Price Elasticity of Demand

Lecture notes · Principles of Economics I · Module 1: Markets, demand and supply · Lesson 2

Learning objectives

O1	Explain what price elasticity of demand measures, and why it uses percentages.
O2	Calculate price elasticity of demand with the midpoint method.
O3	Classify demand as elastic, inelastic or unit elastic, and explain why elasticity differs from slope.
O4	Use the total revenue test to predict how a price change affects sellers' revenue.
O5	Explain the determinants of price elasticity of demand, and apply them to real goods.

Prerequisites: Lesson 1 (KN-UGR-ECO-C01-M01-T01-L01): demand curves and the difference between demand and quantity demanded; percentages.

Contents: 1. What elasticity measures · 2. Why percentages? · 3. The midpoint method · 4. Elastic, inelastic and unit elastic demand · 5. Elasticity is not slope · 6. Elasticity and total revenue · 7. What makes demand more or less elastic? · 8. Price elasticity of supply (introduction) · Worked examples · Summary · References

1. What elasticity measures

Lesson 1 showed that when a price rises, the quantity demanded falls. Price elasticity of demand answers the next question: by how much? It measures how strongly the quantity demanded responds to a change in the good's own price, other things being equal.

Two goods can both obey the law of demand and still behave very differently. A small rise in the price of one brand of breakfast cereal may send many shoppers to another brand; a large rise in the price of table salt hardly changes how much people buy. Elasticity puts a number on that difference.

Analogy, with its limit: a rubber band (elastic) stretches a lot when pulled a little; a steel bar (inelastic) hardly moves when pulled hard. Unlike a rubber band, however, the elasticity of demand is not a fixed property of a good: it usually changes from one part of the demand curve to another.

2. Why percentages?

Elasticity compares two percentage changes: Elasticity = (percentage change in quantity demanded) / (percentage change in price).

Percentages make the answer independent of units. A fall of 200 kg is a fall of 0.2 tonnes; a rise of $1 is a rise of 100 cents. Measured in absolute amounts the numbers change with the units, but the percentage changes, and therefore the elasticity, do not.

Percentages also allow comparisons between very different goods: a $1 rise is large for a kilogram of mangoes and negligible for a car.

Because price and quantity demanded move in opposite directions, the ratio is negative. Most introductory texts, including this course, report its absolute value (the size, without the minus sign). Some books keep the sign; the meaning is the same.

3. The midpoint method

A percentage change depends on what you divide by. On the mango demand curve, a rise from $2 to $3 (quantity 700 kg to 500 kg) measured from the starting point gives 28.6% / 50% = 0.57. Going back from $3 to $2 gives 40% / 33.3% = 1.20. The same two points give two different answers.

The midpoint (or arc) method removes this problem by dividing each change by the average of the two values: percentage change = (new - old) / ((new + old) / 2) x 100.

For the mango example: quantity 200 / 600 = 33.3%, price 1 / 2.5 = 40%, so the elasticity is 0.83 in either direction.

The midpoint method measures the average elasticity between two points (an arc). Section 'Going deeper' below shows how to find the elasticity at a single point.

