buyers switch to tea or drink less, and some roasters blend in cheaper beans. This is the law of demand, stated formally in the box below, and the condition attached to it matters as much as the law itself. The curve describes how the quantity demanded reacts to the price *when everything else that affects buyers stays the same*. When the price changes and nothing else does, the market moves *along* the curve. When something else changes, the whole curve moves to a new position, as Figure 1 shows. Economists keep two phrases apart for these two cases. A **change in the quantity demanded** is a movement along the curve, caused by a change in the good's own price. A **change in demand** is a shift of the whole curve, caused by anything else.

Five things shift a demand curve.

- **Income.** For most goods a higher income shifts demand to the right; such goods are called **normal goods**. For a few goods demand falls when income rises, because buyers move on to something better, and these are **inferior goods**, such as instant noodles or bus journeys for many households.
- **Prices of related goods.** Two goods are **substitutes** when a rise in the price of one shifts the demand for the other to the right, as tea and coffee are. They are **complements** when they are used together, so that a rise in the price of one shifts the demand for the other to the left, as petrol and cars are.
- **Tastes.** A health report, a fashion, or an advertising campaign moves the curve without any price changing.
- **Expectations.** Buyers who expect a higher price next month buy more this month; buyers who expect a new model buy fewer of the old one.
- **The number of buyers.** Market demand is the sum of individual demands, so a growing population or a newly opened export market shifts it to the right.

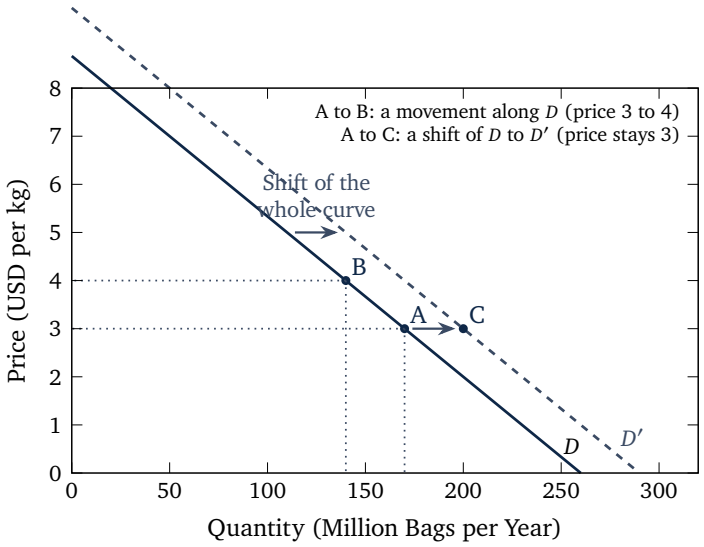


Figure 1. A movement along the demand curve against a shift of the curve. From A to B the price of coffee rises from \$3 to \$4 per kilogram and the quantity demanded falls from 170 to 140 million bags; the curve itself is unchanged. From A to C the price stays at \$3 while the curve shifts to D' because, for example, incomes have risen, and 200 million bags are demanded at the old price.

CHECK YOUR UNDERSTANDING Question 1

The price of tea rises sharply. In the market diagram for coffee, what happens?

(A) The demand curve for coffee shifts to the right
(B) The market moves up along the demand curve for coffee
(C) The demand curve for coffee shifts to the left
(D) The supply curve for coffee shifts to the right

The solution is at the end of the unit.

2.2 Supply

The **quantity supplied** is the amount sellers are willing and able to sell at a given price during a given interval, and the **supply curve**, written S, shows it for every price. For the coffee market of this unit the fitted line is

$$Q_S = -10 + 60P,$$

again in million bags per year and US dollars per kilogram. At \$3 the world's growers bring 170 million bags to market, at \$4 they bring 230 million bags.

The supply curve slopes upwards for a reason that Unit 4 works out in detail. In outline, producing one more bag costs more than the last one did, because the cheapest land, the most skilled pickers, and the best machines are used first, and a higher price is needed before the more costly bag is worth producing. The height of the supply curve at any quantity is therefore the cost of producing one more item, which economists call the **marginal cost**; where the price covers that cost, the item is supplied.

As for demand, a change in the good's own price moves the market along the supply curve, which is called a **change in the quantity supplied**, and anything else shifts the whole curve, which is called a **change in supply**. The shifters are the following.

- **Input prices.** More expensive fertilizer, wages, fuel, or borrowing raise the cost of every bag and shift supply to the left.

- **Technology.** A better harvesting machine or a disease-resistant variety lowers costs and shifts supply to the right.
- **Expectations.** A grower who expects a higher price in six months stores beans now, which shifts today's supply to the left.
- **The number of sellers.** New plantations in Vietnam shifted the world supply of coffee to the right during the 1990s.
- **Weather and harvests.** For farm goods a drought, a frost, or a disease shifts supply to the left for a season, and a good year shifts it to the right; Section 3 follows one such frost.

PRINCIPLES The law of demand and the law of supply

1. **Law of demand.** Other things equal, the quantity demanded of a good falls when its price rises and rises when its price falls.
2. **Law of supply.** Other things equal, the quantity supplied of a good rises when its price rises and falls when its price falls.

