Chapter 9

Transport and the natural environment

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Learning Outcomes:

On reading this chapter, you will learn about:

- The relationship between the macro economy and the environment
- The impact which transport has in terms of the environment
- The main issues surrounding the carriage of freight and its impact on the environment from a balanced perspective
- How economics can aid in our understanding of how transport affects the environment
- The economic options which can be considered as a means of addressing environmental issues.

INTRODUCTION

The link between the demand for transport and economic growth and thus the need for travel has been detailed in Chapter 2. This link has environmental implications and if left unchecked these will impact on economic activity. Vehicle emissions impact on the quality of life both at the local level in terms of air quality and hence individual health, and at a more global level in terms of CO_2 emissions, an important source of greenhouse gases which impact on climate change. This chapter seeks to utilise economic theory as a means of analysing the relationship between transport and the environment. It starts by outlining the background to the general environmental problem, before detailing the various transport emissions and their impact and then specifically examines freight transport's impact on the environment. The chapter then develops an economic model of pollution and explores the types of measures which could be implemented as a means of dealing with the problem.

The macroeconomic concept of the circular flow of income relates to the flow of income and expenditure between households and firms and can be used in order to set the scene in terms of transport and the environment. With respect to the circular flow of income households receive income for the factor services they have undertaken and with that income they buy goods and services, including transport. This can be seen in the upper portion of Figure 9.1.

We have seen part of this diagram already as Figure 2.3 in Chapter 2. What it did not take

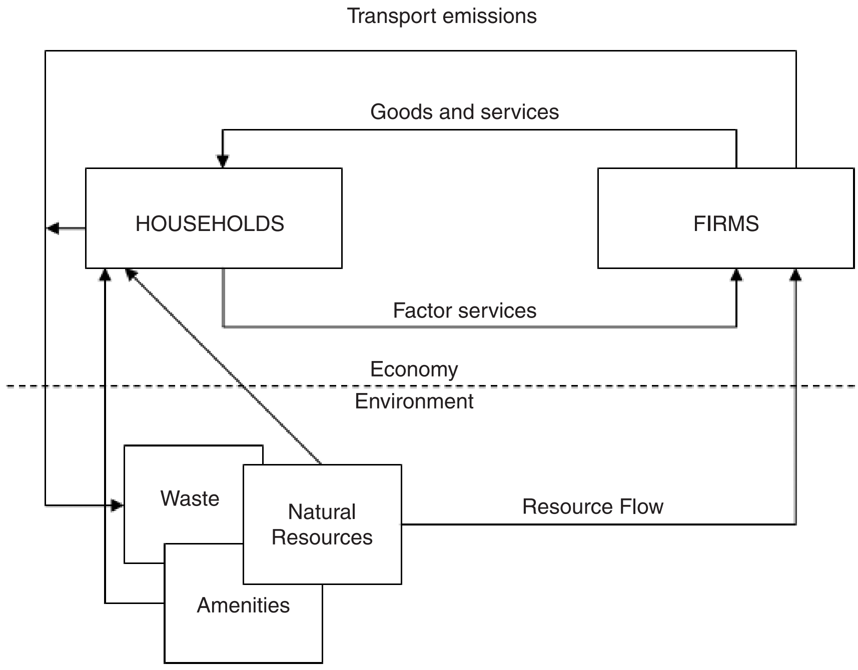

Figure 9.1 *The macro economy and the environment*

account of however was the constraints imposed on the economy by environmental factors, of which transport plays a significant part. These can be seen on the lower part of Figure 9.1 and includes aspects on which transport impact. For example, if you take the period 1996 to 2006 car passenger transport has increased from 622bn to 686bn passenger kilometres (a 10 per cent increase), with car transport comprising 85 per cent of all passenger kilometres (DfT 2007b). As for domestic freight then the road also dominates, representing 64 per cent of all domestic freight transported, increasing from 153.9bn tonne kilometres in 1996 to 163.4bn tonne kilometres in 2006, a 6 per cent increase. (DfT, 2007b). In terms of air transport movements there has been an increase from 0.9bn passenger kilometres in 1996 to 1.2bn passenger kilometres in 2006, which represents a 33 per cent increase. All of these increases in transport activities impact on the environment. In addition, whilst air transport is still relatively small it is a significant contributor to climate change. The reason for this is the release of greenhouse gases into the upper atmosphere (Chapman, 2006). A concern is the projected growth in air transport as seen in Table 9.1.

