PART 1

Microeconomics

CHAPTER 4

Elasticities of demand and supply

Learning outcomes

In this chapter, we explore

- The price elasticity of demand
- The revenue effect of a price change
- Why bad harvests help farmers
- The cross-price elasticity of demand
- The income elasticity of demand
- Inferior, normal and luxury goods
- The price elasticity of supply
- The revenue effect of a price change

4-1 Measuring demand responses

Chapters 2 and 3 introduced the basic ideas of demand and supply. Sometimes, it is sufficient to have a qualitative idea of how things will work out. For example, we may be content to be able to deduce that an increase in demand will make prices go up. But on other occasions we need to know not just the general direction of a change but its magnitude. If you are asked to invest £10 000 in a friend's business, you will want to know not just that it is going to make profits but also the size of these profits.

Moreover, sometimes what appear to be qualitative conclusions still need quantitative analysis. Will cutting the price of your output give you more revenue or less revenue? The answer depends on whether the quantity of your output demanded rises by more or less than enough to compensate for the lower price that you are charging. This is intrinsically a quantitative question. Answering questions like this requires us to discuss further the ways in which we quantify demand and supply responses.

Table 4-1 shows the demand for beer. At £10/pint, nobody buys beer. As the price falls, the quantity of beer demanded increases. At £1/pint, 90 pints are demanded.

By how much does the quantity of beer demanded rise when the price is cut by £1? The answer is by 10 pints. So the price responsiveness of beer demand is 10 pints per £. What happens if we switch to litres?

Table 4-1 The demand for beer

Pints						
£ price P	10	8	6	4	2	1
Quantity demanded Q	0	20	40	60	80	90

Since a pint is about 1.8 litres, the answer is now that the quantity of beer demanded rises by 18 litres for every £1 fall in the price. Suppose we are in New York. Now we need to use dollars not pounds. If $2 exchanges for £1, then instead of saying quantity demanded rises by 10 pints for every £1 fall in the price, we have to say that it rises by 5 pints for every $1 fall in the price.

Even though behaviour is the same in each case, our answer about the price responsiveness of beer demand keeps changing its numerical value depending on the units in which we measure quantity and the currency in which we measure price. Even within a single currency such as sterling, we get different answers depending on whether we measure responsiveness to a £1 price cut or to a 1p price cut. The answer to this dilemma is to work with measures that are unit free. They do not depend on the units in which we measure prices of quantities, so the numerical answers don't change when we change the units of measurement.

To accomplish this, we work with percentage changes. If we explore the effects of cutting the price by 1 per cent, it does not matter whether we are dealing with pounds sterling, US dollars, or euros. Similarly, if we say the quantity demanded increases by 1 per cent, this answer again is independent of the units in which we measure this. If you are still unsure why this is the case, the following example should help.

Suppose the initial quantity is 100 tons. As a result of a price cut, quantity demanded rises to 110 tons. The absolute rise in quantity demanded is 10 tons. This depends on the units in which quantity is measured. In the Imperial system of weights and measures, there are 2240 pounds per ton. So the increase of 10 tons is also an increase of 22 400 pounds. Now examine the effect of percentages. We begin in tons:

$$\begin{aligned}\%\ \text{increase} &= 100 \times [(\text{final amount} - \text{initial amount})/\text{initial amount}] \\ &= 100 \times [(110\ \text{tons} - 100\ \text{tons})/100\ \text{tons}] \\ &= 100 \times [10\ \text{tons}/100\ \text{tons}] = 10\%\end{aligned}$$

They key point is that tons enter in both the numerator and denominator of the percentage calculation and hence the units cancel out. Just to check, we can do it in pounds, too:

$$\begin{aligned}\%\ \text{increase} &= 100 \times [(246\,400\ \text{lb} - 240\,000\ \text{lb})/240\,000\ \text{lb}] \\ &= 100 \times [\ 24\,000\ \text{lb}/240\,000\ \text{lb}\ ] = 10\%\end{aligned}$$

Exactly the same reasoning applies to percentage changes in prices, whether we measure in pence, pounds, euros or dollars.

Equipped with this insight, we can now revert to our question: How do we measure the responsiveness to demand and supply with respect to various changes in variables that affect them?

The price responsiveness of demand

When a cut in the price of a good or service has a large effect on the quantity of that good or service demanded, we say that demand for the good or service is *price elastic*. Consumers are very responsive to prices. When the same size of price cut has a small effect on quantity demanded, we say that demand is *price inelastic*. Consumers are not very responsive to prices.

Table 4-2 The demand for football tickets

(1) Price (£/ticket)	(2) Tickets demanded (000s)	(3) Price elasticity of demand
12.50	0	$-\infty$
10.00	20	–4
7.50	40	–1.5
5.00	60	–0.67
2.50	80	–0.25
0	100	0

The **price elasticity of demand (ped)** measures the responsiveness of quantity demanded to changes in the price of that good or service. The ped is given by the formula

ped = [% change in quantity demanded]/[corresponding % change in price]

Table 4-2 presents a simple example, applied to football tickets.

How do we measure the responsiveness of the quantity of tickets demanded to the price of tickets? Each price cut of £1 raises ticket sales by 8000. But we want to work in percentages.

Suppose a 1 per cent price cut raises the quantity demanded by 2 per cent. The demand elasticity is the percentage change in quantity (+ 2 per cent) divided by the percentage change in price (–1 per cent) and is thus given by –2. The minus sign tells us quantity *rises* when price *falls*, or vice versa. Quantity and price are moving in opposite directions as we move along a downward-sloping demand curve. If a price fall of 4 per cent increases the quantity demanded by 2 per cent, the demand elasticity is $-{}^{1}/_{2}$ since the quantity change (+ 2 per cent) is divided by the price change (–4 per cent). Since demand curves slope down, price and quantity changes always have opposite signs. The price elasticity of demand tells us about movements along a demand curve. The demand elasticity is a negative number.

For further brevity, economists often omit the minus sign. It is easier to say the demand elasticity is 2 than to say it is –2. When the price elasticity of demand is expressed as a positive number, it is implicit that a minus sign must be added (unless there is an explicit warning to the contrary). Otherwise, it implies that demand curves slope up, a rare but not unknown phenomenon.

The price elasticity of demand for football tickets is shown in column (3) of Table 4-2. Examining the effect of price cuts of £2.50, we calculate the price elasticity of demand at each price. Beginning at £10 and 20 000 tickets demanded, consider a price cut to £7.50. The price change is –25 per cent, from £10 to £7.50, the change in quantity demanded is + 100 per cent, from 20 000 to 40 000 tickets. The demand elasticity at £10 is (100/–25) = –4. Other elasticities are calculated in the same way, dividing the percentage change in quantity by the corresponding percentage change in price. When we begin from the price of £12.50, the demand elasticity is minus infinity. The percentage change in quantity demanded is + 20/0. Any positive number divided by zero is infinity. Dividing by the –20 per cent change in price, from £12.50 to £10, the demand elasticity is minus infinity at this price.

