5 How can you account for the fact that income elasticity of demand for food has been estimated to be about 0.15 to 0.2 in more developed countries and about 0.8 in less developed countries?

6 What is one likely explanation behind the observed rapid growth in certain service industries, including health care, education and financial services, compared with other industries such as food (in the primary sector) and furniture (in the secondary sector)?

7 Use the concept of *YED* and a diagram to explain why agricultural product prices tend to fall relative to prices of manufactured products over the long term.

3.4 Price elasticity of supply (*PES*)

Price elasticity of supply

Understanding price elasticity of supply

- 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.

Until now, we have been studying demand elasticities, all of which involve consumer responses. We now turn to examine price elasticity of supply, which concerns firm (business) responses to changes in price. According to the law of supply, there is a positive relationship between price and quantity supplied: when price increases, quantity supplied increases and vice versa. But by how much does quantity supplied change?

Price elasticity of supply (*PES*) is a measure of the responsiveness of the quantity of a good supplied to changes in its price. *PES* is calculated along a given supply curve. In general, if there is a large responsiveness of quantity supplied, supply is referred to as being *elastic*; if there is a small responsiveness, supply is *inelastic*.

Calculating *PES*

- Calculate PES using the following equation.

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

The formula for price elasticity of supply (*PES*) follows the same general form of elasticity formulae, only now we consider the relationship between the percentage change in the price of a good, *X*, and the percentage change in quantity of *X* supplied:

$$\text{price elasticity of supply} = PES = \frac{\text{percentage change in quantity of good } X \text{ supplied}}{\text{percentage change in price of good } X}$$

$$PES = \frac{\%\Delta Q_x}{\%\Delta P_x}$$

which can be rewritten as:

$$PES = \frac{\frac{\Delta Q_x}{Q_x} \times 100}{\frac{\Delta P_x}{P_x} \times 100} = \frac{\frac{\Delta Q_x}{Q_x}}{\frac{\Delta P_x}{P_x}}$$

Suppose the price of strawberries increases from €3 per kg to €3.50 per kg, and the quantity of strawberries supplied increases from 1000 to 1100 tonnes per season. Calculate *PES* for strawberries.

$$PES = \frac{\frac{100}{1000}}{\frac{0.50}{3.00}} = \frac{0.10}{0.17} = +0.59$$

Price elasticity of supply for strawberries is +0.59. We will now see how *PES* is interpreted.

Interpreting price elasticity of supply

The range of values for *PES*

- Explain, using diagrams and PES values, the concepts of elastic supply, inelastic supply, unit elastic supply, perfectly elastic supply and perfectly inelastic supply.

Price elasticity of supply ranges in value from zero to infinity. Because of the positive relationship between price and quantity supplied, *PES* is positive.

The value of *PES* involves a comparison of the percentage change in quantity supplied (the numerator in the formula for *PES*) with the percentage change in price (the denominator). This comparison yields the following possible values and range of values of *PES*, which are illustrated in Figure 3.11 and summarised in Table 3.2:

- **Supply is price inelastic when *PES* < 1.** The percentage change in quantity supplied is smaller than the percentage change in price, so the value of *PES* is less than one; quantity supplied is relatively unresponsive to changes in price, and supply is *price inelastic* or *inelastic*. Figure 3.11(a) shows an inelastic supply curve (*PES* < 1), where a 10% price increase leads to a 5% increase in quantity supplied. When *PES* < 1, the supply curve extends upward and to the right from the horizontal axis; its end-point cuts the horizontal axis. (Higher level students may note that this supply curve has a positive *Q*-intercept[8].)
- **Supply is price elastic when *PES* > 1.** The percentage change in quantity supplied is larger than the percentage change in price, so the value of the *PES* is greater than one; quantity supplied is relatively responsive to price changes, and supply is *price elastic* or *elastic*. Figure 3.11(b) shows an elastic supply curve (*PES* > 1) where the percentage increase in price (10%) is smaller than the percentage increase in quantity (15%). When *PES* > 1, the supply curve extends upward and to the right from the vertical axis; its end-point cuts the vertical axis. (Higher level students may note that this supply curve has a negative *Q*-intercept.[9])

In addition, there are three special cases:

- **Supply is unit elastic when *PES* = 1.** The percentage change in quantity supplied is equal to the percentage change in price, so *PES* is equal to one; supply is *unit elastic*. In Figure 3.11(c), all three supply curves shown are unit elastic supply curves, i.e. for all three, *PES* = 1. Any supply curve that passes through the origin has a *PES* equal to unity. The reason for this is that along any straight line that passes through the origin, between any two points on the line the percentage change in the vertical axis (the price) is equal to the percentage change in the horizontal axis (the quantity). Therefore, for lines that pass through the origin, it is important not to confuse the steepness of the curve with the elasticity of the curve.
- **Supply is perfectly inelastic when *PES* = 0.** The percentage change in quantity supplied is zero; there is no change in quantity supplied no matter what happens to price; *PES* is equal to

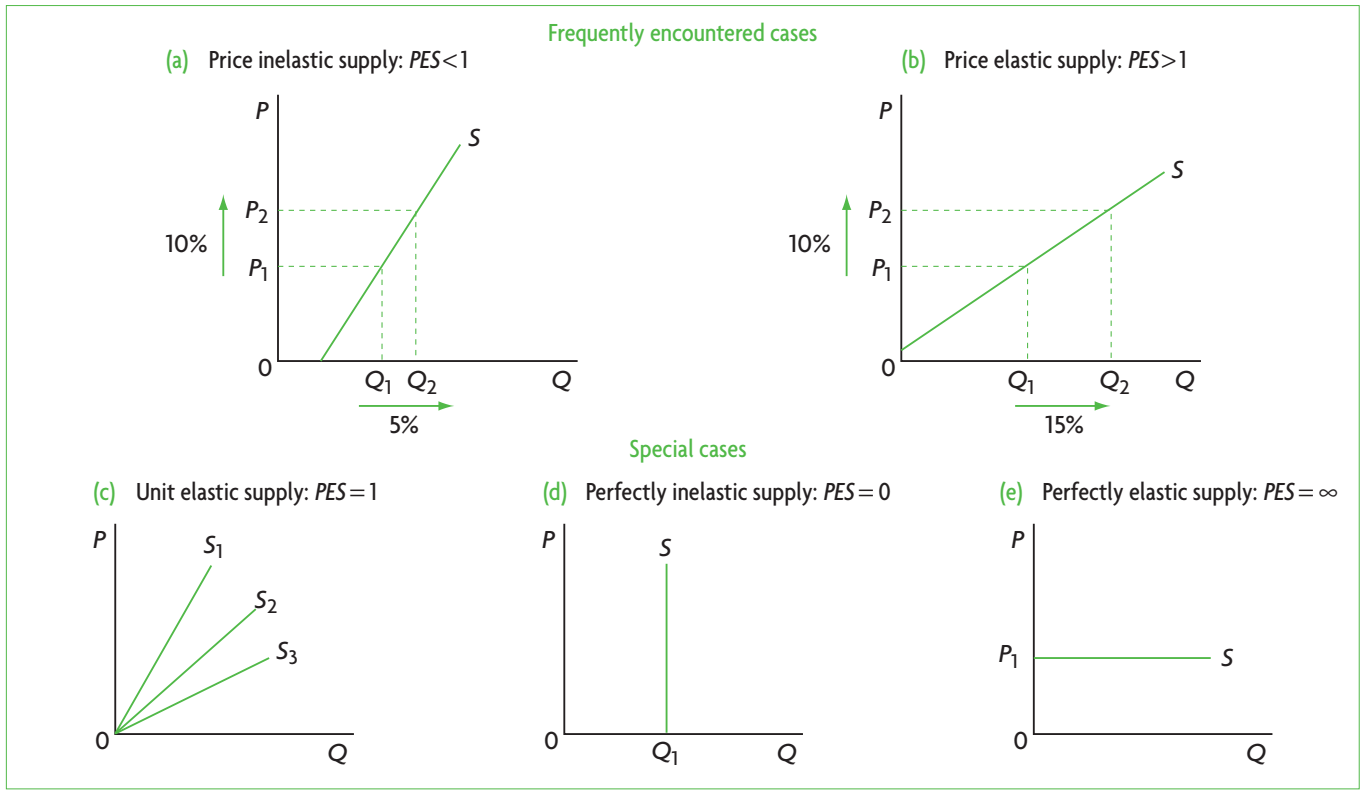

Figure 3.11 Supply curves and *PES*

[8] This means that in the supply function $Q_s = c + d\,P$, $c > 0$

[9] This means that in the supply function $Qs = c + d\,P$, $c < 0$.

