4 ELASTICITIES

4.1 Defining elasticity

Like rubber bands, demand and supply can be elastic (or inelastic).

In Chapter 3, you learned about the fundamental relationships between the price of a particular good and the quantities that consumers demand and that producers supply. The laws of demand and supply hold true in almost every market for goods, services or resources. At higher prices, suppliers are willing to provide more of their good, service or resource to the marketplace while consumers demand less due to the higher opportunity cost of consumption. At lower prices, consumers are willing to purchase more of a good, service or resource while suppliers are willing and able to provide less due to the declining benefits of producing and selling at lower prices.

The relationships between price and quantity demanded and supplied are stable enough to be considered *economic laws*. To extend our analysis of supply and demand, it is useful to introduce an additional component into our analysis of the relationships between price, demand and supply.

The study of elasticities

This study examines the responsiveness of consumers or producers to a change in a variable in the marketplace. Elasticity measures how much one factor changes in response to a change in a different factor. The law of demand tells us that when the price of a good increases, the quantity demanded will decrease. Determining the price elasticity of demand (PED) tells us *how much* the quantity demanded of a good will decrease when the price of that good increases, it is a measure of the *responsiveness* of consumers to a change in price.

PED is only one type of elasticity. We will also examine the responsiveness of consumers of one good to a change in the price of a related good (cross-price elasticity); the responsiveness of a consumer's demand for a particular good to a change in the consumer's income (income elasticity of demand); and the responsiveness of producers to changes in price (price elasticity of supply).

Understanding elasticities provides businesses and government policymakers with important information which can aid in their decisions in the marketplace.

Implications for businesses

- The degree to which consumers respond to changes in the price of a firm's products has major implications on a firm when it is considering raising or lowering its prices.
- Producers of some goods must be aware of the effect that changes in the prices of other goods will have on market demand for their products. A perfect example is the decision by manufacturers such as Toyota and Honda to expand their production of hybrid automobiles in the last decade as gasoline prices have risen steadily around the world.

Implications for governments

- Governments must consider elasticities when deciding which goods to place taxes on and whether or not to raise or lower income tax. Levying taxes on goods for which consumers are highly sensitive to price changes will create little tax revenue yet lead to a large decrease in the quantity sold in such markets.
- Raising or lowering income tax with the goal of stimulating or reducing overall household spending on goods and services may be futile if consumers' demand is unresponsive to changes in disposable income.

Understanding elasticities extends our ability to critically analyse the functions of the market economy. It informs our decisions as consumers, business managers, and citizens in a democratic society.

4.2 Price elasticity of demand (PED)

Learning outcomes

- Explain the concept of price elasticity of demand, understanding that it involves responsiveness of quantity demanded to a change in price, along a given demand curve.
- Calculate PED using the following equation.

$$\text{PED} = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in price}}$$

- State that the PED value is treated as if it were positive although its mathematical value is usually negative.
- Explain, using diagrams and PED values, the concepts of price elastic demand, price inelastic demand, unit elastic demand, perfectly elastic demand and perfectly inelastic demand.
- Explain the determinants of PED, including the number and closeness of substitutes, the degree of necessity, time and the proportion of income spent on the good.
- Calculate PED between two designated points on a demand curve using the PED equation above.
- Explain why PED varies along a straight line demand curve and is not represented by the slope of the demand curve.

The law of demand states that *ceteris paribus*, there is an inverse relationship between the price of a good and the quantity demanded in the marketplace. With only a couple of

exceptions, this law will hold true whenever the price of a good rises or falls. An increase in price reduces the attractiveness of a product to consumers, resulting in a decline in the quantity demanded. A fall in price, on the other hand, makes a good more attractive to consumers, who will want to buy more of it.

Price elasticity of demand (PED) is a measure of the responsiveness of consumers to a change in the price of a particular good.

The price elasticity of demand (PED) is a measure of the responsiveness or sensitivity of consumers to a change in the price of a particular product. If a small increase in price leads to a proportionally large decrease in quantity demanded, consumers are said to be very *price sensitive*, and demand is therefore *price elastic*. On the other hand, if a large increase in price has little effect on the quantity of a good demanded, consumers are not very price sensitive, and demand is said to be *price inelastic*.

The PED coefficient

To measure the sensitivity of consumers to changes in price, we must compare the change in quantity demanded of a particular good with the particular price change of the good that led to the change in demand. To accommodate the different levels of output and price, we measure changes in *percentages*, not raw values. The formula for determining the PED coefficient is:

$$\text{PED} = \frac{\%\Delta Q_D}{\%\Delta P}$$

Where:

$\%\Delta Q_D$ is the percentage change in quantity (Δ, delta, signifies change)

$\%\Delta P$ is the percentage change in price

Thus, to calculate PED we divide the percentage change in quantity demanded of a good resulting from a particular percentage change in price.

If the price of rice rises by 15% and the quantity demanded decreases by 10%, the PED for rice is $-10/15 = -0.66$.

If the price of a digital watch falls by 20% and the quantity demanded increases by 40%, the PED is $40/20 = 2$.

However, we may not know the percentage changes in quantity and price, and would therefore be required to calculate them. The formula for calculating PED between two prices when percentage changes are not known is:

$$\text{PED} = \frac{(Q_{D2} - Q_{D1}) \div Q_{D1}}{(P_2 - P_1) \div P_1}$$

Where:

Q_{D2} is the quantity demanded following the price change

Q_{D1} is the original quantity demanded

P_2 is the new price

P_1 is the original price

Using this formula, we can determine the PED between two prices knowing only the values of quantity demanded and price.

Worked example

Let's assume a luxury sports utility vehicle (SUV) retails for £40 000 in the UK in July.

7000 SUVs are sold in July.

In August, the vehicle is marked down to £37 000.

7200 SUVs are sold in August.

Assuming no other variables changed between July and August, how responsive are UK consumers to the change in price of this SUV? To determine the price elasticity of demand for the vehicles, we can apply the price and quantity information to the equation above.

$$\text{PED} = \frac{(7200 - 7000) \div 7000}{(37000 - 40000) \div 40000}$$

$$\text{PED} = \frac{0.029}{-0.075} = -0.36$$

The price elasticity of demand for these SUVs between £40 000 and £37 000 in the UK is –0.36. A fall in price of 7.5% led to an increase in quantity demanded of 2.9%. Another way of interpreting this is that for every 1% decrease in price, the quantity demanded increased by 0.36%.

The PED coefficient is negative because of the inverse relationship between price and quantity. Since the law of demand applies to nearly all goods and services, we typically ignore the negative sign and express PED as an absolute value. Therefore the PED for the SUVs in the above example between the prices quoted is 0.36.

EXERCISES

1. Calculate the PED if a price increase of 50% causes the quantity demanded to fall by 40%.
2. If P = \$8 and Q_D = 200, calculate the new Q_D resulting from a price increase to \$10 if the PED is 1.5.
3. Explain why the PED coefficient is always negative.

Interpreting the PED coefficient

Depending on the degree to which quantity demanded changes when price changes, demand can be either price elastic, price inelastic or unit elastic. For simplicity, we will here examine the absolute value of the PED coefficient, which enables us to analyse positive numbers when comparing the elasticities of different goods.

PED < 1: → inelastic demand

A coefficient greater than zero but less than one indicates that demand for a good is inelastic. To see why, think about the example of the SUVs. When the price fell by 7.5%, consumers responded by demanding 2.9% more SUVs. The law of demand explains why consumers bought more when the price fell, while the PED coefficient of 0.36 tells us the responsiveness of consumers to the fall in price. Since the percentage change in quantity was less than the percentage change in price, the consumers are rather insensitive to changes in price in this case. Demand is price inelastic.

PED >1: → elastic demand

Now think about the example of the digital watches. When the watches fell in price by 20%, the quantity demanded increased by 40%. The PED is 40/20 = 2. A coefficient greater than one indicates that the percentage change in quantity demanded exceeds the percentage change in price. Consumers are relatively responsive or sensitive to price changes, and demand is said to be price elastic.

PED = 1: → unit elastic demand

If a particular percentage change in price results in an identical percentage change in quantity demanded, then demand is said to be unit elastic. Assume movie tickets increase from $10 to $12 and movie tickets sales drop by 20% in response. The 20% increase in price from $10 to $12 resulted in 20% fewer people buying tickets, so the coefficient is 20/20 = 1.

In the case of almost every good and service imaginable, the PED coefficient will be between 0 and infinity. But in some extreme circumstances, demand can be perfectly inelastic or perfectly elastic.

