4 A CLOSER LOOK AT DEMAND: ELASTICITY OF DEMAND

REAL-WORLD ISSUE:
How do consumers and producers make choices in trying to meet their economic objectives?

By the end of this chapter, you should be able to:

- → Explain the concept of elasticity
- → Define elasticity of demand
- → Define and calculate price elasticity of demand (PED)
- → Explain and illustrate the theoretical range of values for price elasticity of demand
- → Explain and illustrate the relationship between price elasticity of demand and total revenue when demand is price elastic and when it is price inelastic
- HL Explain and illustrate different values of price elasticity of demand along a straight-line, downward-sloping demand curve
- → Explain the determinants of price elasticity of demand
- → Understand the importance of price elasticity of demand for firms and government decision-making
- HL Explain the likely differences in price elasticity of demand for primary commodities and manufactured goods
- → Define and calculate income elasticity of demand (YED)
- → Explain the possible range of values for income elasticity of demand
- HL Understand the importance of income elasticity of demand for firms and in explaining sectoral changes in the structure of the economy.

What is elasticity of demand?

Economists use the concept of *elasticity* to measure how much something changes when there is a change in one of the determinants. Elasticity is a measure of responsiveness.

Key concept

CHANGE

Elasticity of demand is a measure of how much the demand for a product changes when there is a change in one of the factors that determine demand. We will look at two elasticities of demand:

- price elasticity of demand [PED]
- income elasticity of demand [YED].

What is price elasticity of demand and how do we measure it?

Price elasticity of demand is a measure of how much the quantity demanded of a product changes when there is a change in the price of the product. It is usually calculated by using the following equation:

$$\text{PED} = \frac{\text{Percentage change in quantity demanded of the product}}{\text{Percentage change in price of the product}}$$

For example, a publishing firm discovers that when they lower the price of one of their monthly magazines from $5 to $4.50, the number of magazines that are bought by customers each month rises from 200,000 to 230,000. With this information, we can calculate the price elasticity of demand for the magazine in question:

1. The price has fallen by 50¢ from an original price of $5, which is a change of –10%. This is calculated by the equation

$$\frac{-50}{500} \times 100 = -10\%.$$

2. The quantity demanded has increased by 30,000 from an original demand of 200,000, which is a change of +15%. This is calculated by the equation

$$\frac{+30{,}000}{200{,}000} \times 100 = +15\%.$$

3. If we put the two values above into the equation for PED, we get PED = +15%/–10%, which gives a value of –1.5.

4. The negative value indicates that there is an inverse relationship between price and the quantity demanded. However, in order to simplify matters, economists usually ignore the negative value that comes from the equation and simply give the answer as a positive figure. Thus, in this case, the PED for the monthly magazine would be 1.5.

Exercise 4.1

ATL Thinking and Communication

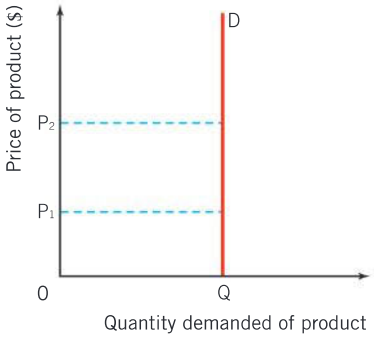
Which do you think would have the bigger impact on consumers' willingness and ability to buy the following products? Why? (Explain your reasoning,)

1. A 10% increase in the price of bottled water from $2.00 per bottle to $2.20 per bottle.
2. A 10% increase in the price of an economy-sized car from $10,000 to $11,000.

What is the range of values of price elasticity of demand in theory?

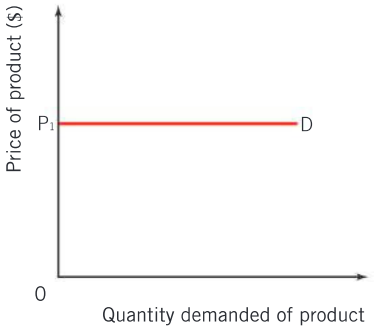
The possible range of values for price elasticity of demand can, in theory, go from zero to infinity. Practically speaking, the actual PED values for a product will lie in between these two extreme theoretical values.