We say that the demand elasticity is *high* if it is a large negative number. The quantity demanded is sensitive to the price. The demand elasticity is *low* if it is a small negative number and the quantity demanded is insensitive to the price. 'High' or 'low' refer to the size of the elasticity, ignoring the minus sign. The demand elasticity falls when it becomes a smaller negative number and quantity demanded becomes less sensitive to the price.

When demand is **elastic**, a 1 per cent price cut raises quantity by more than 1 per cent. Hence total spending by buyers (and hence total revenue of sellers) increases. Quantity rises more than prices fall. Conversely, when demand is **inelastic**, a 1 per cent price cut leads to a rise in quantity by less than 1 per cent. For such goods, a price cut reduces consumer spending and producer revenue. Quantity rises less than prices fall. In the intermediate case between elastic and inelastic demand, we say that demand is **unit elastic**: a 1 per cent fall in prices induces exactly a 1 per cent rise in quantity, leaving spending by buyers and revenue of sellers unaffected.

Why do we care whether demand is elastic or inelastic? We look first at an example about farmers. Suppose a harvest failure reduces by 30 per cent the crop supplied to market. Since the demand elasticity for food is low – people need to eat and if necessary can sacrifice holidays and nights out – it may take a price rise of 60 per cent to reduce quantity demanded by 30 per cent in line with the lower supply. However, if prices rise twice as much as quantity falls, farmers' incomes will *rise* when the harvest is *bad*!

Conversely, a bumper harvest that adds 30 per cent to the quantity of food being sold at market may require a 60 per cent price reduction to induce buyers to buy all this extra quantity. Farmers will then make *low* incomes when the harvest is *good*. This paradox only arises because the demand for food is inelastic – it takes large price changes to induce small changes in quantity demanded.

Here is another application of the use of the price elasticity of demand. Suppose Mercedes has 10 000 cars for sale but 20 000 customers eager to buy at the current price. Knowing the price elasticity of demand for Mercedes cars lets its executives in Stuttgart work out how much they can raise the price while still selling all the cars that they have produced. Without this information, they may underprice their cars (creating long queues of willing customers who would have been prepared to pay more) or overprice their cars (piling up large stocks of unsold Mercedes). Although Mercedes can react subsequently to the evidence about shortages or unsold cars, it is better to get things right at the first attempt. Research on the price elasticity of demand helps them do this.

Price, quantity and revenue

Reducing the price P boosts the quantity demanded Q. The effect on sales revenue, P[*56]Q, depends on how quantity responds to price cuts. When demand is elastic, quantity rises by more than the price falls, so revenue rises. When demand is inelastic, price cuts lower P more than it boosts Q. Hence revenue falls.

In Table 4-3, demand for Stella Artois is elastic but demand for beer as a whole is inelastic. Falls in the price of Stella alone raise spending on Stella by increasing its sales a lot, whereas falls in the price of all beer reduce spending on beer. Table 4-4 relates these results to demand elasticities.

By collectively restricting oil supplies, the oil-producers' organization OPEC made oil prices soar. This raised oil producers' revenue since oil demand was *very* inelastic. Oil users had few alternatives to oil in the short run. Cuts in oil supply caused a big price rise and vast revenue gains for OPEC members.

Table 4-3 Price changes, spending and revenue

Price P	Stella		All beer	
	Q	P × Q	Q	P × Q
2	5	10	30	60
1.5	10	15	32	48
1	20	20	34	34

Box 4-1

What determines demand elasticities?

The price elasticity of demand depends on consumer taste. If everyone must have an iPad, higher iPad prices have little effect on quantity demanded. If tablet computers are thought a frivolous luxury, the demand elasticity is much higher. Psychology and sociology help explain why tastes are as they are. Taking these tastes as given, the easier it is to find a substitute that fulfils the same need, the higher is the demand elasticity.

This also explains why companies advertise so much. If Apple and Samsung can convince you that a tablet is essential, demand will be more inelastic, allowing the makers to raise price without losing so many consumers. This raises profit margins. Apple have spent a lot on advertising to raise awareness of their brand.

Taking a different example, IBM used to be known as the world's most successful produced of computers. Founded in 1911, it was renamed International Business Machines in 1924 and made large computers but also moved into laptops. It still holds more patents than any other US-based technology company and its employees won 5 Nobel prizes. Despite this stellar record, by 2000 it had concluded that the computer hardware business was like to become commoditised – standardized production, many competitors, large volume, profit margins. If one computer would ultimately be much like another, the elasticity of demand would be high and profit margins would be low.

Bravely, IBM quite the hardware business and moved into software instead. Its PC business was sold to Lenovo, and it purchased PricewaterhouseCoopers consulting to help it build its service business. Nowadays, IBM designs computer programmes, promotes new applications in the digital economy, and is famous for its Smarter Planet initiative. In 2011 it overtook software giant Microsoft in market value. As a market leader in services software, it earns profit margins of over 20 per cent, considerably higher than in the commoditised computer hardware business. Demand for bespoke business services, such as specially designed software, is much less elastic – companies that come up with good solutions can charge higher prices their competitors. IBM's strategic change of direction looks to have paid off.

Incidentally, if you are wondering whether Apple is a hardware or a software company, it is often remarked that the basic technology in for example the iPhone is really quite simply – it is in design, understanding of its customers, and ability to supply the app services that they desire that Apple leads the world. Fundamentally, it is a service company, which explains its high markups. Other companies have to struggle to compete. In mobile phones, the 1990s pioneer Nokia is now languishing and Samsung now threatens to overtake Apple. Apple is already on to the next thing. This makes a second point – demand elasticities for new products or services are likely to be lower than for well established products or services.

A third related issue is the distinction between a generic category and a particular brand within that category. If the price of *all* cigarettes rises, addicted smokers buy cigarettes anyway. However, if the price of a single brand of cigarettes rises, smokers switch to other brands to meet their nicotine habit. Thus, for a particular cigarette brand the demand elasticity is quite high, but for cigarettes as a whole it is low. Similarly, if all clubs raise ticket prices, dedicated football fans will probably pay up reluctantly. But if Chelsea alone raise prices, some supporters might switch to other clubs in London. Tottenham and Arsenal are not that far away.

In all these examples, it is the strength of consumer desire and the ease or difficulty of finding substitute ways in which to fulfill this desire that determines whether demand elasticities will be low or high.

