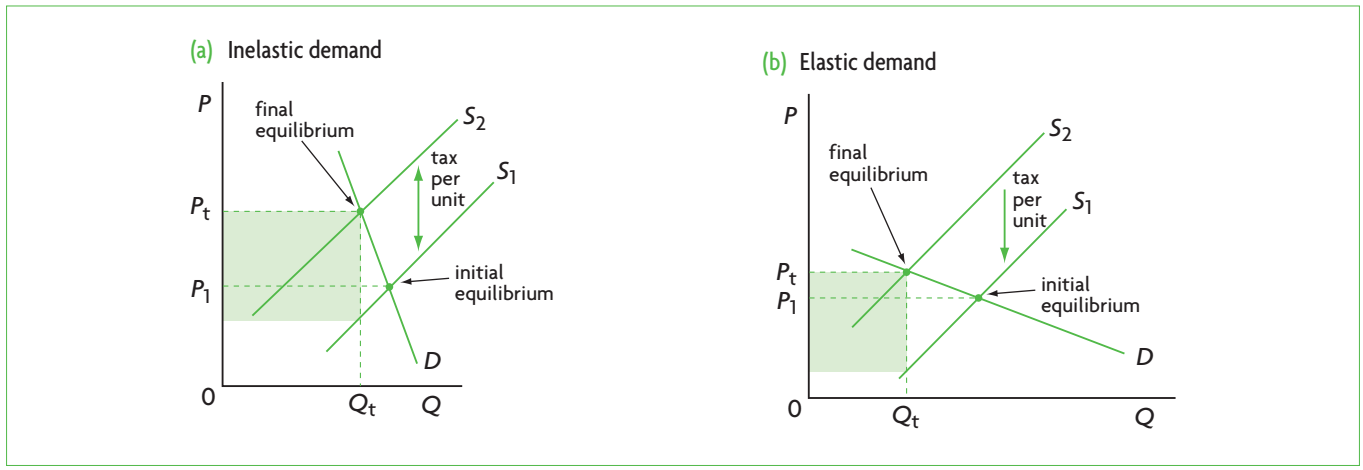

Figure 3.7 *PED*, indirect taxes and government tax revenue

to supply to the market, it must receive a price that is higher than the original price by the amount of the tax. (This is equivalent to a leftward shift of the supply curve; for an explanation see 'Quantitative techniques' chapter on the CD-ROM, page 13.) The curve shifts from S_1 to S_2 so that the vertical distance between S_1 and S_2 is equal to the amount of the tax per unit of output. The new, after-tax equilibrium occurs at price P_t and quantity Q_t, determined by the intersection of the demand curve, D, and the new supply curve, S_2. The shaded area represents the government's tax revenue, obtained by multiplying the amount of tax per unit times the number of units, or quantity Q_t. A comparison of the two figures indicates that tax revenue is larger when demand is inelastic. This result follows from the principle that when demand is inelastic (*PED* < 1), an increase in price (here due to the increase in the tax) leads to a proportionately smaller decrease in quantity demanded, and hence to an increase in total revenue (i.e. tax revenue). Indirect taxes are therefore usually imposed on goods like cigarettes and petrol (gasoline), which have a low *PED*.

Test your understanding 3.4

1 Explain and show, using diagrams, how total revenue will change if:
- **(a)** price increases and demand is elastic
- **(b)** price decreases and demand is inelastic
- **(c)** price increases and demand is perfectly inelastic
- **(d)** price increases and demand is inelastic
- **(e)** price decreases and demand has unit elasticity
- **(f)** price decreases and demand is elastic.

2 How can a firm's knowledge of price elasticity of demand for its product help it in its pricing decisions?

3 Suppose flooding destroys a substantial portion of this season's crop. Using diagrams, explain what is likely to happen to farmers' revenues, assuming the demand for the product they produce is inelastic.

4 **(a)** Why do many primary commodities have a relatively low *PED* while many manufactured products have a relatively high *PED*? **(b)** Use the concept of *PED* and diagrams to explain why agricultural product prices tend to fluctuate more (are more volatile) compared with manufactured product prices over the short term.

