Chapter 4

Transport demand elasticity

Learning Outcomes:

On reading this chapter, you will learn about:

- The importance of an understanding of elasticity of demand in the planning of transport services and the analysis of transport markets
- Elasticity of demand and the three main types of elasticity of demand relevant to the transport sector in the form of own price, cross price and income elasticity
- The major determinants of own price elasticity of demand for transport
- The significance of own price elasticity of demand and the revenue of the firm.

INTRODUCTION

As a general rule, when the price of any good or service rises the quantity demanded will fall. Whilst useful as an analytical tool and as a method of improving our understanding of transport markets, in most cases, particularly those of a practical nature, we will want to know more than that. What is important is not the fact that demand will fall (as that is given by the basic law of demand) but rather by how much the quantity demanded will fall, and thus how price sensitive are consumers in the market? For example, how sensitive are people to purchasing train tickets if the fare was to rise by 2 per cent, 5 per cent or even 20 per cent?

The answer lies in the concept of price elasticity of demand, as this indicates the responsiveness of passengers or potential passengers to changes in the prices on offer. As such, it has a huge impact on transport policy and decision making. Given that all transport markets, particularly those relating to public transport services, are regulated to a greater or lesser extent in most countries, setting the 'right' fare is essential to achieving policy aims and objectives. With fare and/or capacity levels set by the transport authority rather than the market, an understanding of elasticity of demand, even at a basic level, is essential to achieving policy objectives. García-Ferrer *et al.* (2006) for example highlight that transport services need to be priced at an appropriate level to determine best operating practice, and for this to happen it is essential to have a knowledge of how users will respond to changes in price and service characteristics. Furthermore, Goodwin (1992) notes that the price mechanism can be used as an important tool of policy to either raise revenue through the imposition of a tax or by affecting demand through the payment of a subsidy to reduce price. The effectiveness of such a policy tool however is to a very large extent determined by the degree to which consumers are responsive to changes in the price of transport services. For example, paying a subsidy to a transport service where consumers are not price sensitive will only result in lowering the price and have little effect on the numbers using the service.

In a more general sense, such an understanding of transport behaviour is important for any analyst of transport markets. Although most of the focus of demand elasticity tends to be on changes in the price, the idea of elasticity involves the responsiveness of the consumer to changes in any of the determinants of demand, not only the price. Hence the effect of changes in income are measured by income elasticity, cross price elasticity measures the effect of the change in the price of one mode on the demand for another, service elasticity the effect of improvements in the quality of service on demand and so on. A general definition therefore of elasticity of transport demand would be the responsiveness of demand for a transport mode to a change in one of its determinants.

This chapter, under the title of transport demand elasticity, will further focus on the factors behind the demand for transport services by individual consumers before the following chapter provides further focus on supply in the form of the costs of providing transport services. Here the main types of elasticity will be outlined and some simplified elasticities calculated. The chapter also provides a practical perspective to the topic by giving an overview of some of the estimations that have been made of transport elasticities, and this will also help to reinforce many of the ideas presented in the chapter.

PRICE ELASTICITY OF DEMAND FOR TRANSPORT SERVICES

Price elasticity of demand for transport services, as discussed previously, is the consumers' demand responsiveness to changes in the price. This applies to all areas of transport, hence would refer to the operator's price in the case of public transport, the supplier's price in the case of freight carriage and the total price in the case of an individual's private transport. Price elasticity is often referred to as 'own' price elasticity to draw a clear distinction from 'cross' price elasticity, which is the cross-over effect of price changes and will be examined later. In the face of price changes, the law of demand states that consumers (in total) will react by either consuming more in the case of price cuts or less in the case of price increases. As stated above, however, what is of more value is the extent to which consumers react to price changes, i.e. price elasticity.

Price elasticity is therefore the formal mechanism in economics by which price sensitivity is assessed and analysed. This is measured on a quantitative basis, i.e. a number is derived in order to assess the level of price elasticity, which is given by the formula:

$$\text{Price Elasticity of Demand} = \frac{\text{Percentage Change in Quantity Demand}}{\text{Percentage Change in Price}}$$

Or this equation may be expressed in its shorthand form of:

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

Where: PED = price elasticity of demand
% = percentage
Δ = change (represented by the Greek letter 'delta')
D = quantity demanded
P = price

Price elasticity therefore is an assessment of the relative changes in the quantity demanded to relative changes in price, and as such provides an indicator of the price sensitivity of consumers. To give a hypothetical example, say an operator was to increase its fares by 4 per cent but the quantity demanded was to fall by only 1 per cent, then price elasticity would be −0.25, as calculated by:

$$\text{PED} = \frac{\%\Delta D}{\%\Delta P} = \frac{-1\%}{+4\%} = -0.25$$

Notice that the sign of PED is negative. Certainly within transport services this will almost always be the case. This, again, is the basic law of demand. A rise in price (a positive figure) will cause a fall in the quantity demanded (a negative figure). Likewise, a fall in price will cause a rise in the quantity demanded. Thus when working out price elasticity of demand, either a negative figure is divided by a positive one or a positive figure divided by a negative one. Either way this produces a negative value. This of course applies to the definition of a 'normal' good, where a rise in the price will cause a fall in the quantity demanded. Contrast this with what is known as a 'Giffen' good, which exists where an increase in the price of a good or service actually brings about an increase in the quantity demanded, not a decrease. This may apply for example to goods such as cheap jewellery, where a price increase may lead to a perception of higher quality, and hence quantity demanded increases. In such cases, the price elasticity of demand would be positive. Giffen goods however tend to be very rare, although we will see an example of one later.

In the above equation, however, what does the PED figure mean? If say we obtained a value of −2.0, what does that actually signify? Before answering that question, the first important observation to make is that 'higher' elasticity values will always refer to higher *negative* values. Consider the following quote taken from the Southend–London Route Study (Competition Commission, 2004, p. E4):

> *'For most categories of rail traffic, estimated elasticities on the basis of existing studies, particularly in the short run, are likely to be smaller than −1: i.e. an increase in price would lead to a less than proportionate decrease in number of passengers, hence revenue and profits would increase. Rail demand as a whole could therefore be regarded as a separate market. However, for leisure travel on certain routes, elasticities are likely to be larger than −1: i.e. a price increase would lead to a more than proportionate reduction in (the) number of passengers, reducing revenues.'*

What it actually means in the first sentence however is that elasticities on the basis of existing studies are likely to produce smaller *negative* values than −1. The same applies later in the quote where it refers to 'larger than −1', hence −1.5 would be 'larger' than negative one. Hence note that 'larger' values will always refer to larger negative values.

To return to the original question, what does the PED value mean? Price elasticity is a formal measure of the rate of change of the quantity demanded in comparison to the rate of change of the price. Where the price elasticity is greater than negative one, as highlighted in the above quote, this means that the proportionate change in demand is greater than the proportionate change in price. For example, if PED was −2, then the percentage change in demand would be twice the percentage change in price. This would be known as *elastic* demand. Where PED is less than negative one, then the proportionate change in quantity demanded is less than the proportionate change in price, and this would be known as *inelastic* demand. To use our price sensitivity terminology, in the case of elastic demand this would indicate that consumers are relativity price sensitive, whilst inelastic demand that consumers in the market have a relatively low level of price sensitivity. Another way to think about this is that the formula for PED is simply a formal method for comparing changes in demand to changes in price. The value can then be measured against a common scale in order to determine the extent of the price sensitivity of consumers: values greater than negative one indicate they will react strongly to changes in price and values less than negative one that they will not, although note from above that 'large' or 'greater' relates to larger negative values.

If negative one is the important dividing line, what therefore are the upper and lower limits of this 'scale'? Taken to its ultimate conclusion, the most extreme case of elastic demand would exist where any change in the price, either up or down, results in the quantity demanded falling to zero. This would be known as perfectly price elastic demand, as illustrated in Figure 4.1.

Whilst in this context this is purely a theoretical concept, perfectly price elastic demand does have practical implications that will be examined later in the text (this may for example be the demand curve facing an individual firm, i.e. it can only sell at one price, rather than the market demand curve). Importantly in this context, it gives an upper limit for the range of possible price elasticity values. If, for example, the price P_{pe} in Figure 4.1 was £4, at which the quantity demanded is infinite (i.e. the firm can sell as much as it can produce), and then the firm for an

Figure 4.1 *Perfectly price elastic demand*

unknown reason was to increase its price to £5, demand for its product would fall to zero. Price elasticity of demand in this example would therefore be given by:

$$\text{PED} = \frac{\%\Delta D}{\%\Delta P} = \frac{-\infty\%}{25\%} = -\infty$$

This therefore gives the upper limit on our common 'scale' of negative infinity (as given by the symbol ∞). The other extreme would be where a change in price would produce absolutely no change in the quantity demanded, i.e. consumer behaviour is completely unaffected by changes in the price. They will purchase exactly the same quantity of the good whether the price rises or decreases. This extreme case is known as perfectly price inelastic, and is shown in Figure 4.2.

