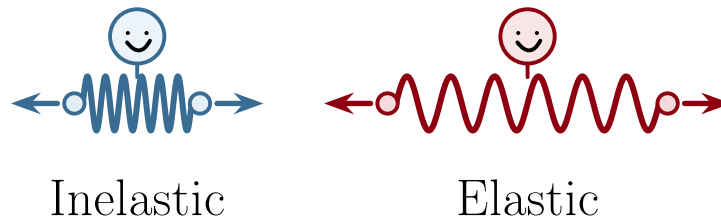


Chapter 5

Elasticity and Its Application



The Price Elasticity of Demand

Definition. **Elasticity** is a measure of the responsiveness of quantity demanded or quantity supplied to a change in one of its determinants.

Definition. The **price elasticity of demand** measures how much the quantity demanded of a good responds to a change in its price. It is computed as the percentage change in quantity demanded divided by the percentage change in price, reported in absolute value and holding other demand determinants fixed.

Loosely speaking, it measures how price-sensitive buyers are. Demand is **elastic** if quantity demanded responds substantially to a price change, and **inelastic** if it responds only slightly.

What Determines the Price Elasticity of Demand?

The availability of substitutes and the importance of the good to the buyer help determine price sensitivity.

Availability of close substitutes. Goods with close substitutes have more elastic demand, because buyers can easily switch. If the price of one brand of instant noodles rises, we can buy another brand. Demand for that brand tends to be more elastic than demand for eggs, which have fewer close substitutes in many uses.

Necessities versus luxuries. Necessities tend to have less elastic demand than luxuries. When the cost of a doctor's visit rises, we do not go much less often. When the price of a trip to Japan rises, many of us skip it. Which is which depends on the buyer, not on the good itself.

Determinants of Elasticity, Continued

Definition of the market. Demand tends to be more elastic for a narrowly defined good. Food as a whole has few substitutes. Bubble tea has other drinks as substitutes, and one shop's bubble tea also has competing shops' drinks as substitutes.

Time horizon. Demand is usually more elastic over longer periods. When gasoline gets more expensive, drivers cut back only a little in the first few months. Over years, they buy scooters or fuel-efficient cars, switch to the MRT, or move closer to work.

Discussion: Which Demand Is More Elastic?

For each pair, compare separate 20 percent price increases, holding other demand determinants fixed. Which quantity would fall by a larger percentage, and why?

1. One brand of instant noodles, or Taiwan High Speed Rail tickets
2. Apple Sidra, or soft drinks in general
3. Insulin, or a Rolex watch
4. Gasoline over the next month, or gasoline over the next five years

Answer: Which Demand Is More Elastic?

1. We would expect the noodle brand to have more elastic demand because other brands are close substitutes. High speed rail passengers may have fewer close substitutes when travel time matters; the comparison depends on the trip.
2. Apple Sidra. It is a narrowly defined good with many substitutes, while soft drinks in general have fewer.
3. The Rolex watch. Insulin is essential for people who depend on it, so we expect relatively inelastic demand. A luxury watch can be given up.
4. Gasoline over five years. In a month, drivers have fewer ways to adjust. In five years, they can change cars, routes, and homes.

Computing the Price Elasticity of Demand

$$\text{Price elasticity of demand} = \left| \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in price}} \right|$$

Example. Suppose a 10 percent increase in the price of bubble tea causes the quantity we buy to fall by 20 percent. Then the price elasticity of demand is $20\%/10\% = 2$. Quantity changes twice as much, in percentage terms, as price.

Because price and quantity demanded move in opposite directions, the signed ratio is negative for downward-sloping demand. We follow the common practice of dropping the minus sign and reporting price elasticities of demand as positive numbers. A larger number then means more responsive buyers.

The Variety of Demand Curves

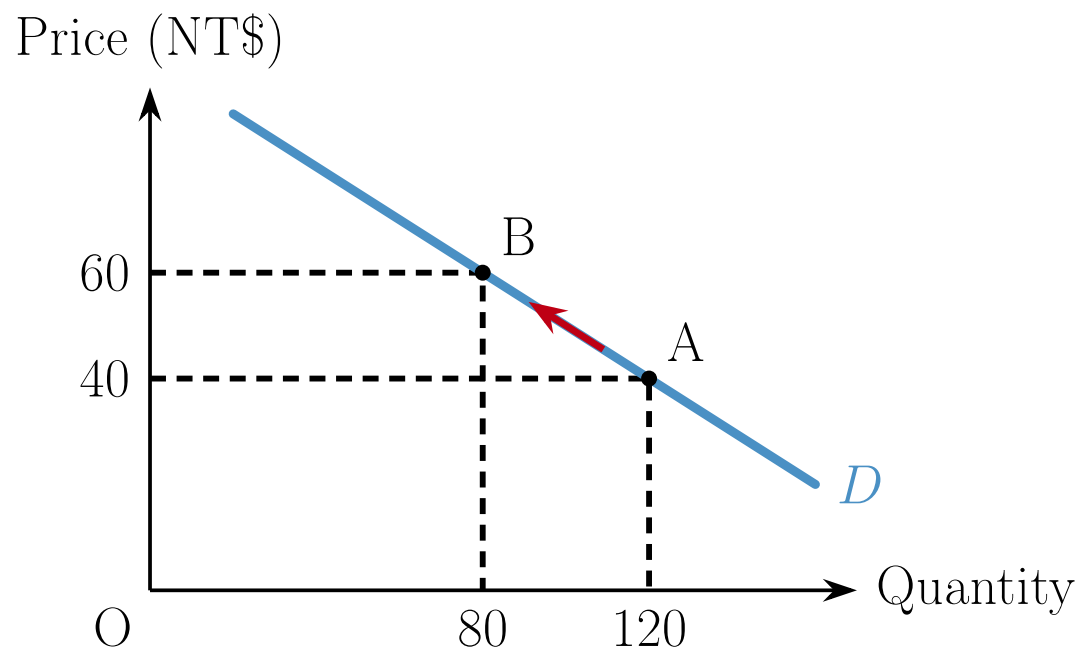
Economists classify demand curves according to their elasticity.