The environment, transport and the economy can be linked in three ways as illustrated in Figure 9.1.

a) *Natural resources*: transport makes use of natural resources most notably oil which is in fact the most dominant source for transportation (Chapman, 2006). According to the International Energy Agency (2002) the transport sector accounts for 54 per cent of the primary oil demand in OECD countries.

Table 9.1 Forecast of air traffic demand: 2004–2030 (Million terminal passengers at UK airports)

	2004	*2010*	*2020*	*2030*
International				
Low	–	225	310	370
Mid	180	230	325	400
High	–	235	340	435
Domestic				
Low	–	50	65	80
Mid	40	50	70	85
High	–	50	70	95

Source: Adapted from DfT 2007a

b) *Waste products*, including transport emissions, are generated by both households and firms in the transport activities in which they are engaged. For example firms in transporting goods from the ports of East Anglia to the Midlands or households travelling by private car to and from work both emit carbon dioxide into the atmosphere and contribute to global warming. The natural environment can be seen as a 'dumping ground' for waste products, and one that apparently comes at a zero economic cost.

c) *Amenity services* relates to the natural environment which provides households with benefits such as recreational space and areas of natural beauty such as National Parks, accessed predominately by the private motor vehicle. These can clearly be affected by economic activity and the related transport decisions made by both households and firms in terms of transport emissions.

In terms of waste output and transport emissions there are a range of pollutants associated with transport and passenger cars in particular. These include emissions of carbon dioxide, carbon monoxide, nitrogen oxide, particulates, benzene and 1,3-butadiene. The pollutant emissions are given in Table 9.3 and it can be seen that transport, and road transport, in particular, are major contributors particularly in terms of carbon monoxide and nitrogen oxide.

Transport is a major consumer of energy. In fact in 2004, 36 per cent of all United Kingdom energy consumption was used by transport.

Case study 9.1 Transport emissions

Carbon dioxide: the largest source of carbon dioxide in the UK is combustion of fossil fuels and in terms of domestic transport accounts for 23 per cent of carbon dioxide emissions which is not insignificant at 23.3 million tonnes of carbon. The non-transport source of carbon dioxide includes sectors most notably domestic, industrial, commercial, agricultural, and the military. Globally, the transport-related emissions of carbon dioxide are growing rapidly with the use of petroleum as a major source of fuel. Carbon dioxide is an important greenhouse gas and one which is estimated to account for in the region of two thirds of global warming. As for the direct health implications the impact is rather less than for other emissions detailed below. In fact, carbon dioxide is all important for the internal respiration in the human body. In saying this, if the levels of carbon dioxide are not in balance then it could lead to health implications, such as asphyxiation.

Carbon monoxide is the product of internal combustion engines, and domestic transport accounts for approximately 50 per cent of carbon monoxide emissions, representing 1,199 thousand tonnes per annum in the UK. It is a toxic substance which impacts, amongst other things, on an individual's respiratory and central nervous system. Catalytic converters have been important in reducing the amount of CO in car exhausts by oxidising CO to CO_2.

Nitrogen oxide is caused by combustion engines and other industrial, residential and commercial sources that burn fuels. It can impact on the environment in a number of ways, once emitted it can be transported many miles before being deposited as acid rain impacting on forests, lakes, wildlife, crops and buildings. This means that buildings and historic monuments can deteriorate and lakes can become uninhabitable in terms of wildlife. The increased nitrogen in rivers and lakes accelerates eutrophication, which leads to a depletion of oxygen thus reducing the stock of fish. It can also react with 1,3-butadiene in the atmosphere with sunlight to form ground level ozone which is a major component of summer time smog. It is also harmful to human health impacting on the functioning on the respiratory and lung system and can in fact cause premature death. Domestic transport comprises 684 thousand tonnes per annum within the UK and accounts for 42 per cent of nitrogen oxide emissions.

Particulates (PM10) also impact on health including effects on both the respiratory and cardiovascular systems. It particularly impacts on asthma sufferers. 27.3 per cent of particulates are the result of domestic transport which represents 40.9 thousand tonnes per annum within the UK.