Table 4-4 Demand elasticities and spending changes

Change in total spending caused by	Price elasticity of demand is		
	Elastic (e.g. 3)	Unit-elastic (1)	Inelastic (e.g. 0.3)
Price rise	Fall	Unchanged	Rise
Price cut	Rise	Unchanged	Fall

Case study Good news! A bad harvest!

There's an awful lot of coffee in Brazil, which supplies a big share of the world market. In 1994, Brazil experienced the most severe frost of the last 20 years, which wrecked the 1995 coffee harvest. The table below shows what happened to coffee exports from Brazil. As a result of the crisis, world coffee prices (measured in US dollars) more than doubled from 90 cents per pound weight to 210 cents/pound. This price increase reflected not a rise in demand but a fall in supply to the world economy. The second row of the table below shows the sharp drop in Brazilian exports, which by 1995 were 20 per cent below their level of 1993. What happened to Brazilian export revenue from coffee? It *increased* by 70 per cent, despite the 'bad' harvest and lower export quantities. The demand for coffee is inelastic – very inelastic. New Yorkers, and many other coffee addicts, cannot do without their coffee fix.

Brazilian coffee exports 1993–95		1993	1995
P	Price (US cents/pound weight, 1995 prices)	90	210
Q	Export quantity (1990 = 100)	113	85
P × Q	Export revenue (P × Q)	10 200	17 900

Source: IMF, *International Financial Statistics*

This case study illustrates a general result. If demand is inelastic, farmers earn more revenue from a bad harvest than from a good one. The demand elasticity is low for many components of our staple diet, such as coffee, milk, bread, tea and meat.

Then demand is inelastic, suppliers *taken together* are better off if supply falls. However, if a fire destroys the crop of a single farmer, that farmer's revenue falls. Lower output from a single farm has almost no effect on total supply. The market price is unaffected. The unlucky farmer sells less output at the same price as before. The individual producer faces an elastic demand – consumers can switch to the output of similar farmers – even if the demand for the crop as a whole is very inelastic.

This sharp contrast between the individual and the aggregate is sometimes called the *fallacy of composition*. What is true in the aggregate need not be true for individuals, and vice versa.

Short run and long run

In the *short run*, customers may be unable to adjust much to changes in prices. For example, when fuel prices rise, people still need to drive their cars and heat their houses, so there is little immediate change in the quantity of fuel demanded. However, as time passes, smaller cars can be designed and built, and people can move back into city centres to save commuting costs, and more is invested in insulating houses to reduce heating bills. In the *long run*, the demand for fuel is more elastic.

Table 4-5 UK price elasticities of demand

Good (broad type)	Demand elasticity	Good (narrow type)	Demand elasticity
Fuel and light	–0.5	Bread	–0.4
Food	–0.6	Fish	–0.8
Clothing	–0.6	Expenditure abroad	–1.6
Services	–0.7	Catering	–2.6

Sources: R. Blundell, P. Pashardes and G. Weber (1993): 'What do we learn about consumer demand patterns fom micro data?' *American Economic Review; National Food Survey 2000.*

This result is very general. Even if addicted smokers can't quit when cigarette prices soar, fewer young people start smoking. In response to a price increase, quantity demanded gradually falls as time elapses.

Measuring price elasticities

Table 4-5 confirms that the demand for broad categories of basic commodities, such as fuel, food, clothing, and services, is inelastic. As a category, only services such as haircuts, the theatre and sauna baths have an elastic demand. Households simply do not have much scope to alter the broad pattern of their purchases.

In contrast, there is a much wider variation in the demand elasticities for narrower definitions of commodities. Even then, the demand for some commodities, such as dairy produce, is very inelastic. However, particular kinds of services such as foreign expenditure and catering have much more elastic demand.

Box 4-2 provides an opportunity for you to see if you have mastered the calculation of price elasticity of demand.

Maths 4-1

Expressing elasticities using calculus

Suppose the demand curve is linear and given by $q = \alpha - \beta p$ where α and β are positive constants, p denotes the price and q the quantity demanded. For a small change in price, the corresponding quantity change dq/dp in this case equals $-\beta$. reminding us that the negative slope is constant for this linear demand curve. The price elasticity of demand, measuring percentage changes, is given by

$$(p/q)\, dq/dp = -b(p/q) = -\beta(\alpha - \beta p)/p = \beta\{\beta - (\alpha/p)\}$$

Since this depends on the level of the price p, the demand elasticity changes as we move along a given demand curve. At low quantities and high prices, the demand elasticity is positive, whereas as higher quantities and correspondingly lower prices, the demand elasticity is negative because the second term on the right hand is negative for any price less than α/β.

Demand curves are not usually straight lines. Suppose instead the formula was $q = e^{-\alpha p}$ where e denotes the exponential function. Hence $\log q = -a \log p$ and hence

$$(p/q)\, dq/dp = -\alpha$$

So for this particular demand curve, the price elasticity of demand is constant whatever the point on the demand curve.

Box 4-2

Practising calculating price elasticity of demand (ped)

P = price (£)	1	2	3	4	5	6
Q = quantity demanded	10	8	6	4	2	1

The rows in the table above give price and quantity data for a particular demand curve. The table below shows five columns, labelled *a*–*e*, each corresponding to a situation in which the price changes by £1 and there is a corresponding change in the quantity demanded.

In column *a*, a 100 per cent price rise (from £1 to £2) induces a – 20 per cent fall in quantity demanded (from 10 to 8), implying a price elasticity of demand of (–20/100) = –0.2. Similarly, in column *c*, a 50 per cent price reduction (from £2 to £1) induces a 25 per cent rise in quantity demanded (from 8 to 10), implying a price elasticity of (25)/(–50) = –0.5.

Try to complete columns *b*, *d* and *e* for yourself.

	a	b	c	d	e
(1) Initial *P* and *Q*	*P* = 1	*P* = 2	*P* = 2	*P* = 4	*P* = 5
	Q = 10	*Q* = 8	*Q* = 8	*Q* = 4	*Q* = 2
(2) New P and Q	*P* = 2	*P* = 3	*P* = 1	*P* =3	*P* = 6
	Q = 8	*Q* = 6	*Q* = 10	*Q* = 6	*Q* = 1
(3) % change in *P*	100 * (2 – 1)/1 =100		100 * (1 – 2)/2 = –50		
(4) % change in *Q* thus induced	100 * (8 – 10)/10 = –20		100 * (10 – 8)/8 =25		
(5) ped = (4)/(3)	–0.2		–0.5		

The cross-price elasticity of demand

The (own-) price elasticity of demand tells us about movements along a given demand curve holding constant all determinants of demand except the price of the good itself. We now hold constant the own-price of the good and examine changes in the prices of *related* goods. The cross-price elasticity tells us the effect on the quantity demanded of the good *i* when the price of good *j* is changed. As before, we use percentage changes.