- Demand is **elastic** when the elasticity is greater than 1, so quantity moves proportionately more than price.
- Demand is **inelastic** when the elasticity is less than 1, so quantity moves proportionately less than price.
- Demand is **unit elastic** when the elasticity is exactly 1, so quantity and price change by equal percentages in absolute value.

Remark. With the same axis units, the flatter the demand curve through a given point, the greater the price elasticity of demand. The steeper it is, the smaller the elasticity.

Two Points on a Demand Curve

Suppose a price increase moves buyers from A to B along the same demand curve, holding other demand determinants fixed.



$A \rightarrow B$: price rises by NT\$20; quantity falls by 40 units.

A Problem with Percentage Changes

Consider two points on a demand curve: at point A the price is NT\$40 and the quantity is 120, and at point B the price is NT\$60 and the quantity is 80.

Going from A to B, the price rises by 50 percent and the quantity falls by 33 percent, so the elasticity seems to be $(1/3)/(1/2) \approx 0.67$.

Going from B to A, the price falls by 33 percent and the quantity rises by 50 percent, so the elasticity seems to be $(1/2)/(1/3) = 1.5$.

The same two points give two different answers, because each percentage change is computed from a different base.

The Midpoint Method

The **midpoint method** divides each change by the average of its initial and final levels. Here P_1, Q_1 are the initial price and quantity; P_2, Q_2 are the final values.

$$\text{Price elasticity of demand} = \left| \frac{(Q_2 - Q_1)/[(Q_2 + Q_1)/2]}{(P_2 - P_1)/[(P_2 + P_1)/2]} \right|$$

In our example, the midpoint is NT\$50 and 100 units. From A to B, the price rises by $20/50 = 40\%$ and the quantity falls by $40/100 = 40\%$. Thus, the elasticity is 1 in either direction. This describes the interval between the two observations, not necessarily every point between them.

When calculating elasticity from two price–quantity observations, use the midpoint method. Other percentage changes may use initial values as the base; we state this explicitly when needed.

Discussion: Compute an Elasticity

Suppose we run a small English tutoring service, charging NT\$450 per hour for 42 hours a month. Our costs are rising, so we raise the price to NT\$550, and the hours customers want to buy fall to 28 per month. Assume other demand determinants stay fixed and we can supply all hours requested.

1. Use the midpoint method to compute the percentage change in price.
2. Use the midpoint method to compute the percentage change in quantity.
3. Compute the price elasticity of demand. Is demand elastic or inelastic?

Answer: Compute an Elasticity

1. The midpoint price is NT\$500, so the percentage change in price is $100/500 = 20\%$.
2. The midpoint quantity is 35 hours, so the percentage change in quantity is $-14/35 = -40\%$.
3. The price elasticity of demand is $|(-14/35)/(100/500)| = 2$. Demand is elastic over this price range.

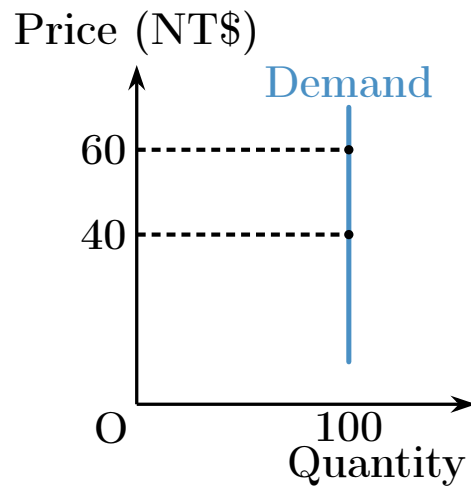
Price rises  20%

Hours demanded fall  40%

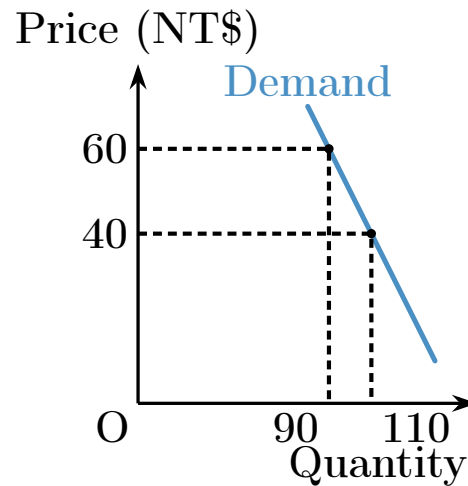
The percentage quantity response is 2 times the percentage price change.