"Other things equal" means that incomes, the prices of other goods, tastes, expectations, the number of buyers, input prices, and technology are all held fixed; when one of them changes, the curve shifts, and the law says nothing until the new curves are drawn. Both laws are regularities observed in data rather than theorems. The law of demand has a rare exception, which Unit 3 mentions; the law of supply has its own, which lie beyond the Foundation units.

EXCURSION *Alfred Marshall's scissors*

Alfred Marshall (1842-1924), professor of political economy at Cambridge, gave the subject the diagram used on every page of this unit, with the price on the vertical axis as Unit 1 announced. His book *Principles of Economics*, published in 1890, was the standard textbook in English for forty years, and economists of his time argued about whether value is set by usefulness to buyers or by the cost of production. Marshall answered that the question is pointless, because "we might as reasonably dispute whether it is the upper or the under blade of a pair of scissors that cuts a piece of paper, as whether value is governed by utility or cost of production". Demand is one blade, supply is the other, and the price is where they meet.

Marshall did not invent the diagram. Antoine Augustin Cournot (1801-1877) drew a demand curve in 1838, with the price on the horizontal axis, and used it to show how a tax moves the price; the German economist Karl Heinrich Rau (1792-1870) drew the first cross with the price on the vertical axis in 1841. Marshall took Rau's layout, and because generations of students learned from his *Principles*, it became the convention. Modern textbooks read the price as the cause and the quantity as the effect, so the diagram has the cause on the vertical axis, where mathematicians put the effect (the y of a function $y = f(x)$); Marshall himself read it the other way, asking what price buyers would pay for a given quantity, which is why his layout made sense to him.

3 Equilibrium

3.1 The crossing point

Figure 2 draws the two coffee lines in one diagram. They cross at a price of $3 per kilogram and a quantity of 170 million bags per year. At that price, and only at that price, the amount growers want to sell equals the amount buyers want to buy, and the market is in **equilibrium**. The equilibrium price is written P^* and the equilibrium quantity Q^*.

The word equilibrium is borrowed from physics, where it means a state with no tendency to change, and that is the sense here. Consider what happens away from the crossing point. At a price of $4 per kilogram, growers would bring 230 million bags to market and buyers would take 140. The difference of 90 million bags is an **excess supply**, often called a surplus, a word that Section 4 uses in a second sense. Warehouses fill, and sellers who are stuck with beans offer them a little cheaper rather than keep them; as the price falls, buyers take more and growers offer less, until the gap closes. At $2 the opposite happens. Buyers want 200 million bags and growers offer 110, which leaves an **excess demand** of 90 million bags, a shortage. Buyers who cannot get beans bid more, the price rises, and again the gap closes. The equilibrium is stable, because any departure from it sets off a movement back towards it.

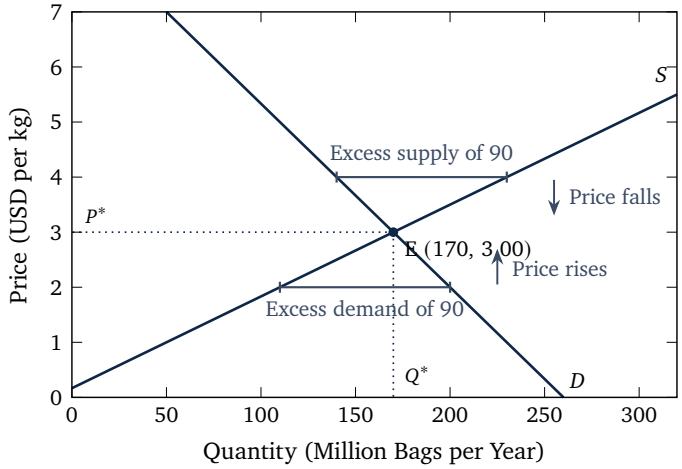


Figure 2. The market cross for the coffee lines of this unit, $Q_d = 260 - 30P$ and $Q_s = -10 + 60P$. At $4 per kilogram growers offer 230 million bags but buyers take only 140, an excess supply of 90 million bags, and unsold stocks push the price down. At $2 buyers want 200 million bags and growers offer 110, an excess demand of 90 million bags, and the price is bid up. Only at E is there no pressure on the price.

EXCURSION *The first auction of the year at Toyosu*

Toyosu market took over the wholesale fish trade of Tokyo from the old Tsukiji market, where the hero photograph of this unit was taken, on 11 October 2018. Most days a large bluefin fetches tens of thousands of dollars; the first auction of the year is different. On 5 January 2019, Kiyoshi Kimura, whose company Kiyomura runs the Sushi Zanmai restaurant chain, paid 333.6 million yen for a 278 kilogram Pacific bluefin tuna caught off Oma in northern Japan. At the exchange rate of that week the bid was worth about 3.1 million US dollars. A fish of that size sells for roughly 60,000 dollars on an ordinary day. The record stood until 5 January 2026, when a 243 kilogram tuna sold for 510.3 million yen, about 3.2 million dollars.

A price like this is still the meeting of demand and supply, but the demand is for something other than fish: the winning bidder buys a morning of television coverage for his restaurants, and since he is almost alone in valuing it, one bidder's willingness to pay sets the price. The ordinary morning auction, with dozens of buyers and dozens of similar fish, is the competitive market of Section 1.