The cross-price elasticity may be positive or negative. It is positive if a rise in the price of good *j* increases the quantity demanded of good *i*. Suppose good *i* is tea and good *j* is coffee. An increase in the price of coffee raises the demand for tea. The cross-price elasticity of tea with respect to coffee is positive. Cross-price elasticities tend to be positive when two goods are substitutes, and negative when two goods are complements. We expect a rise in the price of petrol to reduce the demand for cars because petrol and cars are complements.

Table 4-6 shows estimates for the UK. Own-price elasticities for food, clothing and travel are given down the diagonal of the table, from top left (the own-price elasticity of demand for food) to bottom right (the own-price elasticity of demand for travel). Off-diagonal entries in the table show cross-price elasticities of demand. Thus, 0.1 is the cross-price elasticity of demand for food with respect to transport. A 1 per cent increase in the price of travel increases the quantity of food demanded by 0.1 per cent.

Table 4-6 Cross-price and own-price elasticities of demand in the UK

% change in quantity	Caused by a 1% price change in demand of		
	Food	Clothing	Travel
Food	–0.4	0	0.1
Clothing	0.1	–0.5	–0.1
Travel	0.3	–0.1	–0.5

Source: R. Blundell, P. Pashardes and G. Weber (1993): 'What do we learn about consumer demand patterns fom micro data?' *American Economic Review*

The own-price elasticities for the three goods lie between –0.4 and –0.5. For all three goods, the quantity demanded is more sensitive to changes in its own price than to changes in the price of any other good.

The response of demand to income changes

Finally, holding constant the own-price of a good and the prices of related goods, we examine the response of the quantity demanded to changes in consumer incomes. As in Chapter 3, we neglect the possibility of saving. For the moment, we assume that a rise in the income of consumers will typically be matched by an equivalent increase in total consumer spending.

In Chapter 2 we introduced the concepts of normal and inferior goods, and of necessities and luxuries. These described, other things equal, how quantity demanded responds to an increase in income. As with responses to price changes, it is helpful to quantify the magnitude of these responses.

The **income elasticity of demand (ied)** measures the change in the quantity demanded in response to a 1 per cent rise in income. The ied is given by

ied = [% change in quantity demanded]/[corresponding % change in income]

The income elasticity of demand measures how far the demand curve shifts horizontally when incomes change. Figure 4-1 shows two possible shifts caused by a given percentage increase in income. The income elasticity is larger if the given rise in income shifts the demand curve from *DD* to *D″D″* than if the same income rise shifts the demand curve only from *DD* to *D′D′*. When an income rise shifts the demand curve to the left, the income elasticity of demand is a negative number, indicating that higher incomes are associated with smaller quantities demanded at any given prices.

In Chapter 2 we distinguished *normal* goods, for which demand increases as income rises, and *inferior* goods, for which demand falls as income rises. Thus, normal goods have a positive income elasticity (since income and quantity demanded change in the same direction as one another), whereas inferior goods have a negative income elasticity (showing that income and quantity demanded change in opposite directions).

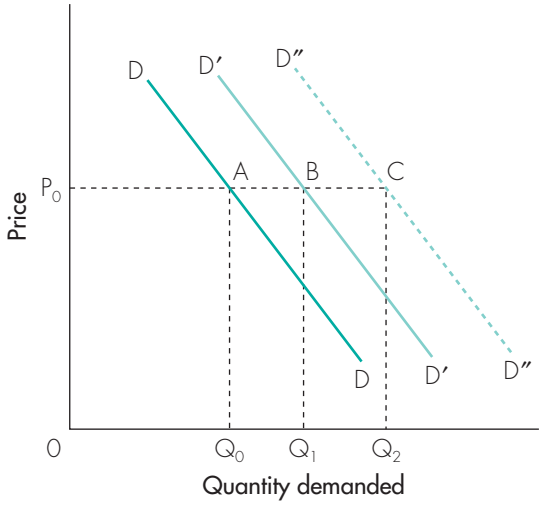

Figure 4-1 Income elasticity and shifts in the demand curve

We also distinguished luxury goods and necessities. All inferior goods are necessities, and have negative income elasticities of demand. However, necessities also include normal goods whose income elasticity of demand lies between zero and one. Luxuries have an income elasticity of demand in excess of one.

These definitions tell us what happens to budget shares when incomes are changed but prices remain unaltered. The budget share of inferior goods falls as incomes rise. Higher incomes and household budgets are associated with lower quantities demanded at constant prices. Conversely, the budget share of luxuries rises when income rises. Because the income elasticity of demand for luxuries exceeds one, a 1 per cent rise in income increases quantity demanded (and hence total spending on luxury goods) by more than 1 per cent. Rises in income *reduce* the budget share of normal goods that are necessities. A 1 per cent income rise leads to a rise in quantity demanded but by less than 1 per cent, so the budget share must fall.

Table 4-7 summarizes the demand responses to changes in income, holding constant the prices of all goods. The table shows the effect of income increases. Reductions in income have the opposite effect on quantity demanded and budget share.

Table 4-8 reports income elasticities of demand in the UK, for broad categories of goods in the first two columns and narrower categories in the last two columns. Again, the variation in elasticities is larger for narrower definitions of goods. Higher incomes have much more effect on the way in which households eat (more prawns, less bread) than on the amount they eat in total. Food is a normal good but not a luxury. Its income elasticity is 0.45.

Table 4-7 Demand responses to a 1% rise in income

Good	Income elasticity	Quantity demanded	Budget share	Example
Normal	Positive	Rises		
Luxury	Above 1	Rises more than 1%	Rises	BMW
Necessity	Between 0 and 1	Rises less than 1%	Falls	Food
Inferior	Negative	Falls	Falls	Bread

Table 4-8 UK income elasticities of demand

Broad categories	Income elasticity	Narrower categories	Income elasticity
Tobacco	0.5	Coal	2.0
Fuel	0.3	Bread and cereals	0.5
Food	0.5	Dairy produce	0.5
Alcohol	1.1	Vegetables	0.9
Clothing	1.2	Travel abroad	1.1
Durables	1.5	Leisure goods	2.0
Services	1.8	Wines and spirits	2.6

Sources: J. Muellbauer, 'Testing the Barten model of household composition effects and the cost of children', *Economic Journal*, 1977; A. Deaton, 'The measurement of income and price elasticities', *European Economic Review*, 1975

The last column indicates that, within the food budget, higher income leads to a switch towards vegetables (whose income elasticity is higher than that for food as a whole) and away from bread, for which the quantity demanded declines. Rich households can afford to eat expensive salads to avoid getting fat. Poor people need large quantities of bread to ward off the pangs of hunger. Notice that tobacco is an inferior good, with its largest budget share among poor people. Richer people get their kicks in other (more expensive) ways.