If PED is equal to zero, then a change in the price of a product will have no effect on the quantity demanded at all. The percentage change in quantity demanded would therefore be zero and so would the value on the top of the PED equation. Since zero divided by anything is zero, no matter what the percentage change in price, the PED value will be zero. A demand curve with a PED value of zero is shown in Figure 4.1 and, in this case, demand is said to be perfectly inelastic – it is completely unresponsive to price changes. Whether price is P_1, P_2, or any other price, the quantity demanded will be Q.



▲ **Figure 4.1** A perfectly inelastic demand curve

A PED value of infinity is best explained by using a diagram and the situation is shown in Figure 4.2. In this case, demand is said to be perfectly elastic. At the price P_1, the demand curve goes on forever and so the quantity demanded is infinite. However, if price is raised above P_1, even by the smallest amount, demand will fall to zero, an infinite change. Because of this, the value in the numerator of the equation would be infinity. Since infinity divided by anything is infinity, no matter what the percentage change in price, the PED value will be infinity.



▲ **Figure 4.2** A perfectly elastic demand curve

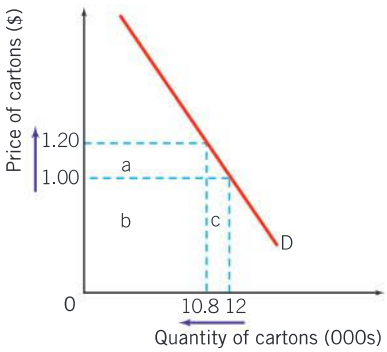
As stated before, it must be remembered that the extreme values of PED are simply theoretical and there are no single products that would possess a PED value of zero or infinity. Normal products have values of PED between the two and we will now look at those values. The range of values of PED is normally split into three categories.

1. *Inelastic demand*: The value of PED is less than one and greater than zero. If a product has inelastic demand, then a change in the price of the product leads to a proportionally smaller change in the quantity demanded of it. This means that if the price is raised, the quantity demanded will not fall by much in proportion, and so the total revenue gained by the firm (the number of units sold x the price of the product) will increase.

   For example, when the price of a carton of strawberry yoghurt is raised from $1 to $1.20, the firm finds that quantity demanded per week falls from 12,000 cartons to 10,800 cartons. Thus, a 20% increase in price is causing a 10% fall in the quantity demanded. We can work out the PED by using the equation:

$$\text{PED} = \frac{\%\ \Delta \text{ in Quantity Demanded}}{\%\ \Delta \text{ in Price}} = \frac{10\%}{20\%} = 0.5 \text{ (Where } \Delta \text{ is "change")}$$

   As we can see, the PED is 0.5, less than one, so the demand for the yoghurt is inelastic. Before the price increase, the total revenue gained by the firm was 12,000 × $1 = $12,000. After the increase, the total revenue becomes 10,800 × $1.20 = $12,960. The firm has increased revenue by raising the price. This is shown in Figure 4.3.



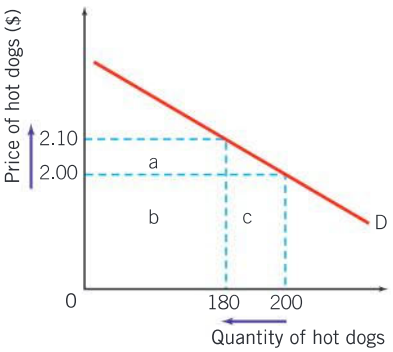
▲ **Figure 4.3** The demand for strawberry yoghurt

Exercise 4.2

ATL Thinking and Communication

A firm producing decorative candles lowers the price of one of its scented candles from $4 to $3.60 and finds that the weekly quantity demanded of the candles goes up from 600 per week to 630.

1. Calculate the percentage changes in price and quantity demanded.
2. Calculate the price elasticity of demand for the scented candles.
3. Calculate the change in total revenue that the firm will experience following the fall in price.
4. Draw a "revenue box" diagram to illustrate the effect on quantity demanded and total revenue following the price change for the scented candle.
5. Was the firm sensible to lower the price of the scented candles? Explain your answer.