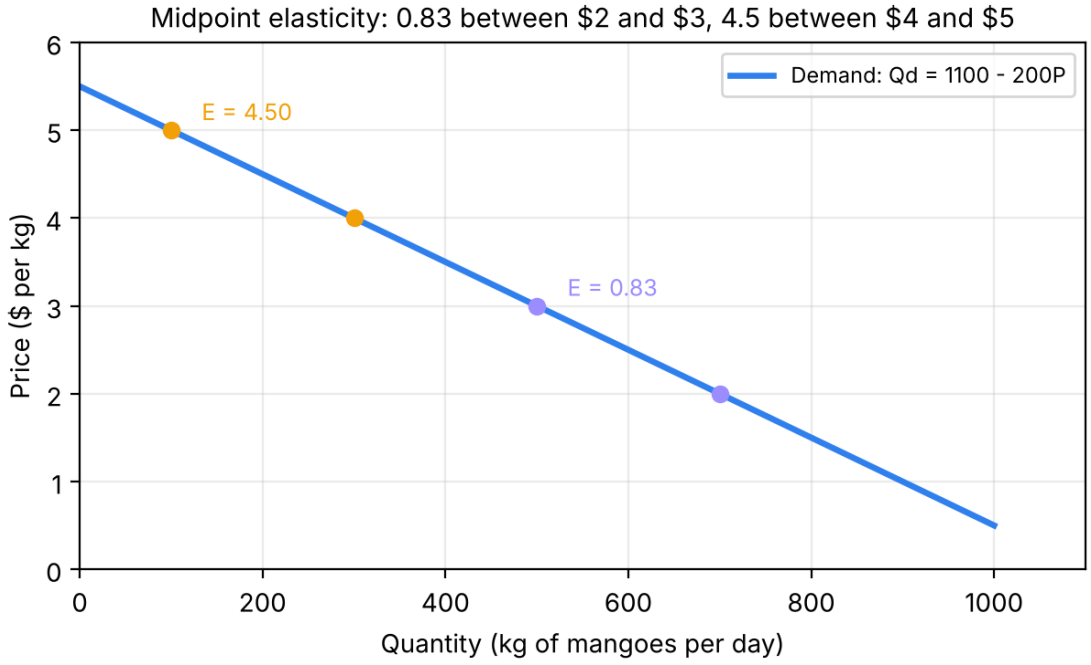


Figure 1. The same demand line, two very different elasticities (midpoint method).

4. Elastic, inelastic and unit elastic demand

Elastic demand (elasticity greater than 1): the quantity demanded changes by a larger percentage than the price.

Inelastic demand (elasticity less than 1): the quantity demanded changes by a smaller percentage than the price. The mango market between $2 and $3 (0.83) is inelastic. Inelastic does not mean buyers do not react; they react less than proportionally.

Unit elastic demand (elasticity exactly 1): the two percentage changes are equal.

Polar cases. Perfectly inelastic demand (elasticity 0) is a vertical demand curve: the same quantity is bought at every price. Perfectly elastic demand (infinite elasticity) is a horizontal demand curve: buyers take any amount at one price and nothing at any higher price. Real goods lie between these extremes; the polar cases are useful reference points.

5. Elasticity is not slope

Along the straight demand line Qd = 1100 - 200P, every $1 rise lowers the quantity demanded by 200 kg: the slope is constant. Yet the elasticity is 0.83 between $2 and $3 and 4.5 between $4 and $5.

The reason is that elasticity compares percentage changes. At low prices and large quantities, 200 kg is a small percentage of the quantity and $1 is a large percentage of the price, so demand is inelastic. At high prices and small quantities the opposite holds, so demand is elastic.

On any straight, downward-sloping demand line, demand is elastic above the midpoint of the line, inelastic below it, and unit elastic exactly at the midpoint. For the mango market that point is $2.75 per kg and 550 kg per day.

