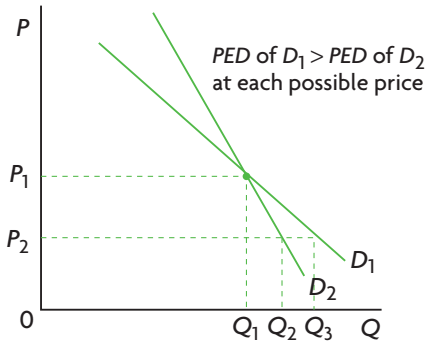


Figure 3.4 Demand curves and *PED*s

more elastic is the demand.[2] This generalisation holds only for comparisons between two demand curves at a particular price. It does not hold for different prices because of the variability of *PED* along the demand curve.

If demand curves do not intersect, comparing *PED*s on the basis of steepness, even for a particular price, can be misleading. For example, the two parallel demand curves in Figure 3.4(b) do not share a price–quantity combination. It is tempting to conclude that their *PED*s are the same at each price since they are parallel. However, this would be incorrect, because for each price, D_2 is less elastic than D_1. To see why, consider price P_1, which corresponds to the midpoint of D_1, and hence is the point at which *PED* = 1 for D_1. At this price, *PED*<1 for D_2, as it lies in the inelastic portion of this demand curve. Therefore at P_1, *PED* corresponding to D_2 is lower than *PED* corresponding to D_1.

Test your understanding 3.3

1 How would you show price elastic and price inelastic demand in the same diagram? Explain.

2 Why must we always compare *PED*s of different demand curves at the same price?

Applications of price elasticity of demand

Price elasticity of demand is a very important concept in economics, with numerous applications. Some of these will be considered below; others will be studied in later chapters.

PED and total revenue

- Examine the role of PED for firms in making decisions regarding price changes and their effect on total revenue.

PED and the effects of price changes and total revenue

Total revenue (*TR*) is the amount of money received by firms when they sell a good (or service), and is equal to the price (P) of the good times the quantity (Q) of the good sold. Therefore, $TR = P \times Q$.

We are interested in examining what will happen to the firm's total revenue (*TR*) when there is a change in the price of the good it produces and sells. We know that P and Q are negatively related to each other: an increase in P leads to a decrease in Q demanded and vice versa. What can we say about the resulting change in total revenue? Will it increase or decrease? The change will depend on price elasticity of demand of the good. We have the following three possibilities.

[2] To see why this is so, the more advanced student can consider the ratio of *PED*s of D_1 and D_2 in Figure 3.4(a):

$$\frac{PED_1}{PED_2} = \frac{\frac{\%\Delta Q_1}{\%\Delta P}}{\frac{\%\Delta Q_2}{\%\Delta P}}.$$

where $\%\Delta Q_1$ is the percentage change in quantity for D_1, $\%\Delta Q_2$ is the percentage change in quantity for D_2, and $\%\Delta P$ is the percentage change in price when price changes from P_1 to P_2. The $\%\Delta P$ cancels out from the numerator and denominator, and we are left with

$$\frac{PED_1}{PED_2} = \frac{\%\Delta Q_1}{\%\Delta Q_2}$$

in other words, the ratio of *PED*s is equal to the ratio of percentage changes in quantity. This is exactly what we see in Figure 3.4(a): the flatter demand curve D_1, with the larger *PED*, has the larger percentage change in quantity.