▲ **Figure 4.4** The demand for hot dogs

The "revenue boxes" in the diagram clearly show why a price increase causes an increase in total revenue, when the demand for a product is inelastic. In this case, before the price rise, the firm was getting revenue equal to "revenue box b" + "revenue box c". After the price increase, the firm loses "revenue box c", because quantity demanded falls to 10,800 cartons, but gains "revenue box a", because the remaining cartons are now sold at $1.20 each. Since "revenue box a" (10,800 × 0.20 = $2,160) is clearly larger than "revenue box c" (1,200 × $1 = $1,200), the firm's total revenue rises by $960.

Thus, if a firm has relatively inelastic demand for its product and wishes to increase total revenue, it should raise the price of the product.

2. *Elastic demand*: The value of PED is greater than one and less than infinity. If a product has elastic demand, then a change in the price of the product leads to a greater than proportionate change in the quantity demanded of it. This means that if price is raised, the quantity demanded will fall by more in proportion, and so the total revenue gained by the firm (the number of units sold × the price of the product) will fall.

For example, when the price of a hot dog is raised from $2 to $2.10, a hot-dog seller finds that quantity demanded per week falls from 200 hot dogs to 180 hot dogs. Thus, a 5% increase in price is causing a 10% fall in the quantity demanded. We can work out the PED by using the equation:

$$\text{PED} = \frac{\%\,\Delta \text{ in Quantity Demanded}}{\%\,\Delta \text{ in Price}} = \frac{10\%}{5\%} = 2$$

As we can see, the PED is 2, greater than 1, so the demand for the hot dog is elastic. Before the price rise, the total revenue gained by the hot-dog seller was 200 × $2 = $400. After the increase, the total revenue becomes 180 × $2.10 = $378. The seller has caused a fall in revenue by raising the price. This is shown in Figure 4.4.

The "revenue boxes" in the diagram clearly show why a price increase causes a decrease in total revenue, when the demand for a product is elastic. In this case, before the price rise, the hot dog seller was earning revenue equal to "revenue box b" + "revenue box c". After the price increase, the hot-dog seller loses "revenue box c", because quantity demanded falls to 180 hot dogs, but gains "revenue box a", because the remaining hot dogs are now sold at $2.10 each. Since "revenue box a" (180 × $0.10 = $18) is clearly smaller than "revenue box c" (20 × $2 = $40), the hot-dog seller's total revenue falls by $22.

Thus, if a firm has elastic demand for its product and wishes to increase total revenue, it should not raise the price of the product.

3. *Unit elastic demand:* The value of PED is equal to one. If a product has unit elastic demand, then a change in the price of the product leads to a proportionate, opposite, change in the quantity demanded of it. This means that if price is raised by a certain percentage, then the quantity demanded will fall by the same percentage, and so PED is

equal to 1 and the total revenue gained by the firm (the number of units sold × the price of the product) will not change. A curve that has unit elasticity at every point is shown in Figure 4.5. It is known as a rectangular hyperbola.

The rectangular hyperbola is drawn in such a way that price multiplied by quantity at any point is constant. This means that the total of the "revenue boxes" always has the same area and if the revenue does not change when price changes, then PED must be unity. Thus, in Figure 4.5, the two rectangles a + b have the same area as the two rectangles b + c, and so since revenue does not change when price changes, PED must be unity.

What do PED values mean?

Price elasticity of demand	Value (ignoring the negative sign)	Meaning	Change in price	Effect on total revenue (TR)
Inelastic	0 < PED < 1	% Δ in price < % change in Qd	Price ↑	TR↑
Inelastic	0 < PED < 1	% Δ in price < % change in Qd	Price ↓	TR↓
Elastic	1 < PED < ∞	% Δ in price > % change in Qd	Price ↑	TR↓
Elastic	1 < PED < ∞	% Δ in price > % change in Qd	Price ↓	TR↑
Unity	PED = 1	% Δ in price = % change in Qd	Price ↑	No change in TR
Unity	PED = 1	% Δ in price = % change in Qd	Price ↓	No change in TR

▲ **Table 4.1** The meaning of PED values

Exercise 4.4

ATL Thinking and Communication

Economists often use the language of mathematics and symbols to express theoretical relationships. For each of the rows in Table 4.1, turn the mathematical expression into a sentence.