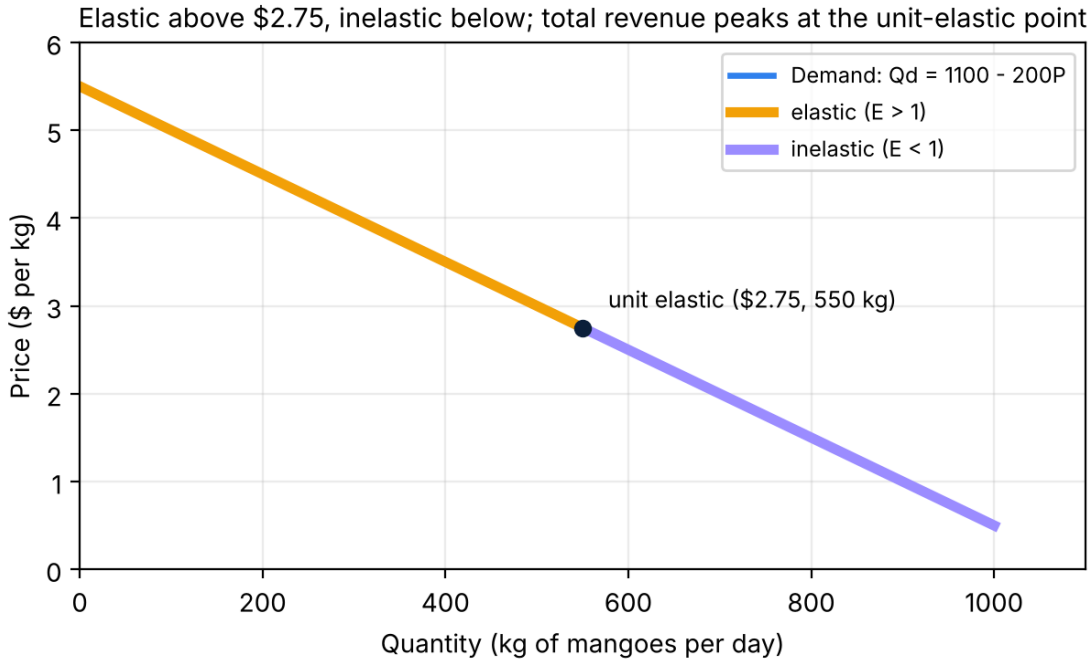


Figure 2. Along a straight demand line, elasticity falls as the price falls.

6. Elasticity and total revenue

Total revenue (TR) is the money sellers receive, and equals what buyers spend: TR = P x Q. On a demand diagram it is the area of the rectangle under the price, out to the quantity sold.

A price rise has two opposite effects on revenue: a gain (the price increase on every unit still sold) and a loss (the units no longer sold, at the old price). From $2 to $3 the gain is $500 and the loss is $400, so revenue rises from $1,400 to $1,500. From $4 to $5 the gain is $100 and the loss is $800, so revenue falls from $1,200 to $500.

The total revenue test: if demand is inelastic, price and revenue move in the same direction; if demand is elastic, they move in opposite directions; if demand is unit elastic, revenue does not change (for small price changes). It also works in reverse: observing what happened to revenue after a price change tells you whether demand was elastic or inelastic over that range.

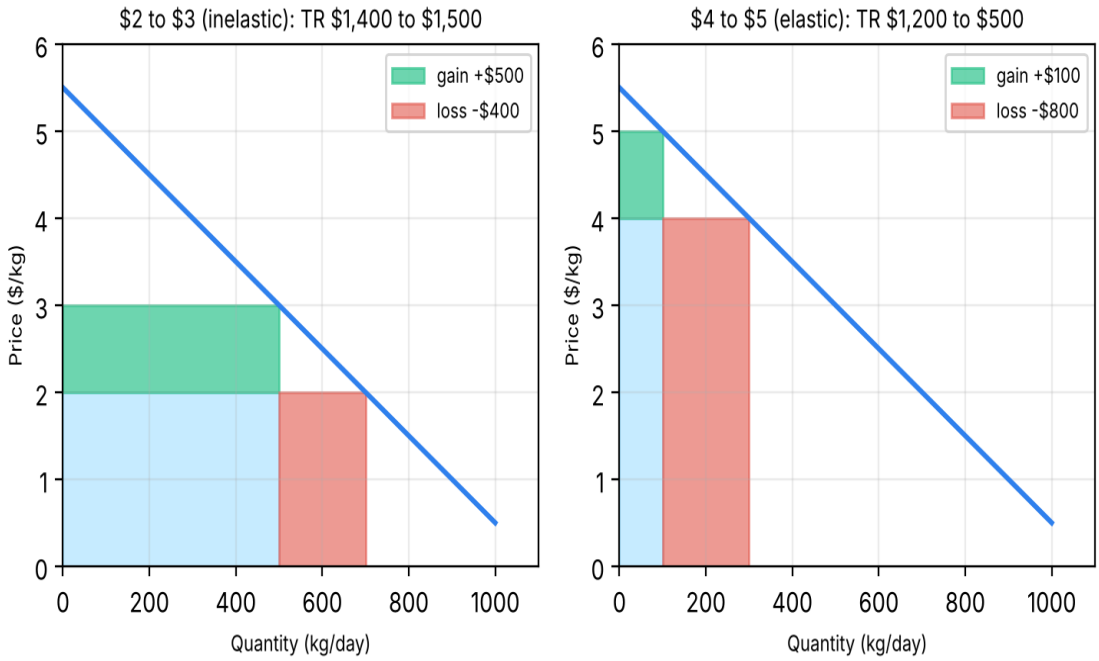


Figure 3. Revenue gain (green) and loss (red) from a $1 price rise in the inelastic and elastic ranges.