Value of *PES*	Classification	Interpretation
Frequently encountered cases		
0 < *PES* < 1 (greater than zero and less than one)	inelastic supply	quantity supplied is relatively unresponsive to price
1 < *PES* < ∞ (greater than 1 and less than infinity)	elastic supply	quantity supplied is relatively responsive to price
Special cases		
***PES* = 1**	unit elastic supply	percentage change in quantity supplied equals percentage change in price
***PES* = 0**	perfectly inelastic supply	quantity supplied is completely unresponsive to price
***PES* = ∞**	perfectly elastic supply	quantity supplied is infinitely responsive to price

Table 3.2 Characteristics of price elasticity of supply

zero and supply is said to be *perfectly inelastic*. In Figure 3.11(d), the supply curve is vertical at the point of fixed quantity supplied, Q_1. This is the same as the supply curve shown in Figure 2.7 in Chapter 2, page 27). Examples of a vertical supply curve include the supply of fish at the moment when fishing boats return from sea; the season's entire harvest of fresh produce brought to market; the supply of Picasso paintings.

- **Supply is perfectly elastic when *PES* = ∞.** The percentage change in quantity supplied is infinite; a very small change in price leads to a very large response in quantity supplied; supply in this case is called *perfectly elastic*, and is shown in Figure 3.11(e) as a horizontal line. (We will encounter such a supply curve in Chapters 7 and 13.)

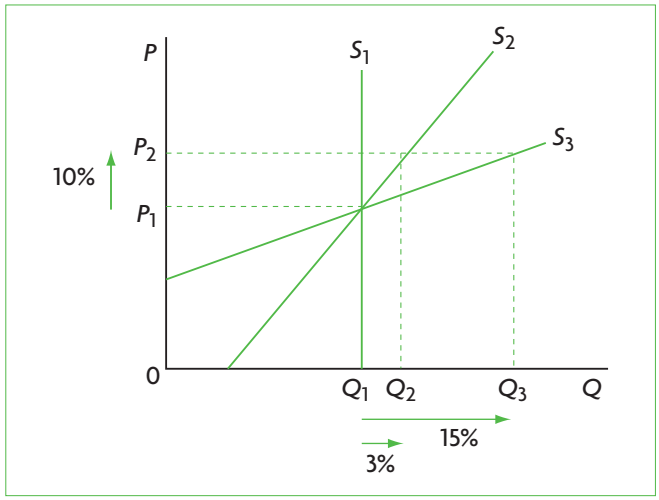

Figure 3.12 The length of time and *PES*

Price elasticities of supply most commonly encountered in the real world are those representing elastic or inelastic supply, with perfectly elastic, perfectly inelastic and unit elastic supply being special cases. Note that only when two supply curves intersect (when they share a price and quantity combination) is it possible to make comparisons of price elasticities of supply by reference to the steepness of the curves. (We have the same condition for making comparisons of *PED*s in the case of demand curves; see page 53). In the case of intersecting supply curves, the flatter the supply curve, the more elastic it is at any given price. For example, in Figure 3.12, at any one particular price level, S_3 is more elastic than S_2, which is more elastic than S_1.

It may also be noted that *PES* varies along upward sloping straight-line supply curves (as in the case of *PED* and demand curves). A constant *PES* is found in supply curves that go through the origin (unit elasticity), as well as perfectly elastic and perfectly inelastic supply curves (constant *PES* at infinity and zero, respectively). Therefore, when comparing *PES* of two different supply curves, this should be done only at a specific price or price range.

Determinants of price elasticity of supply

- Explain the determinants of PES, including time, mobility of factors of production, unused capacity and ability to store stocks.

Length of time

An important factor determining *PES* is the amount of time firms have to adjust their inputs (resources) and the quantity supplied in response to changes in price. Over a very short time, the firm

may be unable to increase or decrease any of its inputs to change the quantity it produces. In this case, supply is highly inelastic, and may even be perfectly inelastic ($PES = 0$). In Figure 3.12, this is represented by S_1. For example, a fishing boat upon its return from a fishing trip has only so many fish to supply in the market. Even if the price of fish rises, there can be no response in quantity supplied. As the length of time that firms have increases, the responsiveness of quantity supplied to price changes begins to rise, and *PES* increases. In Figure 3.12, the supply curve S_2 corresponds to a time period when the fishing boat can be taken out to sea more often, and more labour can be hired to fish, so as price increases to P_2, quantity supplied increases to Q_2 (the 10% price increase from P_1 to P_2 leads to a 3% increase in quantity supplied, indicating inelastic supply, as $PES < 1$). If an even longer time period goes by, the ability of firms to respond to price changes becomes much greater. The owner of the fishing boat can now not only hire more labour but can also buy more fishing boats, thus greatly increasing the amount of fish that can be supplied. This is shown by the supply curve S_3, for which the price P_2 gives rise to the much larger quantity Q_3 (the 10% price increase from P_1 to P_2 leads to a 15% increase in quantity supplied, indicating elastic supply, as $PES > 1$). Therefore, the larger amount of time firms have to adjust their inputs increases, the larger the *PES*.