For example:

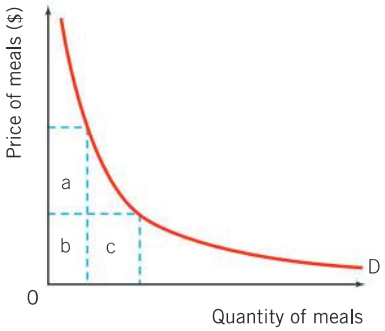
1. When demand for a product is inelastic, the value of PED lies between 0 and 1. This means that if the price of a product increases, there will be a proportionately smaller fall in quantity demanded. This would result in an increase in producer's revenue.

Exercise 4.3

ATL Thinking and Communication

A pizzeria lowers the price of its most popular takeaway pizza, the Margherita, from $5 to $4.50 and finds that the weekly quantity demanded of the pizzas goes up from 60 per week to 72.

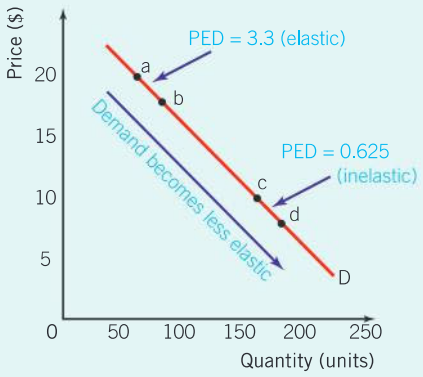
1. Calculate the percentage changes in price and quantity demanded.
2. Calculate the price elasticity of demand for the pizzas.
3. Calculate the change in total revenue that the pizzeria will experience following the fall in price.
4. Draw a "revenue box" diagram to illustrate the effect on quantity demanded and total revenue following the price change for the Margherita.
5. Was the firm sensible to lower the price of the Margherita? Explain your answer.



▲ **Figure 4.5** A rectangular hyperbola where PED = 1 at every point

A mathematical note about elasticity: Why are there different values of price elasticity of demand along a straight-line, downward-sloping demand curve?

It is a common mistake for students to assume that elasticity is a measure of the slope of the demand curve and that the value is always the same at any point on the curve. This is not the case. For a straight-line, downward-sloping demand curve, the value of PED falls as price falls. This is shown in Figure 4.6.



▲ **Figure 4.6** PED values for a normal demand curve

Higher Level

When price falls from $20 to $18, quantity demanded increases from 60 to 80 units. Thus the PED value is:

$$\text{PED} = \frac{\%\Delta QD}{\%\Delta P} = \frac{33.3\%}{10\%} = 3.3$$

The value of PED is 3.3, elastic, when we move from point a to point b.

When price falls from $10 to $8, quantity demanded increases from 160 to 180 units. Thus, the PED value is:

$$\text{PED} = \frac{\%\Delta QD}{\%\Delta P} = \frac{12.5\%}{20\%} = 0.625$$

The value of PED is 0.625, inelastic, when we move from point c to point d.

Thus, we can see that the value of PED falls as we move down a demand curve. It is logical that this should happen. Low-priced products have a more inelastic demand than high-priced products, because consumers are less concerned when the price of an inexpensive product rises than they are when the price of an expensive product rises.

What are the determinants of price elasticity of demand?

Different products will have different values for PED. For example, the demand for a restaurant meal may have a PED value of 3, ie the demand is elastic, whereas the demand for petrol may have a PED value of 0.4, which is inelastic. What actually determines the value of PED for a product? There are a number of determinants:

1. The number and closeness of substitutes

The number and closeness of substitutes that are available is certainly the most important determinant of PED. It is fair to say that the more substitutes there are for a product, the more elastic the demand will be for it. Also, the closer the substitutes available, the more elastic the demand will be.