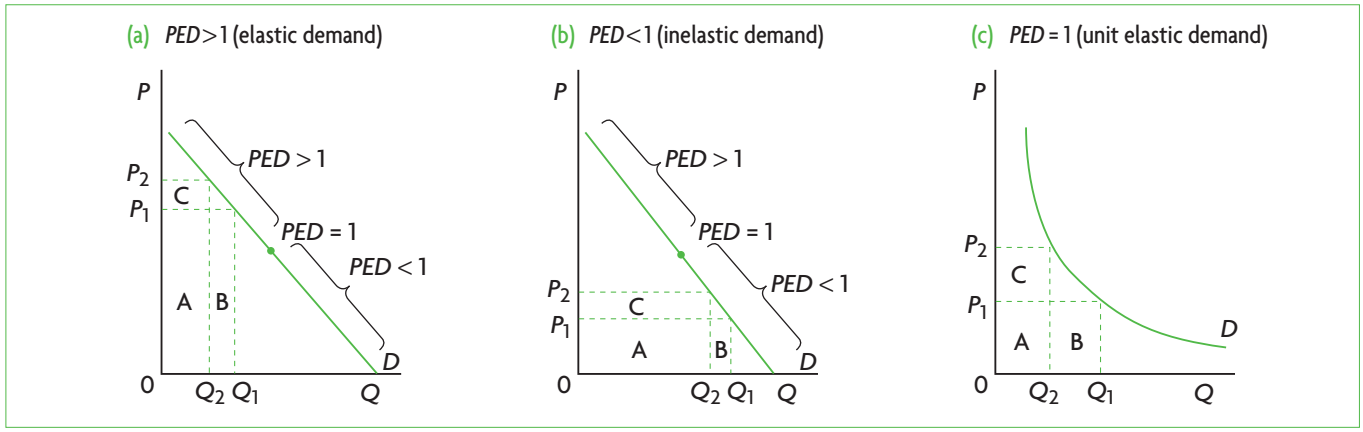


Figure 3.5 *PED* and total revenue

Demand is elastic (PED > 1)

When demand is elastic, an increase in price causes a fall in total revenue, while a decrease in price causes a rise in total revenue. To see why, consider that if demand is elastic, a 10% price increase will result in a larger than 10% decrease in quantity demanded (since $PED > 1$). The impact on total revenue of the decrease in quantity is bigger than the impact of the increase in price; therefore, total revenue falls. If there is a price decrease, a 10% price fall results in a larger than 10% increase in quantity demanded, and total revenue increases.

These results are shown in Figure 3.5(a). Since we are considering elastic demand, we examine a price change in the upper left portion of the demand curve. Total revenue is represented by the area of the rectangles obtained by multiplying price times quantity (since $TR = P \times Q$). At the initial price and quantity, P_1 and Q_1, total revenue is given by the sum of the rectangles A and B. When price increases to P_2 and quantity drops to Q_2, total revenue is given by the sum of the rectangles A and C. What happened to total revenue due to the price increase? The rectangle B was lost and the rectangle C was gained. Since the loss (B) is larger than the gain (C), total revenue fell.

We can use the same diagram to explore a price decrease when $PED > 1$, simply by assuming that the initial price and quantity are P_2 and Q_2; price then falls to P_1 while quantity increases to Q_1. The gain in *TR* is given by rectangle B, which is greater than the loss shown by rectangle C, thus total revenue increases.

When demand is elastic, an increase in price causes a fall in total revenue, while a decrease in price causes a rise in total revenue.

Demand is inelastic (PED < 1)

When demand is inelastic, an increase in price causes an increase in total revenue, while a decrease in price causes a fall in total revenue. Since $PED < 1$, the percentage change in quantity demanded is smaller than the percentage change in price. Therefore, a 10% price increase produces a smaller than 10% decrease in quantity demanded, and total revenue rises. The effect on total revenue of the increase is larger than the effect of the decrease. If price falls, a percentage price decrease gives rise to a smaller percentage increase in quantity demanded and total revenue falls.

These results can be seen in Figure 3.5(b). We now examine the bottom right portion of the demand curve where demand is inelastic ($PED < 1$). With a price increase, total revenue gained (rectangle C) is larger than total revenue lost (rectangle B); therefore, total revenue increases. If price falls from P_2 to P_1, the gain in total revenue (rectangle B) is smaller than the loss (rectangle C) and total revenue falls.

When demand is inelastic, an increase in price causes an increase in total revenue, while a decrease in price causes a fall in total revenue.

Demand is unit elastic (PED = 1)

When demand is unit elastic, the percentage change in quantity is equal to the percentage change in price, and total revenue remains constant. In Figure 3.5(c), as price and quantity change, the gain in total revenue is exactly matched by the loss, and total revenue remains unchanged.

When demand is unit elastic, a change in price does not cause any change in total revenue.

These results may be summarised as follows:
Elastic *PED* ($PED > 1$): price and total revenue change in opposite directions.

Inelastic *PED* ($PED < 1$): price and total revenue change in the same direction.

Unit elastic *PED* (*PED* = 1): as price changes, total revenue remains unchanged.

PED and firm pricing decisions

The above discussion shows that businesses must take *PED* into account when considering changes in the price of their product. If a business wants to increase total revenue, it must drop its price if demand is elastic, or increase its price if demand is inelastic. If demand is unit elastic, the firm is unable to change its total revenue by changing its price.