Inelastic and Unit-Elastic Demand

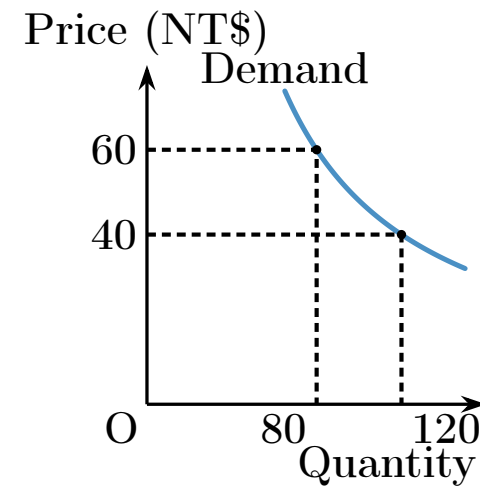
(a) Perfectly inelastic:
elasticity 0



(b) Inelastic: elasticity
below 1



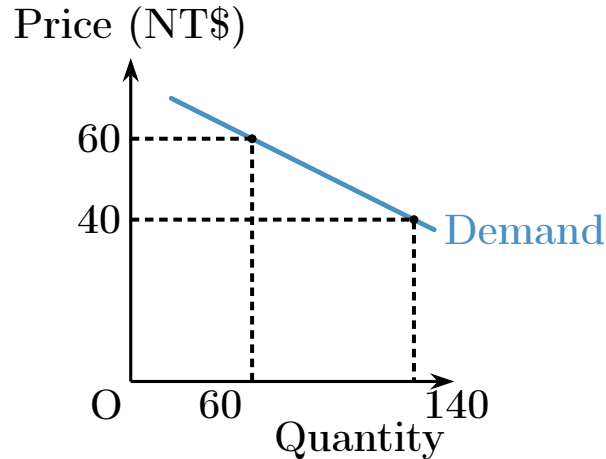
(c) Unit elastic:
elasticity 1



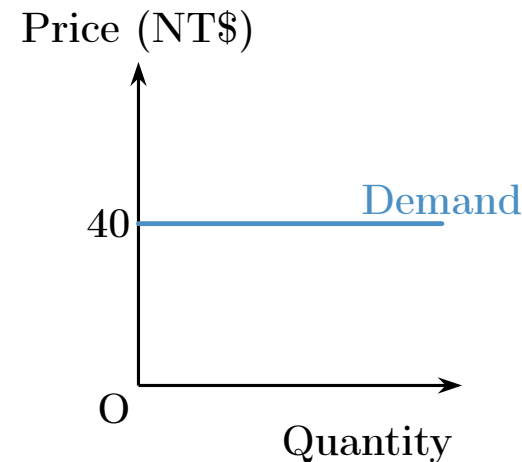
In every panel the price rises from NT\$40 to NT\$60, a 40 percent increase. In panel (a), quantity stays at 100. In panel (b), it falls from 110 to 90, a 20 percent decrease, so elasticity is 0.5. In panel (c), it falls from 120 to 80, a 40 percent decrease, so elasticity is 1.

Elastic Demand Curves

(d) Elastic: elasticity above 1



(e) Perfectly elastic: elasticity infinite



In panel (d), the same 40 percent price increase cuts quantity demanded from 140 to 60, an 80 percent decrease, so elasticity is 2. In panel (e), at any price above NT\$40 the quantity demanded is zero, at exactly NT\$40 buyers take any quantity, and below NT\$40 the quantity demanded is unlimited.

Remark. Perfectly inelastic demand is vertical; perfectly elastic demand is horizontal. Both are limiting cases.

A Few Elasticities from the Real World

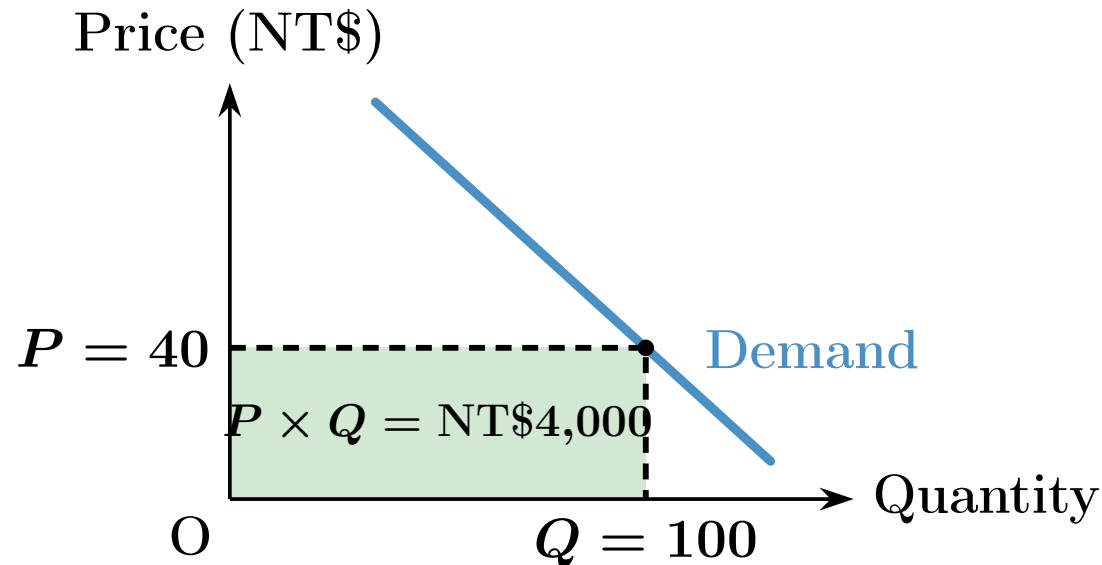
These estimated price elasticities illustrate differences across goods and market definitions.

Good	Elasticity	Good	Elasticity
Eggs	0.1	Beef	1.6
Healthcare	0.2	Peanut butter	1.7
Cigarettes	0.4	Restaurant meals	2.3
Rice	0.5	Cheerios	3.7
Housing	0.7	Mountain Dew	4.4

These are study-specific estimates, not universal constants. Elasticity can vary with the population, time horizon, and position on the demand curve. Cheerios is a cereal brand; Mountain Dew is a soft-drink brand.

Total Revenue

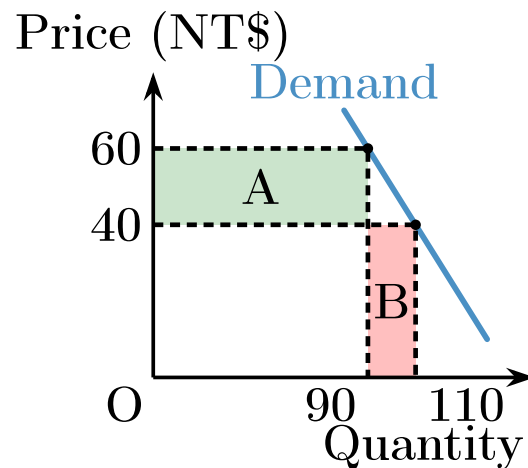
Definition. Total revenue is the amount sellers receive from sales: the price received per unit times the quantity sold, $P \times Q$. Without a tax wedge, this also equals buyers' total spending.