PED = 0: → perfectly inelastic demand

In this scenario, any change in price is met with no change in quantity demanded. The existence of goods for which demand is perfectly inelastic is highly unlikely, but theoretically possible. Imagine, for instance, that the price of a good such as insulin rises. Insulin is demanded by only a handful of people in the world, specifically diabetics. The quantity of insulin demanded by a particular diabetic individual is extremely constant and, without that quantity, the individual would suffer serious health consequences, maybe even death. As the price of insulin falls, diabetics will continue to demand the same amount as before, and no one else will demand insulin, so the quantity demanded will remain unchanged. As the price rises, diabetics will continue to demand the same quantity, since the risk of experiencing serious health consequences means they cannot afford to cut back on their consumption. The demand for insulin among diabetics is therefore perfectly inelastic. Of course, in the extreme case that the price rises to a level where it is beyond the means of some diabetics, the reality is that some individuals will simply not be able to afford it, so at a certain point even demand for necessities such as insulin is not perfectly inelastic.

PED = infinity: → perfectly elastic demand

The implication of a PED coefficient of infinity is that any change in price leads to an infinite change in quantity demanded. If the price of such a product increases even by 1% the quantity demanded falls to zero. A 1% decrease in price leads to an infinite increase in quantity demanded, in other words, every single consumer in the market will want to buy the product. While perfectly elastic demand is mostly theoretical, there are goods for which demand can be nearly perfectly elastic. Assume a good has thousands of perfect substitutes that are all easily available to the consumer, who has perfect information about the prices and products being sold. If one seller were to raise his price above the equilibrium level in the market, rational consumers will shun that seller and instead buy from one of the hundreds of other sellers. On the other hand, if one seller decides to lower his price below equilibrium, if only by one or two percent, all rational consumers will wish to buy from that seller and will shun all other sellers whose prices now appear too high. Such a scenario is imaginable, but extremely rare even in highly competitive markets such as agriculture, clothing, restaurants, taxis and so on.

Some of the goods for which demand is highly elastic may have very high PED coefficients, but will be less than perfectly elastic. Imagine, for instance, a company that sells phone cards. If you buy a phone card for $30, you receive $30 worth of credit for phone calls on your mobile phone. Imagine now that the price of a $30 phone card drops to $25. Almost everyone who finds out about this deal will want to buy the phone cards since it appears that they will get $5 of 'free' credit by paying $25 for a $30 card. Imagine that the number of cards sold increases from 20 000 to 500 000. Demand is highly elastic. To determine how elastic, the coefficient formula can be applied.

$$\text{PED} = \frac{(500\,000 - 20\,000) \div 20\,000}{(25-30) \div 30}$$

$$\text{PED} = \frac{24}{0.167} = 143.71$$

The PED for $30 phone cards is 144. For every 1% decrease in price, sales increase by 144%. While this is highly elastic, it is clearly not perfectly elastic. A 1% increase in price would likely lead to an extremely large decrease in the quantity demanded, perhaps even close to zero.

Relative elasticity and the slope of the demand curve

Graphically, relative price elasticities of demand can be compared by examining the slopes of demand curves drawn on the same axes. The steeper the slope of demand for a good, the less elastic the demand for that good. The more nearly horizontal the slope, the more elastic the demand. A demand curve that is vertical is perfectly inelastic, since the quantity demanded does not change as price changes. A horizontal demand curve is perfectly inelastic since any change in price will lead to an infinite change in quantity demanded. A downward-sloping demand curve may be relatively elastic or inelastic, depending on the particular changes in price and quantity being examined, but its PED will be greater than zero and less than infinity (Figure 4.1).

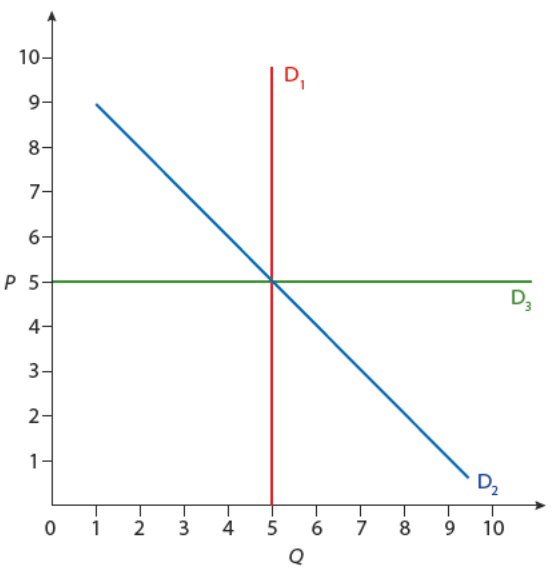

Figure 4.1
PED is reflected in the relative slope of the demand curve.

In Figure 4.1, D_1 corresponds with perfectly inelastic demand. Whether the price is 1 or 10, the quantity demanded will always remain at 5 units of this good. Consumers are totally unresponsive to changes in price. D_3 is perfectly elastic. Any change in price will lead to an infinite change in quantity demanded. If the price falls from 5 to 4, the amount of demand will be immeasurable as every consumer will wish to buy this good. If the price increases to 6, the quantity demanded will be zero as no rational consumer would continue to demand this good. The slope of D_2 is –1, indicating that demand is neither perfectly elastic nor perfectly inelastic. Depending on the price and quantity, demand for a good represented by D_2 can be relatively elastic (at higher prices) or relatively inelastic (at lower prices). D_3 and D_1 represent two extremes of elasticity that are rare if they exist at all in the real world.

The relative slopes of demand curves on the same axis indicate the relative elasticities of demand for the goods they represent. Goods for which demand is highly elastic reflect their

elasticity in the flat slope of the demand curve, while goods for which demand is relatively inelastic show demand curves closer to vertical.

Worked example

The demand curves In Figure 4.2 represent more realistic ranges of elasticity.

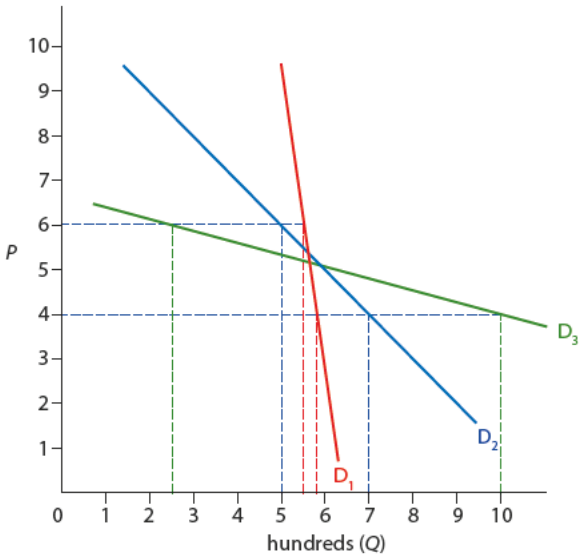

Figure 4.2
PED can be calculated using data in a demand diagram.

Assume the following:

- D_1 represents demand for cigarettes
- D_2 represents demand for movie tickets
- D_3 represents demand for chocolate ice cream.

To determine the elasticity for each of the three goods as their prices falls from \$6 to \$5, we use the PED coefficient formula.

First, we determine the percentage change in the price.

$$\%\Delta P = \frac{4-6}{6} = -0.33 \times 100 = 33\%$$

Next, we calculate the percentage change in the quantity for the three goods in response to the fall in price.

- Cigarettes: $\%\Delta Q_D = \frac{560-530}{530} = 0.056 \times 100 = 5.6\%$
- Movie tickets: $\%\Delta Q_D = \frac{700-500}{500} = 0.4 \times 100 = 40\%$
- Chocolate ice cream: $\%\Delta Q_D = \frac{1000-250}{250} = 3 \times 100 = 300\%$

A decrease in price of 33% from \$6 to \$4 led to drastically different changes in the quantity demanded for the three goods. To determine the exact PED for the three goods, we divide the percentage change in quantity by the percentage change in price.

- PED for cigarettes = $\frac{5.6}{33} = 0.17$
- PED for movie tickets = $\frac{40}{33} = 1.21$
- PED for chocolate ice cream = $\frac{300}{33} = 9.09$

Of the three goods, demand for cigarettes is the most inelastic and demand for chocolate ice cream is the most elastic. Demand for movie tickets is elastic (the coefficient is greater than one), but not nearly as elastic as for chocolate ice cream.