Where demand is perfectly inelastic, then no matter the price consumers will purchase exactly the same quantity of the good or service, i.e. the demand curve is vertical. As this is an extreme case, again this has few practical applications although certain habit-forming goods will tend to be highly inelastic as consumers will generally purchase the same quantities irrespective of the price. Using our previous example of increasing the price from £4 to £5, then the value in this example of PED would be given by:

$$\text{PED} = \frac{\%\Delta D}{\%\Delta P} = \frac{0\%}{25\%} = 0$$

Zero is therefore the lower boundary of price elasticities values on our common scale. Note however that these upper and lower boundaries only relate to own price elasticity of demand and not the other types of elasticity outlined later. To complete the set, a final example would be where a relative change in price is exactly matched by the same relative change in the quantity demanded. This is known as unitary price elastic demand and is shown in Figure 4.3.

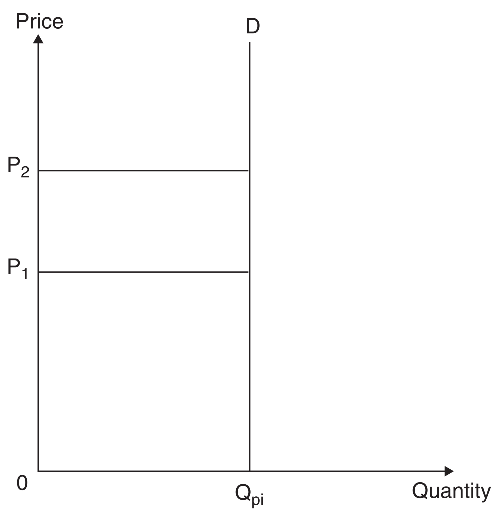


Figure 4.2 *Perfectly price inelastic demand*

Figure 4.3 *Unitary price elastic demand*

In this diagram the simplified method of drawing demand curves as straight lines has been relaxed, as in simple terms unitary demand cannot be shown on a straight line. This is because the level of price elasticity will vary along different points on any straight line; however, in this case it is the same across the whole curve.

Using again the example of a price increase of £4 to £5, then rather than demand falling to zero (perfectly elastic), or remaining unchanged (perfectly inelastic), demand falls in direct proportion to the change in price. Thus if the quantity demanded was say 100 units at £4, then the increase to £5 would produce a reduction in the quantity demanded of 20 per cent, i.e. the same proportionate change, hence demand would fall to 80 units. Just to confirm, price elasticity of demand under such a scenario would be given by:

$$\text{PED} = \frac{\%\Delta D}{\%\Delta P} = \frac{(80-100)/100}{(5-4)/5} = \frac{-20\%}{20\%} = -1$$

To quickly summarise the main issues surrounding price elasticity of demand, this measures the relative level of consumer price sensitivity. If consumers are relatively price sensitive, then market demand will be relatively elastic; if consumers are not price sensitive, then market demand will be relatively inelastic. It is measured on a quantitative scale, with values ranging from zero to negative infinity which allows elasticity values to be divided into inelastic demand, unitary demand and elastic demand.

Determinants of price elasticity of transport demand

If that is what price elasticity of demand is, then what are the factors that affect the extent to which consumers in the market are price sensitive or not, i.e. the determinants of price elasticity of transport demand? In summary these can be grouped under three headings; however, some confusion can arise between determinants of price elasticity and the actual determinants of demand itself, such as the price, income, the price of substitutes and complementary goods and so on. The important distinction is that the determinants of demand are the factors that determine the quantity of goods or services that consumers will purchase at a given price (and as such represent the conditions of demand). The determinants of price elasticity of demand on the other hand are those factors that determine the extent to which the quantity demanded will change in reaction to changes in the price. These are therefore the factors that determine the extent to which consumers in the market are price sensitive.

The three basic determinants of price elasticity of demand for transport services are:

- The number and closeness of alternative modes of travel (substitutes)
- The proportion (and timing) of disposable income purchased on the mode of travel
- The time dimension.

The number and closeness of alternative modes of travel (substitutes)

The higher the number of alternative modes available and the closer they are in meeting the same basic travel need, the higher will be the price elasticity for a particular transport service. If I use the Blue Bus Company's service to travel to work, and Blue Bus should increase its price, then I am far more likely to switch to an alternative mode if that alternative is readily available. If the Red Bus Company's service left from the same stop one minute later and took the same journey time, then for this particular trip that would be an almost perfect substitute for Blue's service as I could easily make the switch to Red Bus. If however Blue's service was the only one available to me, then the only alternatives I would have would be to either pay the higher fare or not make the journey, i.e. quit my job! This, for example, is one reason why the price of petrol in particular localities varies very little from petrol station to petrol station; there exists a high number of available substitutes (Esso, BP, Shell, Jet, Morrisons, Sainsbury etc etc) and it is an identical product that is being sold. Hence there is a very high level of substitutability, and if one company was to increase its price then consumers can easily switch to one of the other providers.

Proportion of disposable income spent on the mode of travel

We have seen income already as a determinant of demand, i.e. the quantity purchased. The proportion of income spent, however, is also a determinant of price elasticity of demand. It refers however to the proportion of disposable income as opposed to net income, i.e. income after tax has been paid. In simple terms, the higher the proportion of disposable income spent on the mode of travel, then the higher the price elasticity of demand. If consumers are about to part with a large part of their income on any good or service, then they are likely to shop around first to ensure they are getting the best deal. No one however would shop around before purchasing a chocolate bar because it is simply not worth it – the amount saved is likely to be marginal and certainly less than the cost involved (i.e. time) of ensuring that the lowest priced chocolate bar has been purchased. Generally speaking, within transport services the proportion of income spent in most (but not all) instances will be relatively small, although these will add up to significant amounts. That does raise the question of just what proportion of income is spent on transport activities. This is shown in Figure 4.4, which outlines the relative percentages of consumer household expenditure on various goods and services for the UK in 2007.

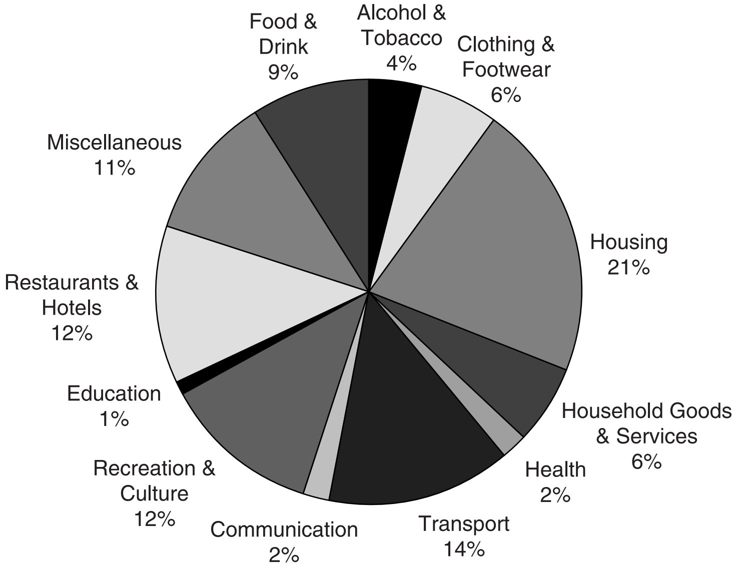


Figure 4.4 *Shares of household final consumption expenditure, 2007*

Source: Drawn from ONS Statistics (ONS, 2008)

This gives the percentage breakdown of consumer expenditure by type of good or service purchased. It is therefore expenditure net of taxes and savings, i.e. all monies actually spent. Thus for example expenditure on Education and Health services are very low, only accounting for 3 per cent of the total, because for most households these are provided by the state and funded out of general taxation. The first point to note is the relatively high level of expenditure on transport. What is perhaps most surprising is that more is proportionately spent on transport than on food, recreation and clothing. In fact, only housing has a higher percentage of disposable income spent on it. It should be remembered however that this is for the 'average' household and there will be considerable variations in household structure. Large-family groups for example may be expected to spend a lower proportion on transport in relation to other goods and services (particularly food!), whilst single-occupier households would spend a relatively higher percentage on transport. It should also be noted that this takes no account of the actual income bracket of the 'household'. Other statistics from the Department for Transport (DfT, 2005) strongly suggest that lower-income groups spend a higher proportion of their income on transport services. This is for the simple reason that in a market-based economy most households need to earn an income, and thus transport costs as such are an unavoidable expense of earning that income (i.e. a derived demand), irrespective of the level of income ultimately earned. Putting these two issues together regarding household structure and income levels, there is no such thing as 'the average' household, as no household type could be described as 'typical'. Figure 4.4 however does give a very general idea as to the proportion of income that is spent on transport.

Relatively speaking, therefore, in a developed economy a large proportion of income is spent on transport. Most of this however will relate to expenditure on private vehicles. Using figures from the DfT (2007), the 'average' household owns 1.11 cars (note the point above about the 'average' household!). Cars new and old tend to be a major drain on household finances. We may expect therefore that taken on its own, demand for private motoring should be fairly elastic; however, from the limited evidence presented later in Case study 4.1, that is very much not the case. If we consider housing, interest rates have a major impact on the housing market, for the fact that a high proportion of household income is spent on housing, thus house buyers are very price elastic. Why therefore is this not the case for the second largest item, transport? The simple fact is that it is the other determinants of elasticity that are over-riding this effect. Hence it is not so much the number, but very much the 'closeness' of substitutes to the car that are generally perceived to be few in number. Not only that, however, what this stresses are the first two sentences of this book – 'Most individuals, whatever their walk of life, have a basic need to travel from one location to another. Modern life as such is structured around accessing goods and services that lie outside of the immediate vicinity of the home.' Transport is therefore essential, and in the main that transport comes in the form of a car, because the car is viewed as the most convenient way of doing it and is thus seen as a necessity of modern life.