3.2 Two straight lines

When both curves are straight lines, the equilibrium can be computed rather than read off a drawing. Write the demand line as $Q_d = a - bP$ and the supply line as $Q_s = c + dP$, where a, b, and d are positive numbers and c may have either sign. The intercept a is the quantity buyers would take if the good were free, b says by how many bags demand falls when the price rises by one dollar, d says by how many bags supply rises for the same dollar, and c is the quantity sellers would offer at a price of zero, negative when the first bag needs a positive price before anyone grows it.

KEY EQUATION Market equilibrium

$$Q_{\mathrm{d}}(P^*) = Q_{\mathrm{s}}(P^*), \qquad \text{and for straight lines} \qquad P^* = \frac{a - c}{b + d}, \quad Q^* = a - bP^*.$$

The equilibrium price P^* makes the quantity demanded equal to the quantity supplied, Q^*; the formulas hold for $Q_{\mathrm{d}} = a - bP$ and $Q_{\mathrm{s}} = c + dP$ in a competitive market.

DERIVATION Solving the two lines

At the equilibrium price the two quantities are equal, so $a - bP^* = c + dP^*$. Add bP^* to both sides and subtract c from both sides, which collects the terms with P^* on one side, $a - c = (b + d)P^*$, and then divide by $b + d$. Substituting the result into either line gives the quantity, and both lines must give the same number. Two more checks are worth making: the price and the quantity must both be positive, and the price should lie in the range for which the lines were fitted, because a line fitted to prices between \$2 and \$4 says nothing reliable about \$12.

WORKED EXAMPLE The equilibrium of the world coffee market

The two coffee lines of this unit are fitted to the world market of 2019 and 2020, when green beans of the Arabica species, which supplies most of the world's coffee (the rest is the cheaper Robusta), sold for about \$3 per kilogram and the world crop was about 170 million bags, according to the World Bank's commodity price data and the US Department of Agriculture. With $a = 260$, $b = 30$, $c = -10$, and $d = 60$,

$$P^* = \frac{260 - (-10)}{30 + 60} = \frac{270}{90} = 3.00 \text{ USD per kg}, \qquad Q^* = 260 - 30 \times 3.00 = 170 \text{ million bags}.$$

The supply line gives the same quantity, $-10 + 60 \times 3.00 = 170$, so the arithmetic is consistent. Both numbers are positive, and \$3 lies in the middle of the prices the lines were fitted to. The equilibrium is a price of \$3.00 per kilogram and 170 million bags a year, which is about 10 million tonnes of beans, or 1.3 kilograms for every person on Earth.

3.3 When a curve shifts

The questions economists ask of this model have the form "what happens to the price and the quantity when something changes?", and the method for answering them is called **comparative statics**, which means drawing the old equilibrium, shifting the curve that the change affects, and reading off the new one. It takes three steps.

1. Decide which curve shifts. A change on the buyers' side moves demand, a change on the sellers' side moves supply, and the good's own price moves neither.
2. Decide the direction. More demand or more supply at every price is a shift to the right.
3. Compare the new crossing point with the old one.

To see the steps at work, suppose that incomes rise. Demand shifts to the right, so at the old price of \$3 buyers now want more bags than growers offer, which is an excess demand, and the price is bid up as in Section 3. As the price rises, growers move up along the unchanged supply curve and offer more, so the quantity rises together with the price.

With one curve shifting, the result is always definite, and Table 1 lists the four cases. With two curves shifting at once, one of the two answers is definite and the other depends on which shift is larger. For example, when demand rises and supply falls, as in the coffee market of 2021, the price must rise, because both shifts push it the same way, while the quantity may go either way; a reader who finds a definite answer for both has drawn one particular picture and mistaken it for the general case.

Shift	Example	Price	Quantity
Demand rises	higher incomes, a new export market	rises	rises
Demand falls	a health scare, a cheaper substitute	falls	falls
Supply rises	better technology, a good harvest	falls	rises
Supply falls	a frost, more expensive inputs, fewer sellers	rises	falls

Table 1. Comparative statics with one shifting curve. Price and quantity move together when demand shifts and in opposite directions when supply shifts, which is how an economist tells from the data which curve moved.

For straight lines the size of the move can be computed. If the supply line shifts by Δc (negative for a shift to the left) and nothing else changes, the equilibrium price and quantity change by

$$\Delta P^{*} = -\frac{\Delta c}{b + d}, \qquad \Delta Q^{*} = \frac{b\,\Delta c}{b + d}, \tag{1}$$

which follows from the key equation: with the new intercept $c + \Delta c$ the price is $(a - c - \Delta c)/(b + d)$, and subtracting the old price $(a - c)/(b + d)$ leaves $-\Delta c/(b + d)$; the change in the quantity then follows from $Q^{*} = a - bP^{*}$. The same shock moves the price more when the lines are steep in the diagram, that is, when b and d are small, because a small b or d means that a dollar of price change moves the quantity only a little, so neither buyers nor sellers do much to absorb the shock. Unit 3 turns this remark into the concept of elasticity.