For example, there are many different brands of butter available on the market and so an increase in the price of one brand will lead to a large number of customers changing their demands to another brand. Thus, the demand for products with lots of substitutes, such as brands of household products, types of meat and types of fruit, will tend to have elastic demand.

Products with few substitutes, such as oil, will tend to have relatively inelastic demand, with the quantity demanded falling relatively little as the price goes up.

2. The necessity of the product and how widely the product is defined

Food is a necessary product. Indeed, if we do not have food, then we will die, so it is very necessary. Thus we would expect the demand for food to be very inelastic, which it is. However, if we define food more

narrowly and consider meat, we would expect the demand to be less inelastic, since there are many alternatives, such as vegetables. Once again, if we then define meat more narrowly and consider chicken, beef, lamb and pork, we could once again reasonably assume that the demand for each would be relatively elastic, since the consumer can easily change from one type of meat to another, if the price of one rises. As the product is defined even more narrowly, into chicken products and then identical, but branded, chicken products, demand becomes even more elastic. This is shown in Figure 4.7.

It is worth remembering that for many goods, necessity will change from consumer to consumer, since different people have different tastes and necessity is often a subjective view.

For example, in Malaysia, chicken is very popular among the population and so the demand for it is less elastic than it would be in Italy, where it is not valued as highly. Necessity may go to extremes when individuals consider products to be very "necessary", such as habit-forming or addictive goods **– for example,** cigarettes, alcohol or chocolate. Such products tend to have inelastic demand.

3. The proportion of income spent on the good

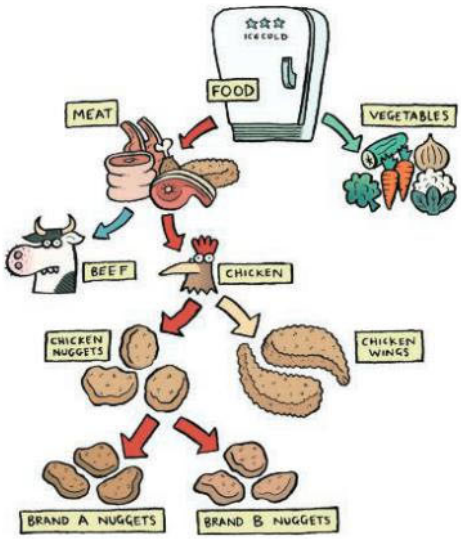
If a good costs very little and constitutes a very small part of a person's budget, then a change in price may cause very little change in quantity demanded, ie the demand will be quite inelastic.

For example, if a person earning a relatively good salary buys a coffee on the way to work each day and it costs $1.50, then a 10% increase in price to $1.65 will be unlikely to curtail her expenditure on coffee. It is worth considering that behavioural economists might explain this in terms of the *status quo bias*.

4. The time period considered

As the price of a product changes, it often takes time for consumers to change their buying and consumption habits. PED thus tends to be more inelastic in the short term and then becomes more elastic, the longer the time period it is measured over.

For example, when heating oil prices rose sharply in Austria, the demand for oil that winter changed by a proportionately smaller amount than the change in price. Demand was relatively very inelastic, since people did not really have many alternative products that they could switch to. They still needed heating oil for their central heating. However, over the next few years, the demand for heating oil began to fall as people started to change their heating systems to ones that used gas, coal or wood. The PED, when measured over a longer time period, was certainly more elastic.



▲ **Figure 4.7** Level of definition

Exercise 4.5

ATL Thinking and Communication

For each of the following pairs of goods, identify the one that you would expect to have the higher price elasticity of demand and explain your choice by referring to at least one of the determinants of elasticity. There may not necessarily always be a "correct" answer. It may depend upon your viewpoint and reasoning.

1. Heineken beer vs beer
2. A prescription tablet to reduce blood pressure vs a tablet to reduce headache pain
3. Milk vs orange juice
4. A motor car vs a daily newspaper

Exercise 4.6
ATL Thinking and Communication

Estimates based on studies of the US population suggest that a 10% increase in the price of cigarettes would reduce overall consumption by adults by 3% to 5%. The same 10% increase would reduce the consumption by youths by 13%.