Income elasticities help us forecast the pattern of consumer demand as the economy grows and people get richer. Suppose real incomes grow by 15 per cent over the next five years. The estimates of Table 4-8 imply that tobacco demand will rise by 7.5 per cent but the demand for wines and spirits will rise by 39 per cent. The growth prospects of these two industries are very different. These forecasts will affect decisions by firms about whether to build new factories and government projections of tax revenue from cigarettes and alcohol.

Similarly, as poor countries get richer, they demand more luxuries such as televisions, washing machines and cars.

Box 4-3

Store wars in an age of austerity

Since 2008, families have faced a substantial squeeze. Many incomes have failed to keep pace with inflation, and there have been large increases in the real cost of food and fuel. Taxes have been raised, and welfare benefits reduced, as the government struggles to get the budget deficit under control. As supermarkets battle it out for supremacy, or just for survival, how has the change in the economic climate affected competition?

Our theory predicts that, other things equal, a fall in real income should lead to a reduction in demand for all normal goods (having a positive income elasticity of demand) but a rise in demand for inferior goods (having an negative income elasticity of demand). Let's think first of all about clothing. By 2012, upmarket Aquascutum had gone bust as the demand for its high-quality clothes collapsed. Aquascutum fits the theory nicely. But why then has Burberry, another business with a flagship store in London's Regent Street, done so well? Burberry managed to diversify out of the UK, becoming a global brand, and recently taking advantage of the huge growth of the affluent middle class in China. During 2011, Burberry sales to China alone grew by 30 per cent.

For poorer UK households, some of whom have experienced dramatic falls in family purchasing power, we should expect this loss of real income to lead to a search for cheaper goods with a negative income elasticity of demand. This is easily confirmed in the market place. Budget clothes retailer Primark enjoyed a 16 per cent increase in sales during 2011, whereas clothing sales in UK family favourite Marks and Spencer fell over the same period. With less to spend, people generally but back on clothes spending, but the switch towards budget clothing was sufficiently strong that companies like Primary benefitted considerably.

Like M&S, Tesco sells clothes as well as food. Tesco tried to respond to the austerity squeeze with a major price discounting campaign over the 2011 Christmas period. The price drop proved a big flop. Struggling consumers had to go somewhere even cheaper than Tesco if they wanted to buy clothes.

A similar story emerges in food retailing. German budget supermarket Aldi experienced a 25 per cent increase in UK sales during 2011, not because people were feeling richer but because they were feeling poorer. Tesco, previously the huge success story of the last ten supermarket years, lost

out in its food business as well as its clothing business, and its price drop campaign failed to stem the tide. People deciding to tighten their belts went somewhere else entirely.

The same phenomena can be observed in other industries. Think of the success of budget hotel chains Travelodge and Premier Inn, and the plight of package tour operators who have been victim of people deciding to stay in the UK for their vacation. Consumers have also switched from smart restaurants to ready meals, delayed home improvements, and made the ageing car last a bit longer.

Thinking about the income effect on demand is useful not only in understanding how demand patterns change during recession and recovery, it is also useful in thinking about the consequences of major global transformations. In China there are now 1 million millionaires and six hundred billionaires. In the aggregate, the Chinese economy is making the equivalent of a new Italy every year. Similar effects, at a slower pace, are taking place in India, Brazil and Russia. These changes will profoundly affect the pattern of global demand. Companies able to plug into this demand growth – such as Mercedes, BMW, Burberry – will do very well indeed.

4-2 Measuring supply responses

The price responsiveness of supply

When a price rise has a large effect on quantity supplied, we say that the supply of the good is *elastic*. Suppliers are very responsive to prices. When the same size of price rise has a small effect on quantity supplied, we say that supply is *inelastic*. Sellers are not very responsive to prices.

The **elasticity of supply** measures the *responsiveness* of quantity supplied to the price that suppliers receive. The (price) elasticity of supply is measured by

Supply elasticity = [% change in quantity supplied]/[% change in price]

When supply is elastic, a 1 per cent price rise increases quantity supplied by more than 1 per cent. Supply is price responsive. When supply is inelastic, a 1 per cent price rise increases quantity supplied by less than 1 per cent. Supply is less responsive to price. In the extreme cases, a horizontal supply curve means that quantity supplied is infinitely responsive to the price: the elasticity of supply is infinity. Conversely, a completely vertical supply curve means that producers supply the same quantity whatever the price. The price elasticity of supply is zero.

In the previous chapter, whether demand was elastic or inelastic affected whether revenue (price × quantity) fell or rose when the price increased. Because demand curves slope down, prices and quantities change in opposite directions, which is why it is important to know which effect dominates the other. For supply, there is no such conflict. Supply curves slope upwards. Prices and quantities always change in the same direction: high prices go with high quantities, low prices with low quantities. Hence, a price increase always raises the total revenue received by sellers (both price and quantity increase), and a price fall always reduces the revenue of sellers since both price and quantity are lower. In Figure 4-2, a price increase from P_0 to P_1 increases total revenue received by suppliers from OP_0AQ_0 to OP_1AQ_1.

Let us try to put our knowledge of supply elasticities to work. As we showed in Chapter 1, oil prices have shot up to all time record levels. Truckers and fishermen are on strike around Europe, protesting at the high cost of fuel. We know that emerging economies are continuing to add to the demand for energy: they want cars, air travel, central heating, air conditioning, and power for their factories, all on a scale never seen before. So we can safely assume that the demand for energy is very strong. It will stay strong unless the global economy has an implosion. Possible sources of an implosion include a worldwide banking crisis, wars caused by rising food prices or scarce water, and fights over energy resources themselves.

But suppose none of these catastrophes occur. Emerging markets continue to prosper and world economic growth continues. What do you think will happen to oil prices. Will those who were amazed to see oil rise above $100/barrel next have to cope with oil at $200/barrel?

This is where supply elasticities get into the story. Recall the oil price hikes of 1973 and 1981. For a short time, oil prices were very high but then market forces got to work. Oil firms explored ever more costly and remote environments, and they did discover more oil. Lots of it. The supply elasticity of oil turned out to be much higher in the long run than in the short run. And as this extra quantity supplied came on stream, scarcity diminished and the price of oil came down. In fact, at one point it had fallen back to only $8/barrel.