Remember that *PED* falls as price falls along a downward-sloping straight-line demand curve. In the upper left portion, where prices are high, demand is highly elastic, and a firm can increase its total revenue by lowering price. Total revenue will continue to increase as price falls until price reaches the point on the demand curve where *PED* is unit elastic. If price falls further, total revenue will begin to fall because price is now in the inelastic range of the demand curve. *This means that total revenue is at a maximum when price is at the point where demand is unit elastic*.

A firm's total revenue should not be confused with *profit*. Profit is total revenue minus total costs. A firm interested in maximising profits may not want to maximise total revenue. As total revenue rises, it is possible that total costs may rise faster, in which case the firm's profit will be lower. Costs will be examined in Chapter 6 (at higher level).

PED in relation to primary commodities and manufactured products

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

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

Primary commodities are goods arising directly from the use of natural resources, or the factor of production 'land' (see Chapter 1, page 3). Primary commodities therefore include agricultural, fishing and forestry products, as well as products of extractive industries (oil, coal, minerals, and so on). Agricultural products include food, as well as other, non-edible commodities (such as cotton and rubber).

Many primary commodities have a low *PED*, which is usually lower than the *PED* of manufactured products (as well as services). Food has a highly price inelastic demand, because it is a necessity and it has no substitutes. The same applies to a variety of other primary products (such as oil and minerals). In the case of food, in developed countries the *PED* is estimated to be between 0.20 and 0.25. By contrast, the demand for manufactured products tends to be more price elastic, because these products, though they may be necessities (in some cases), they usually do have substitutes. Therefore, given a price change, quantity demanded is generally more responsive in the case of manufactured products compared with primary commodities. (Note, however, that there are exceptions. For example, medications are manufactured products, yet their demand tends to be inelastic because they are necessities and have no substitutes.)

Many primary commodities have a relatively low *PED* (price inelastic demand) because they are necessities and have no substitutes (for example, food and oil). The *PED* of manufactured products is relatively high (price elastic demand) because they usually have substitutes.

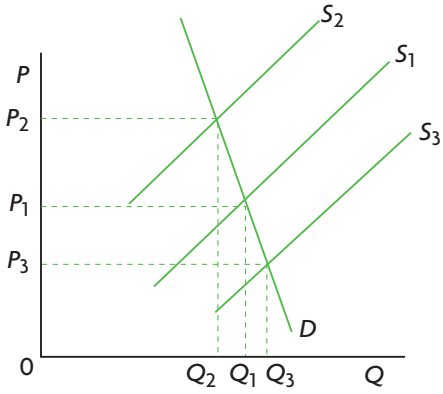
Consequences of a low PED for primary commodities

(This topic is included in learning outcomes in Chapters 15 and 17.) Low price elasticity of demand, together with fluctuations in supply over short periods of time, creates serious problems for primary commodity producers, because they result in large fluctuations in primary commodity prices, and these also affect producers' incomes. Let's see why.

Consider the diagrams in Figure 3.6. Part (a) shows relatively inelastic demand (such as for primary commodities) and part (b) shows relatively elastic demand (such as for manufactured products).[3] Both diagrams show the effects on price and quantity when there is a decrease in supply (from S_1 to S_2) and when there is an increase in supply (from S_1 to S_3). A comparison of the two diagrams reveals that shifts in the supply curve result in large price fluctuations when demand is inelastic, and much milder ones when demand is elastic. Large price fluctuations over short periods of time are referred to as *price volatility*. (Volatility means instability or high variability.)

[3] Note that we are assuming that the two demand curves are drawn on the same scale, and that if they were drawn in the same diagram they would intersect, therefore it is okay to compare *PEDs* (see page 53).

(a) Primary commodities: supply shifts with inelastic demand



(b) Manufactured products: supply shifts with elastic demand

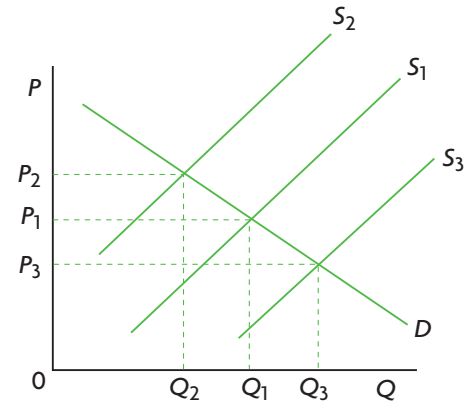


Figure 3.6 Price fluctuations are larger for primary commodities because of low *PED*

Figure 3.6 explains why in the real world, prices of primary commodities can be highly volatile, whereas they tend to be much less so in the manufacturing and services sectors.