7. What makes demand more or less elastic?

Availability of close substitutes: the more and the closer the substitutes, the more elastic the demand.

Necessities versus luxuries: goods that buyers regard as necessities tend to have less elastic demand than luxuries. What counts as a necessity depends on the buyer and the setting.

Share of the budget: goods that take a large share of income (rent, cars) tend to have more elastic demand than goods that take a tiny share (salt, matches).

Time horizon: demand is usually more elastic in the long run than in the short run, because buyers have more time to find substitutes and change habits or equipment.

Definition of the market: the more narrowly a market is defined, the more elastic its demand (food in general < mangoes < mangoes from one stall), because narrow markets have more close substitutes.

8. Price elasticity of supply (introduction)

The same idea applies to sellers: price elasticity of supply = (percentage change in quantity supplied) / (percentage change in price). It is positive, because the quantity supplied rises with price.

For the mango supply curve Qs = -100 + 200P, from $2 to $3 the quantity supplied rises from 300 kg to 500 kg: 50% / 40% = 1.25, so supply is elastic over this range.

Supply tends to be more elastic when output can be expanded quickly and cheaply, and when producers have more time to adjust. Later lessons use supply elasticity to explain who bears the burden of a tax.

Going deeper: point elasticity on a straight line

For a small change, elasticity can be written as E = (change in Q / change in P) x (P / Q). The first factor is the reciprocal of the slope of the demand curve as drawn (price on the vertical axis); the second factor depends on where you are on the curve. This is the precise reason elasticity is not the same as slope.

For a linear demand curve Q = a - bP, the change in Q per unit change in P is b at every point, so the point elasticity is E = bP / (a - bP). It is 0 where P = 0, equals 1 where P = a / (2b) (the midpoint of the line), and grows without limit as Q approaches 0.

For the mango market a = 1100 and b = 200, giving the unit-elastic price 1100 / 400 = $2.75, exactly half the price at which the quantity demanded would fall to zero ($5.50).

A demand curve with the same elasticity everywhere is not a straight line but a curve that becomes flatter as quantity increases (a 'constant elasticity' curve). Such curves are often used in applied work.

A general method for elasticity questions

1. Identify the two price-quantity points (or read them off a schedule or equation).

2. Compute the change and the average for quantity; divide to get the percentage change.

3. Do the same for price.

4. Divide the quantity percentage by the price percentage and report the absolute value.

5. Compare with 1 to classify the demand, and, if asked about revenue, apply the total revenue test (or check by computing P x Q at both prices).

Common mistakes to avoid

Dividing the price change by the quantity change (the formula is quantity over price).

Using the starting value instead of the average, which gives different answers for rises and falls.

Treating a steep curve as 'inelastic everywhere': steepness depends on the axis scales, and elasticity varies along a straight line.

Concluding that a price rise always raises revenue: it does only when demand is inelastic over that range.

Saying 'inelastic' when meaning 'buyers do not react at all': that is the special case of perfectly inelastic demand.

Applying the idea: the bumper-harvest puzzle (qualitative)

Food in general has inelastic demand: people do not eat much more just because food is cheaper. Suppose good weather raises a crop's supply sharply.

To persuade buyers to take the larger quantity, the price must fall by a large percentage. With inelastic demand the percentage rise in quantity sold is smaller than the percentage fall in price, so total revenue to farmers falls, even though they sell more.

This is why good harvests can be bad news for farm incomes, and one reason some governments run price-support or storage schemes. Whether such schemes are good policy is a separate question, which later lessons on price controls examine.

Worked examples

Worked example 1: the midpoint method, both directions

On the mango demand curve, the price changes between $2 and $3 per kg. Calculate the price elasticity of demand with the midpoint method, first for a rise and then for a fall.