A second point is that it is not the actual expenditure that is important, but rather the perception of that expenditure that matters as ultimately it is perceptions that affect behaviour. Unlike housing where a large proportion of income is spent in a single large amount, i.e. the monthly rent or mortgage payment, transport expenditure in many cases is far more scattered and, outside of car purchase, tends to be in relatively small amounts. Thus whilst spending a pound each way on the bus journey to work is a very small proportion of income, over the course of a month or a year this adds up to a fairly significant total. Thus the actual proportion of income spent on transport is likely to have less of an impact on the elasticity of demand than say for housing, as the perception of that expenditure will be to considerably underestimate it – ask any individual their monthly rent or mortgage payment and they will give you a very accurate figure, ask them how much they spend a month on transport and they will almost certainly understate the total.

Time

The final determinant of price elasticity is the time factor. In many instances in the short term individuals are tied in to using a certain company's products or services; however, time may bring about a change in behaviour. To use our Blue Bus Company example from above, while this was the only service in the short term I would have little choice but to use their service, hence price elasticity of demand would be relatively inelastic. In the longer term, however, I may decide to purchase a car or alternatively another bus company, such as Red Bus, may decide to start up a competing service. In this case demand would be more elastic. Time therefore is an important dimension in determining price elasticity of demand as elasticity can vary between the short and long run. Over a longer period of time, habits can change, thus there will almost always be a difference between long- and short-run elasticities, with the former almost certainly more elastic.

Also closely related to the time dimension is the essential nature of the journey to be undertaken. An essential journey, such as where commuters have to travel into the centre of a city each day for work or business purposes, will have relatively inelastic demand, as there is little choice but to make the journey at that point in time. With non-essential journeys on the other hand, such as a family day-out to the countryside, there is a far higher degree of flexibility with regard to when the journey can actually be made, and hence this would be more price elastic. The extent to which a particular journey can be deemed to be essential or not is therefore related to time as essential journeys have a very narrow time frame within which they need to be undertaken, and hence this also affects the price elasticity of demand.

Case study 4.1 Practical estimations and reviews of own price elasticity of demand for transport services

We have outlined the theory behind price elasticity of demand; however, there has been much research carried out into the actual values of transport elasticities. This can however be a particularly confusing area of study, as most studies provide different answers that in many cases are in complete contradiction of one another. In simple terms, therefore, there is no definite answer to general questions such as 'What is the price elasticity of rail services?', as it depends upon the particular characteristics affecting a particular rail market. Pucher and Kurth (1995) highlight that demand elasticities will vary between different locations, different modes, times of the day and so on. In simple terms, consumers in different situations will respond in different ways to changes in the price of any of the other determinants of demand. There is therefore no general value attributable to all situations in all locations, although there is a common consensus that public transport demand is relatively inelastic (Pucher and Kurth, 1995). Nevertheless, an overview of some of the estimations that have been derived for price elasticities in transport is useful to examine the practical issues involved and to reinforce the theory outlined above.

The starting point when considering any research into (own) price elasticity of demand for transport services is Professor Goodwin's review and assessment of around 180 elasticity studies for car and bus travel throughout Europe (Goodwin, 1992). For urban bus travel, the review calculated an average value of price elasticity of –0.41, but indicated a wide variation between short- and long-term impacts. These are reported fully in Table 4.1.

Table 4.1 *Urban bus price elasticities broken out by time period*

Time period	*Average elasticity*
Around 6 months	–0.21
0 to 6 months	–0.28
0 to 12 months	–0.37
Over 4 years	–0.55
5 to 30 years	–0.65

Source: Goodwin (1992)

From Goodwin's review, a very clear trend emerges with regard to price elasticity and time – over time demand becomes more elastic. Whilst this is consistent with the theory outlined earlier, the range of values found, from –0.21 in the very short term to –0.65 in the very long term, do underline the importance of the time dimension as a determinant of the price elasticity of demand for transport services. What, however, do these values mean? As a basic illustration, consider the price elasticity of demand equation given below:[1]

$$\text{PED} = \frac{\%\Delta D}{\%\Delta P},$$

then for the period zero to 6 months:

$$\text{PED} = \frac{\%\Delta D}{\%\Delta P} = -0.28$$

Thus a 10 per cent increase in price will produce a 2.8 per cent decrease in demand, i.e. demand in the short term is highly inelastic. Over time, however, elasticity increases. Thus over the following six months, demand would fall by another 0.9 per cent, and over the next three years after that by a further 1.8 per cent. Thus over that whole 4-year period, demand would have fallen by 5.5 per cent. Goodwin's review also indicated that over time elasticity values for transport have been increasing, hence consumers of transport services have been becoming more price sensitive over time.

Goodwin's research may be considered to be slightly dated now, particularly given the time period reviewed. Examination of more recent studies into the subject however confirms that elasticity figures have increased slightly over the intervening period. These are best summarised in TRL (2004), a summary of which has since been published in Transport Policy under Paulley *et al.* (2006), who conducted an extensive review and study of public transport elasticities. Their research team concluded that with regard to bus fare elasticity, broadly speaking average values of –0.4 in the short run, –0.55 in the medium term and –1.00 in the long run could be considered to be the norm, slightly higher than Goodwin's 1992 values.

As both the TRL and Goodwin reviews are overviews that derived average elasticities from the literature reviewed, what they do not communicate is the high degree of variability between most elasticity studies and that each finding only applies to that particular situation. This can be illustrated by García-Ferrara *et al.'s* (2006) study of public transport in the Madrid Metropolitan Area. The authors calculated price elasticities using monthly data over the time period January 1987 to December 2000. They compared two of the four basic modes available, namely the Metro and the Municipal Bus Company services, by ticket type – single and ten trip tickets for bus and metro and a regular travel card covering all modes for adults and juniors. The actual elasticity values found are given in Table 4.2.

Table 4.2 *Elasticity values, Garcia-Ferrara* et al. *(2006)*

Ticket type	*Single*	*10 Ticket*	*Travel card*
Bus	–1.06	–0.52	
Metro	–1.03	–2.17	
Adult			–0.01
Junior			0.56

From Table 4.2, in simple terms single fares were found to be generally unitary elastic, the 10 ticket metro ticket highly elastic whilst the 10 ticket bus fare was relatively inelastic. Finally the adult travel card was almost perfectly inelastic, and interestingly the junior travel card with a value of +0.56 off the end of our scale! What the last value means is that as the price increased for the junior travel card, demand increased. This is a classic case of a Giffen good highlighted earlier in the chapter; in this case the increase in price probably raised awareness of the junior travel card and hence led to more people buying it. Table 4.2 illustrates the very high degree of variation in the elasticity values derived, and suggests that the relatively high values found for the single and 10 journey tickets were primarily due to the travel card option. This indeed was the case, as the backdrop was one of a transport authority that had actively pursued a policy of encouraging travellers, through the price mechanism, to use the travel card in preference to single and multiple tickets. By 2001, for example, 60 per cent of trips were made using the travel card. What this shows is that elasticities can vary considerably between different settings, policy contexts and different ticket types. In this example the –1.06 value for the single bus fare could never be generalised to other contexts as this value is only relevant in this particular context.

As demand for transport is a derived demand, elasticity has also been found to vary depending upon the purpose of the journey. The normal division is made between business, commuting and leisure trips. Research into rail fare elasticities for example (ATOC, 2002) found values of –0.2 for business, –0.3 for commuting and –1.0 for leisure, which underlines the greater flexibility involved in the last purpose mentioned. Other studies, such as White (1981) and Grimshaw (1984), have examined the impact of the distance travelled on the price elasticity of demand. Not surprisingly, for bus journeys elasticities have generally been found to increase the longer the journey under consideration. White (1981) for example found that a price elasticity value of –0.4 for medium-length trips doubled to –0.8 for longer-length journeys. This however is not simply a function of distance, but rather reflects the magnitude of say a 10 per cent rise on a £1 fare compared with that of a 10 per cent rise on a £20 fare, i.e. the key determinant is the proportion of disposable income spent on the transport. Furthermore, longer journeys are made less frequently, thus people are more likely to shop around prior to purchase than for shorter distances. They also tend to involve leisure rather than business travel. Note also that since most of that research was published (in the mid 1980s), price elasticity for longer distances has probably become even more elastic, as the rise of the internet has made it easier for individuals to compare prices and the relative merits of different alternatives.

However, as before, the issue is not as straightforward as it may at first appear. Preston (1998), for example, in an examination of the effect of distance on price sensitivity for rail services, found that whilst the pattern was not particularly clear, overall it appeared that elasticity decreased with distance, hence became more inelastic. This effect for rail services has also been found by other research in this area. This led Paulley *et al.* (2006) in their review to cite the 'tapering' effect of rail fares as the main reason behind this effect, where the unit cost per kilometre travelled falls the further the distance travelled. As a full explanation however this is not entirely convincing, with a possible further reason being that over longer distances the number of real viable alternatives to rail (e.g. bus and car) may be far fewer. As a consequence, individuals are less price sensitive to changes in the price of long-distance rail journeys.