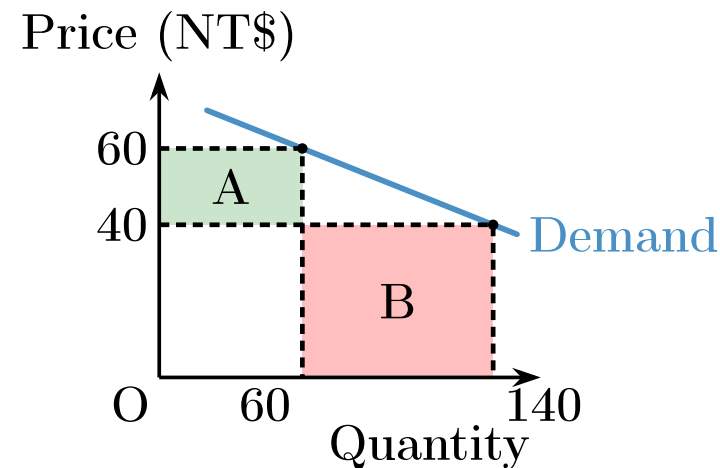
Graphically, total revenue is the area of the box under the demand curve, with height P and width Q . Here it is NT\$40 times 100 units, or NT\$4,000.

How Total Revenue Changes When Price Changes

(a) Inelastic demand



(b) Elastic demand



A price increase has two effects on revenue. Area A is the extra revenue from selling each unit at a higher price. Area B is the revenue lost from selling fewer units. In panel (a), demand is inelastic, quantity falls from 110 to 90, and revenue rises from NT\$4,400 to NT\$5,400. In panel (b), demand is elastic, quantity falls from 140 to 60, and revenue falls from NT\$5,600 to NT\$3,600.

The Elasticity–Revenue Rule

Along a fixed demand curve, elasticity determines whether the price effect or the quantity effect on total revenue, $P \times Q$, is stronger.

Demand	Price rises	Price falls
Inelastic ($E < 1$)	Revenue rises	Revenue falls
Unit elastic ($E = 1$)	Revenue unchanged	Revenue unchanged
Elastic ($E > 1$)	Revenue falls	Revenue rises

With inelastic demand, price and revenue move in the same direction. With elastic demand, they move in opposite directions.

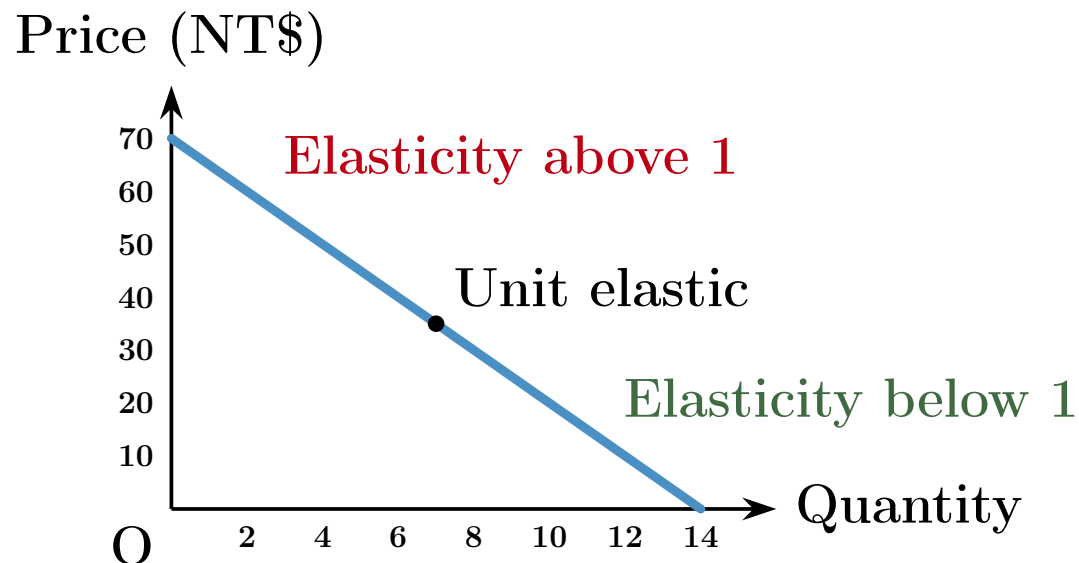
Our Scenario: Should We Raise the Price?

At NT\$450 per hour and 42 hours, our tutoring revenue is NT\$18,900 a month.

Raising the price to NT\$550 cuts hours to 28. Demand is elastic (elasticity 2), and revenue falls to $550 \times 28 = \text{NT\$}15,400$.

If hours instead fall only to 38, quantity falls by $4/40 = 10\%$. Demand is inelastic (elasticity 0.5), and revenue rises to $550 \times 38 = \text{NT\$}20,900$. In either case, the effect on profit also depends on costs.

Elasticity along a Linear Demand Curve



A straight line has a constant **slope**: each NT\$10 price increase cuts quantity demanded by 2 units. But its **elasticity** is not constant, since elasticity is a ratio of percentage changes. At high prices and low quantities, NT\$10 is a small share of the price and 2 units a large share of the quantity, so demand is elastic. At low prices and high quantities, the opposite holds, so demand is inelastic.

Discussion: Elasticity and Total Revenue

1. Pharmacies raise the price of insulin by 10 percent. Does their total revenue from insulin rise or fall?
2. A hot-spring resort in Beitou cuts its weekend room rates by 20 percent. Does the resort's total revenue rise or fall?

Assume other demand determinants stay fixed and sellers can meet demand. State a plausible elasticity assumption, then explain what it implies for revenue. The price change alone does not determine the answer.

Insulin

Higher price $\times$ fewer units
= higher or lower revenue?

Resort rooms

Lower price $\times$ more bookings
= higher or lower revenue?

Answer: Elasticity and Total Revenue

1. We expect relatively inelastic demand for insulin. If demand is inelastic over this price range, the higher price more than offsets the loss of sales, so total revenue rises.
2. We expect elastic demand for resort stays because buyers have many substitutes. If demand is elastic over this price range, the increase in bookings more than offsets the lower room rate, so total revenue rises.

Other Demand Elasticities

Definition. The **income elasticity of demand** measures how much the quantity demanded of a good responds to a change in consumers' income. It is the percentage change in quantity demanded divided by the percentage change in income.

Keep the sign. It is positive for a **normal good** and negative for an **inferior good**. Necessities generally have income elasticities between 0 and 1; luxuries have income elasticities above 1.

Definition. The **cross-price elasticity of demand** is the percentage change in the quantity demanded of one good divided by the percentage change in the price of another good.

Keep the sign here, too. It is positive for **substitutes**, like bubble tea and coffee, and negative for **complements**, like scooters and gasoline.