Both **benzene** and **1,3-butadiene** emitted from car exhausts are seen to be a human carcinogen, which means it is an agent that is directly involved in the promotion of cancer. It can also suppress the immune system, increasing the risk of infection. Benzene is present in vehicle exhausts and evaporative emissions of gasoline-dispensing systems. As for 1,3-butadiene it arises from the combustion of petroleum products. The introduction of catalytic converters in 1991 had a major impact on the emissions of 1,3-butadiene from road transport. In terms of emissions then domestic transport accounts for 25 per cent (3.5 thousand tonnes) of benzene emissions and 63 per cent (1.7 thousand tonnes) of 1,3-butadiene.

Lead has historically been a major source of emission from motor vehicles and industry. With the prohibition of lead-based petrol (four star), however, lead emissions have fallen dramatically from the transport sector, with domestic transport now only comprising 2.3 per cent of all emissions, at 2.1 thousand tonnes per annum. Lead has an impact on health in terms of damage to the kidneys, liver, brain and nerves. Exposure to lead can also lead to osteoporosis and reproductive disorders.

In terms of Figure 9.1 there is a need to break the link between the economy, and its related transport activity, and the environment, which could be argued is unsustainable. Sustainable transport can be defined as 'the ability to meet society's need to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values, today or in the future' (WBCSD, 2002). The Eddington Study (2006) reports that transport sector emissions are a 'significant and growing contributor (around a quarter in 2004) to the UK greenhouse gas emissions' and these emissions are seen to have an impact on long-term UK economic growth. This is reinforced by the Stern Review (2006) which provides evidence of the negative impact climate change will have on economic growth. The UK Government is of the opinion that climate change is 'the greatest long-term challenge facing the world today and that transport policies can make an important contribution to tackling climate change' (DfT, 2007a).

Case study 9.2 Aviation and the environment

There has been a growth in air transportation in the past 40 years and Table 9.2 illustrates that growth, in terms of airport traffic over the period 1990–2006. It reveals an increase in international and domestic air transport movements, both landing and take-off, of 86 and 42 per cent respectively.

The table also reveals that while all airports have experienced growth in air transport movements some have shown greater growth than others, such as Stansted, with significant low-cost airline development, Manchester and Edinburgh. There are undoubted benefits in terms of the growth in passenger and cargo movements, not least in terms of employment opportunities created and the enhanced mobility of the population. For example, there were 85,071 employed directly by UK airlines worldwide in 2006 positions such as pilots and co-pilots, cabin

Table 9.2 *Traffic (in thousands) at UK airports: 1990–2006*

	1990	*1994*	*1998*	*2002*	*2006*
International:					
UK operators	479	529	655	753	808
Foreign operators	340	403	480	543	713
Domestic:	301	308	331	364	427
TOTAL:	1,120	1,240	1,476	1,660	1,948
Of which:					
Gatwick	189	182	240	234	254
Heathrow	368	412	441	460	471
Luton	40	17	44	55	79
Stansted	24	58	102	152	190
Birmingham	66	71	88	112	109
East Midlands	29	33	39	49	56
Manchester	122	146	162	178	213
Edinburgh	48	61	72	105	116
Belfast	38	33	37	38	48

Source: Adapted from DfT statistics

attendants, maintenance and overall personnel, tickets and sales personnel. In addition, there are thousands employed in areas such as cargo handling and travel agencies. Like other modes of transport however there are negative effects of aircraft movements in terms of the environment.

Table 9.3 illustrates the emissions from civil aircraft over the period 1995–2005 with resulting effects on health and the quality of life. The figures for civil aircraft are insignificant when compared to road transport but as can be seen pollution emissions from road transport and non-transport end users have been declining over the period in question, unlike civil aircraft. In addition, by definition air travel is a major generator of road traffic as passengers and cargo need to get to and from the airport.

Aircraft noise is an additional external effect of aviation. Aircraft noise is measured as an equivalent continuous sound level (L_{eq}) averaged over a 16-hour day (0700 to 2300) and is calculated during the peak summer months. 57 L_{eq} is seen as the onset of disturbance, 63 L_{eq} and 69 L_{eq} as moderate and high disturbance respectively. The 471 thousand air transport movements based on Heathrow in 2006 affected a population of 258,000 within the 57 L_{eq} contour. For Gatwick the figure was 45,000 population within the 57 L_{eq} contour (DfT, 2007b).