1. Calculate the price elasticity of demand for cigarettes among US adults and among US youths.
2. Suggest possible reasons for the different magnitude of elasticity between the two groups.
3. Explain two possible reasons why a government would place a tax on cigarettes.

Why is a knowledge of price elasticity of demand important for decision making by governments and firms?

An understanding of price elasticity of demand can be very useful for firms and also for the government.

For firms, as we have seen, the main use is for predicting the effects of their pricing decisions on quantity demanded and also on total revenue.

For governments, they need to be aware of the possible consequences on a number of economic variables when they impose indirect taxes, such as sales taxes, on products. If a government puts a tax on a product, then its price will usually rise. This means that the quantity demanded of the product in question is likely to fall and this will have consequences for the amount of tax revenue that the government will receive. (This is dealt with in more detail in Chapter 8.) There will also be consequences for employment in the industry concerned. If the demand for the product is very elastic, then a price increase as a result of the imposition of a tax on the product will lead to a relatively large fall in the demand for the product. This means that the demand for workers in the industry is likely to fall significantly, increasing unemployment in the economy.

Since governments are not usually keen to increase unemployment, they may place higher taxes on products where demand is relatively inelastic, so that the demand for the product will not fall by a significant amount, and will thus not lead to high unemployment. However, the choices that governments face about which products to tax and how much tax to place on a good depends on much more than simply the elasticity.

Higher Level

What is the difference between the price elasticity of demand for primary commodities and manufactured products?

"Primary commodities" is another term for raw materials, such as cotton or coffee. Such products tend to have inelastic demand as they are necessities to the "consumers" who buy them and they have few or no substitutes. It must be noted that consumers of primary commodities are not everyday households. The consumers of primary commodities are manufacturing industries which process the raw material into finished products. They require the primary commodities in order to produce their processed products. For example, if there is an increase in the price of green coffee (raw coffee beans), then the coffee processing companies who buy the green coffee to make instant coffee for consumers have little choice but to continue buying the coffee, and thus the quantity demanded will fall by a proportionately smaller amount. For those coffee processing companies, there are no substitutes for the raw coffee beans. Similarly, if there were to be a decrease in the price of green coffee

the processing companies would not want proportionately more coffee as their production targets would already have been set and they have no use for further inputs, regardless of the price.

On the other hand, demand for manufactured goods tends to be more elastic, as there are usually many more substitutes available to consumers, since the product can be differentiated by different producers. This ties in with the determinant of PED mentioned earlier – "the number and closeness of substitutes". For example, if the price of one branded vacuum cleaner increases significantly, consumers have the option of many other brands and will be likely to switch their purchasing to one of those. For most consumer goods, there are many ways that producers can differentiate their products, giving consumers lots of choice.

Processing coffee beans

What is income elasticity of demand (YED) and how do we measure it?

Income elasticity of demand is a measure of how much the demand for a product changes when there is a change in the consumer's income. It is usually calculated by using the equation below:

$$\text{YED} = \frac{\text{Percentage change in quantity demanded of the product}}{\text{Percentage change in income of the consumer}}$$

Take an example. A person has an increase in annual income from $60,000 per year to $66,000. She then increases her annual spending on holidays from $2,500 to $3,000. With this information, we can calculate her income elasticity of demand for holidays.

1. Her income has risen by $6,000 from an original income of $60,000, which is a change of +10%. This is calculated by the equation $\frac{+6{,}000}{60{,}000} \times 100 = +10\%$.

2. The quantity demanded of holidays has increased by $500 from an original demand of $2,500, which is a change of +20%. This is calculated by the equation $\frac{+500}{2{,}500} \times 100 = +20\%$.

3. If we put the two values above into the equation for PED, we get +20%/+10%, which gives a value of 2.

What is the range of values for income elasticity of demand?

In YED, the sign obtained from the equation (ie whether it is positive or negative) is important. The sign of YED tells us whether the product we are looking at is a normal good or an inferior good.

Remember that the demand for a normal good rises as income rises and the demand for an inferior good falls as income rises.