Certain individuals depend on particular goods for their survival – for example, diabetics need insulin to live. Is it unethical for the producers of such necessary goods to exploit the consumers and charge as high a price as possible? Where should we draw a line on what is a fair price for goods on which individuals depend for survival?

The determinants of PED

What determines whether demand for a particular good is elastic or inelastic? This is another way of asking what determines the sensitivity of consumers to price changes. The degree to which consumers respond to price changes depends on several factors, which can be summarized using the acronym SPLAT:

- S: substitutes
- P: proportion of income
- L: luxury or necessity
- A: addictive or not
- T: time to respond.

Number of substitutes

The number of substitutes a good has is one of the primary determinants of how elastic demand will be. Consumers will be more responsive to changes in the price of a good with a large number of substitutes than a good with very few or no substitutes. Coffee is a good with almost no perfect substitutes. Coffee consumers are therefore relatively unresponsive to changes in the price of coffee. On the other hand, any particular coffee shop has many substitutes. In a given city, there may be several dozen coffee shops, so if one unilaterally raises its prices while the others keep theirs constant, the chances are that consumers will be more responsive to that particular instance of a higher price than they would be if all coffee became more expensive.

Proportion of income

The proportion of the consumer's income the price of a good represents is another determinant of PED. Demand for goods that make up a large proportion of a consumer's income tends to be more elastic since a particular percentage change in price will appear much larger to the consumer than the same percentage change in price of a good that makes up a very small proportion of income. Take two examples: beach vacations and toothpicks. A 10% drop in the price of a family beach vacation may mean a savings of $1000 to a family of four considering an island getaway. $1000 is a significant amount of money and will therefore have a considerable impact on the number of families taking beach vacations. On the other hand, a 10% fall in the price of toothpicks may represent only a few cents savings on a box of a thousand toothpicks. Toothpicks are already so cheap and make up such a minute proportion of the typical consumer's budget that a fall in their price will have little or no effect on the overall quantity demanded.

Luxury or necessity?

Whether a good is a luxury or necessity affects its PED. Goods that are necessary to consumers will have less elastic demand than the luxuries they can do without if the price rises. Consumers are likely to be more responsive to a 20% increase in the price of fine leather handbags than a 20% increase in the price of natural gas. We depend on natural gas to heat our homes and to cook our meals, but we do not *need* fine leather handbags – we can do without them when their prices rise. Some consumers will be less responsive than others to increases in the price of luxuries – for example, those whose incomes are sufficiently high for even the price of luxury goods to be a relatively small proportion of their income.

Addictive or not?

Whether a good is addictive or not affects the PED. Addictive goods (for example, alcohol, tobacco, drugs, and fatty or salty foods) tend to have relatively inelastic demand. The reason is obvious: consumers with a physical dependence on a good will be unwilling or unable to respond to price increases to much degree. This helps explain why certain illicit drugs sell for extremely high prices on the streets of many cities; once a user is addicted, he or she is willing to pay almost anything for a drug like heroine or cocaine. If tobacco were not addictive, the chances are that many more people would quit smoking in response to the often massive taxes levied on cigarettes by governments.

Time to respond

The amount of time consumers have to respond to a price change determines the price elasticity of demand. Immediately following a change in price, it is unlikely that consumers will adjust their consumption by much. It is difficult to identify suitable substitutes for a good that has increased in price in the short run, but in the long run new options can be identified and consumers can further reduce their consumption of the more expensive good. If the price of a particular good falls, it will take time for consumers to notice the price change but once they do, it is likely that market demand will respond to the change in price.

4.3 Applications of price elasticity of demand

Learning outcomes

- Examine the role of PED for firms in making decisions regarding price changes and their effect on total revenue.
- Explain why the PED for many primary commodities is relatively low and the PED for manufactured products is relatively high.
- Examine the significance of PED for government in relation to indirect taxes.

Being able to determine a good's price elasticity of demand at a particular price allows businesses that produce that good to make informed and sound decisions regarding the optimal level of output and price. A firm or industry considering a decrease in output of its product is wise to consider the effect that the resulting price increase would have on the firm's or industry's total revenues. Figure 4.3 shows that the PED for a particular good is not constant across all prices. The higher the price of a good, the more responsive consumers are to a change in price; the lower the price, the less sensitive consumers are to price changes.

The demand curve (Figure 4.3a) shows the quantity demanded for this good at a series of prices between \$10 and \$0. At the high price of \$10, the total market demand is 0 units, so the total revenues for producers is \$10 × 0 = \$0. But 10 units can be sold for \$8 each, generating a total revenue of \$80.

Figure 4.3b plots the total revenue in the industry at each price and quantity combination. At a price of \$6, 20 units are sold for a total revenue of \$120. It can be assumed that at a price somewhere between \$6 and \$4, and a quantity between 20 and 30 units, the revenues earned by producers will be maximized.

A decrease in price from $10 to $5 leads to an increase in the quantity demanded and an increase in the total revenues earned by producers. This indicates that the percentage increase in the quantity demanded must have exceeded the percentage decrease in the price, evidence that demand is elastic between $10 and $5.

However, as the price falls below $5, the quantity demanded continues to increase but producers' revenues fall, indicating that the percentage increase in the quantity demanded is proportionally smaller than the percentage decrease in the price.

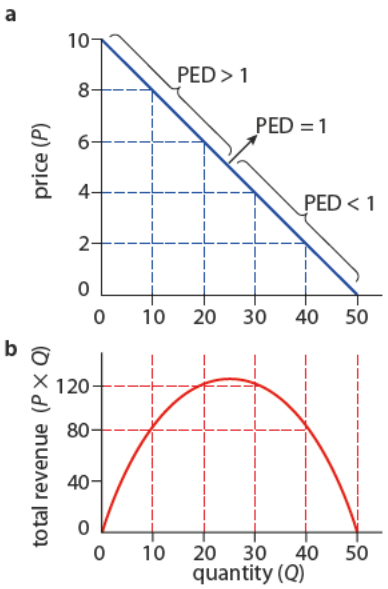

Figure 4.3
The total revenue test of PED.

The total revenue test of PED

The total revenue test of price elasticity of demand allows us to determine whether demand for a good is price elastic or price inelastic by examining the impact that a change in price has on the total revenue in the market. Generally speaking, at higher prices, demand tends to be relatively elastic for most goods. But as the price falls and the quantity demanded increases, the percentage changes in price become larger and the percentage changes in quantity become smaller, causing the PED to decrease at lower prices and higher quantities.

To confirm the concept, we can calculate the PED coefficient between two sets of prices.

Worked example

Using the example in Figure 4.3, the price first falls from $8 to $6, and then from $4 to $2. If the total revenue test holds true, we should find that PED is greater than one at the high prices and less than one at the low prices.

- PED between $8 and $6: $\text{PED} = \frac{(20-10) \div 10}{(6-8) \div 8} = \frac{1}{0.25} = 4$
- PED between $4 and $2: $\text{PED} = \frac{(40-30) \div 30}{(2-4) \div 4} = \frac{0.33}{0.5} = 0.66$

Between $8 and $6, the PED coefficient is 4, so demand is elastic, supporting our observation that an increase in total revenue following a decrease in price proves that consumers are relatively responsive to the lower price.

Between $4 and $2 the percentage decrease in price is larger than it was between $8 and $6, since the starting price is now lower. Additionally, although quantity demanded increases by the same number of units as it did following the earlier $2 price drop, the percentage increase in Q_D is smaller since the starting quantity is now larger. When price falls from $4 to $2, the total revenue in the industry declines from $120 to $80. This is evidence that consumers are no longer very responsive to lower prices, and that the percentage increase in quantity demanded must be smaller than the percentage decrease in price.

The PED coefficient of the above example at the lower price range is only 0.66, proving that a fall in price resulting in a decrease in total revenue is evidence of the inelasticity of

demand between two points on a demand curve. At lower prices, consumers are no longer as responsive to price decreases as they were at higher prices. If the industry or firm were to decrease output and raise its price from $2 to $4, firms would experience an increase in total revenue because the inelastic nature of demand at low prices means that consumers are relatively unresponsive to the higher price, thus despite the lower quantity sold, the industry's revenues would rise.

EXERCISES

4 Assume the demand for a good is expressed by the function $Q_D = 500 - 20P$. Calculate the PED for this good when:

a the price increases from $5 to $6

b the price increases from $10 to $11

5 Using your answer to exercise 4, explain what happens to the PED for a good with a linear demand curve as the price of the good increases.