The Price Elasticity of Supply

Definition. The **price elasticity of supply** measures how much the quantity supplied of a good responds to a change in its price. It is the percentage change in quantity supplied divided by the percentage change in price.

Supply is **elastic** if quantity supplied responds substantially to price, and **inelastic** if it responds only slightly. What matters is how flexible sellers are in changing the amount they produce.

Land along Taipei's riverside has inelastic supply, since it is almost impossible to make more of it. Manufactured goods often have more elastic supply, since factories may be able to run longer hours. And supply is more elastic in the long run than in the short run, because over time firms can build or close factories and enter or exit the market.

Computing the Price Elasticity of Supply

Example. Suppose the price of a cup of bubble tea rises from NT\$57 to NT\$63, and the quantity shops are willing to supply rises from 9,000 to 11,000 cups per month. Hold input prices, technology, and other supply determinants fixed.

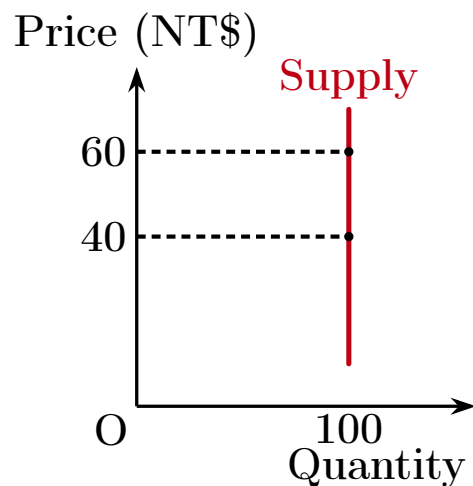
The percentage changes are $(63 - 57)/60 = 10\%$ in price and $(11,000 - 9,000)/10,000 = 20\%$ in quantity supplied.

The price elasticity of supply is therefore $20\%/10\% = 2$. Quantity supplied changes twice as much, in percentage terms, as price.

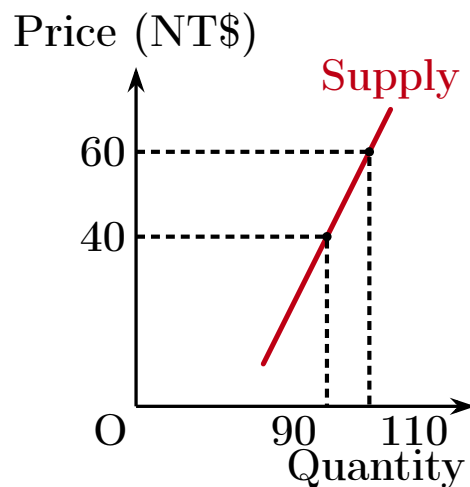
For an upward-sloping supply curve, this elasticity is positive. Perfectly inelastic supply has elasticity zero.

Inelastic and Unit-Elastic Supply

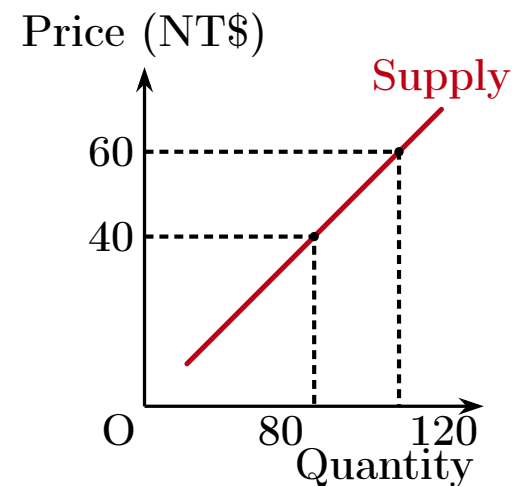
(a) Perfectly inelastic:
elasticity 0



(b) Inelastic: elasticity
below 1



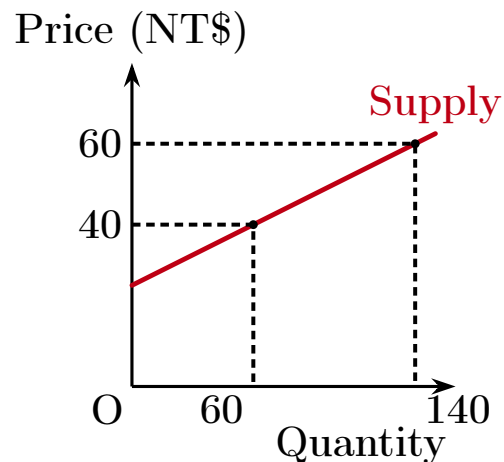
(c) Unit elastic:
elasticity 1



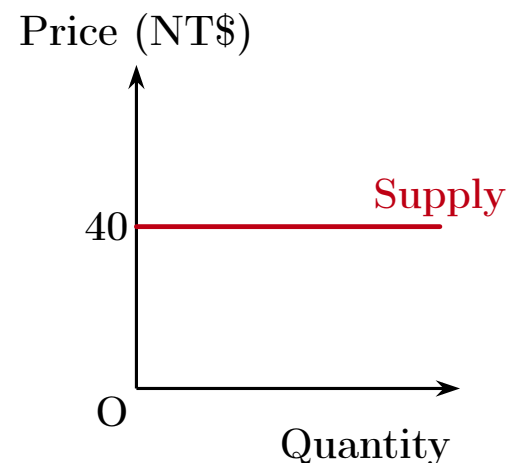
In every panel the price rises from NT\$40 to NT\$60, a 40 percent increase. In panel (a), quantity stays at 100. In panel (b), it rises from 90 to 110, a 20 percent increase, so elasticity is 0.5. In panel (c), it rises from 80 to 120, a 40 percent increase, so elasticity is 1. At a given point and with the same axis units, flatter supply is more elastic.