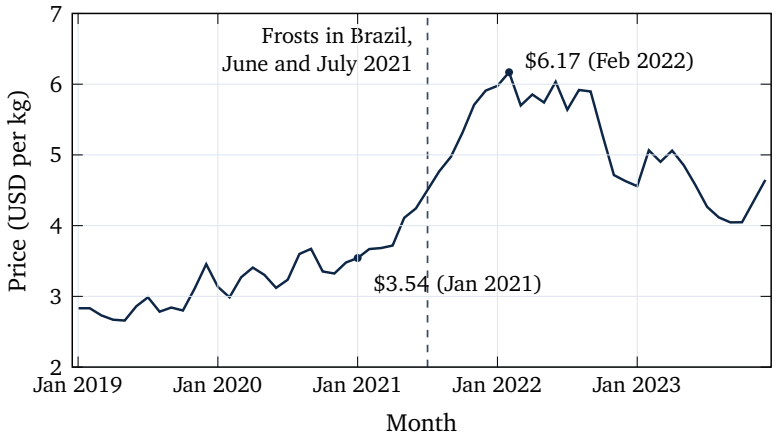


Figure 3. The monthly average price of Arabica coffee from January 2019 to December 2023 in US dollars per kilogram. The dashed line marks the frosts of June and July 2021; the price had already begun to rise with the drought and the recovery of demand after the pandemic. Source: World Bank Commodity Price Data (the Pink Sheet), series Coffee, Arabica, accessed November 2026.

WORKED EXAMPLE The Brazilian frost of 2021

Brazil grows about 40 per cent of the world's coffee in a normal year. After a severe drought in 2020 and early 2021, frosts in the last days of June and on 20 and 30 July 2021 damaged coffee trees in Minas Gerais, São Paulo, and Paraná, and the frost of 20 July was the worst since 1994. The US Department of Agriculture put Brazil's Arabica crop of 2021/22 at 35.0 million bags, down 14.7 million bags from the record of the previous year, and world coffee production at 167.5 million bags, down 8.5 million from 176.0 million the year before, because a larger harvest of Robusta offset part of the loss.

In the model this is a shift of the supply line to the left by $\Delta c = -8.5$ million bags. Equation (1)

with the lines of this unit gives

$$\Delta P^* = -\frac{-8.5}{30+60} = 0.094 \text{ USD per kg}, \qquad \Delta Q^* = \frac{30 \times (-8.5)}{90} = -2.8 \text{ million bags}.$$

The predicted quantity, about 167 million bags, is close to what was harvested. The predicted price rise of about 9 cents per kilogram is far too small. Figure 3 shows what happened: the monthly average price of Arabica beans rose from \$3.54 per kilogram in January 2021 to \$5.91 in December 2021 and peaked at \$6.17 in February 2022, which is a rise of about two thirds within one year. The lines of this unit are fitted to several years, over which growers plant and buyers adjust. Within a single season neither side can do much, since a coffee tree takes three to four years to bear its first crop, so the lines that describe a single season are far steeper than the fitted ones, and a small cut in quantity needs a large price change to clear the market. Traders also expected the damaged trees to give a short 2022 crop, and demand was recovering from the pandemic; all three effects push the price the same way.

CHECK YOUR UNDERSTANDING Question 2

In one season, incomes rise in the importing countries and a drought cuts the harvest. Which statement about the new equilibrium is certain?

(A) The price rises and the quantity falls

(B) The price rises; the quantity may rise or fall

(C) The quantity falls; the price may rise or fall

(D) The price and the quantity both rise

The solution is at the end of the unit.

4 The gains from trade

A market does more than find a price: every trade at P^* makes both sides better off, and the diagram measures by how much. Read the demand curve from the top down, as a list of the buyers in the order of what each would pay at most. The first bags go to whoever values coffee most, a buyer who would have paid \$8 rather than go without; the buyer of the 80 millionth bag would have paid up to \$6, the height of the demand curve there. Each of them pays only P^*. The difference between what a buyer would have paid at most and what she actually pays is her gain from the trade, and the sum of these gains over all buyers is the **consumer surplus**. In the diagram it is the area below the demand curve and above the price line, shown in Figure 4.

The same reading works for sellers. The height of the supply curve at any quantity is the cost of producing that bag, so a grower whose bag costs \$1 and who sells it for \$3 gains \$2. The sum over all bags sold is the **producer surplus**, the area above the supply curve and below the price line. The two areas together are the **total surplus**, the whole gain that the existence of the market creates.

KEY EQUATION Consumer surplus and producer surplus

$$CS = \tfrac{1}{2}\,(P_{\max} - P^*)\,Q^*, \qquad PS = \tfrac{1}{2}\,(P^* - P_{\min})\,Q^*,$$

for straight-line curves, where $P_{\max} = a/b$ is the price at which demand reaches zero and $P_{\min} = -c/d$ the price at which supply starts (the formula for PS needs $c \le 0$, because for $c > 0$ the supply line

meets the quantity axis instead of the price axis and the area is no longer a triangle). In general, consumer surplus is the area below the demand curve and above the price, producer surplus the area above the supply curve and below the price, and both are measured in money per interval.