6 Identify two explanations for the changing price elasticity of demand along a straight line demand curve.

7 If PED = 1, what will be the effect on total revenue of a fall in the price of 5%? Explain.

For a logical explanation of the decrease in elasticity at lower prices along a straight-line demand curve, we can return to the determinants of PED. To illustrate this phenomenon, consider a top-end smartphone with touch-screen technology which, when first launched, sold for around $400. At that price, demand for the product was highly elastic.

It wasn't long before the price was brought down in most markets, which resulted in huge increases in sales and further growth in revenues. The high levels of sensitivity to changes in price when the phone was new indicated that demand was very elastic, likely due to the high price but also the perception among consumers that this was a luxury product that they could do without until the price was brought down.

To make up for the loss of prestige and the increasingly inelastic demand for their products as prices fall over time, manufacturers of items such as smartphones must continually release new models with increasingly innovative features. This may help to explain why, within four years of the first iPhone's launch, there have been four versions of this enormously popular product.

It was not long before the uniqueness and luxury status of the product began to wear off. Due to market saturation, it was soon no longer the luxury product it had been in the first year of its launch. As the prestige and uniqueness waned, so did the responsiveness of consumers to changes in price. The latest generations of this phone sell for as little as $100 in most markets, and the manufacturer's unprecedented sales growth over the first year of the product's launch has slowed, even as price has continued to fall.

When the price of this luxury phone fell from $400 to $300, sales more than doubled. This reflects the highly elastic demand for the product when it was first launched. A price cut of around 25% led to sales increases of more than 100%. However, if the price now falls from $100 to $50, it is unlikely that sales will double again. Why? The product has lost its prestige, the price now represents a smaller proportion of the typical consumer's income, and there are simply not enough people out there who do not already have such a phone for the manufacturer to keep experiencing phenomenal sales growth with each new price cut.

The price elasticity of demand for most products decreases as the price decreases because when the price is lower, such goods lose their luxury status and the price is a smaller proportion of consumers' income.

For businesses making decisions about output and price, understanding price elasticity of demand is invaluable. A firm producing at a quantity and price combination along the inelastic range of its demand curve can always benefit by reducing its output and increasing its price, since consumers will be relatively unresponsive to the higher prices

and total revenues will therefore increase. However, if a firm is producing at an output and price combination along the elastic range of its demand curve, the firm may benefit from lowering its price since consumers are relatively price sensitive and the percentage increase in quantity sold will exceed the percentage decrease in price, improving the firm's revenue figures. Table 4.1 provides a quick reference guide.

TABLE 4.1 THE TOTAL REVENUE TEST: A QUICK REFERENCE

If ...	Leads to ...	Then demand is ...
a fall in price	an increase in total revenue	elastic
a fall in price	a decrease in total revenue	inelastic
an increase in price	a decrease in total revenue	elastic
an increase in price	an increase in total revenue	inelastic
a change in price	no change in total revenue	unit elastic

PED and indirect taxes

The price elasticity of demand of various goods also matters to economic policymakers, specifically regarding the question of what types of good should be taxed to generate government revenue. The effect that PED has on consumers, producers and the government when taxes are placed on particular goods or services is explored in depth in Chapter 5.

To access Worksheet 4.1 on understanding price elasticity of demand, please visit www.pearsonbacconline.com and follow the onscreen instructions.

4.4 Cross-price elasticity of demand (XED)

Learning outcomes

- Outline the concept of cross-price elasticity of demand, understanding that it involves responsiveness of demand for one good (and hence a shifting demand curve) to a change in the price of another good.
- Calculate XED using the following equation.

$$\text{XED} = \frac{\text{percentage change in quantity demanded of good X}}{\text{percentage change in price of good Y}}$$

- Show that substitute goods have a positive value of XED and complementary goods have a negative value of XED.
- Explain that the (absolute) value of XED depends on the closeness of the relationship between two goods.
- Examine the implications of XED for businesses if prices of substitutes or complements change.

Cross-price elasticity of demand (XED) is a measure of the responsiveness of consumers of one good to a change in the price of a related good.

A second type of elasticity measures the responsiveness of consumers of a particular good to a change in the price of a related good. As you learned in Chapter 2 (pages 31–35), one of the determinants of demand for a good is the price of other related goods, both complements and substitutes. A fall in the price of a complement leads to an increase in the demand for the good in question. The XED tells us how much demand will increase for a good when the price of a complement falls. Likewise, if a substitute becomes cheaper, demand for a good will decrease since consumers will buy more of its substitutes. XED measures how much demand for a good decreases when the price of a substitute falls.

The XED coefficient

The formula for determining the XED coefficient is:

$$\text{XED} = \frac{\%\Delta Q_A}{\%\Delta P_B}$$

Where:

$\%\Delta Q_A$ is the percentage change in quantity of good A

$\%\Delta P_B$ is the percentage change in price of good B

The formula measures the responsiveness of consumers of good A to a change in the price of good B. Unlike PED, the coefficient for XED can be either negative or positive. A negative XED coefficient indicates that the two goods compared are complements for one another; a positive coefficient indicates that the goods are substitutes.

The size of the XED coefficient is an indication of how closely related the two goods in question are. For example, if a change in the price of fizzy drink C has a large effect on the quantity demanded of fizzy drink P, then the XED coefficient will be a number greater than one, and we can therefore conclude that the two goods are strong substitutes for one another. On the other hand, if fizzy drink C becomes more expensive and the quantity demanded of fizzy drink S changes only slightly, the XED is said to be relatively inelastic and the goods are not strong substitutes for one another.

The same concept applies for complementary goods. The higher the XED coefficient, the more closely related the goods in question are to one another.

To illustrate, two examples can be used: complementary goods have a negative XED coefficient; substitute goods have a positive XED coefficient.

Complementary goods: negative XED coefficient

Imagine two related goods, such as charcoal barbecues and charcoal. These two goods are complements, since the use of one requires the other. As you learned in Chapter 2 (page 33), if the price of charcoal rises, the demand for charcoal barbecues will decrease as consumers switch to gas or electric barbecues instead. There is, therefore, an inverse relationship between the price of charcoal and demand for charcoal barbecues. We can determine the responsiveness of barbecue consumers to changes in the price of charcoal by measuring the XED for charcoal and charcoal barbecues (Figure 4.4a and b).

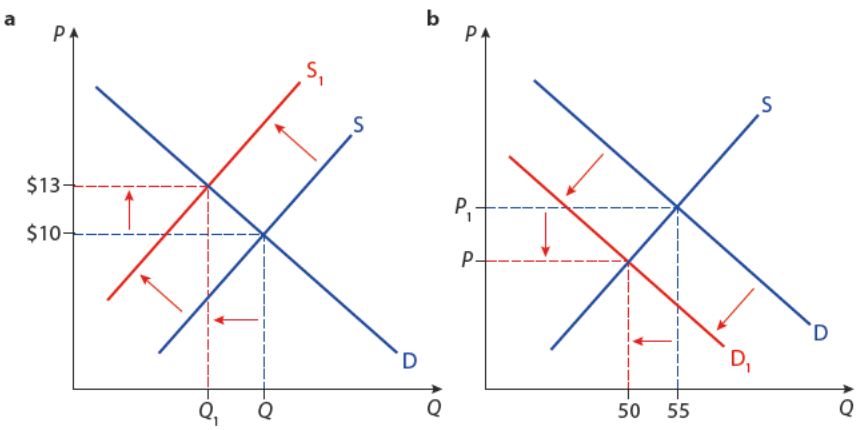

Figure 4.4
XED for complementary goods: an increase in the price of one leads to a decrease in the demand for the other. Charcoal; charcoal barbecues.

Worked example

In Figure 4.4, we see that as the price of charcoal rises from $10 to $13, the quantity of charcoal barbecues sold falls from 55 to 50. Using these numbers we can determine the cross-price elasticity of demand for charcoal and charcoal barbecues. If Q_B is the quantity of barbecues demanded and P_C is the price of charcoal:

$$\text{XED} = \frac{(Q_{B2} - Q_{B1}) \div Q_{B1}}{P_{C2} - P_{C1}) \div P_{C1}}$$

$$= \frac{(50 - 55) \div 55}{(13 - 10) \div 10}$$

$$= \frac{-0.09}{0.3} = -0.3$$

We are able to determine that the cross-price elasticity of demand for charcoal barbecues and charcoal is around –0.3.