5 The government would like to levy indirect taxes (excise taxes) on certain goods to raise tax revenue. Using diagrams, explain how price elasticity of demand can help it decide which products it should tax.

3.2 Cross-price elasticity of demand (*XED*)

Cross-price elasticity of demand

Understanding cross-price elasticity of demand

- 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.

In Chapter 2, page 24, we learned that the prices of substitutes and complements of a good are among the factors that influence demand for the good and affect the position of its demand curve. We saw that changes in prices of substitutes and complements cause demand curve shifts. What we now want to ask is by

how much a demand curve will shift, or what is the responsiveness of demand, given a change in the price of a substitute or complement?

Cross-price elasticity of demand (*XED*) is a measure of the responsiveness of demand for one good to a change in the price of another good, and involves demand curve shifts. It provides us with information on whether demand increases or decreases, and on the size of demand curve shifts.

The formula for *XED*

- Calculate XED using the following equation.

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

The formula for cross-price elasticity of demand has the same basic form as the formula for *PED*, only now we consider the relationship between the percentage change in quantity demanded of one good (X) and the percentage change in the price of another good (Y):[5]

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

$$XED = \frac{\%\Delta Q_x}{\%\Delta P_y}$$

which can be rewritten as:

$$XED = \frac{\frac{\Delta Q_x}{Q_x} \times 100}{\frac{\Delta P_y}{P_y} \times 100} = \frac{\frac{\Delta Q_x}{Q_x}}{\frac{\Delta P_y}{P_y}}$$

Interpreting cross-price elasticity of demand

- 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.

Cross-price elasticity of demand provides two kinds of information:

- the sign of *XED*: unlike *PED*, whose minus sign is ignored, cross-price elasticity of demand is either positive or negative, and the sign is very important for its interpretation
- the value of *XED:* how small or large is its absolute value (the absolute value of a number is its numerical value without its sign).

Substitutes and degree of substitutability

The meaning of a positive XED

Cross-price elasticity of demand for two goods is positive ($XED > 0$) when the demand for one good and the price of the other good change in the same direction: when the price of one increases, the demand for the other also increases. This occurs when the two goods are *substitutes* (see page 24).

For example, Coca-Cola® and Pepsi® are substitutes. Let's consider what happens to the demand for Pepsi, shown in Figure 3.8(a), as the price of Coca-Cola changes. If the

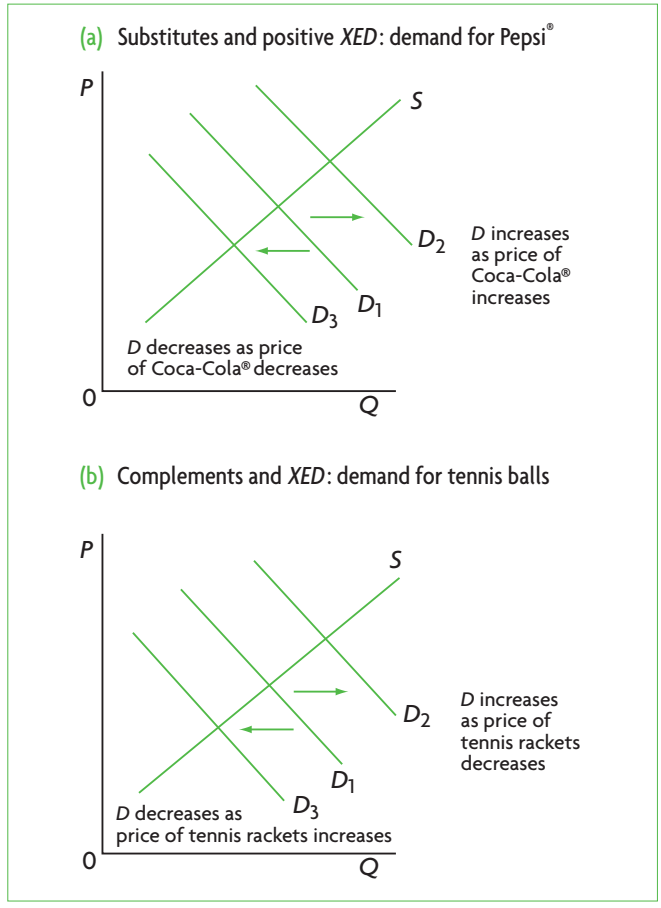

Figure 3.8 Cross-price elasticities

[5] You may have noticed something odd: whereas *XED* is defined as responsiveness of 'demand', it is measured as a % change in 'quantity demanded'. *XED* is concerned with demand curve shifts, hence with responsiveness of 'demand'. However, when we measure *XED*, we do so by measuring changes in purchases of a good, hence in '*Q* demanded', with the understanding that this involves a shift to a new demand curve.