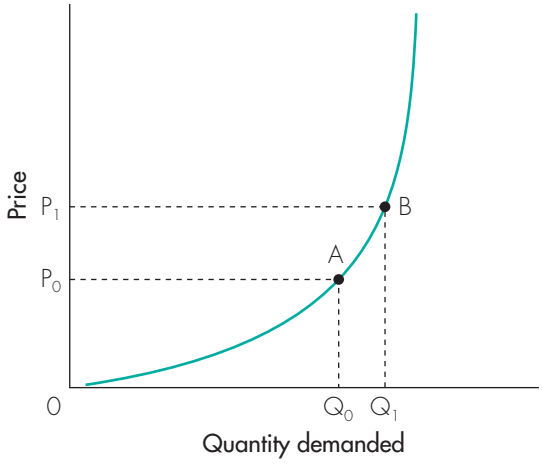

Figure 4-2 Prices and the supply response

Box 4-4

What determines supply elasticities?

The elasticity of supply is determined by how profitable it is for suppliers to increase quantity supplied when they are offered higher prices for their output. In part, this reflects technology. With a mass production line, it may be relatively easy to respond to opportunities to sell at higher prices, but doubling the TV revenue money for football clubs is no guarantee that another Lionel Messi will emerge.

As with demand, we need to distinguish between supply to the market as a whole and the behaviour of individual suppliers. If prices rise, a particular supplier may or may not be able to increase output by much. Some, such as a supplier of online services, may be able to increase supply by a lot. Others, such a copper mine operating near full capacity already, may have little ability or willingness to increase the quantity supplied.

But increasing the supply of existing producers is not the whole story. Higher prices may entice new suppliers into the market, thereby enlarging total supply. Total supply is then more elastic than the supply of individual producers. The rise in air passengers in the last two decades reflected the growth of easyJet and Ryanair, rather than a major expansion by British Airways and Air France.

As with elasticity of demand, elasticity of supply is higher in the long run than the short run. Given more time, it is easier for producers to respond to a price change. It may take time to build new production capacity to respond to a price increase. A period of sustained high oil prices has finally made it profitable for energy companies to extract shale gas. So spectacular has this been in North America that it is now forecast the United States will be self sufficient in energy over the next two decades, a far cry from its energy dependence on OPEC producers in the 1970s. To take an even more obvsiou example, suppose energy prices ever became so high that the world concluded that the only feasible solution was nuclear power. It probably take 20 years to build these nuclear power stations.

Similarly, closing factories or laying off workers is not something producers undertake on the first day that prices fall. They wait a bit to see if the price reduction is permanent, and even then

it takes time to organize a production and employment response. Overnight, supply can be pretty inelastic.

Europe has far too many car producers. Elite brands such as BMW and Mercedes as enjoying the demand created in booming emerging markets, but the volume car business continues to struggle. Can a country such as France really support Citroen and Peugeot and Renault in a global industry in which large scale and a global supply chain is the key to delivering quality at reasonable prices? Recently, SAAB went bust, but further rationalization has been predicted for the last decade at least. Achieving exit by long-established players takes time. In the meantime, supply is quite inelastic.

To sum up, supply curves are often steep in the short run, showing that price changes have only small effects on quantity supplied. In the longer run, supply is more elastic and supply curves become flatter, indicating that quantity supplied varies more with price changes. Some of the longer run response is achieved by incumbent companies adjusting their output, but some is achieved by entry of new firms or exit of old ones.

What about this time round? Unlike 30 years ago, when OPEC curtailed supply, this time it is a surge in demand that has initiated the process. Last time, supply only had to rise back to its initial level to redress the balance; this time, a sustained increase in supply will be needed. From where is it to come?

It is important to realize that it is really the market for energy not oil that we are discussing. And there are many potential sources of new energy – solar, wind, nuclear, biofuels – in addition to ways of adding to the supply of oil itself (e.g. from shale deposits not previously exploited). These new technologies share one thing in common – they were not economic to exploit when the price of oil was low. At oil prices below $30/barrel, it was much more profitable to rely on oil to supply our energy needs. But if prices are sustained above $60/barrel, many of these alternative technologies begin to become attractive; at prices above $100/barrel, they are even more lucrative. The more energy analysts depict a scenario of sustained high oil prices, the more people will decide to invest in alternative technologies.

Some are still experimental and will take years to perfect. Other technologies are already perfected but it will still take years to build the required capacity to produce on a sufficient scale to bid energy prices down again. And therein lies the catch. If investors believe someone else may invest in the capacity to increase energy supply significantly, they may start to doubt how long high energy prices are going to remain. This may make their own planned investment in additional supply less profitable. Yet if everyone draws the same conclusion, nobody will invest in the capacity needed to increase supply and prices will remain high!

This is probably too pessimistic an outcome. The prospect of high energy prices is probably robust enough to encourage a considered effort being devoted to increasing future energy supply. The supply elasticity will prove higher in the long run than it has been in the short run. It has been the surge in demand, coupled with the near-vertical short-run supply curve for oil, that has caused such a surge in oil prices. But don't bet on $200/barrel in 2030. The odds are that important new energy sources, viable at much lower prices than this, will be on stream by then. Some of these sources have the potential for considerable quantities of supply and should be able to cope with substantial rises in world demand for energy.

Figure 4-3 shows the forecast by BP in 2012 of how the energy market will evolve until 2030. Oil remains important, coal and natural gas grow even more, and the fastest growth is in biofuels and renewable energy, but from a tiny baseline.

Summing up

Price changes move a market along given supply and demand curves. Provided prices are free to adjust, the market gets to an equilibrium in which quantity supplied equals quantity demanded.

[1] If you want not merely to get tax revenue but also to make people healthier, should you set a tax rate above or below that which maximizes revenue from cigarette taxation?