An increase in price of around 30% for charcoal leads to a decrease in quantity demanded for charcoal grills of around 9%. Barbecue consumers are relatively unresponsive to changes in the price of charcoal. The negative sign here remains as evidence of the relationship between the two goods. XED is not always negative.

Substitute goods: positive XED coefficient

Two goods that are substitutes in consumption exhibit a positive relationship between the price of one good and demand for the other. Take chicken and beef, for instance. Both meats are eaten as a source of protein. If an outbreak of bird flu leads to a fall in the supply of chicken and an increase in its price, the demand for beef rises because consumers begin to substitute the now relatively cheaper beef for the pricier chicken. The XED for beef and chicken measures the responsiveness of beef consumers to changes in the price of chicken (Figure 4.5).

Beef *vs* chicken: how responsive are the consumers of one to a change in the price of the other?

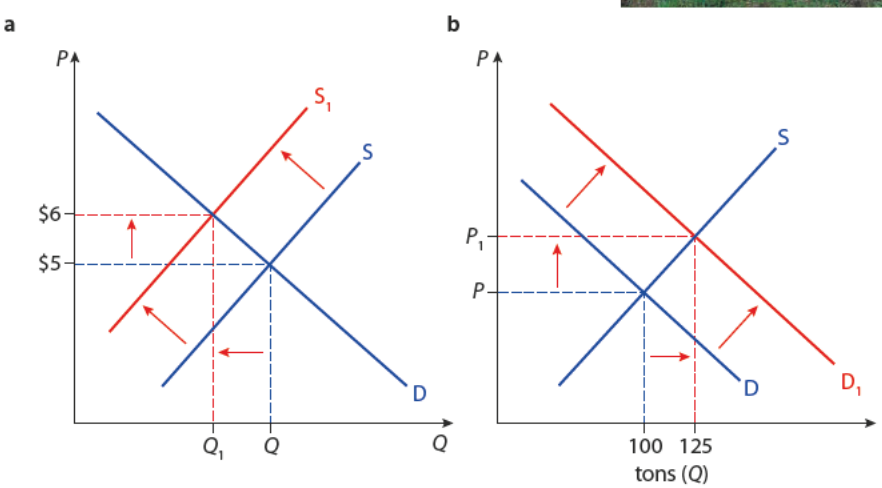

Figure 4.5
XED for substitute goods: an increase in the price of one leads to an increase in demand for the other.
a Chicken; **b** beef.

Worked example

In Figure 4.5, the price of chicken increases from $5 to $6 and the quantity of beef sold increases from 100 tons to 125 tons. With this information, we can calculate the cross-price elasticity of demand for beef and chicken.

$$\text{XED} = \frac{(125 - 100) \div 100}{(6 - 5) \div 5}$$

$$\text{XED} = \frac{0.25}{0.2} = 1.25$$

Beef consumers are relatively responsive to changes in the price of chicken. The cross-price elasticity coefficient of 1.25 indicates that a particular percentage increase in the price of chicken leads to a larger percentage increase in the demand for beef. The fact that the coefficient is positive is evidence of the relationship between beef and chicken. The two goods are substitutes, meaning that there is a direct relationship between the price of one and the demand for the other, hence the positive XED coefficient.

The recent rise in demand for hybrid cars, electric cars and compact, fuel-efficient cars is almost certainly a demonstration of the concept of cross-price elasticity of demand. The demand for such vehicles is perfectly correlated with oil and fuel prices – the more expensive a tank of petrol becomes, the greater the quantity of hybrid cars demanded.

Interpreting the XED coefficient

Interpretation of value of the XED coefficient is similar to interpretation of the value of the PED coefficient. A value of < 1 indicates that the two goods are cross-price inelastic, a value of 1 indicates unit elasticity and a value > 1 indicates that demand is cross-price elastic. A coefficient of zero indicates that demand between two goods is perfectly inelastic.

In the case of PED, examples of goods for which demand is perfectly inelastic are rare. But in the case of XED, perfect inelasticity indicates that the two goods are unrelated. If the price of airplane tickets rises by 10% and the demand for running socks remains constant, then the XED coefficient = 0/10 = 0. We can easily conclude that these two goods are unrelated since the change in price of one good has no effect on the demand for the other. Demand is cross-price perfectly inelastic for two goods that are neither complements nor substitutes.

EXERCISES

8 The price of good M increases by 15%, causing a fall in the Q_D of good N by 5%. Calculate the XED and comment on the relationship between the two goods. Identify an example of two goods that may demonstrate this relationship.

9 The price of good A falls from $25 to $20, leading to an increase in the quantity of good B demanded from 600 per week to 1000 per week. Calculate the XED for the two goods and comment on the relationship between goods A and B. Identify an example of two goods that may demonstrate this relationship.

10 Assume the XED for tennis balls and tennis rackets is –0.8. Calculate the change in quantity of tennis rackets demanded if the price of a can of tennis balls increases from $4 to $5.

CASE STUDY

Cross-price elasticity of demand in the news: camel demand soars in India

Farmers in the Indian state of Rajasthan are rediscovering the humble camel.

As the cost of running gas-guzzling tractors soars, even-toed ungulates are making a comeback, raising hopes that a fall in the population of the desert state's signature animal can be reversed.

'It's excellent for the camel population if the price of oil continues to go up because demand for camels will also go up,' says Ilse Köhler-Rollefson of the League for Pastoral Peoples and Endogenous Livestock Development. 'Two years ago, a camel cost little more than a goat, which is nothing. The price has since trebled.' The shift comes not a moment too soon for a national camel population that has fallen more than 50% over the past decade, to about 450 000, according to government figures.

Market prices for these 'ships of the desert', which crashed with the growing affordability of motorized transport, are rising again as oil prices soar. A sturdy male with a life expectancy of 60–80 years now fetches up to Rs40 000 ($973), compared to Rs5000–Rs10 000 three years ago, according to Hanuwant Singh of the Lokhit Pashu-Palak Sansthan, a non-profit welfare organization for livestock keepers. Entry-level tractors cost around $4000.

'It's very good news,' says Mr Singh, whose organization aims to dispel the image of backwardness associated with camel ownership and tries to promote higher economic returns for breeders. 'We had started to see camels, even female ones, being slaughtered for their meat. Now they are replacing the tractor again.'

It is too soon to say that the future for camels is bright. Shrinking grazing areas and a lack of investment in fodder trees may thwart a sustainable revival. Inadequate nutrition undermines the resilience of camel herds, making them vulnerable to disease and lowering birth rates.

The LPPS is encouraging the Raika community – traditional guardians of the camel population since the days when Maharajahs rode them into battle – to diversify into products such as camel milk, optimistically dubbed 'the white gold of the desert', camel leather handbags and camel bone jewellery.

Animal-lovers hope that the surge in oil prices will enhance the status of camel-breeders, who resent the lack of respect society has accorded their traditional knowledge, and give the Raika a strong incentive to stop selling female camels for slaughter.

Jo Johnson for the *Financial Times*, 2 May 2008

EXERCISES

11 How are camels and oil related goods? What should be true about the XED coefficient of camels and oil based on the relationship between these two goods?

12 As the price of oil rose from $110 to $130 per barrel, the quantity of camels in Rajasthan increased from 250 000 to 350 000. Calculate the cross-price elasticity of demand for camels and oil.

13 Other factors may affect the return of camels as a beast of burden in India. How might 'shrinking grazing areas and a lack of investment in fodder trees' counteract the effect of higher oil price on the camel market?

4.5 Income elasticity of demand (YED)

Learning outcomes

- Outline the concept of income elasticity of demand, understanding that it involves responsiveness of demand (and hence a shifting demand curve) to a change in income.
- Calculate YED using the following equation.

$$\text{YED} = \frac{\text{percentage change in quantity demanded}}{\text{percentage change in income}}$$

- Show that normal goods have a positive value of YED and inferior goods have a negative value of YED.

- Distinguish, with reference to YED, between necessity (income inelastic) goods and luxury (income elastic) goods.
- Examine the implications for producers and for the economy of a relatively low YED for primary products, a relatively higher YED for manufactured products and an even higher YED for services.

Income elasticity of demand (YED) is a measure of the responsiveness of consumers' demand for a particular good to a change in their income.

Income elasticity of demand (YED) measures the responsiveness of consumers' demand for a particular good to a change in income. As a determinant of demand introduced in Chapter 2 (page 32), changes in income have different effects on demand for different goods depending on the nature of the good in question.

The YED coefficient

If a good is a normal good, then rising income leads to greater demand. Normal goods may include restaurant meals, taxi rides, clothes, air travel, DVDs or anything else consumers tend to buy more of as their incomes rise.