price of Coca-Cola increases, the quantity of Coca-Cola demanded falls, and the demand for Pepsi increases as consumers switch from Coca-Cola to Pepsi, and there results a rightward shift in the demand curve for Pepsi. If the price of Coca-Cola falls, the quantity of Coca-Cola demanded increases, and the demand for Pepsi falls as consumers now switch from Pepsi to Coca-Cola; there results a leftward shift in Pepsi's demand curve. (Note that in the case of Coca-Cola, whose own price is changing, we refer to increases or decreases in the 'quantity demanded', whereas with Pepsi we refer to increases or decreases in 'demand' because of demand curve shifts.)

In fact, the cross-price elasticity of demand for Coca-Cola® and Pepsi® has been estimated to be about +0.7.[6] This means that a 1% increase in the price of one leads to a 0.7% increase in demand for the other; or a 10% increase in the price of one leads to a 7% increase in the demand for the other. This is considered to be an example of fairly high substitutability.

Given two pairs of substitute goods, the larger the value of cross-price elasticity of demand, the greater the substitutability between two goods, and the larger the demand curve shift in the event of a price change. For example, two substitute goods with a *XED* of +0.7 are stronger substitutes for each other than two goods with a *XED* of +0.3.

Calculating XED in the case of substitutes

Suppose the price of coffee increases from $10 per kilogram (kg) to $12 per kg and the amount of tea purchased increases from 1500 kg to 1650 kg. What is the *XED*?

$$XED = \frac{\frac{150}{1500}}{\frac{2}{10}} = \frac{0.1}{0.2} = +0.5$$

XED is +0.5; the positive sign tells us that coffee and tea are substitutes.

Complements and degree of complementarity

The meaning of a negative XED

Cross-price elasticity of demand for two goods is negative ($XED < 0$) when the demand for one good and the price of the other good change in opposite directions: when the price of one good increases, the demand for the other falls. This occurs when the two goods are *complements* (see page 24).

Figure 3.8(b) shows the demand for tennis balls. If the price of tennis rackets increases, the quantity of tennis rackets demanded falls, and since tennis rackets are used together with tennis balls, the demand for tennis balls also falls; there will therefore be a leftward shift in the demand curve for tennis balls. If there is a fall in the price of tennis rackets, the quantity of tennis rackets demanded increases, and the demand for tennis balls also increases; the demand curve for tennis balls will shift to the right.

The larger the absolute value of the negative cross-price elasticity of demand, the greater is the complementarity between two goods, and the larger is the demand curve shift in the event of a price change. Two goods with a *XED* of –0.8 are stronger complements than two goods with a *XED* of –0.5.

Calculating XED in the case of complements

Suppose the price of pencils increases from $1.00 per pencil to $1.30 and the quantity of erasers purchased falls from 1000 erasers to 800. What is the *XED*?

$$XED = \frac{\frac{-200}{1000}}{\frac{0.30}{1.00}} = \frac{-0.20}{0.30} = -0.67$$

XED is –0.67; the negative sign tells us that pencils and erasers are substitutes.

Zero *XED*: unrelated products

If cross-price elasticity of demand is zero ($XED = 0$) or close to zero, this means that two products are unrelated or independent of each other. For example, potatoes and telephones are unrelated to each other: a change in the price of one is unlikely to affect demand for the other.

Applications of cross-price elasticity of demand

- Examine the implications of XED for businesses if prices of substitutes or complements change.

There are some situations where businesses would be interested in knowing cross-price elasticities of demand for various products.