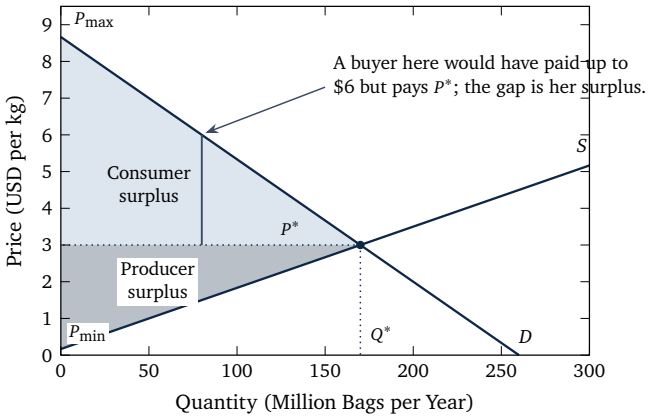


Figure 4. Consumer surplus (light) and producer surplus (dark) in the coffee market of this unit. The buyer of the 80 millionth bag would have paid \$6 and pays \$3; her \$3 is one slice of the consumer surplus. $P_{\max}$ is the price at which demand would fall to zero and $P_{\min}$ the price below which nothing would be supplied.

The reason economists care about these areas is a result that this unit states and Unit 6 examines. In a competitive market, the equilibrium quantity Q^* makes the total surplus as large as it can be, because every bag up to Q^* is worth more to its buyer than it costs its grower and every bag beyond it would cost more than it is worth. The proof that no other arrangement could do better goes beyond this unit. The result holds under the four assumptions of Section 1; Unit 6 shows what happens when a market harms people who are neither buyers nor sellers, as pollution does, and the crossing point is no longer the best quantity. The surplus areas are the measuring stick for what taxes and price controls do.

5 A tax on a market

Governments tax petrol, tobacco, and alcohol wholly or partly by a fixed amount per litre or packet. Suppose the tax is t per litre of petrol and the law says the petrol station must pay it. The station now needs the old price plus t to keep what it kept before, so at every quantity the supply curve sits t higher; equivalently, there is a **tax wedge** between the price buyers pay and the price sellers keep,

$$P_{\text{b}} - P_{\text{s}} = t,$$

where P_{b} is the price buyers pay at the pump and P_{s} the amount sellers keep after sending the tax to the treasury. Figure 5 shows the new situation. The quantity traded falls to Q_t, the quantity at which the demand curve is exactly t above the supply curve. Buyers pay more than before, sellers keep less than before, and the two changes add up to t.

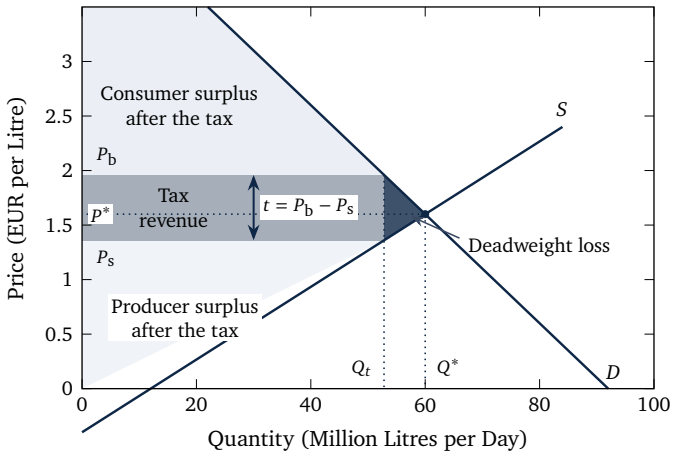


Figure 5. A tax per litre in the petrol market of this unit, drawn with a tax of 60 cents so that the areas are visible (the worked example uses 18 cents). The tax drives a wedge t between the price buyers pay, P_b, and the price sellers keep, P_s, and the quantity falls from Q^* to Q_t. The rectangle is the tax revenue, the small dark triangle the deadweight loss, and the lighter areas are what is left of the consumer and producer surplus.

Who pays the tax? The law names the seller, but the law does not decide the matter. Economists distinguish the statutory incidence of a tax, which says who hands the money over, from its **economic incidence**, which says whose surplus shrinks. The diagram shows that the split depends on the slopes of the two curves. If the demand curve is steep, buyers hardly reduce their purchases when the price rises, so sellers can pass most of the tax on to them. If the supply curve is steep, sellers cannot easily cut production and have to accept a lower price themselves. It also makes no difference which side the law names: a tax collected from buyers shifts the demand curve down by t instead of the supply curve up by t, and the wedge, the quantity, the two prices, and the revenue come out identical.

KEY EQUATION The tax wedge, its incidence, revenue, and deadweight loss

$$P_b - P_s = t, \qquad P_b - P^* = \frac{d}{b+d}\,t, \qquad \text{revenue} = t\,Q_t, \qquad DWL = \tfrac{1}{2}\,t\,(Q^* - Q_t).$$

A tax of t per item raises the price buyers pay by the share $d/(b+d)$ of the tax and lowers the price sellers keep by the share $b/(b+d)$, for the straight lines $Q_d = a - bP$ and $Q_s = c + dP$; the side whose curve is steeper, with the smaller slope coefficient, bears the larger share. The government collects t on each of the Q_t items still traded, and the surplus lost on the items no longer traded, the deadweight loss, is the triangle between the two curves over the lost quantity.

The tax also destroys something. Between Q_t and Q^* there are litres that buyers value more than they cost to produce, which is why they were traded before, and that are no longer traded because of the wedge. The surplus they would have created is lost to everyone, the treasury included, since no tax is paid on a litre that is not sold. This loss is the **deadweight loss** of the tax, the dark triangle in Figure 5.