If a rise in income leads to a decrease in consumption of a particular good, that good is said to be inferior. Inferior goods may include items such as fast food, generic brand groceries, public transport, second-hand clothes or any other product consumers tend to consume less of as incomes rise. Because consumers' demand for certain goods responds differently to changes in income, the YED coefficient can be either negative or positive.

YED is found by dividing the percentage change in quantity demanded for a good by the percentage change in the consumer's income.

$$\text{YED} = \frac{\%\Delta Q_D}{\%\Delta Y}$$

$\%\Delta Q_D$ is the percentage change in quantity demanded

$\%\Delta Y$ is the percentage change in income

If the percentage changes in quantity and price are not known but the values are known, then the simple YED formula can be used to determine the coefficient:

$$\text{YED} = \frac{(Q_{D2} - Q_{D1}) \div Q_{D1}}{(Y_2 - Y_1) \div Y_1}$$

Where:

Q_{D2} is the quantity demanded following the income change

Q_{D1} is the original quantity demanded

Y_2 is the new income

Y_1 is the original income

If there is a direct relationship between income and demand, then the YED coefficient will be positive, indicating that the good in question is a normal good. If, on the other hand, the relationship between income and demand is indirect, in which case a rise in income would lead to a smaller quantity and a fall in income to an increase in the quantity, then the YED coefficient will be negative, indicating the good in question is inferior.

Income elasticity of demand can be applied to measure the change in an individual's consumption of particular goods following a change in the individual's income, or it can be applied to analyse the effects of changes in national income on the demand for particular goods and services in a nation as a whole.

For instance, it was found in 2008 that while incomes in the US were falling due to the nationwide recession, the sale of bicycles began to increase. It turns out that bicycles may be inferior goods. When incomes are rising, car sales tend to increase, indicating that cars are normal goods. But as the US recession put downward pressure on average incomes, more people turned to bicycles since they present a more affordable option for getting around than fuel-consuming vehicles.

If bikes are an inferior good, demand should rise when incomes fall.

Interpreting the YED coefficient

As with the other types of elasticity covered in this chapter, YED can be elastic, inelastic or unit elastic.

If a good is income elastic, then a particular percentage change in income will lead to a larger percentage change in the quantity demanded for the good. For instance, if a rise in consumer income of 5% results in a 12% increase in the quantity demanded of hybrid cars, the YED for hybrid cars is 12/5 or 2.4. Demand for hybrids is said to be income elastic.

If a good is income inelastic, then a particular percentage change in income will lead to a smaller percentage change in the quantity demanded for the good. If a 5% rise in income leads to a 3% fall in the demand for fast food meals, the YED for fast food is 3/5 or –0.6. The negative sign indicates that fast food is an inferior good, and the fact that the absolute value of the YED coefficient is less than one is evidence that demand for fast food is income inelastic. Fast-food consumers are relatively unresponsive to changes in their income.

If a good is income unit elastic, then a particular percentage change in income will lead to an identical percentage change in the quantity demanded. If a 5% rise in consumer incomes leads to a 5% increase in the quantity of air travel demanded, then the YED coefficient is one and air travel (a normal good) is income unit elastic.

Fluctuations in bicycle sales are based on many variables. For consumers who view bikes as a means of transport, they are an inferior good. For consumers who view them as a recreational good, bikes may be a normal good. Bike sales also respond greatly to changes in the price of oil. Why do you think this is?

EXERCISES

14 Calculate the YED if an increase in income of 8% leads to an increase in the quantity demanded for good X of 12%. Identify an example of a product that good X could represent.

15 Assume the following levels of income and the quantities demanded of good A. Y_{2010} = \$40 000. Y_{2011} = \$55 000. Q_{D2010} = 45 units. Q_{D2011} = 40 units.

- **a** From the information above, calculate the YED for good A and comment on your response.
- **b** Identify an example of a product that good A could represent.

16 For the following three products, comment on the elasticity values.

- **a** Gourmet ice cream: YED = 0.6
- **b** Fast food hamburgers: YED = –1.2
- **c** Air travel: YED = 1.8

Applications of income elasticity of demand

Understanding YED allows businesses and governments to analyse the effects of changing incomes among consumers and taxpayers on the level of demand for particular goods in an economy. A firm that must decide on production numbers for its product may wish to determine whether the incomes of its consumers are likely to rise or fall in the future. If a firm produces a good considered inferior, then a recession could be good for business and it will increase its output in order to meet the rising demand among consumers whose incomes are harmed by the recession. Producers of normal goods, on the other hand, may scale back production as incomes decline. Understanding the responsiveness of consumers of their products to changes in income better enables firms to produce at a more efficient level of output over time.

The economic term 'inferior good' has a very specific and technical definition. What evidence is needed to determine if a particular good is inferior or normal from an economic standpoint? What about from a non-economic perspective? What might make a particular good 'inferior'?

Governments also must recognize the effects of varying income elasticities of demand for different goods produced by their nation's economy. The largest source of tax revenue for most governments is a direct tax on income. A government's decision to raise or lower income tax on households will directly affect disposable income and therefore demand for goods and services in a nation. A tax increase that decreases disposable income will reduce demand for normal goods across the nation's economy and increase demand for inferior goods. A government must consider these effects in order to make informed decisions regarding tax policy.

4.6 Price elasticity of supply (PES)

Learning outcomes

- Explain the concept of price elasticity of supply, understanding that it involves responsiveness of quantity supplied to a change in price along a given supply curve.
- Calculate PES using the following equation.

$$\text{PES} = \frac{\text{percentage change in quantity supplied}}{\text{percentage change in price}}$$

- Explain, using diagrams and PES values, the concepts of elastic supply, inelastic supply, unit elastic supply, perfectly elastic supply and perfectly inelastic supply.
- Explain the determinants of PES, including time, mobility of factors of production, unused capacity and ability to store stocks.
- Explain why the PES for primary commodities is relatively low and the PES for manufactured products is relatively high.

Price elasticity of supply (PES) is a measure of the responsiveness of a producer of a particular good to a change in the price of that good.

PES measures the responsiveness of producers of a particular good to a change in the price of that good. The law of supply tells us that, *ceteris paribus*, there is a direct relationship between the price of a particular product and the quantity supplied in the marketplace. The sensitivity of producers to changes in price may be very low or very great, depending on the type of good produced, the availability of inputs, and the amount of time following the change in price.

The PES coefficient

Like PED, PES can be inelastic, unit elastic or elastic; it can range from zero to infinity. The formula for determining the PES coefficient is similar to that for PED, except that we

measure movements along the supply curve rather than movements along the demand curve:

$$PES = \frac{\%\Delta Q_S}{\%\Delta P}$$

Where:

$\%\Delta Q_S$ is the percentage change in quantity supplied

$\%\Delta P$ is the percentage change in price

As in the case of the other elasticities, if the percentage changes in price and quantity are not known, then PES can be calculated using the simple elasticity formula:

$$PES = \frac{(Q_{S2} - Q_{S1}) \div Q_{S1}}{(P_2 - P_1) \div P_1}$$

Where:

Q_{S2} is the quantity supplied following the price change

Q_{S1} is the original quantity supplied

P_2 is the new price

P_1 is the original price

As with PED, PES can be highly elastic, highly inelastic, or somewhere in between (Figure 4.6). Take two goods, for instance: croissants and fighter jets. The market for croissants is highly competitive; any bakery can make a greater or lesser quantity of croissants day after day depending on the demand. If the demand for croissants grows, putting upward pressure on the price, bakeries can respond quickly and easily to the higher price, increasing the quantity supplied almost instantly to meet the higher demand.

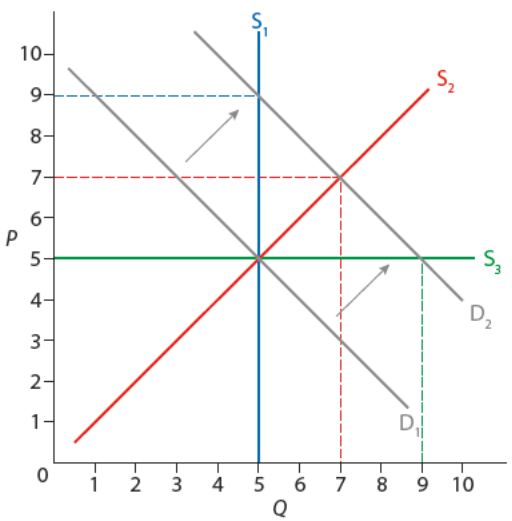

Figure 4.6
The extremes of PES.