Finally, whilst earlier we saw that over time elasticities would be expected to increase over the longer term, the one good that appears to buck this trend is the elasticity of petrol, with some studies finding a larger short run than long run effect. For example, research by Barns (2002) into the effect of price changes on demand for petrol derived elasticity values of

−0.195 for the short run and −0.065 for the long run. Some other studies have produced similar results, with Puller and Greening (1999) finding a stronger initial reaction to petrol increases in the quarter of the price rise, but in subsequent quarters behaviour in terms of vehicle miles travelled returning to where it was before. This suggests that after the initial price increase, there is a general drift back towards the original position. Khazzoom (1991) (cited in Barns, 2002) argues that initially a price rise will reduce short-run demand, but why travel behaviour returns to the original position in the long run is due to consumers switching to vehicles that are more fuel efficient. Note also in Barns' study with such low elasticity values that an increase in the tax on petrol in order to attempt to limit car use would have very little impact.

As said at the very beginning of this case study, research into this area can be confusing and contradictory. A basic understanding of the issues involved however is vital to understanding the effect of using the price mechanism to influence travel behaviour. To summarise and finish, values of around −0.4 and −0.8 can be taken as 'ball park' figures for short- and long-run public transport own price elasticities; however, these can vary considerably under different contexts.

Price elasticity, total revenue and demand curves

Before going on to look at cross price elasticity, it is worthwhile to first consider further the significance of price elasticity in the analysis of transport markets. The preceding section has shown it to be a mechanism for assessing the extent to which consumers will react to changes in the price or other demand determinants of transport services. Does price elasticity of demand however have any further practical implications? The answer is yes, but first requires a simple lesson in algebra before examining it.

Put in simple terms, a company's total revenue from selling a good or service can be found by multiplying the quantity sold by the price of each unit sold. If for example 100 units are sold at £5 each, then total revenue would simply be £500. In a more generic form, this could be written as P * Q, where P is the price (£5) and Q is the quantity sold (100 units). This can be illustrated using demand curves, as is done in Figure 4.5.

Basically, the area of the rectangle outlined by points 0, P_a, a and Q_a shown in light grey in Figure 4.5 is the total revenue received from selling at price P_a. Using the example of a £5 selling price from above, then the area would be given by the length (100 units) times the breadth (5 pounds) and would represent the total revenue, £500. If the price was to increase to P_b, then we could show the gain and loss in revenue such a price change would bring about. If the firm was to increase price, it would sell less units (basic law of demand), but would receive more per unit sold, hence the overall impact this would have upon total revenue would not be known. This is illustrated further in Figure 4.6.

Beginning at price P_a (examined above), the company sells quantity Q_a, and the rectangle outlined by the area 0, P_a, a, Q_a represents the total revenue to the firm. This is just what was shown in Figure 4.5. Using the same logic, however, if the firm was to sell at price P_b, it would sell quantity Q_b and the total revenue would be given by the rectangle outlined by 0, P_b, b, Q_b. What you should be able to see is that there is a common area shared by these two different scenarios. That is the cross-hatched area above and labelled unimaginatively as the 'Common Area'. In effect, that proportion of revenue will accrue to the firm if it applies price P_a or price P_b. If however the

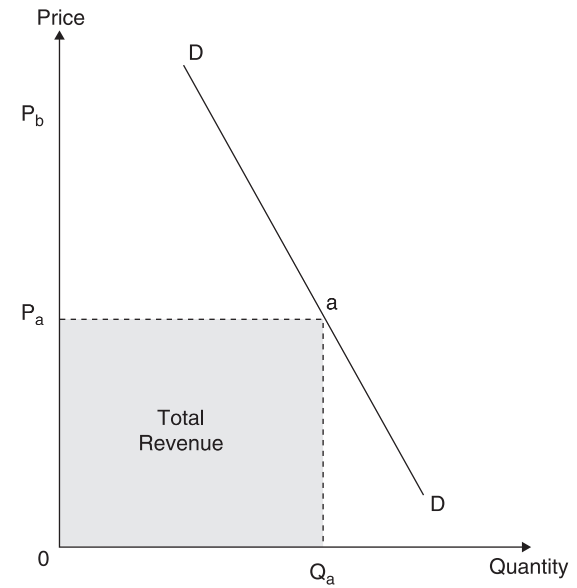


Figure 4.5 *Illustrating total revenue using demand curves*

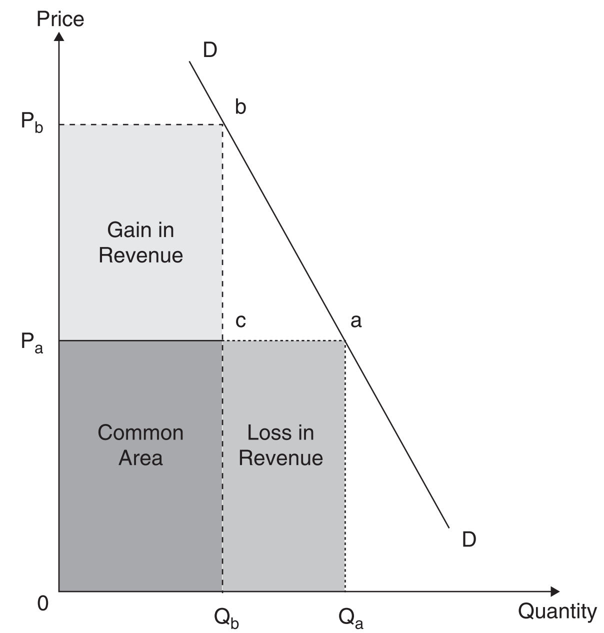


Figure 4.6 *Illustrating changes in total revenue using demand curves*

firm was to increase its price from P_a to P_b, then it would not receive the revenue in the area labelled 'Loss in Revenue' as it would be selling less units overall. This 'loss' however would be offset by a gain in the revenue received for each unit sold, labelled 'Gain in Revenue' in Figure 4.6. The key issue to be examined is the balance between the gain per unit sold and the loss from selling less units. You should be able to see that in this example the area of the gain is greater than the area of the loss. Hence increasing price from P_a to P_b will lead to an increase in total revenue. This is because demand is relatively inelastic. If however this example had concerned a cut in the price from P_b down to P_a, then total revenue would actually have decreased.

At this stage, the effect on profitability is unknown, because the supply side of the market (specifically the effect on costs) has not yet been examined. For example, if in the previous example the price had been cut from P_b to P_a, then this would have decreased total revenue. However, the potential effect on unit costs from increasing supply from Q_b to Q_a is unknown, thus nothing can be said about profitability. If unit costs were for example to reduce significantly, then such a price cut may reduce total revenue but actually increase total profit.

To further illustrate, consider the graph shown in Figure 4.7 where demand is relatively elastic.

In this example, a rise in price from P_a to P_b will reduce demand from Q_a to Q_b, with the loss in revenue given by the area Q_b, c, a, Q_a and the gain shown by the area outlined by P_a, P_b, b, c. In this case, therefore, the increase in price has led to a decrease in total revenue. Note again that if the price change had been the other way around, then total revenue would have increased.

Whilst only affecting total revenue and not profit, this does nevertheless have important implications in many transport markets. Reconsider the quote from the Competition Commission regarding the Southend–London rail route on page 65, as it specifically states that if demand is

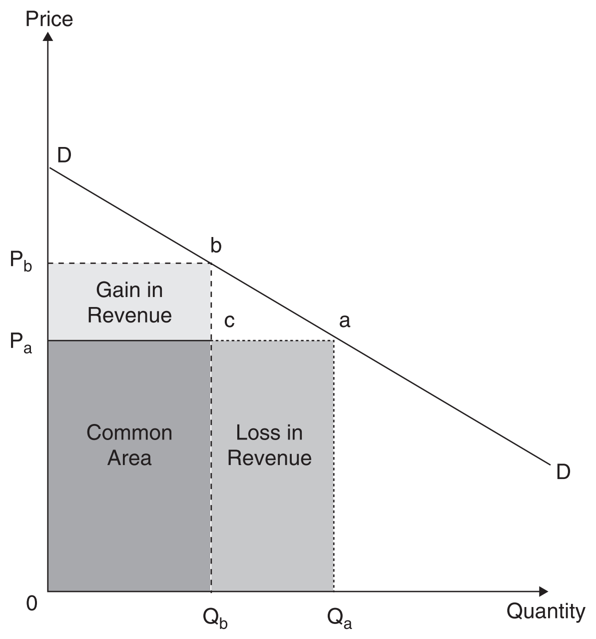


Figure 4.7 *The effect on revenue of price changes of a relatively elastic good*

inelastic, i.e. less than negative one, then increasing the price will increase both revenue *and* profits. In this example why this is the case is that the level of output will not change, as train-operating companies are contracted under the terms of the franchise to run at specific frequencies. Thus if the level of output will not change, it follows that the level of costs will not change either. Therefore in this instance, increasing revenues equates to increasing profits. This is not an unusual occurrence in many public transport markets, where certainly within the short run a network of services is operated regardless of small changes in demand, and thus any change in revenue directly impacts on profits. This idea is considered further in Exercise 4.2 at the end of the chapter.