Two results follow from this:

- As primary commodity prices fluctuate widely, so do producers' incomes, which depend on the revenues (price×quantity) producers receive from selling their output.
- In view of the relationship between *PED* and total revenue (see page 55), a fall in the supply of a primary commodity with inelastic demand (from S_1 to S_2 in part (a) of Figure 3.6) leads to an increase in total revenue of producers because the percentage increase in price is larger than the percentage decrease in quantity. An increase in supply leads to lower revenues (the percentage decrease in price is larger than the percentage increase in quantity).

These points lead to some unexpected conclusions. They show that a poor crop in agriculture, say due to poor weather conditions, which results in a fall in supply (S_2 in part (a) of Figure 3.6), leads to higher prices and higher total revenue for farmers. A good crop resulting in a supply increase, or S_3, leads to lower prices and lower farmers' revenues. We come, therefore, to the ironic conclusion that a poor crop may be good for farmers because it increases their revenues while a good crop may be bad for them.

If supply of agricultural products were relatively stable, the problem would be less serious as agricultural product prices would also be more stable. However, agricultural production depends on many factors beyond the farmer's control, such as drought, pests, floods, frost and other such natural disasters, as well as exceptionally good weather conditions, which occur over short periods of time. These cause frequent and large supply changes (supply curve shifts).

The problem of unstable farmer revenues is an important reason behind government intervention to support farmer incomes, which we will study in Chapter 4. The implications of unstable primary product prices for farmer revenues and the economy will be explored in Chapters 15 and 17.

PED and indirect taxes

♦ Examine the significance of PED for government in relation to indirect taxes.

Governments often impose taxes on specific goods. Such taxes are a type of indirect tax (to be discussed in Chapter 4). If governments are interested in increasing their tax revenues, they must consider the *PED* of the goods to be taxed. *The lower the price elasticity of demand for the taxed good, the greater the government tax revenues*.

This can be seen in Figure 3.7, showing the case of inelastic demand in part (a) and elastic demand in part (b).[4] When a tax is imposed on a good, it has the effect of shifting the supply curve upward. The reason is that for every level of output the firm is willing and able

[4] Here, too, as in the case of Figure 3.6, we are assuming that the two demand curves are drawn on the same scale, and that if they were drawn in the same diagram they would intersect, therefore the *PEDs* are comparable (see page 53).

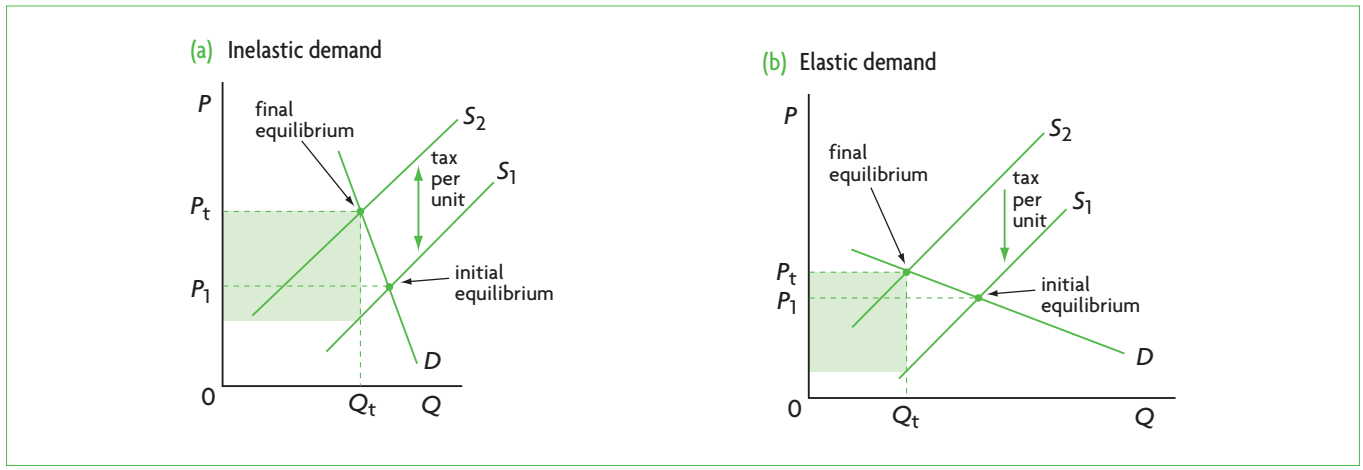


Figure 3.7 *PED*, indirect taxes and government tax revenue

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