Elastic Supply Curves

(d) Elastic: elasticity above 1



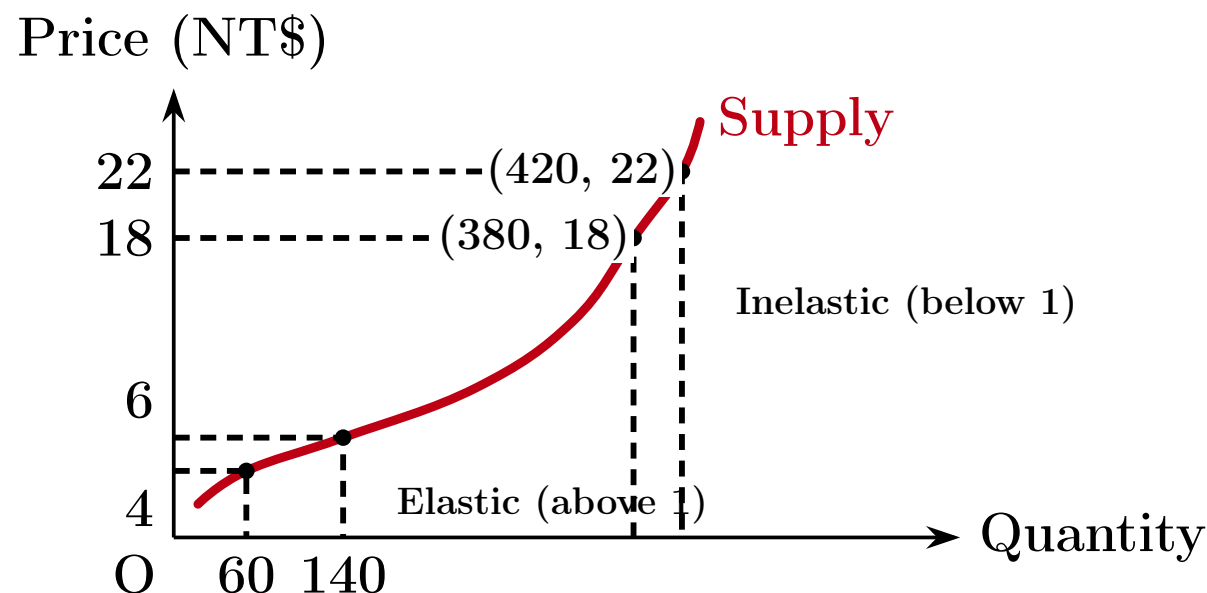
(e) Perfectly elastic: elasticity infinite



In panel (d), price rises from NT\$40 to NT\$60, or 40 percent, while quantity supplied rises from 60 to 140, or 80 percent. Supply elasticity is $80\%/40\% = 2$.

In panel (e), sellers supply any quantity at NT\$40 and none below it. Above NT\$40, quantity supplied is unlimited in this limiting case. Perfectly elastic supply is horizontal.

How the Price Elasticity of Supply Can Vary



Firms often have a maximum capacity. When output is low and plants sit idle, a price increase from NT\$4 to NT\$6 (40 percent) raises quantity supplied from 60 to 140 (80 percent), so elasticity is 2. Near capacity, a price rise from NT\$18 to NT\$22 (20 percent) raises quantity from 380 to 420 (10 percent), so elasticity is 0.5.

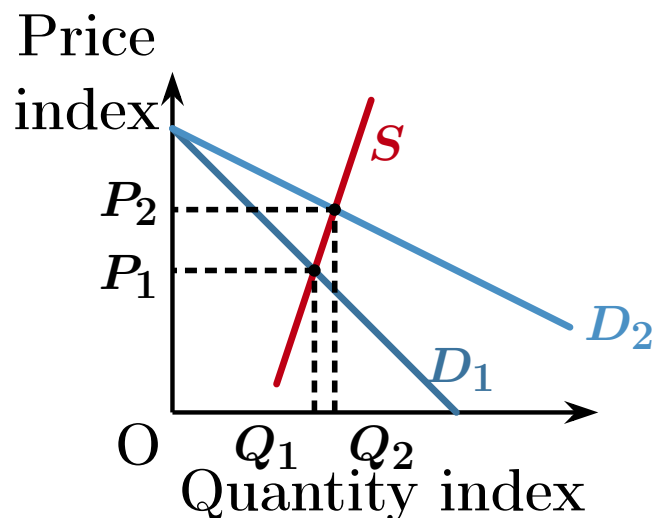
Discussion: Elasticity and Changes in Equilibrium

Assume parking spaces have inelastic supply and bubble tea has elastic supply. To isolate this difference, suppose both markets start at the same price and quantity and have the same demand curve in normalized units. Enrollment growth then doubles quantity demanded at every price.

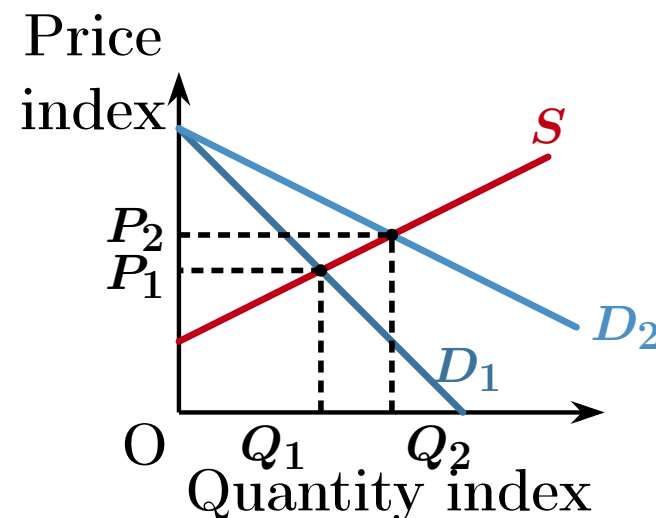
1. Which market has the larger percentage increase in equilibrium price?
2. Which has the larger percentage increase in equilibrium quantity?
3. Draw the old and new equilibria in each market.

Answer: Elasticity and Changes in Equilibrium

Parking spaces: inelastic supply



Bubble tea: elastic supply



With the same initial demand and the same proportional demand shift, the market with inelastic supply has the larger percentage increase in equilibrium price. The market with elastic supply has the larger percentage increase in equilibrium quantity.