Mobility of factors of production

Another determinant of *PES* is the ease and speed with which firms can shift resources and production between different products. The more easily and quickly resources can be shifted out of one line of production and into another (where price is increasing), the greater the responsiveness of quantity supplied to changes in price, and hence the greater the *PES*.

Spare (unused) capacity of firms

Sometimes firms may have capacity to produce that is not being used (for example, factories or equipment may be idle for some hours each day). If this occurs, it is relatively easy for a firm to respond with increased output to a price rise. But if the firm's capacity is fully used, it will be more difficult to respond to a price rise. The greater the spare (unused) capacity, the higher is *PES* (the more elastic the supply); the less the spare capacity, the smaller the *PES* (the less elastic the supply).

Ability to store stocks

Some firms store stocks of output they produce but do not sell right away. Firms that have an ability to store stocks are likely to have a higher *PES* for their products than firms that cannot store stocks. Note, however, that this is something that can affect *PES* over relatively short periods of time, because once stocks are released in the market and sold, other factors determining *PES* (such as the ones noted above) come into play.

Test your understanding 3.7

1 **(a)** Explain the meaning of price elasticity of supply. **(b)** Why do we say it measures responsiveness of quantity *along a given supply curve*?

2 Specify the value or range of values for each of the following *PES*s, and show, using diagrams, the shape of the supply curve that corresponds to each one: **(a)** perfectly elastic supply, **(b)** unit elastic supply, and **(c)** perfectly inelastic supply.

3 **(a)** Which price elasticity of supply values or range of values do we see most frequently in the real world? **(b)** How would you compare these by drawing supply curves in a single diagram?

4 Explain the determinants of *PES*.

5 Suppose that in response to an increase in the price of good *X* from \$10 to \$15 per unit, the quantity of good *X* produced **(a)** does not respond at all during the first week, **(b)** increases from 10 000 units to 12 000 units over five months, and **(c)** increases from 10 000 to 18 000 units over two years. Calculate *PES* for each of these three time periods.

6 **(a)** How can you account for the difference in the size of the three elasticities of question 5? **(b)** Draw a supply curve that is likely to correspond to each of the three elasticities in a single diagram.

Applications of price elasticity of supply

PES in relation to primary commodities and manufactured products

- Explain why the PES for primary commodities is relatively low and the PES for manufactured products is relatively high.

Why many primary commodities have a lower PES compared with the PES of manufactured products

In general, primary commodities usually have a lower *PES* than manufactured products. The main reason is the time needed for quantity supplied to respond to price changes. In the case of agriculture, it takes a long time for resources to be shifted in and out of agriculture. Farmers need at least a planting season to be able to respond to higher prices. In most areas there is a limited amount of new land that can be brought into cultivation. In some regions of the world land appropriate for agriculture is shrinking due to environmental destruction (caused by overfarming that depletes the soil of minerals needed by crops). Under such conditions, what is needed is an increase in output per unit of land cultivated (crop yields), but this requires technological change in agriculture, involving new seeds or other inputs that are more productive, and takes a great deal of time. Also needed are more and better irrigation systems, although many countries face a growing water shortage. All these factors explain why a long time is needed for the quantity of an agricultural commodity to respond to increases in price.

In the case of other primary products, such as oil, natural gas and minerals, time is needed to make the necessary investments and to begin production. Because of the costs involved, firms do not respond quickly to price increases, and wait for a serious shortage (excess demand) in the commodity to arise before they take actions to increase production.

Consequences of a low PES for primary commodities

(This topic is included in learning outcomes in Chapters 15 and 17.)

Earlier, in our discussion of price elasticity of demand (*PED*), we saw that price inelastic demand for primary products is an important factor contributing to short-term price and revenue instability for producers such as farmers. Now we will see that price inelastic supply of agricultural and other primary products also contributes to price and income instability for primary product producers.

Figure 3.13 shows a fluctuating demand curve: in part (a) it interacts with inelastic supply, which is typical in the case of primary products, and in part (b) with elastic supply, which is more typical of manufactured products. Clearly, price fluctuations are substantially larger in the case of inelastic supply. Large price fluctuations mean large revenue fluctuations, or unstable revenue for producers of primary commodities. We will come back to the implications of unstable prices and revenues for producers and for the economy in Chapters 4, 15 and 17.