A final thought on price elasticity of demand

As shown in Case study 4.1, the demand for urban bus travel is relatively price inelastic, with Goodwin (1992) calculating an average value of around –0.4. This indicates that a 1 per cent increase in fares will lead to a 0.4 per cent decrease in demand. In terms of total revenue, therefore, a fare increase would increase the total revenue take, as the revenue lost from the reduction in passengers (0.4 per cent) will be more than offset by the additional revenue gained from the fare increase (1 per cent). If this is the case, therefore, why don't operators simply keep increasing the fare? Given our knowledge of theory to date, plus if it is assumed that bus companies operate essentially the same network and services, costs would remain unchanged whilst revenue would increase, thus the increase in revenue would be all profit. Such actions would be consistent with the underlying assumption of profit maximisation.

The insight into research on price elasticity of demand for transport services however has already partially answered this question by drawing a distinction between short-run and long-run elasticities. Whilst in the short run such an action by operators would increase profits, in the longer run some passengers would find alternative modes, hence revenue would fall. That said, Goodwin's (1992) value for long-run elasticity was –0.65, i.e. still price inelastic. On its own this would still suggest that operators should increase the price, as in the long run this would increase revenue and given the assumption of an identical network of services, increase profits. This issue can be resolved by examining the other determinants of price elasticity of demand, and firstly the proportion of income spent on the good or service. As prices increase, so also does the proportion of income spent on travel, and hence elasticity would increase, even in the short run. A second determinant that would be likely to change with such action would be the number and closeness of substitutes. As prices increase, this would present an opportunity for new operators to enter the market and hence compete away the higher profits now being achieved, which in the longer term would almost certainly be more detrimental to the existing operator. The market itself therefore would regulate against such action. The point to stress is that although demand for a certain good or service may be inelastic (hence suggesting a price rise), there are other factors (the determinants of price elasticity of demand) that also need to be considered in any such evaluation. These will determine the extent to which 'the market' regulates against such action.

CROSS PRICE ELASTICITY

Most of the concepts examined under own price elasticity of demand also apply to the other types of elasticity of demand. Rather than the sensitivity of consumers to changes in price, however, it is the sensitivity of consumer demand in relation to a change in one of the other determinants of demand, whether that be income, price of other goods, advertising and so on. Two of these are formally examined here, but these ideas apply to any of the determinants of demand.

The first to be examined is known as cross price elasticity of demand. This is a measure of the effect of a change in the fares or rates of one mode of transport or transport operator on the demand for the services of another mode/transport operator. Again this is assessed quantitatively, and formally calculated as:

$$\text{Cross price elasticity} = \frac{\text{Percentage change in quantity demanded of service A}}{\text{Percentage change in price of service B}}$$

Or using a shortened formula:

$$\text{CPED} \quad = \quad \frac{\%\Delta D_A}{\%\Delta P_B}$$

Where: CPED = cross price elasticity of demand
D_A = quantity demanded of service A
P_B = price of service B

Examination of cross price elasticity of demand therefore involves examining two goods or services. Within the transport sector, these services could be examined at different levels. This could be the cross price elasticity between two different transport modes, such as the train versus the car. Secondly, cross price elasticity could be calculated within the same mode, such as National Express's East Coast Glasgow to London rail service versus Virgin's West Coast Glasgow to London rail service. Finally, it could be examined within a single operator if they offer a variety of fares for the same journey but different standards of service. For example a train operator could examine the quantity demanded of their standard service versus the first class fare charge. This would assess the extent to which changes in the price of one of the services offered (first class) impacts upon demand for the other (standard class), and hence gives the elasticity between different market segments.

Cross price elasticity of demand also allows a distinction to be made between substitute goods and services and complementary goods and services. If the effect of a price increase in one good has a positive effect in terms of the demand for another, then these two goods or services would be considered to be substitutes. For example, say a reduction in the subsidy paid to rail operators caused an increase in the price of rail services, then what may be expected to happen in the gas market is shown in Figure 4.8.

This is the standard demand and supply curves from Chapter 3, with the reduction in subsidy to rail operators effectively representing an increase in costs. This causes a shift in the supply curve to the left and eventually leads to an increase in the price (P_{R1} to P_{R2}). As in many locations bus

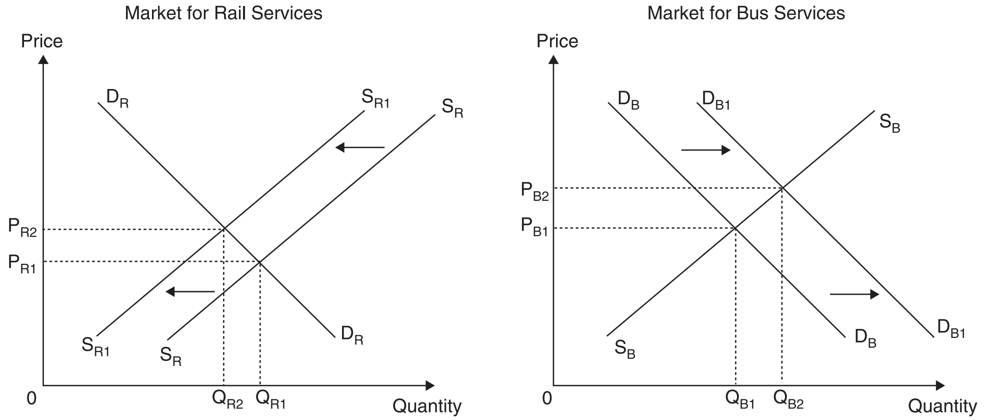


Figure 4.8 *Cross price elasticity of demand, substitutes*

services are an alternative to rail travel (i.e. a substitute), then this increase in the price of rail will cause an increase in the demand for bus services. This is shown on the right hand diagram in Figure 4.8 by a shift of the demand curve to the right from D_B to D_{B1}. You should be able to clearly see that in terms of the price of rail travel, P_{R2} is greater than P_{R1}, thus when this difference is expressed as a percentage this will produce a positive value, i.e. a price increase. Likewise, in terms of the bus market, the quantity traded of Q_{B2} is greater than Q_{B1}, thus again when expressed as a percentage will produce a positive value, i.e. a quantity increase. When these values are put into the cross price elasticity equation we obtain:

$$\text{CPED} \quad = \frac{\%\Delta D_B}{\%\Delta P_R} = \frac{^{+}ve}{^{+}ve} = {^{+}ve}$$

Where:

$\%\Delta D_B$ = percentage change in quantity demanded of bus services
$\%\Delta P_R$ = percentage change in the price of rail services
^{+}ve = a positive value

As a positive value is divided by a positive value, the net outcome would be a positive CPED figure. Thus for substitute transport services, cross price elasticity will always be positive. As the price of one service rises, demand for the alternative service also rises and vice-versa. The greater the degree of substitutability between the two services being compared, then the higher the value cross price elasticity will be. Note however that unlike own price elasticity of demand, there is no particular significance attached to the value of 1 and there are no upper or lower limits to the scale.

By the same logic, the cross price elasticity of demand will be negative for goods and services that are complements. Consider the following example of the price of cars and the market for petrol. If the cost of manufacturing motor cars was to rise, then this would cause an increase in the price of cars and a reduction in the level of quantity demanded. If there are less cars on the road, then less petrol will be required, hence there will be a decrease in demand for petrol. These are illustrated in Figure 4.9.

Again, this is illustrated by standard demand and supply curves, with the increase in the cost of manufacturing motor cars shown by a shift to the left of the supply curve and resulting in an increase in the price (P_{C1} to P_{C2}). As cars and petrol are consumed at the same time, this increase in the price of cars changes the market conditions for petrol, causing a decrease in demand, as shown on the right in the market for petrol by a shift in the demand curve to the left. As with above, you should be able to see that in terms of the price of cars, P_{C2} is greater than P_{C1}, thus when the difference is expressed as a percentage, this will be positive. This time, however, in terms of the quantity traded of petrol, Q_{P2} is less than Q_{P1}, thus when expressed as a percentage this produces a negative value. As above, when these values are put into the cross price elasticity equation, we obtain:

$$\text{CPED} \quad = \frac{\%\Delta D_P}{\%\Delta P_C} = \frac{{}^{-}ve}{{}^{+}ve} = {}^{-}ve$$

Where:

$\%\Delta D_P$	=	percentage change in quantity demand of bus services
$\%\Delta P_C$	=	percentage change in the price of rail services
${}^{-}ve$	=	a negative value

As a negative value is being divided by a positive, this produces a negative figure. Thus for complementary transport services, cross price elasticity will always be negative. As the price of one service rises, demand for the complementary good or service will decrease and vice-versa. Again the higher the negative value, the more the two goods are interdependent. Where the value is around zero however, this indicates that the two goods are completely independent, i.e. neither substitutes nor complements.