DERIVATION Incidence and deadweight loss for straight lines

After the tax, buyers face P_b and sellers receive $P_s = P_b - t$. The quantity is the same on both sides, so $a - bP_b = c + d(P_b - t)$, hence $a - c + dt = (b+d)P_b$, which gives

$$P_b = \frac{a - c + dt}{b+d} = P^* + \frac{d}{b+d}\,t, \qquad P_s = P_b - t = P^* - \frac{b}{b+d}\,t.$$

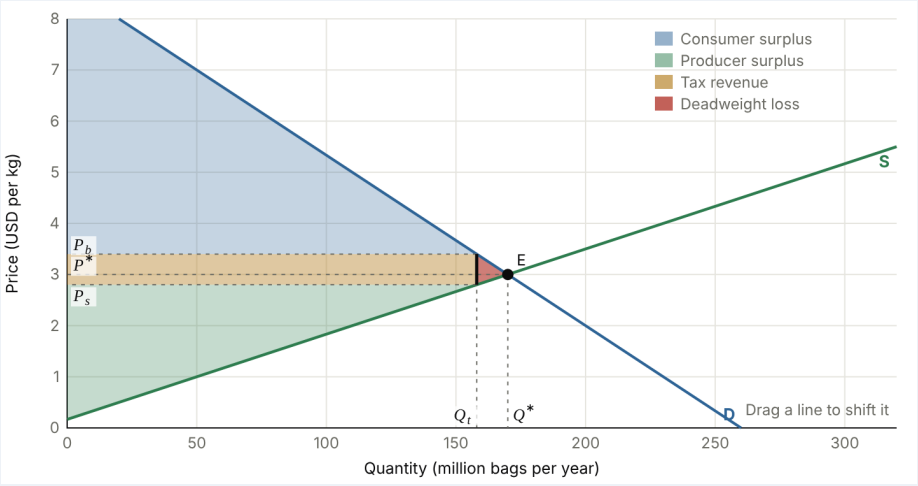
The quantity falls to $Q_t = a - bP_b = Q^* - \dfrac{bd}{b+d}\,t$. The deadweight loss is the triangle whose base is the wedge

t (measured along the price axis) and whose height is the lost quantity $Q^* - Q_t$, so its area is

$$DWL = \tfrac{1}{2}\, t\,(Q^* - Q_t) = \tfrac{1}{2}\,\frac{bd}{b+d}\,t^2.$$

The second form shows that the loss grows with the square of the tax: doubling a tax quadruples the deadweight loss while at most doubling the revenue.

INTERACTIVE The market cross with a tax



Drag the demand or the supply line up and down to shift it, change the slopes with the sliders, and add a tax per kilogram. The readouts give the equilibrium, the prices buyers pay and sellers keep, the revenue, and the deadweight loss, and the shaded areas show the consumer surplus, the producer surplus, the revenue, and the loss. Notice that the side with the steeper line bears more of the tax, and that doubling the tax quadruples the loss.

Click the picture or this link to try it in the online version of this unit.

WORKED EXAMPLE A petrol tax of 18 cents per litre

A country's petrol market is described by $Q_\mathrm{d} = 92 - 20P$ and $Q_\mathrm{s} = 12 + 30P$, with P in euros per litre and Q in million litres per day; these lines are chosen for the example, and real fuel taxes are several times larger (the United Kingdom's fuel duty, for instance, is 52.95 pence per litre in 2026). Without a tax, $P^* = (92 - 12)/(20 + 30) = 1.60$ euros per litre and $Q^* = 92 - 32 = 60$ million litres per day. The government introduces a tax of $t = 0.18$ euros per litre, about 11 per cent of the price.

The buyers' share of the tax is $d/(b+d) = 30/50 = 0.6$, so the pump price rises by $0.6 \times 18 = 10.8$ cents to $P_\mathrm{b} = 1.708$ euros, and sellers keep $P_\mathrm{s} = 1.528$ euros, which is 7.2 cents less than before. The quantity falls to $Q_t = 92 - 20 \times 1.708 = 57.84$ million litres per day, a drop of 2.16 million litres or 3.6 per cent. The revenue is $0.18 \times 57.84 = 10.4$ million euros a day, about 3.8 billion euros a year, and the deadweight loss is

$$DWL = \tfrac{1}{2} \times 0.18 \times 2.16 = 0.194 \,\text{million euros per day},$$

about 71 million euros a year, or 1.9 per cent of the revenue. So buyers bear 60 per cent of the tax, 10.8 of the 18 cents, because the supply line is the flatter of the two in the diagram ($d = 30$ against $b = 20$), that is, because sellers change their quantity more strongly than buyers do when the price moves by one euro. Unit 3 restates this result with elasticities, which are the slopes made free of the units of measurement.

CHECK YOUR UNDERSTANDING Question 3

A city collects a tax of 2 euros per taxi ride from the passengers instead of from the drivers, as before. The demand and supply curves are unchanged. What changes?

(A) Nothing: the prices paid and kept, the rides, and the revenue are the same

(B) Passengers now bear the whole tax, since they hand it over

(C) Drivers now bear a smaller share than before

(D) The deadweight loss falls, since drivers no longer reduce their supply

The solution is at the end of the unit.