[6] F. Gasmi *et al.* (1992) 'Econometric analysis of collusive behavior in a soft-drink market' in *Journal of Economics & Management Strategy*, Vol. 1/2, Summer.

Substitute goods

Substitutes produced by a single business

When a business produces a line of products that are similar to each other, such as Coca-Cola® and Sprite®, both produced by Coca-Cola, it must consider the *XED* for these products when making decisions about prices. Since the two goods are substitutes, a fall in the price of Coca-Cola would be followed by a fall in the demand for Sprite. Should Coca-Cola cut the price of Coca-Cola? To make a decision it must have information about:

- *PED* for Coca-Cola, so that it can determine whether a price cut will lower or raise total revenue from Coca-Cola
- *XED* for Coca-Cola and Sprite; it is not enough to know that $XED > 1$ (that the two goods are substitutes). It is also important to know the degree of substitutability between them. If the value of *XED* is positive but low (low substitutability), a percentage decrease in the price of Coca-Cola® will produce only a small percentage drop in demand for Sprite®, so that the sales of Sprite would not be seriously affected. But if the value of *XED* is positive and high, a fall in the price of Coca-Cola will produce a large drop in demand for Sprite. Increased sales of Coca-Cola would come at the expense of Sprite sales and revenues – something that the company would probably want to avoid.

Substitutes produced by rival businesses

A business is also interested in knowing the *XED* of substitutes when these are produced by rival businesses. For example, Coca-Cola would be interested in knowing the *XED* between Coca-Cola and Pepsi. A large *XED* would mean that if Coca-Cola dropped its price, Pepsi would suffer a serious drop in sales, whereas a low *XED* would mean that Pepsi would not be seriously affected. Coca-Cola would also want to know this *XED* in order to be able to predict the effect on Coca-Cola sales and revenues of any change in the price of Pepsi.

Substitutes and mergers between firms

A *merger* takes place when two firms unite to form a single firm. Businesses producing close substitutes with a high positive *XED*, might be interested in merging because that way they would eliminate the competition between them (although this is usually illegal and prevented by governments). For this reason they might want to know the size of *XED*.

Complementary goods

Knowledge of *XED* for complementary products is also useful for business pricing decisions. Products that have a low absolute value of a (negative) *XED* are weakly complementary and will not be of much interest. However, a high absolute value of a (negative) *XED* means that lowering the price of one good can result in a large increase in demand and sales for the other.

Businesses producing strongly complementary goods often collaborate. For example, sports clothing and sports equipment are highly complementary, as are charter flights and holiday hotels. A fall in the price of charter flights is likely to produce a substantial increase in holiday hotel occupancy. We find airlines frequently collaborating with hotels to take advantage of such complementarities, thus increasing sales and revenues.

It is also possible to use *XED* to estimate the impact of an indirect (excise) tax on one good on the sales of a complementary good. If two goods have a relatively high *XED*, a large tax on one could result in a significant decrease in sales of the other. For example, increases in gasoline (petrol) taxes can have a large impact on the demand for large cars.

Test your understanding 3.5

1 Explain the meaning of cross-price elasticity of demand. Why do we say it involves *a shifting demand curve?*

2 What can you conclude about the relationship of goods A and B in the following situations?

(a) Sales of good A increase by 10% in response to a price decrease in good B of 15%.

(b) Sales of good B decrease by 10% in response to a price decrease in good A of 15%.

(c) Sales of good B remain unchanged in response to a price decrease in good A of 15%.

3 Suggest examples of pairs of goods that might correspond to goods A and B in parts **(a)**, **(b)** and **(c)** of question 2.

4 If *XED* between Coca-Cola® and Pepsi® is 0.7, how will the demand for Coca-Cola change if the price of Pepsi increases by 5%? (Your answer should be in percentage terms, and should indicate whether the demand for Coca-Cola will increase or decrease.)

5 For the answer to question 4 show, using diagrams, **(a)** the 'change in quantity demanded', and **(b)** the 'change in demand' for Pepsi and Coca-Cola, respectively, that will result from the 5% increase in the price of Pepsi.

6 Suppose goods A and B have a *XED* of +0.2 and goods B and C have a *XED* of +0.8. **(a)** What is the relationship between the two goods in