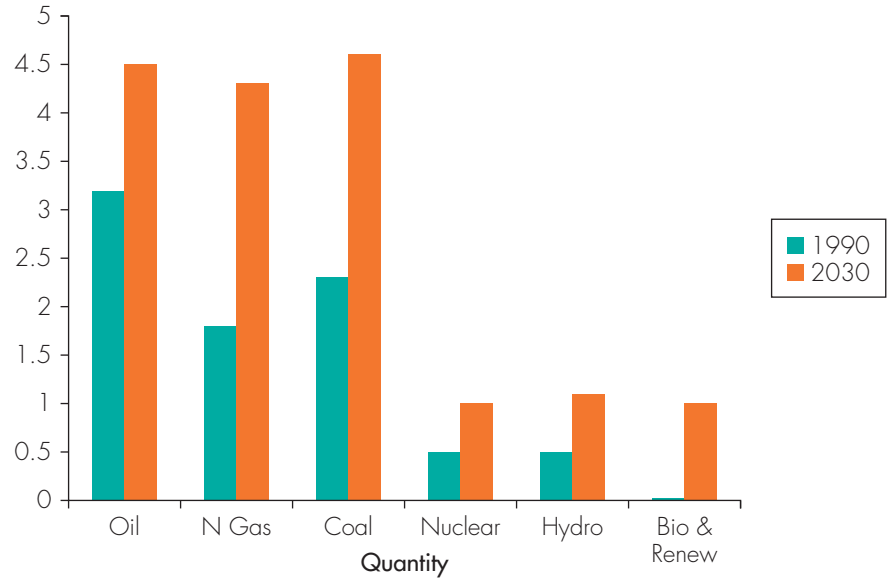

Figure 4-3 Energy Production (billion metric tons equivalent) 1990-2030

Source: BP Energy Outlook 2030

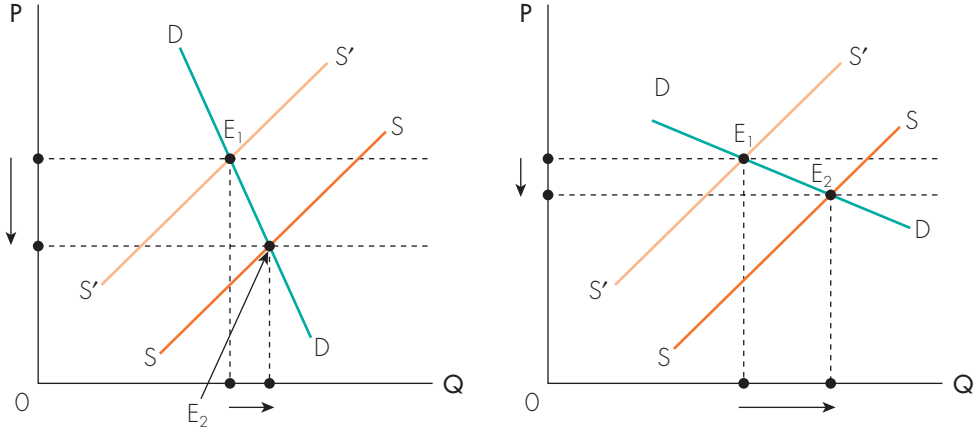

Figure 4-4 Demand elasticity affects the revenue consequences of a supply shift

Starting from this equilibrium, the consequences of a given shift in the one curve depend on the elasticity of the *other* curve.

Figure 4-4 shows a supply shift from *SS* to *S'S'* as a result of an increase in supply, shifting equilibrium from E_1 to E_2.

When demand is inelastic, price falls a lot but quantity hardly rises. Revenue falls, from the rectangle whose diagonal is OE_1 to the rectangle whose diagonal is OE_2, as in the left hand part of Figure 4-4.

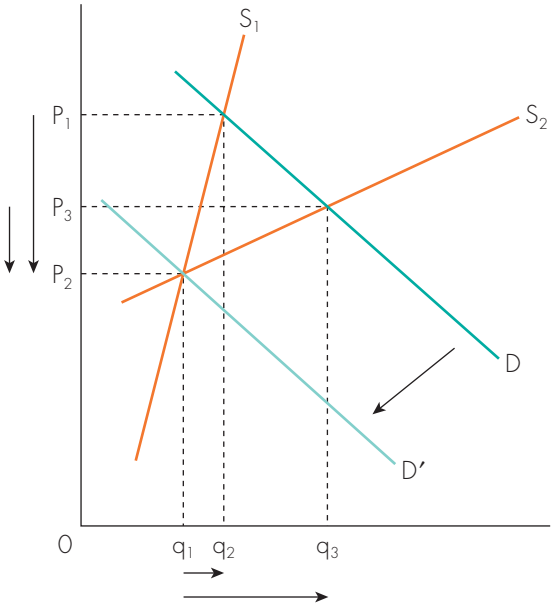

Figure 4-5 How supply elasticities affect the consequences of a demand shift

Conversely, when demand is elastic, as in the right hand part of Figure 4-4, the same supply shift from *SS* to *S'S'* leads to a large quantity increase and only a small price decrease. Now the revenue rectangle whose diagonal is OE_2 exceeds the original revenue rectangle whose diagonal is OE_2.

The same type of reasoning can be applied to a shift in demand. Now the consequences depend on the elasticity of the supply curve. In Figure 4-5, we consider a downward shift in demand from the curve labeled *D* to that labeled *D'*. When the supply curve S_1 is almost vertical, the demand shift induces a large fall in price (from P_1 to P_2 but only a small increase in quantity from q_1 to q_2, whereas when the supply curve is much flatter, as shown by S_2, the same fall in demand leads to a much lower fall in price but a much greater fall in quantity.

Thus, producers with an inelastic supply curve experience larger price changes when demand shifts, but they face smaller quantity changes, so the implications for revenue rectangles are much affected by the elasticity of supply.

Recap

- The price elasticity of demand (sometimes simply called the elasticity of demand) is the percentage change in quantity demanded when the price of that good or service increases by 1 per cent.
- Demand is elastic (inelastic) when a 1 per cent price fall induces a rise in the quantity demanded by more (less) than 1 per cent.
- Price cuts raise (lower) total spending and producer revenue when demand is elastic (inelastic). Spending and revenue are unchanged if demand is unit-elastic.
- The cross-price elasticity of demand shows how the quantity demanded of one good responds to a change in the price of a related good.
- The income elasticity of demand shows the percentage change in quantity induced by a 1 per cent rise in income and total spending. Higher income increases demand for normal goods and reduces demand for inferior goods.
- Luxuries have an income elasticity above 1. Necessities have an income elasticity below 1. Inferior goods have a negative income elasticity.
- Supply is elastic if quantity supplied is very responsive to price, inelastic if quantity supplied is not very responsive to price. Provided the supply curve remains given, revenue of suppliers always changes in the same direction as price, since price and quantity change in the same direction as we move along a given supply curve.

- Supply elasticities are never negative. An elasticity above 1 means that a 1 per cent increase in the price leads to an increase in quantity supplied by more than 1 per cent. Supply is elastic. An elasticity below 1 means that a 1 per cent increase in the price leads to an increase in quantity supplied by less than 1 per cent. Supply is inelastic. A vertical supply curve has a supply elasticity of 0, a horizontal supply curve has an infinite supply elasticity.

Review questions

To check your answers to these questions, go to page 334.

EASY

1 Why is demand more elastic in the long run than in the short run? Could it ever be less elastic in the long run?

2 Which of the following statements refer to the income elasticity of demand and which to the price elasticity of demand? (a) A Mercedes is a luxury, (b) I am addicted to nicotine, (c) bread is cheap and so attractive to poor students, (d) only the rich have servants, (e) the minimum wage has increased the cost of employing servants, so nowadays few people can afford them.