6 Price ceilings and price floors

Sometimes a government, rather than taxing a market, decides that the equilibrium price is wrong and sets a legal limit on it. A **price ceiling** is a maximum price that may be charged, with rent control as the common case; a **price floor** is a minimum price that must be paid, with the minimum wage as the common case. A limit that lies on the wrong side of the equilibrium does nothing: a ceiling above P^* or a floor below it is not **binding**, because the market price obeys it anyway.

Figure 6 shows a rent ceiling. At the capped rent more households want flats, and fewer are offered, because some landlords sell their flats to people who will live in them, turn them into holiday rentals, or stop maintaining buildings that no longer pay. The gap between Q_d and Q_s is a shortage, and since the price may not rise to remove it, something else decides who gets the scarce flats: waiting lists, personal connections, side payments for keys or furniture, and the preferences of landlords who can now choose among many applicants. Tenants who already hold a lease at the capped rent gain. Households that need to move, newcomers, and the young lose, because the flats they would have rented at the market rent are not offered at the capped rent, and the lost trades are again a deadweight loss.

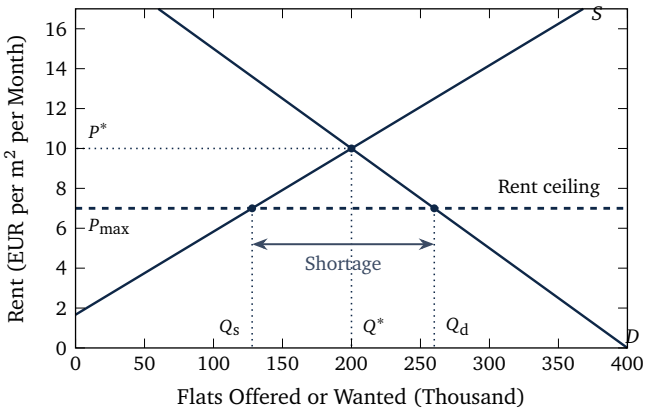


Figure 6. A rent ceiling below the equilibrium rent. At the ceiling P_{max} tenants want Q_d flats and landlords offer only Q_s, so the difference is a shortage that does not go away, because the price is not allowed to rise and close it. The lines are illustrative and are not fitted to a real city.

WORKED EXAMPLE Berlin's rent cap of 2020 to 2021

On 23 February 2020 the state of Berlin put a rent cap, the Mietendeckel, into force. Rents for an estimated 95 per cent of the city's rented flats were frozen at what they had been on 18 June 2019,

new lettings were capped at fixed amounts per square metre, and buildings first occupied from 2014 onwards were exempt. A study by economists at the DIW Berlin research institute and two partner institutes compared rental advertisements before and after the cap, with the exempt flats and the surrounding towns as the comparison. In the first year, advertised rents of capped flats fell by about 11 per cent relative to uncapped ones, so the ceiling was binding and the price did fall. At the same time the number of flats advertised for rent in Berlin fell by more than half, and advertised rents in the surrounding towns rose, by about 12 per cent in Potsdam. On 25 March 2021, in a decision published on 15 April 2021, the Federal Constitutional Court declared the law void, because rent law is a matter for the federal parliament, which had already legislated on it, and the cap ended. For the model of this section the lesson is that the ceiling cut rents for those who had a flat and halved the supply of flats for those who were looking for one. Whether the trade-off was worth it is a political judgement, which the data do not make.

A price floor produces the mirror image. The United Kingdom's National Living Wage, for example, is 12.71 pounds an hour for workers aged 21 and over from April 2026, and it binds in occupations whose market wage would be lower. In the simplest version of the model the workers are the sellers and the employers the buyers, with the hours of work on the horizontal axis and the wage on the vertical, and a floor above the equilibrium wage raises the hours offered by workers and lowers the hours demanded by employers, and the gap is unemployment among the affected workers: those who keep their jobs at the higher wage gain, and those who do not find work at it lose. How large the loss of jobs really is has been one of the most argued questions in economics since the study by Card and Krueger that Unit 1 described, because the answer depends on how far the labour market departs from the assumptions of Section 1; that debate goes beyond this unit.

CHECK YOUR UNDERSTANDING Question 4

The equilibrium rent in a town is 9 euros per square metre. The council sets a legal maximum rent of 12 euros per square metre. What does the model predict?

(A) A shortage of flats, since ceilings always reduce supply

(B) Rents rise to 12 euros, since landlords charge the maximum allowed

(C) A surplus of empty flats, since the ceiling acts like a floor

(D) No change, since the ceiling lies above the equilibrium rent

The solution is at the end of the unit.

7 Markets without prices

The model says that whenever a buyer values something more than it costs the seller, a price exists at which both gain, and that blocking the trade destroys surplus; societies nevertheless block many trades. It is illegal almost everywhere to sell a kidney, a vote, a child for adoption, a place at a public school, or a place in the queue for a transplant. The economist Alvin E. Roth has called such trades **repugnant transactions**: trades that some people would like to make and that others do not want them to make, even when the others are not harmed in any way the model measures. Repugnance changes with time and place: lending money at interest was repugnant in medieval Europe and is now the business of banks, and selling a human being was legal in the United States until 1865 and is unthinkable now.