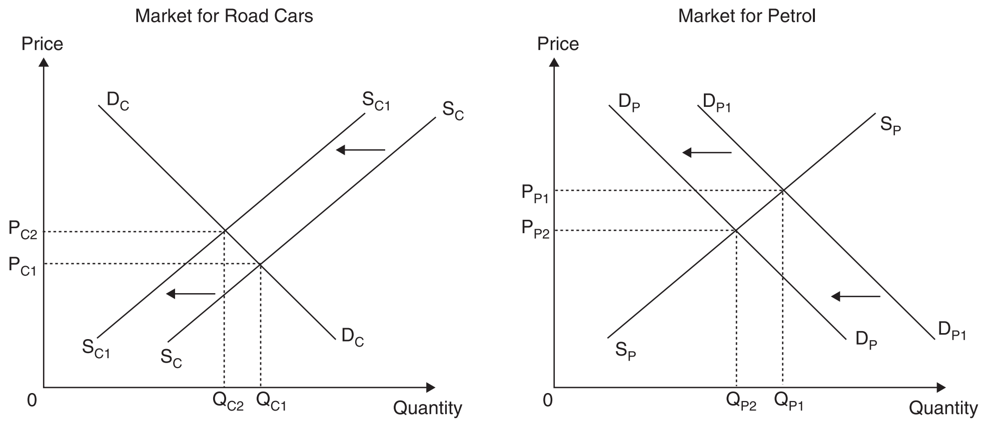


Figure 4.9 *Cross price elasticity of demand, complements*

To summarise, cross price elasticity of demand measures the interdependence of two modes of transport or services. Where this is positive, these are substitute services, with higher values indicating closer substitutability between the two modes being examined. Note also that this partly ties in with own price elasticity of demand, as other things being equal, if two products have a high cross price elasticity of demand then by implication own price elasticity should be highly elastic. This is because each of these services has a very close substitute available, which was the first determinant of price elasticity of demand examined. Complementary goods on the other hand will produce negative cross price elasticities, as these goods/services are consumed at the same time, thus a rise in the price of one will produce a decrease in the demand for the other.

Case study 4.2 Issues in cross price elasticity of demand

This case study takes a closer look at cross price elasticity and highlights a number of important issues surrounding the topic. It uses three research studies into cross price elasticity to illustrate these ideas, although many others exist. This should allow us to explore the topic further and as we will see, whilst the equation for cross price elasticity may appear to be fairly straightforward, working with some real life examples should help to bring certain aspects into perspective. We begin with Oum *et al.*'s (1990) review of around 70 studies relating to both passenger and freight transport with regard to both own and cross price elasticities. Here we are only concerned with cross price elasticity, thus a summary of the results of two of the studies examined, with the first set concerning freight presented in Table 4.3.

Table 4.3 *Cross price elasticities freight transport demand in Canada, mid range values, summary of Oum* et al. *(1990)*

Mode	*Truck*	*Rail*	*Waterway*
Truck	–	0.127	–0.100
Rail	0.020	–	0.175
Waterway	0.005	0.710	–

Source: Adapted from Oum *et al.* (1990)

Note: the change in quantity A is shown on the rows, hence for example the truck-rail figure of 0.127 is the percentage change in truck haulage as a result of a price increase in rail freight.

The first point to note is that both these figures and the ones shown later in Table 4.4 relate to Canada, and this will have implications on the interpretation of the findings, particularly the geographical aspects of the country and the sheer distances involved. This will impact directly on the values shown, because as with own price elasticity, cross price elasticities will vary from market to market. For example, in an earlier study on Canadian freight, Oum (1989) found a mid range value of +0.16 for Rail-Truck, significantly higher than that shown in Table 4.3. The difference is that the earlier study only examined the interregional market, rather than the total market, and hence the two modes are more likely to be substitutes in the longer-distance sector of the market. A further point to note purely for reference, is that the review originally devised a subjective range of upper and lower values from the studies examined, hence to simplify the mid range point is shown in Table 4.3. Returning to the table, you should note that there is no 'symmetry' in cross price elasticity values, i.e. a comparison of rail-truck is not the same as a comparison of truck-rail. The difference is that in the former it is the effect of a change in the price of truck on the demand for rail services, whilst the latter examines the effect of a change in the price of rail on the demand for trucking services. There is no reason to believe that rail users, due to an increase in the price of rail services, would react in exactly the same way by switching to truck haulage as truck haulage users would react by switching to rail as a result of an increase in the price of road haulage. The two are quite different concepts and we will see a clearer example of this below.

In Table 4.3, the highest value at +0.710 is given for the Waterway-Rail comparison. The positive value indicates that these two modes are substitute goods, and if this value is put into the CPED equation, we obtain:

$$\text{Cross elasticity} = \frac{\text{percentage change in quantity demanded of service A – waterways}}{\text{percentage change in price of service B – rail freight}}$$
$$= 0.710$$

Thus using a 10 per cent increase in the price of rail freight as an illustration, this would result in a 7.1 per cent increase in the demand of water transport, underlining the apparent high degree of substitutability between the two modes. These two modes therefore would appear to be in competition with each other, but even so it should be said that this is a very large value for a cross price elasticity. Rail-waterway on the other hand shows a very much smaller figure, at 0.175, indicating less cross over to railways as a result of increases in the price of water transport. Given the geography of Canada and the fact that 93 per cent of domestic water transport is located in only four provinces, this makes sense. Thus whilst water is a substitute for the train, the train is far less a substitute for water transport. Another key point to note, however, is that cross price values will be dependent upon relative market shares, with those modes with higher market shares having lower cross price elasticities as the relative increase in demand will be lower. This is best illustrated by an example. Say 100 million tonne kilometres go by water and this represents 20 per cent of the market, and a 10 per cent increase in the price of water transport results in 5 million tonne kilometres shifting to rail. If prior to the price increase rail carried 200 million tonne kilometres and thus 40 per cent of the market, this would give a cross price elasticity value rail-water of +0.125, as the 10 per cent increase in the price of water transport would cause a 1.25 per cent increase in the level of rail freight. If then the price of rail was to increase by 10 per cent and as a result the same shippers moved their cargo back to water, the cross price value water-rail would be far higher at +0.256, which is almost double because rail has double the market. Thus the 5 million tonne kilometres that are switching between the two modes is far less of a proportion of total rail transport than it is of total water transport. The impact of this effect on our Canadian freight example is that just under twice as much freight tonnage goes by rail than water in Canada. Thus whilst this partly accounts for the difference between the two cross price values, it still strongly suggests that water transport is more of a substitute for rail than rail is for water.

The second set of figures relates to passenger transport, and these are shown in Table 4.4.

Table 4.4 *Cross price elasticities intercity passenger transport demand in Canada, mid range values, Oum and Gillen (1983)*

Mode	*Air*	*Bus*	*Rail*
Air	–	–0.015	0.025
Bus	–0.085	–	–0.340
Rail	0.295	–0.675	–

Source: Adapted from Oum *et al.* (1990)

Note again that quantity A is shown on the rows.

A far clearer picture emerges with these figures. In simple terms, there is little substitutability between air and bus, and it is only in the bus and rail markets that there appears to be a two-way degree of dependence between them. Interestingly, however, the negative sign in both cases indicates they are complementary goods. As this concerns intercity services, this is a surprising result, although may indicate that bus services feed into intercity rail services, and that this effect is far stronger than the direct competition between the two on intercity routes. The table also shows that while the plane competes with the train, the train does not compete with the plane. Put another way, a change in air fares has an impact on rail travel demand, but a change in rail fares has little effect on air travel demand. This is because whilst a decrease in the air fare may cause some rail passengers to 'trade up' to air travel, a decrease in the price of rail travel will not have the same effect of causing some air travellers to 'trade down' to rail.

Turning to public transport, given below are the results of a study undertaken by Gilbert and Jalilian (1991) estimated from a monthly time series that covered the period 1972 to 1987. This study examined own and cross price elasticities for the London bus and underground, with the short run elasticity values reported in Table 4.5.

Table 4.5 *Short run own and cross price elasticities, London bus and underground ordinary tickets, Gilbert and Jalilian (1991)*

	Prices		
Mode	*Bus*	*Underground*	*Rail*
Bus	–0.839	0.476	0.082
Underground	0.041	–0.355	0.160

Source: Gilbert and Jalilian (1991)

This also appears to be more straightforward than our previous freight example. Reading for the bus first of all, then again taking a 10 per cent increase in the average fare as an illustration, this in the short run would be expected to produce an 8.39 per cent fall in bus usage. This contrasts quite markedly with Goodwin's –0.41 figure from above, and would suggest that the demand for London buses is far more price elastic than in other parts of the country. This value however was one of the highest estimates seen in the compilation of this case study for the elasticity of London buses, hence may be overstating the 'true' value. Nevertheless, continuing with our 10 per cent example, this would also cause a 4.76 per cent increase in underground patronage. The bus-rail cross elasticity suggests that the impact of changes in rail fares is very small on the demand for bus services. Speaking in general terms, therefore, the bus own price elasticity is very high, the underground is a substitute for the bus and the effect of rail prices on bus usage is very small. This suggests that in London the bus and railways serve two distinct markets.