3 The price of a service rises and people demand more of it. Is the service normal or inferior? Why?

4 Suppose London introduces a congestion charge for Londoners but also gives £500 a year subsidy to all Londoners so that the average Londoner is neither better nor worse off from the combined effect of the two measures. Answer true or false for each of the following statements: (a) People's behaviour will change because of the income effect of the combined policies. (b) People's behaviour will change because of the substitution effect of the combined policies. (c) Demand for driving vehicles in London will fall compared to what it would otherwise have done. (d) Whether demand falls or not depends on whether the alternative (public transport) is normal or inferior.

MEDIUM

5 Complements are goods for which there is a joint demand (shoes and shoelaces, right shoes and left shoes), whereas substitutes are alternative goods that satisfy a similar need (tea and coffee, bread and potatoes). (a) Do you think the cross-price elasticity of demand for shoes and shoelaces is positive or negative? (b) Do you think the cross-price elasticity of demand for tea and coffee is positive or negative? (c) Does this suggest a way to define complements and substitutes?

6 Unit-elastic demand is the special case in which a price change has no effect on the spending of buyers and the revenue of sellers. Is there a corresponding interpretation of unit-elastic supply? Why or why not?

7 You harvest your fresh but delicate strawberries and set up a market stall to sell them. It is a hot day. What is your elasticity of supply? Describe the shape of your supply curve for strawberries.

8 **Intermediate question** Why are rail fares higher during the rush hour? Comment on the following justifications (a) Total demand is higher at these times (b) Business people have to get to work at those times and have no alternative but to pay (c) Otherwise the train operators would have to buy more trains that would be completely unused outside the rush hour.

9 **Intermediate question** If during austerity a budget clothes retailer grabs market share from a mid-market clothes retailer, why does the latter not completely copy the behaviour of the former when times are tough, selling only cheap and cheerful clothing?

HARD

10 **Harder question** A new government imposes a ceiling on rents in order to help poor students. (a) If you are a private landlord, what is the immediate effect on the quantity of student flats that you supply? (b) If the ceiling persists for ten years, what do you think has now happened to the total supply of student flats? (c) Is the supply elasticity of student flats higher in the short run or in the long run?

11 **Harder question** (a) If the government wants to maximize revenue from cigarette tax, should it simply set a very high tax rate on cigarettes? (b) If the government achieves its objective, what is the elasticity of demand for cigarettes at the price corresponding to this tax rate? (c) If you want not merely to get tax revenue but also to make people healthier, should you set a tax rate above or below that which maximizes revenue from cigarette taxation?

12 **Essay question** Suppose climate change causes flooding that wipes out much of UK agriculture. Discuss what happens to the price of food in the UK: (a) in the short run and (b) in the long run. Did you assume that the UK made and consumed all food itself or did you allow for international trade? How does the outcome differ in these two cases?

13 **Essay question** The operation to sell tickets for the 2012 UK Olympics was widely criticized. What process would you have set up? What objectives would you be trying to accomplish

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Box 4-4

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Indian rice farmers © Ana Abrad

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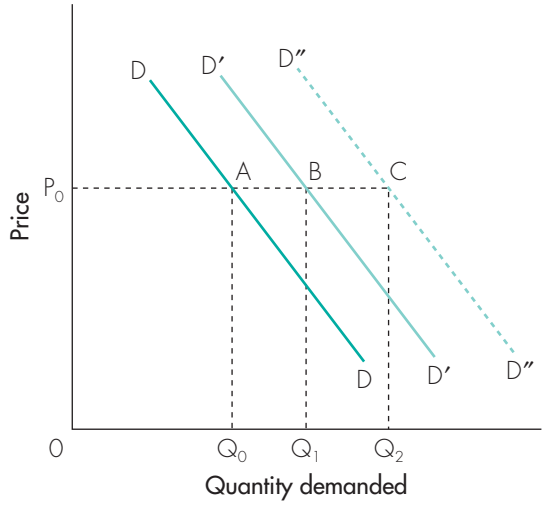

Income elasticity and shifts in the demand curve

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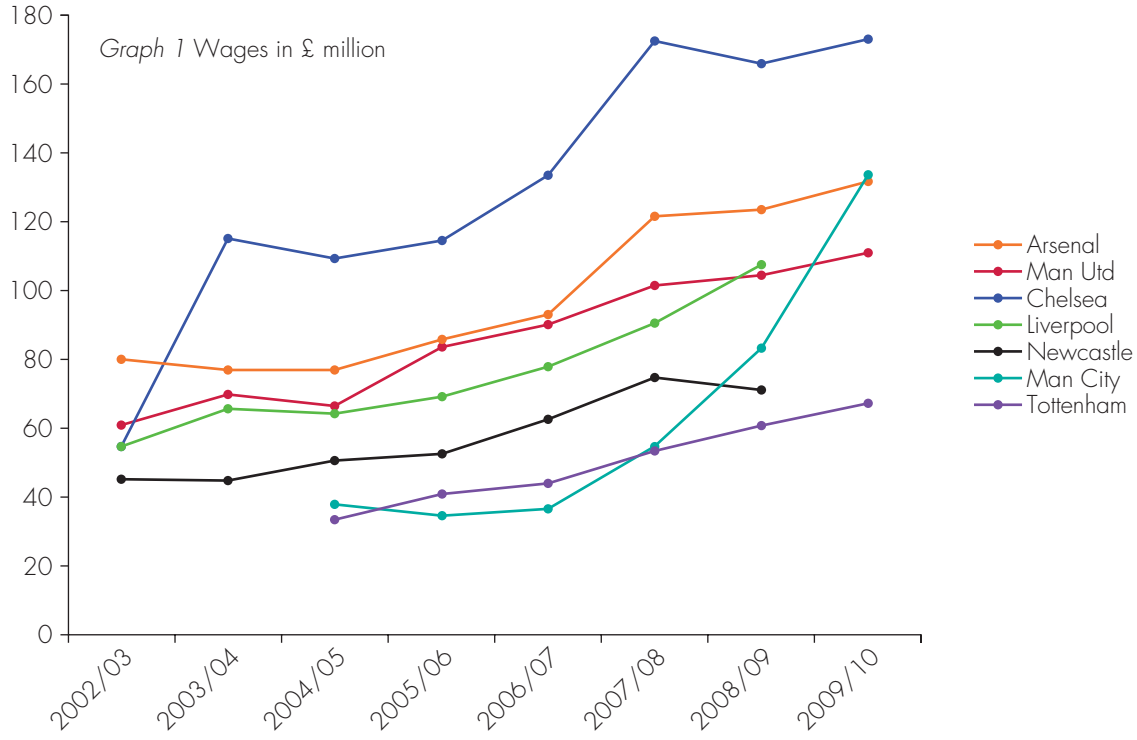

Figure 7.1

Sources: http://abehnisch.com/tag/premier-league; www.deloitte.com