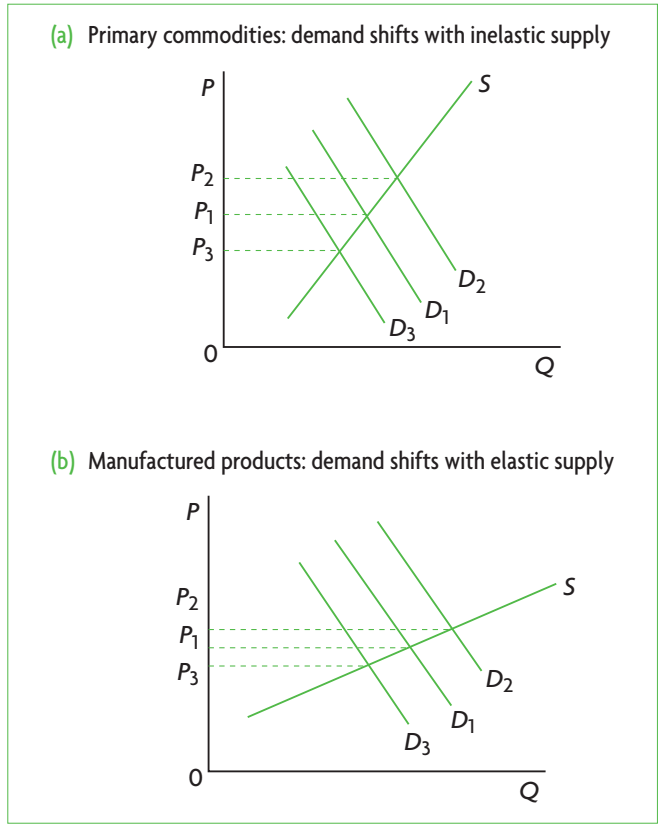

Figure 3.13 Price fluctuations are larger for primary commodities because of low *PES*

Short-run and long-run price elasticities of supply

It was noted above that agricultural products (as well as other primary commodities) usually have lower price elasticities of supply than manufactured products because they need more time to respond to price changes. This suggests that over longer periods of time the *PES* of agricultural products is larger.

Table 3.3 shows that this is in fact the case. The longer the time producers have to make the necessary adjustments, the greater the responsiveness of quantity supplied to price changes (see Figure 3.12).

Commodity	Short-run PES	Long-run PES
Cabbage	0.36	1.20
Carrots	0.14	1.00
Cucumbers	0.29	2.20
Onions	0.34	1.00
Green peas	0.31	4.40
Tomatoes	0.16	0.90
Cauliflower	0.14	1.10
Celery	0.14	0.95

Table 3.3 Short-run and long-run *PES* for selected agricultural commodities

Test your understanding 3.8

1 **(a)** Explain why the *PES* for many primary commodities is relatively low and for many manufactured products is relatively higher.
(b) Use the concept of *PES* to explain why agricultural product prices are volatile over the short term.

2 Why is it important to make a distinction between short-run and long-run price elasticities of supply?

Assessment

The Student's CD-ROM at the back of this book provides practice of examination questions based on the material you have studied in this chapter.

Standard level

- Exam practice: Paper 1, Chapter 3
  - SL/HL core topics (questions 3.1–3.8)

Higher level

- Exam practice: Paper 1, Chapter 3
  - SL/HL core topics (questions 3.1–3.8)
- Exam practice: Paper 3, Chapter 3
  - HL topics (questions 4–6)

Table 3.4 provides a summary of key characteristics of all the elasticities considered in this chapter.

Elasticity	Formula	Values	Description
Price elasticity of demand	$PED = \frac{\%\Delta Q_x}{\%\Delta P_x}$	$PED = 0$	perfectly inelastic
		$PED < 1$	price inelastic
		$PED = 1$	unit elastic
		$PED > 1$	price elastic
		$PED = \infty$	perfectly elastic
Cross- price elasticity of demand	$XED = \frac{\%\Delta Q_x}{\%\Delta P_y}$	$XED > 0$	substitutes
		$XED < 0$	complements
		$XED = 0$	unrelated
Income elasticity of demand	$YED = \frac{\%\Delta Q_x}{\%\Delta Y}$	$YED > 0$	normal good
		$YED < 0$	inferior good
		$YED > 1$	income elastic
		$YED < 1$	income inelastic
Price elasticity of supply	$PES = \frac{\%\Delta Q_x}{\%\Delta P_x}$	$PES = 0$	perfectly inelastic
		$PES < 1$	price inelastic
		$PES = 1$	unit elastic
		$PES > 1$	price elastic
		$PES = \infty$	perfectly elastic

Table 3.4 Elasticity concepts: a summary