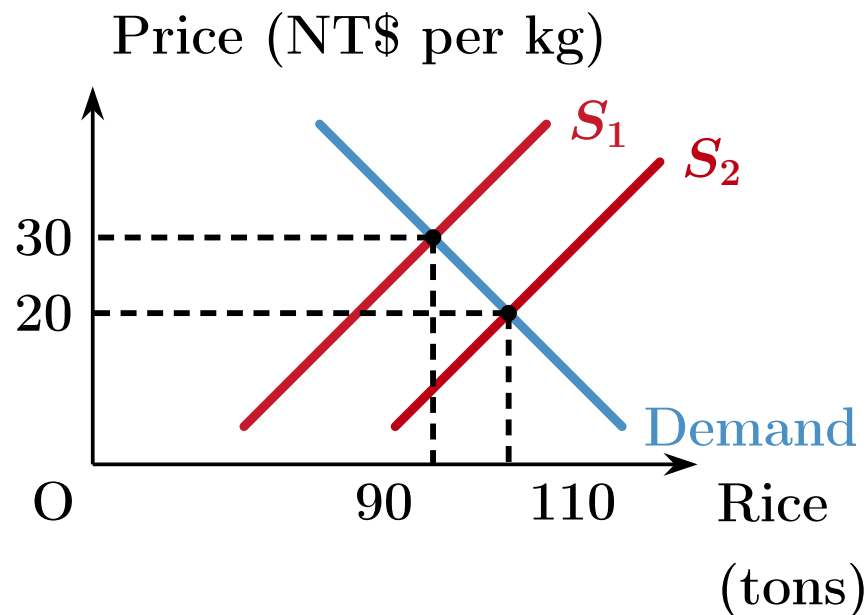
Application 1: Can Good News for Farming Be Bad News for Farmers?

Consider a hypothetical competitive rice market in Taiwan's Chianan Plain, with no imports, exports, or government price support. Farmers take the market price as given.

Suppose a new rice variety lowers production costs without changing the rice's quality. Farmers can supply more rice at every price, so **supply shifts right**. Demand stays fixed. The equilibrium price falls and quantity rises.

Farmers sell more rice but receive less per kilogram. What happens to their **total revenue**? The answer depends on demand elasticity. Whether profit rises also depends on production costs.

An Increase in Supply in the Market for Rice



Farmers' total revenue is $P \times Q$. The new variety raises Q but lowers P . In this illustration, demand elasticity is $(20/100)/(10/25) = 0.5$, so demand is inelastic over this range. The price falls from NT\$30 to NT\$20 per kilogram, and quantity rises from 90 to 110 tons. Converting tons to kilograms, revenue falls from NT\$2,700,000 to NT\$2,200,000.

Why Adopt the New Variety at All?

The market-wide revenue effect differs from an individual farmer's incentive.

Each farmer is a small part of the market and takes the price of rice as given. If the new variety lowers costs, an individual farmer can profit by adopting it at the given price. When all farmers adopt it, supply rises and the price falls. Total revenue falls with inelastic demand; the effect on profit also depends on cost savings.

The same logic explains why restricting output can raise farmers' revenue. Consider a policy that pays farmers to leave some land fallow. With inelastic demand, a smaller market-wide crop can raise sales revenue. An individual price-taking farmer cannot raise the market price by withholding output. Consumers pay the higher price; the subsidy also has a public cost.

Application 2: Why Did OPEC Fail to Keep the Price of Oil High?

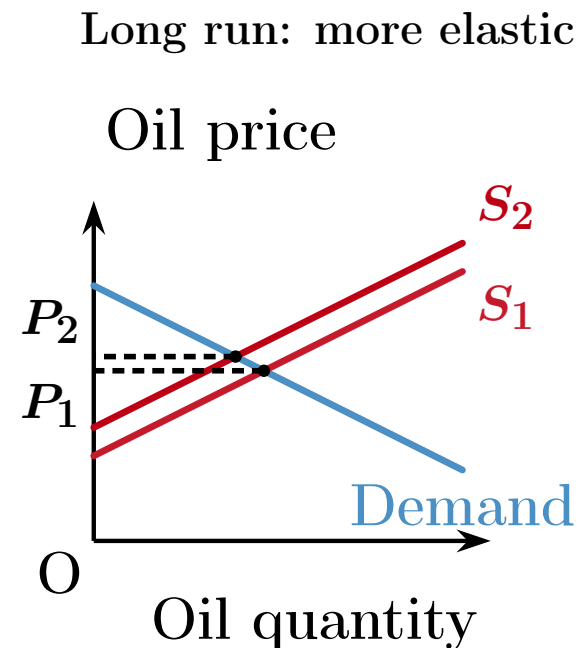
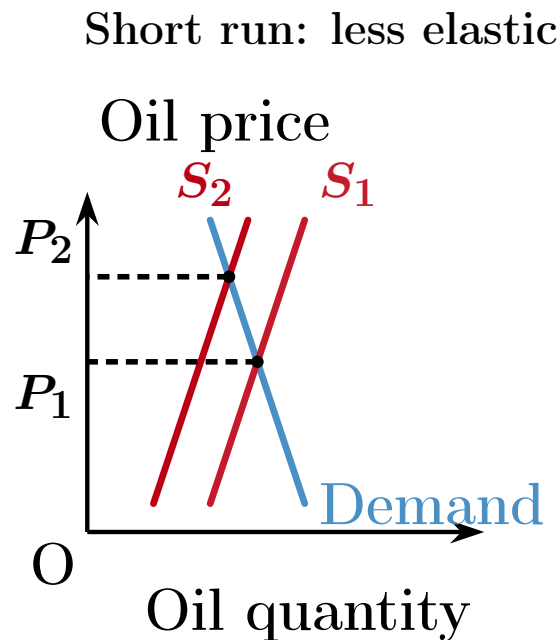
The **Organization of the Petroleum Exporting Countries (OPEC)** seeks to influence oil prices by coordinating its members' production.

Oil prices rose sharply after Arab exporters restricted supply in 1973–74. The Iranian Revolution and the Iran–Iraq War caused further disruptions in 1978–81. These episodes had several causes.

High prices encouraged conservation and new production outside OPEC. In 1986, Saudi Arabia stopped holding back output, other members increased production, and oil prices fell sharply.