The supply of croissants is therefore nearly perfectly elastic. An increase in price of 10% will be met by a much larger increase in the quantity supplied since the inputs needed are easily acquired and the numerous producers can respond instantly and easily to changes in price. The end result of an increase in demand for croissants, therefore, will be almost no increase in the price but a large increase in the quantity supplied, as indicated by S_3 in Figure 4.6, showing a perfectly elastic supply curve.

On the other had, the supply of fighter jets is highly, if not perfectly, inelastic – especially in the short run. If the demand for fighter jets grows from D_1 to D_2, the producers of these jets will be unable to respond quickly to the change in price, and the quantity of fighter

jets produced will remain nearly constant in the short run. A large increase in price will lead to almost no increase in the quantity of fighter jets sold, indicating that in the period immediately following an increase in demand, the supply of fighter jets is nearly perfectly inelastic, illustrated by S_1 in the diagram above.

Over time, as weapon and airplane manufacturers are able to acquire the scarce inputs needed for jet production and allocate more resources towards increasing their production of fighter jets, producers will become more responsive to the higher demand.

Croissants and fighter jets represent two extreme examples of price elasticity of supply. For the former, producers are extremely responsive to changes in demand but for the latter, producers are extremely unresponsive, particularly in the short run. In between these two extremes, supply can be relatively inelastic (PES < 1), relatively elastic (PES >1) or unit elastic (PES = 1). S_2 above, which originates at the origin, represents a unit elastic supply curve, indicating that a particular percentage increase in the price will lead to an identical increase in the quantity supplied.

In the real world, examples of goods for which supply is either perfectly inelastic or perfectly elastic are rare, but not nearly as rare as are goods for which demand is perfectly elastic or inelastic. Any good that is completely fixed in its supply due to its physical scarcity is perfectly inelastic in supply. Gold, for instance, is mined in only a few places in the world. Therefore, even a small increase in the demand for gold leads to a large increase in its price since gold producers have only limited capacity to increase their output of gold in the short run. Certain antiques or artwork will exhibit perfectly inelastic supply as well. Picasso's paintings, for instance, only exist in a limited number, and no matter how much demand rises or falls, the number of Picassos in the world will remain totally constant.

Supply can be perfectly elastic for a good if large inventories exist for that good. Inventories are the amount of a good held in stock by a firm. If demand for a good rises and large inventories exist, producers can respond to the increase in price instantly by releasing their inventories on the market to meet the increase in consumer demand. Even in the short run, supply can be perfectly elastic in markets in which firms have substantial quantities of inventory.

The determinants of price elasticity of supply

A good's PES depends on:

- the amount of time following a change in price
- the mobility of factors of production
- the ability to store stocks
- the amount of unused capacity.

Time following a change in price

Another important determinant of PES is the amount of time following a change in price over which producers are able to adjust their output. Figure 4.7 shows three supply curves for the same product: corn. Suppose a nation's government announces that by the end of the current decade, 20% of automobiles must be able to run on ethanol manufactured from corn. Thereafter, the demand for corn increases and the price rises from $5 per bushel to $6 per bushel as ethanol producers begin ramping up their production of fuel made from corn. In the days, weeks, months and years following an increase in the price of corn, we would expect to see the price elasticity of supply change as producers have time to adjust their output to the higher demand and price in the corn market.

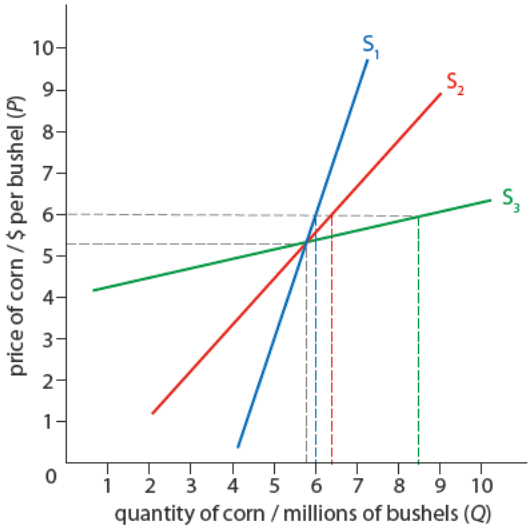

Figure 4.7
PES changes over time.

S_1: the market period

The period immediately following a change in price is known as the market period, and during this time supply would be highly inelastic, corresponding with S_1. In the market period, producers do not have the time to adjust their output to changes in price. Corn producers can release the little inventory they have and can perhaps harvest their crop earlier than planned, but the amount of land, labour and capital allocated to growing corn is fixed in the market period. In the market period, supply is highly inelastic and output can increase from 5.7 million bushels to around only 5.9 million bushels of corn following an increase in price from $5 to $6 per bushel.

S_2: the short run

Within a few months of the increase in the corn price, growers will be able to increase the intensity with which they use their fixed capital and land resources for growing corn. More labour and better or more fertilizer and pesticides can be applied to the existing crop in an attempt to increase the yield in order to meet the rising demand. The short run is the period of time over which land and capital are fixed, but labour is variable and therefore the intensity with which land and capital are used can increase, resulting in more elastic supply than was possible in the market period. S_2 represents the supply curve in the short run following an increase in the price of corn. In the short run, output can be increased from 5.5 million bushels to about 6.5 million bushels.

S_3: the long run

In the long run, supply is highly elastic. The long run is defined as the period of time over which all factors of production are variable. In the case of corn, the long run may be one or two years, a period of time over which farmers can switch land that was being used for other crops to corn production and bring idle land into production of corn as well. In addition, farmers can allocate more capital and labour towards growing corn, allowing them to be much more responsive to the increase in price. In the long run, following an increase in the price of corn from $5 to $6, output can be increased from 5.5 million bushels to around 8.6 million bushels.

Over time, producers are much more responsive to changes in the price of a good. In the period immediately following a change in price, all factors of production are fixed and therefore firms are unable to change their output to much extent. In the short run, capital and land are fixed but firms can hire more workers to meet increasing demand or lay

workers off to adapt to falling demand, thereby using existing land and capital more or less intensively. In the long run, all factors of production are variable, so firms can be highly responsive to changes in demand in the marketplace.

Mobility of the factors of production

The more mobile the factors of production (the labour, land and capital resources needed for the production of a good), the more responsive a firm can be to changes in price. Whether a good is land intensive in its production or labour-and-capital intensive makes a significant difference to producers' ability to quickly shift resources into or out of production following a change in price.

Relatively elastic supply: manufactured goods and low-skilled services

Low-tech manufactured goods (e.g. clothes, toys and simple electronics) and low-skilled services (e.g. haircuts, laundry services, housekeeping) tend to have relatively elastic supply. Producers can easily hire more workers and acquire more raw materials and capital resources to meet increases in demand for such goods, thus they are highly responsive to increases in the price. When demand falls, producers of these goods find it quick and easy to lay off workers, take capital out of production, and cancel orders for raw materials, thus they can respond quickly to decreases in demand as well. The easy mobility of resources for manufactured goods and low-skilled services allows for supply of these items to be relatively responsive to changes in price.

The supply of corn and other commodities is highly inelastic.

Relatively inelastic supply: primary commodities and heavy industrial goods

The harder it is to shift factors of production into or out of the production of a good, the more inelastic the good's supply will be. The markets for airplanes, residential and commercial construction, automobiles, high-tech goods and highly skilled services (e.g. doctors, financial experts or university professors) tend to exhibit highly inelastic supply. Additionally, primary commodities that are land-intensive in production, such as coffee, rice, corn, wheat, coal, oil, gas and minerals also exhibit immobility of the factors of production. It is extremely time-consuming and costly to bring into production new plants for heavy industrial goods and primary commodities to meet rising demand, or to take them out of production in response to falling prices. Thus, the supply of such goods tends to be relatively inelastic.

The ability to store stocks

If large inventories of a good can easily be stored in warehouses or kept on hand by producers, then supply of the good can be highly responsive to changes in the price. Items such as video games, software, low-tech manufactured goods and certain non-perishable commodities can be produced in large quantities that aren't necessarily sold but added to inventories to be stored and used to meet future demand.

If, in the future, demand for such goods rises, the producers can quickly and easily release stored inventory on to the market to meet the increase in demand and prevent rapid rises in the price, responding to price rises with larger proportional increases in the quantity supplied. Likewise, when the demand for non-perishable commodities falls, producers can

respond by putting supply into inventory and quickly reducing the quantity available in the market.