Step 1. Quantities: Qd(2) = 1100 - 400 = 700 kg and Qd(3) = 1100 - 600 = 500 kg.

Step 2. Rise: %change in Q = (500 - 700) / 600 = -33.3%; %change in P = (3 - 2) / 2.5 = +40%.

Step 3. Elasticity = -33.3 / 40 = -0.83; reported as 0.83.

Step 4. Fall: %change in Q = (700 - 500) / 600 = +33.3%; %change in P = (2 - 3) / 2.5 = -40%; elasticity 0.83 again.

Step 5. Since 0.83 < 1, demand is inelastic between $2 and $3.

Worked example 2: the total revenue test

A seller faces the mango demand curve and is choosing between $4 and $5 per kg. Which price gives more revenue? Explain with the gain and loss areas, and relate the answer to elasticity.

Step 1. At $4: Q = 300 kg, revenue = 4 x 300 = $1,200.

Step 2. At $5: Q = 100 kg, revenue = 5 x 100 = $500.

Step 3. Gain from the higher price on units still sold: $1 x 100 = $100. Loss from units no longer sold: 200 x $4 = $800.

Step 4. Net change: 100 - 800 = -$700, so $4 gives more revenue.

Step 5. Consistent with the test: the midpoint elasticity is 4.5 > 1 (elastic), so raising the price lowers revenue.

Worked example 3: finding the unit-elastic point and maximum revenue

For the linear demand curve Qd = 1100 - 200P, find the price at which demand is unit elastic, and show that revenue is largest there.

Step 1. Point elasticity on a straight line: E = (change in Q per $1) x (P / Q) = 200P / (1100 - 200P).

Step 2. Set E = 1: 200P = 1100 - 200P, so 400P = 1100 and P = $2.75.

Step 3. Q = 1100 - 200 x 2.75 = 550 kg; revenue = 2.75 x 550 = $1,512.50.

Step 4. Check nearby prices: revenue at $2.50 is $1,500 and at $3.00 is $1,500, both lower.

Step 5. Interpretation: below $2.75 demand is inelastic, so raising the price raises revenue; above $2.75 demand is elastic, so raising the price lowers revenue. Revenue therefore peaks at the unit-elastic price.

Worked example 4: price elasticity of supply

Using Qs = -100 + 200P, calculate the price elasticity of supply between $2 and $3.

Step 1. Qs(2) = 300 kg and Qs(3) = 500 kg.

Step 2. %change in Qs = 200 / 400 = 50%; %change in P = 1 / 2.5 = 40%.

Step 3. Elasticity of supply = 50 / 40 = 1.25: elastic supply over this range.

Summary

• Price elasticity of demand = % change in quantity demanded / % change in price (reported as a positive number).

• Midpoint method: divide each change by the average; mango market $2 to $3 gives 0.83 both ways.

• Elastic (> 1), inelastic (< 1), unit elastic (= 1); polar cases are vertical (0) and horizontal (infinite) demand curves.

• Elasticity is not slope: a straight demand line is elastic above its midpoint ($2.75 here) and inelastic below it.

• Total revenue test: inelastic, price and revenue move together; elastic, they move in opposite directions.

• Determinants: substitutes, necessity vs luxury, budget share, time horizon, market definition.

References

References: KN-UGR-ECO-C01-M01-T02-L01
OpenStax, Principles of Economics 3e (2023), ch. 5 "Elasticity": price elasticity of demand and supply, the midpoint (arc) method, polar cases (perfectly elastic and perfectly inelastic), elasticity and pricing (total revenue). https://openstax.org/details/books/principles-economics-3e. Cited only; no OpenStax text or figures are reproduced (their licence is CC BY-NC-SA).

N. Gregory Mankiw, Principles of Economics (Cengage, any recent edition), ch. 5 "Elasticity and Its Application": determinants of price elasticity of demand, total revenue along a linear demand curve, applications (farm harvests). Cited only.
The mango market is illustrative (the same equations as Lesson 1). No real-world elasticity estimates are quoted; the real-life examples are stated as general patterns.
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