Elasticity explains one part of this history. Buyers and producers have more ways to adjust over time, making a sustained output restriction less effective at keeping prices high.

Oil Supply Cuts over Different Horizons



Both panels start at the same price and quantity, with the same horizontal supply cut. In the short run, capacity and consumption adjust little, so price rises more. Over time, producers outside OPEC expand capacity and consumers conserve. More elastic curves imply a smaller price rise.

Application 3: Drug Interdiction and Crime

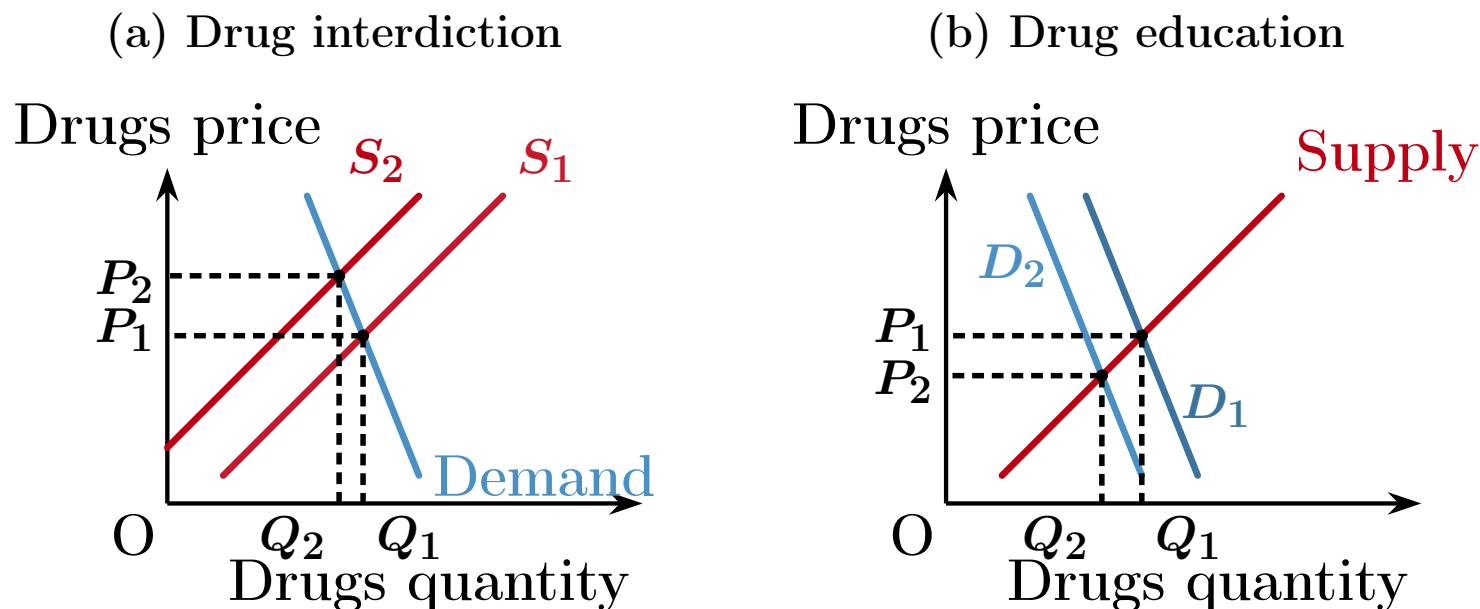
Consider a hypothetical market for an addictive illegal drug. **Interdiction** means efforts to restrict supply, such as intercepting shipments and arresting smugglers.

Suppose stronger interdiction raises sellers' costs while demand stays fixed. Supply shifts left, the equilibrium price rises, and quantity falls.

If demand is inelastic over this range, total spending rises despite the fall in use. This can increase pressure to finance purchases through crime for users who already rely on that source of money.

Remark. The effect on crime depends on how users finance the extra spending; elasticity alone does not determine it.

Two Policies to Reduce Drug Use



In panel (a), demand is inelastic over the relevant range. Interdiction raises price and reduces quantity, but total spending, $P \times Q$, **ris**es.

In panel (b), suppose education reduces demand while supply stays fixed. Both price and quantity fall, so total spending **falls**. These spending effects can affect crime committed to finance purchases, but neither diagram establishes the overall effect on crime or welfare.

Discussion: A Tobacco Tax

In a hypothetical cigarette market, a new NT\$20 tax per pack raises the retail price from NT\$90 to NT\$110. Monthly sales fall from 1,050 to 950 packs. Assume other demand determinants stay fixed and ignore other taxes.

1. Compute demand elasticity. How do buyers' total spending and sellers' revenue after tax change?
2. If all sellers raise the retail price further, will their combined revenue after tax rise? What must we assume about demand over the new range?
3. If only one company raises its price, can we use the market elasticity to predict its revenue? Explain the role of competing brands.

Answer: A Tobacco Tax

1. Price rises by $20/100 = 20\%$ and quantity falls by $100/1,000 = 10\%$, so demand elasticity is $10\%/20\% = 0.5$. Demand is inelastic over NT\$90–110. Buyers' spending rises from NT\$94,500 to NT\$104,500. Sellers receive NT\$90 per pack after tax, so their revenue falls to NT\$85,500.
2. With the tax fixed at NT\$20, a further price rise increases combined revenue after tax if market demand remains inelastic over that range. The first calculation alone does not establish this assumption.
3. One company's demand may be more elastic because buyers can switch brands. Market elasticity does not determine that firm's revenue effect. Revenue also differs from profit, which depends on costs.

Takeaways

Elasticity measures how strongly quantities respond to change.

- **Price elasticity** is the percentage change in quantity divided by that in price. Use midpoint percentages for two points and report price elasticity of demand in absolute value. Above 1 is elastic; below 1 is inelastic; 1 is unit elastic.
- Demand is more elastic with close substitutes, luxuries, and narrow markets. Both demand and supply are usually more elastic in the long run.
- Along a fixed demand curve, a price rise raises $P \times Q$ with inelastic demand and lowers it with elastic demand.
- **Income elasticity** is positive for normal goods and negative for inferior goods. **Cross-price elasticity** is positive for substitutes and negative for complements.