But not all goods can be easily stored. When demand for such perishable goods as milk, fruit, some grains and large-scale industrial goods such as airplanes and ships rises, producers have a very limited stock to dip into to meet rising demand. Likewise, inventories cannot be added to when demand falls; producers are not very responsive and must accept a lower price to sell the current output that would otherwise go bad or be very costly for the firm to store.

The amount of unused capacity

Excess capacity refers to the amount a firm is able to produce in the short run without having to expand its plant size and the amount of capital and land employed in production. If an industry is operating at a level of output at which it has large amounts of unused capacity, then producers are able to quickly and easily respond to changes in the demand for the good in question. If, however, an industry is operating at or near full capacity, supply will be highly inelastic in the short run, as in order to meet any increase in demand firms must first acquire new capital equipment and open new factories to meet the rising demand for their output. Such expansion takes time and means that supply will be relatively inelastic following an increase in demand.

Excess capacity is the amount of output an industry can produce in the short run beyond its current level without having to expand its plant size. If large amounts of excess capacity exist, producers can be highly responsive to changes in the price. With little excess capacity, producers cannot respond quickly to changes in price.

EXERCISES

17 Calculate the PES if a price increase of 9% causes the quantity supplied to increase by 3%.

18 Assume the price of good A is $4 and the quantity supplied is 400 units. With a PES of 0.5, how will a fall in the price from $4 to $3 affect the quantity supplied of good A?

19 The supply for good B is expressed with the function $Q_S = 30 + 2.5P$. Calculate the PES for this good if:

a the price increases from $10 to $11

b the price decreases from $5 to $4

20 'The price elasticity of supply for a good changes the more time goes by following a change in the demand for the good'. Using an example, explain how this is so.

Applications of price elasticity of supply

Understanding price elasticity of supply allows firm managers and government policymakers to better evaluate the effects of their output decisions and economic policies.

Excise taxes and PES

A tax on a particular good, known as an excise tax, is paid by both the producers and the consumers of that good. When a government taxes a good for which supply is highly elastic, it is the consumer who ends up bearing the greatest burden of the tax, as producers are forced to pass the tax onto buyers in the form of a higher sales price. If the producer of a highly elastic good bears the tax burden itself, it may be forced to reduce output to such a degree that production of the good becomes no longer economically viable. A tax on a good for which supply is highly inelastic will be borne primarily by the producer of the good. The price paid by consumers will only increase slightly while the after-tax amount received by the producer will decrease significantly, but in the case of inelastic supply this

will have a relatively small impact on output. A graphical representation of the effects of taxes on different goods is introduced in Chapter 5 (page 101).

Price controls and PES

A common policy in rich countries aimed at assisting farmers is the use of minimum prices for agricultural commodities. In the European Union (EU), the Common Agricultural Policy (CAP) involves a complex system of subsidies, import and export controls and price controls, the objective of which is to ensure a fair standard of living for Europe's agricultural community. The use of minimum prices in agricultural markets can have the unintended consequence of creating substantial surpluses of unsold output. Take the example of butter in the EU.

Prior to reform of the CAP in 2013, the EU used to purchase millions of tonnes of surplus dairy produce every year. It did so at stated guaranteed market prices, and stored the reserves in vast quantities in what became known as Europe's 'butter mountains' and 'milk lakes'.

These excess reserves were the subject of fierce criticism and although they were said to have been eradicated in 2007, in January 2009 fears of a butter mountain loomed large once again.

Following a sharp drop in demand for butter and milk the European Commission bought 30,000 tonnes of unsold butter and 109,000 tonnes of unwanted skimmed powder milk at above market prices, costing €255 million.

Commission officials said the measure was a temporary move to stop dairy farmers going out of business in the wake of a drastic slump in milk prices and a 33 per cent fall in butter exports.

The situation in the EU butter market can be attributed to underestimation by policymakers of the responsiveness of butter producers to the price controls established under the CAP. A minimum price scheme of any sort, if effective, will result in surplus output of the good in question, but the 30 000 tons of unsold butter in Europe appears to exceed the expected surplus considerably. Figure 4.8 illustrates why.

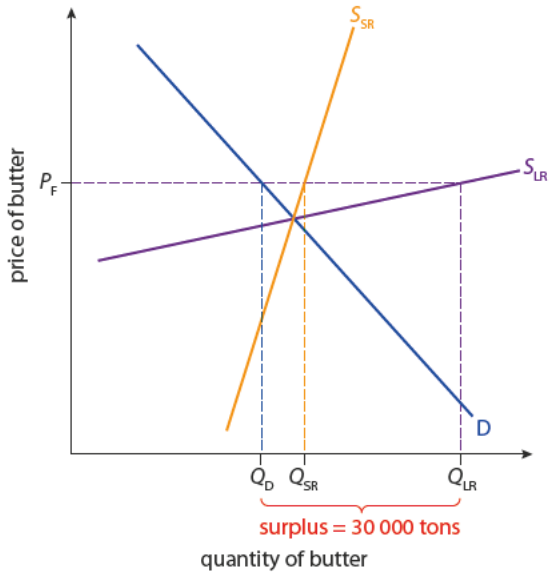

Figure 4.8
The effect of a price floor depends on the responsiveness of producers to the higher price.

A price floor (P_F) is set above the equilibrium price of butter established by the free market. Butter producers in Europe are guaranteed a price of P_F euros, and any surplus not sold at this price will be bought by the European Commission (EC). Assuming a relatively

inelastic supply, which corresponds with the short-run period (S_{SR}), the increase in butter production is relatively small (Q_{SR}), resulting in a relatively small surplus ($Q_{SR} - Q_D$).

In the short run, the amount of surplus butter the EU governments needed to purchase was minimal. But as you learned earlier, when producers of goods have time to adjust to the higher price (here, the price guaranteed by the EC), they become more responsive to the higher price and are able to increase their output by much more than in the short run. S_{LR} represents the supply of butter in Europe in the long run, after years of the minimum-price scheme. As demand fell due to the global economic slowdown, butter producers continued to produce at a level corresponding to the price floor, thus leading to ever-growing butter stocks and the need for the EC to spend 69 million euros on surplus butter.

Understanding the behaviour of producers in response to changes in prices, whether due to excise taxes or price controls, better allows both business managers and government policymakers to respond appropriately to conditions experienced by producers and consumers in the marketplace and thus to avoid inefficiencies resulting from various economic policies.

This chapter extended your analysis of the interactions of supply and demand for goods and services in the marketplace by focusing on the responsiveness of producers and consumers to changes in factors such as the price of the good, the price of related goods and the income of consumers.

The formulas for elasticities of demand, supply, income and cross-elasticity each measure the percentage change in quantity over the percentage change in another variable. Elasticity's applications are varied and wide; they affect consumers and producers of particular goods, as well as government policymakers who are trying to achieve various economic objectives while addressing the inefficiencies resulting from taxes and price controls.

In Chapter 5, you will explore in more depth the various forms of government intervention in free markets, expanding your understanding of the reasons for and effects of various government actions including indirect taxes, subsidies and price controls.

Government interference always reduces efficiency in the free market. Therefore, any attempt by government to help producers or consumers will make society worse off. What evidence would we need to support or refute this claim?

To access Worksheet 4.2 on price elasticity of supply, please visit www.pearsonbacconline.com and follow the onscreen instructions.

To learn more about elasticity, visit www.pearsonhotlinks.com, enter the title or ISBN of this book and select weblink 4.1.

To access Worksheet 4.3, a multiple-choice quiz on this chapter, please visit www.pearsonbacconline.com and follow the onscreen instructions.

PRACTICE QUESTIONS

1 **a** With the use of examples, explain why some products have a low price elasticity while others have a high elasticity. (10 marks) [AO2]

b If you were employed as an economist by a business, discuss why a knowledge of the price elasticity of demand of your product would be useful. (15 marks) [AO3]

2 **a** Carefully explain what it is that price, income and cross-elasticities of demand are meant to measure. (10 marks) [AO2]

b Discuss the practical importance of the concept of price elasticity of demand for the government. (15 marks) [AO3]

3 **a** Explain the factors which influence price elasticity of supply. Illustrate your answer with reference to the market for a commodity or raw material. (10 marks) [AO2]

b Discuss the importance of price elasticity of supply and price elasticity of demand for producers of primary commodities in less developed countries. (15 marks) [AO3]