Having analysed the impact of a change in the fare of the bus, the results for the underground should not be unexpected, and this is indeed the case. For the underground, own price elasticity of demand is far smaller (almost half the value of the bus), and an increase in the underground fare would cause only a very small increase in patronage of the bus. For example, using our 10 per cent example from above would only cause a 0.41 per cent increase in bus patronage. The impact of rail fares on underground usage although larger than for the bus is still relatively small. This study again underlines the non-symmetrical nature of cross price elasticities, showing that whilst the underground is a substitute for the bus, the bus is not a substitute for the underground. We could also perhaps further conclude that the proportion of trips on the underground that could be considered as 'essential' to be far higher than for the bus. This is because an increase in the price would lead to a far lower decline in patronage on the underground than the bus.

Combined with the earlier section on research into own price elasticities, there is a lot in this section to digest, and certainly a lot that can lead to confusion – even basic issues such as the direction of the comparison is not always clear. The point of the exercise however was not to bewilder or even to give 'definitive answers' to transport elasticities, as none exist that can be applied to all situations. Rather, the point is to give a realistic feel for the issues surrounding transport elasticities, how these can be used to analyse transport markets and to focus thinking on these key topics. This last example underlines particularly well the issues involved, and hopefully has illustrated the significance of own and cross price elasticity when planning any transport system.

INCOME ELASTICITY

Income elasticity of demand is a measure of the responsiveness of demand to changes in income. As real incomes are likely to increase over time, income elasticity identifies those markets that may be expected to see an increase in demand in the future and those markets that perhaps, if other things remain equal, may expect to see a decline.

Income elasticity of demand is calculated as:

$$\text{Income elasticity} = \frac{\text{Percentage change in quantity demanded}}{\text{Percentage change in income}}$$

Or using a shortened formula:

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

Where: YED = income elasticity of demand
D = quantity demanded of the good or service
Y = income

By this stage you should notice that when any elasticity is being measured, changes in demand are always put on the numerator and changes in the determinant being examined on the denominator. Note also that income is always represented in economics by the letter Y, as similarly price is always represented by the letter P. Hence, YED stands for the income elasticity of demand. When income elasticity is measured, it is not the total income of consumers that is used in the assessment but rather disposable income, i.e. net of income tax.

As outlined in Chapter 3, transport is defined as a normal good, in that more is demanded at higher levels of income. It should follow therefore that income elasticity of demand should be positive for transport. A re-examination of Case study 3.1 from Chapter 3 should confirm that this is indeed the case, which showed that as national income (GDP) has risen, so also has the level of transport. With regard to individual modes, however, whilst the car, the train and air travel, all of which are generally used by higher-income groups, would be considered to be normal goods, this does not apply to all modes of transport or to all situations. The bus for example may be considered as an inferior good, in that demand will fall for this form of public transport as incomes rise. Again, Case study 3.2 would appear to verify this.

Does this mean therefore that because real incomes have been rising over time (and continue to rise), the demand for bus services will eventually disappear altogether? Whilst there are many products in the past that have now vanished from the market due to this effect, this is highly unlikely for bus travel, and again a distinction needs to be drawn between the short and the longer terms. In the short term, income elasticity for bus travel is negative, and hence as real incomes increase consumers will use other forms of transport, most notably the private car. For this to continue into the longer term, however, all other things would have to remain equal. With particular reference to the bus, it is extremely unlikely that this will be the case, as issues such as pollution, land use, safety and so on become more acute. Hence in the longer term the income elasticity of demand for bus services is likely to become less negative. This effect is something again that Case study 3.2 illustrated had already taken place in the case of London, where bus patronage has been rising since the mid 1990s.

Finally, it is worth highlighting that not only can income elasticity change over time but also that there are limits on short-term income elasticity because travel is limited by the amount of time available. It has been suggested that although business and leisure travel increases with income, there comes a point when the demand curve flattens out or even begins to fall because limits are placed on the time available for travel. What this means is that incomes have little effect on travel demand as in simple terms there is simply no more time available to use on the activity.

Case study 4.3 Issues surrounding income elasticity of demand

This is the last case study into the issues surrounding demand elasticities, and should be the most straightforward. Nevertheless, there are some important considerations when examining income elasticity of transport demand which this case will attempt to bring out, again with the assistance of real life examples. The first is what is known as the 'car ownership effect' (TRL, 2004). This occurs where the income elasticity for public transport is affected both directly by the increase in income that will be generating an increased demand for travel, but also by increasing levels of car ownership. Thus for example an increase in income will cause an increase in the demand for rail travel; however, this would be smaller than expected if everything else remained equal as it will be partially offset by increasing levels of car ownership. Some studies adjust for such effects whereas others do not. A second point is that whilst it may be expected that there will be a greater overall consistency in income elasticity of demand for transport than for either own or cross price elasticities, it will nevertheless still be to a large extent dependent upon the area and hence the transport market in which people travel. In London, for example, the car ownership effect will tend to be far smaller as opportunities for actually using the car are far more constrained, hence if not taken into account income elasticities for public transport will tend to be larger. As we will see, however, this is not the case for other major conurbations in Britain.

We first examine the effect of changes in income on bus demand. Table 4.6 presents values from Dargay and Hanly (1999), who examined demand elasticities in the British bus market and broke these down into ever smaller geographical areas. Hence national refers to the total, which is then broken down into around 11 regions and finally county and PTE areas (the 6 largest English conurbations outside of London) within these regions. They also importantly broke elasticity effects into short and long run periods. The short run was defined as anything less than a year, the long run anything over that.

Table 4.6 *Bus-income elasticities*

Journeys	*Short run*	*Long run*
National Data	0.00	–0.45 to –0.80
Regional Data	0.00 to –0.29	–0.64 to –1.13
County Data	–0.30 to –0.40	–0.60 to –0.70
PTE Data	–0.70	–1.60

Source: Dargay and Hanly (1999)

These values for income elasticity of demand for bus services confirm that the bus is considered as an 'inferior' good. This is because all are negative. Hence, as income rises demand for bus services falls. Using the short run PTE value of –0.70, this means that a 10 per cent increase in real incomes will lead to a 7 per cent fall in the use of the bus in the major conurbations outside of London. Again, notice that in all cases the long run effect is significantly larger than the short run, hence following an increase in income consumers will continue to switch to alternative modes of transport over time. In this study, the relative breakdown into the different geographical areas also makes interesting reading. Changes in income have the largest impact on bus services in the PTE areas, i.e. the largest conurbations in Britain, and the lowest impact on the regions. This may be directly related to usage, where the level of car ownership tends to be far higher in more sparsely populated areas, thus whilst strange to say, those not using the bus are already not using it and thus the effect of income on bus usage will be lower.

Turning to the train, very different results may be expected and the findings presented in Table 4.7 from a study by the ATOC (2002) confirm this to be the case.

Table 4.7 *South East Britain income rail elasticities (2002)*

Area	*Income elasticity*
South East to London	2.07
London to South East	1.90
South East Non London	0.89
Non London	0.11

Source: ATOC (2002)

The ATOC study was based upon relatively short journeys (of less than 20 miles/32 kilometres), and as expected all are positive; hence an increase in income would result in an increase in the demand for rail services. The variations between the different area/routes however are quite substantial. This is obviously strongly related to the economic importance and pulling power of the British capital, London. Trips into London therefore from the surrounding districts would increase the most with changes in income. In this case, however, some symmetry between the income elasticity of trips out of London to the South East and from the South East into London may be expected (as for example commuters have to go both ways!); however, the estimates have put the former at a slightly higher value. It is nevertheless worth remembering the basic formula for income elasticity of demand, and hence a 5 per cent increase in incomes in the south east would lead to a 10.35 per cent increase in rail travel from the south east to London, which represents a massive impact. Outside of the south east, however, the effect of rising incomes on the demand for rail travel is far less pronounced, which may be related to a greater choice of alternative modes, particularly the car, in those areas. That said, the disparity between the south east and the rest of the country would appear to be overly stated, with the last figure appearing to be unrealistically low (TRL, 2004). Further research by TRL (2004) found this value to be +0.41 for non PTE areas, which would appear to be more realistic.

This case has examined the impact of changes on income on the demand for transport. Despite initial expectations in the introduction of a higher level of consistency in values across markets, the actual case study does not appear to have borne this out – long run bus income elasticity values ranged from –0.45 to –1.6 and rail showed an even higher variation between markets from +0.41 up to +2.07. This again reflects different market conditions, and hence the effect of an increase in income will be different across these markets. Generally speaking, in highly densely populated urban areas impacts on rail transport will tend to be strong in an upward direction, whilst in less populated areas the relatively higher car ownership levels will tend to dominate and consequently income elasticities for public transport as a whole are likely to be considerably lower.

One final thought on this case study is to return to the question posed before – with rising real incomes, will the bus vanish as a mode of transport? What current income elasticity values, even those relating to the long run, are picking up is that if real income levels increase at present rates, then the overall demand for transport will increase and this will not be by the bus. The final thought is that in many urban areas, if mobility levels do considerably rise, then the bus, whilst space efficient, will not be able to satisfactorily cope with the rise in demand, and other more efficient 'movers of the masses' will have to be introduced. This of course refers to light rail and metro systems and hence in some areas, despite the earlier proposition, the bus will indeed die out as a mode of transport.