A ban on the price does not remove the scarcity. In the United States, where the National Organ Transplant Act of 1984 forbids buying or selling an organ (only the donor's expenses may be reimbursed), more than 140,000 adult registrations were on the waiting list for a kidney at some point during 2023, a count in which a patient listed at two centres appears twice, and 4,002 patients, about eleven a day, were removed

from the list that year because they had died. Many patients have a relative or friend willing to give them a kidney but cannot accept it, because the blood types do not match or because the patient's antibodies would attack the donor's tissue. Roth and his co-authors Tayfun Sönmez and Utku Ünver showed in 2004 how a clearing house, a central office that collects all such pairs and searches for matches among them, can match incompatible pairs with one another, so that the donor of each pair gives to the patient of another, and helped to found the first regional clearing house of this kind, the New England Program for Kidney Exchange, in 2004. Figure 7 shows the simplest cycle of three pairs. No money changes hands, each donor still gives one kidney, each patient receives one, and the trades that repugnance forbids at a price happen in kind, that is, kidney for kidney rather than for money.

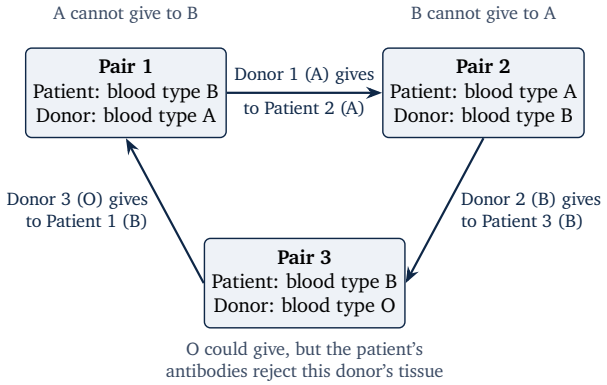


Figure 7. A kidney exchange cycle of three incompatible patient-donor pairs. Within each pair the donor cannot give to his or her own patient, but each donor is compatible with the patient of the next pair, so three transplants take place at once, without any payment.

WORKED EXAMPLE **Kidney exchange in the United States in 2023**

The OPTN/SRTR Annual Data Report, published by the registry that tracks every transplant in the United States, counts 6,226 living kidney donors in 2023, up from 5,226 in the pandemic year 2020, and reports that 20.6 per cent of these donations went through an exchange rather than directly to the donor's own patient. That is about 1,280 kidney transplants made possible by exchange in one year. When Roth wrote his 2007 essay, the new regional exchanges still managed only dozens a year. Exchange cannot help patients without a willing donor, so the argument about payment continues.

The same idea, allocation by a designed rule rather than by a price, runs through other markets society keeps money out of, such as places at public schools in New York City and Boston, which are assigned by a matching procedure that takes families' ranked choices. Designing such rules so that people have no reason to lie about what they want is the subject of **market design**.

RESEARCH SPOTLIGHT

Alvin E. Roth *Stanford University*

Why some trades are kept out of markets

Alvin E. Roth, Craig and Susan McCaw Professor of Economics at Stanford University, shared the 2012 Nobel prize in economic sciences for the theory of stable allocations and the practice of market design. In a 2007 essay in the *Journal of Economic Perspectives* he asked why some transactions that would benefit both parties are nonetheless forbidden, and answered that distaste for certain trades, which he calls repugnance, is a constraint on markets as real as technology or the need for the right incentives. His list of examples runs from trades that became repugnant, such as slavery, to trades that ceased to be, such as lending at interest, and to the case he examined

most closely, the ban on buying and selling kidneys, in force almost everywhere except Iran. He found that arguments resting only on the gains from trade of Section 4 rarely move such bans, because the objection is to the price itself, and he drew the conclusion of Section 7: exchanges in kind, such as the kidney exchange he had helped to design, had not aroused the repugnance that payment does, and could do some of the work a market is not allowed to do.

Read the paper: Roth (2007), Repugnance as a Constraint on Markets, Journal of Economic Perspectives 21(3), 37

KEY POINTS

- A competitive market has many price-taking buyers and sellers, a standardized good, free entry, and full information; the later units relax each assumption.
- The equilibrium is the crossing point, $Q_{\mathrm{d}}(P^*) = Q_{\mathrm{s}}(P^*)$; for straight lines $P^* = (a - c)/(b + d)$. Excess supply pushes the price down and excess demand pushes it up, so the equilibrium is stable.
- Comparative statics: decide which curve shifts and in which direction, then compare the crossing points. One shift gives a definite answer for price and quantity; two shifts leave one of them open.
- Consumer and producer surplus measure the gains from trade, and the competitive equilibrium makes their sum as large as possible under the four assumptions.
- A tax of t per item drives a wedge $P_{\mathrm{b}} - P_{\mathrm{s}} = t$, is shared in proportion to the slopes regardless of who hands it over, raises $t\,Q_t$, and destroys the surplus $\frac{1}{2}t(Q^* - Q_t)$. A binding price ceiling creates a shortage and a binding floor a surplus, and those a control was meant to help do not always gain.

Solutions to the questions in the text: 1-A, 2-B, 3-A, 4-D. The online version of this unit explains each answer.