CHAPTER SUMMARY AND REFLECTION

In this chapter we have examined the elasticity of demand of consumers. Three types of elasticity relevant to the transport sector have been outlined, namely own price, cross price and income elasticity, although the elasticity of any of the determinants of demand can be assessed using the same principles. Elasticities are measured quantitatively with the change in demand on the numerator and the change in the determinant being examined on the denominator. The main determinants of own price elasticity were examined and a practical illustration on the size of such values showed that there are no generic values for the elasticity of public transport services, as how consumers will react to price changes will vary from one situation and one market to another. Ball park values of –0.4 for the short run and –0.8 for the long run however would appear to be reasonable. Both cross price and income elasticities also showed the same level of variation from one situation to another, similarly reflecting differences between markets.

Demand elasticity will feature in subsequent chapters. We have already seen that elasticity values vary from market to market, and this is primarily due to the number and closeness of substitutes in these markets. Market structure, therefore, has a big impact on demand elasticity. This will be considered further in Chapter 6; however, the next chapter examines the supply side of the market and the issues surrounding the cost of providing the service.

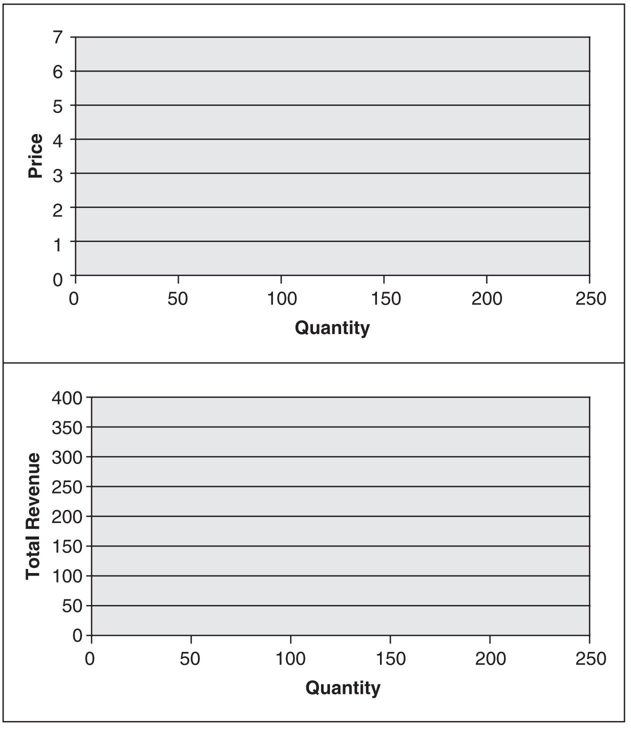
CHAPTER EXERCISES

Exercise 4.1 Own price elasticity

Presented below are price and quantity figures facing a UK rail operator. The current price is £1 and estimated demand figures are given for sequential price reduction from £6 down to a free fare, and demand rises from zero up to 240. What you have to do is calculate the missing figures, and then graph out the relationship between price and quantity and quantity and revenue on something akin to the two blank charts below before answering the following questions.

Table 4.1a

Price	*per cent Change*	*Quantity*	*per cent Change*	*PED*
6	–	0	–	–
5		40	–	–
4		80		
3		120		
2		160		
1		200		
0		240		



a) How does this exercise relate to the theory concerning price elasticity of demand outlined earlier in this chapter?
b) What does this tell us about the profit maximising position of the company?
c) What do you consider to be the main determinant that is affecting the elasticity values as the price falls?

Exercise 4.2 Price elasticity of demand, a practical exercise

A local bus company is facing strong competition in its 'home' market, as a consequence its demand curve is relatively elastic due to the existence and closeness of a high number of readily available substitute transport services.

Nevertheless, the workforce of the company, after years of accepting low pay deals, have put in a wage demand significantly above the rate of inflation which could potentially put £1m onto the costs of the firm. In order to counter this potentially serious situation, the management board have brought you in as a consultant to advise on its possible courses of action. After studying the situation, you outline three alternative 'strategies' that are open to the board. These are:

1 Bargain strongly with the workforce from the negotiating position that large pay increases will cost jobs.
2 Agree to the workforce's pay claim, but tie any such payment agreement with significant increases in productivity and possible redundancies.
3 As with two above, agree to the workforce's pay claim, tying in any such pay agreement with significant increases in productivity, but in this case undertake an expansionist competitive position by slightly increasing services levels and cutting prices.

When you put these options to the board, they 'like' option 1 although they don't quite understand it, option 2 they simply don't understand and are completely baffled by option three. They point out that as the firm is facing potentially a large increase in its costs, that will surely mean increased fares and a possible reduction of services, which is the exact opposite of option 3. Your counter that it is all to do with the price elasticity of demand fails to shed any further light on the matter.

Part A

i In order to convince the board of the viability of each of your options, briefly outline the concepts of elastic and inelastic demand.
ii Outline each of the alternative options explaining how they 'work'.
iii Point out to the board what their options (and the related 'strength' of their bargaining position) would have been if demand for their services had been relatively inelastic.

Now that you have explained that, the board seem quite keen to pursue option 3. As a consequence, you advise them to commission a market survey to investigate the possible effect of changes in the fare on the company's total revenue. The results of this survey are presented below.

Table 4.2a

Fare	*Demand (million journeys per year)*	*Total revenue (£ms)*	*Old cost (£ms)*	*New cost (£ms)*
£0.80	18.0	14.4	11.0	12.0
£1.00	12.0	12.0	11.0	12.0
£1.20	8.0	9.6	11.0	12.0

As it stands, the company currently charge a £1 flat fare on all of its routes at all times, hence the £1 fare above represents the current position in terms of fare and demand levels. With the current wage agreement, profits are therefore £1m per annum. As can be seen, however, this profit may be entirely wiped out if the workforce's pay claim is agreed without any concessions. If the company was to increase the fare to £1.20 then the survey confirms that this would actually significantly increase losses. Even at the 'breakeven' position of the £1 fare, the firm would have no funds for investment and could potentially in the longer term be driven out of business as it would have no profits from which to fund new buses when the existing stock wears out.

Part B

In order to further illustrate the principles involved to the board, you should answer the following three questions:

i Calculate the price elasticity of demand for the price decrease of £1 to 80p and for the price increase from £1 to £1.20.
ii Should the firm have brought you in earlier as a consultant, i.e. was the fare set at the right level at the beginning in order to maximise profits?
iii With regard to the 80p fare reduction option, the above information is accurate as long as the increase in demand is met by current underutilised services. As highlighted above, however, some increase in services will be required to meet this increased demand – how should the board decide whether this is a viable option or not?

Part C

i What is the major assumption that the above analysis presupposes?
ii What, if anything, have you learned from undertaking this exercise?

Exercise 4.3 Income, own and cross price elasticities

This is a totally artificial exercise; however, it is designed to try to get you to think about own price, cross price and income elasticities. Presented below are some completely hypothetical passenger figures for public transport services in a hypothetical city somewhere near you!

Transport Mode:	Rail	Bus	Underground	Total
Annual usage (millions):	38	90	23	151

For this hypothetical public transport market, the following elasticities apply:

Table 4.3a

	Rail	*Bus*	*Underground*
Income elasticity of demand:	0.41	–0.50	0.32

		Price		
Own & cross price elasticities		*Rail*	*Bus*	*Underground*
	Rail	–0.45	–0.40	–0.30
Quantity	Bus	0.08	–0.40	0.10
	Underground	0.02	0.05	–0.20

Note: modes listed on rows relate to the quantity change in demand, those listed in columns relate to change in price

Using all of these values you should be able to answer the following questions – as a side note, if you have the necessary skills you may find a spreadsheet useful to assist with this exercise.

a) If there is a 5 per cent rise in income, what would be the new daily modal splits and the new total daily usage?
b) Using your answer for the new total daily usage from part (a), what is the overall income elasticity to travel?
c) How does your answer from part (b) compare with the results presented in Case study 3.1 in Chapter 3 and what might be the reason for any such differences? (Hint: you will need to calculate a rough elasticity from the values presented in the case study.)
d) Calculate the effect on modal splits and the new monthly usage of the impact of the following factors (each should be considered on its own) and from your answers highlight which modal fare has the largest impact on the overall demand for travel in this city.

   i a 15 per cent increase in the level of rail fares
   ii a 15 per cent increase in the level of bus fares
   iii a 15 per cent increase in the level of underground fares

e) What might be expected to happen to the cross price elasticity of the train across all other modes if the level of rail travel was to significantly increase? Why would this happen?
f) Roughly speaking, why have we got the answers that we have got for part c and what does this underline with regard to own and cross price elasticities of public transport services?

Exercise 4.4 Elasticity and the tax take – why all the good things in life are taxed!

In order to finance a considerable improvement in public transport provision, the government needs to raise significant levels of public finance. Increasing income tax is not seen as a realistic option due to the unpopularity of such taxes with the electorate. The government therefore decides to raise this finance through an expenditure (as opposed to an income) tax. What type of good (price elastic or inelastic) should the government impose this tax upon? In order to help answer this question, you should draw two illustrations in the form of the basic market graph, which illustrate the shift in the supply curve as a result of the increase in tax and then note the effect this would have on an elastic and an inelastic good. Note also that the resultant change in revenue would be the effect on the total tax take, as all additional revenue raised is tax. What does this exercise tell us about general taxation policies; are, for example, cigarettes taxed purely for health reasons or petrol taxed purely because of environmental/conservation concerns?