Table 9.3 *Pollution emissions from transport and other end users in the UK: 1995–2005*

Thousand Tonnes/percentage

Pollution type:	*1995*	*1997*	*1999*	*2001*	*2003*	*2005*	*% of 2005 total*
Nitrogen oxides:							
Road transport	1,098	1,014	900	749	636	549	34
Civil aircraft	4.4	4.9	6.3	7.3	7.5	9.1	0.6
All transport	1,204	1,127	1,004	840	756	684	42
Non transport users	1,180	1,030	965	988	972	983	58
Carbon monoxide:							
Road transport	4,180	3,664	3,003	2,128	1,594	1,124	46
Civil aircraft	31	39	47	59	47	58	2.4
All transport	4,224	3,717	3,065	2,200	1,655	1,199	50
Non transport users	2,072	1,957	1,875	1,691	1,292	1,218	50
Sulphur dioxide:							
Road transport	52	28	14	4.2	4	3	0.4
Civil aircraft	0.3	0.5	0.4	0.5	0.5	0.6	0.1
All transport	83	58	39	23	31	43	6
Non transport users	2,239	1,583	1,188	1,096	960	660	94
Particulates (PM_{10}):							
Road transport	54	47	43	38	36	34	22
Civil aircraft	0.1	0.1	0.1	0.1	0.1	0.1	0.1
All transport	59	53	48	42	42	41	27
Non transport users	179	161	149	136	113	109	73

Source: Adapted from DfT (2007b)

Overall therefore, there are global impacts and local environmental impacts associated with aircraft movements. At the global level there is the effect of aircraft emissions on climate change. Aviation emissions are small but growing, as illustrated in Table 9.3, and it is estimated that by 2050 aviation's contribution to man-made climate change will be somewhere between 3 and 7 per cent. At the local level there is the local air quality effects of emissions from aircraft at airports, the effect of aircraft noise, the noise, emissions and congestion resulting from surface access to airports as well as the land take and urbanisation as a result of airport development.

FREIGHT TRANSPORT AND THE ENVIRONMENT

This short section will consider the main issues surrounding freight transport and its impact upon the natural environment. As shown in Chapter 2, over time levels of freight transport activity have been very closely related to economic growth as measured by GDP. As we will see later in Chapter 12, however, the levels of both factors have also been affected by the reduction in trade restrictions between nations over the period. This is no more so present than within the European Union, which since the introduction of the Single European Act in 1986 (which introduced the single European market) has seen a considerable rise in the movement of goods between member states. With that has come increased freight transport activity and concern over the impact this has had upon the environment. This has been particularly true in geographical areas that have seen large increases in freight transport flows but that are also regions of particular environmental sensitivity, the most obvious example being the Alps. Perhaps surprisingly, although air pollution is an international issue, this has led to strong national policies rather than policies at the EU level. This is particularly true in Switzerland, which introduced a through truck 28 tonne weight limit, and Austrian decisions on night and weekend road haulage movements. What exactly however is the problem with freight transport and the environment?

We have already seen earlier in this chapter the impact of road transport on the environment. With regard to freight, these issues are also generally tied up with road haulage; however, two particular problems for the road haulage sector is that its relative share of nitrogen oxides has been growing considerably as more private cars have been fitted with catalytic converters. The second problem is that its share of carbon dioxide will also probably become a relatively greater problem as cars become more fuel efficient. As a consequence, over time the issue with road haulage's impact on the environment will become more acute as the impact of the car is lessened.

Nevertheless, actual figures on the impact of freight transport upon the environment are difficult to obtain. Given in Figure 9.2 however are the relative levels of road transport by type of transport and the level CO_2 emissions for each (road-based) mode.

This in many ways highlights the problem with road haulage, specifically that it has a far larger share of CO_2 emissions (and NO_X emissions) than its share of road transport, thus it has a disproportionately high polluting effect. Road haulage is also particularly high in the emission of particles, with DfT statistics (DfT, 2007b) quoting values of emissions per vehicle kilometre some nine times higher than that for a diesel private car. Since the introduction of Euro emissions standards, however, particularly Euro III,[1] these have been considerably reduced by just over a factor of two; however, this is still considerably less than the impact of Euro standards on private vehicles

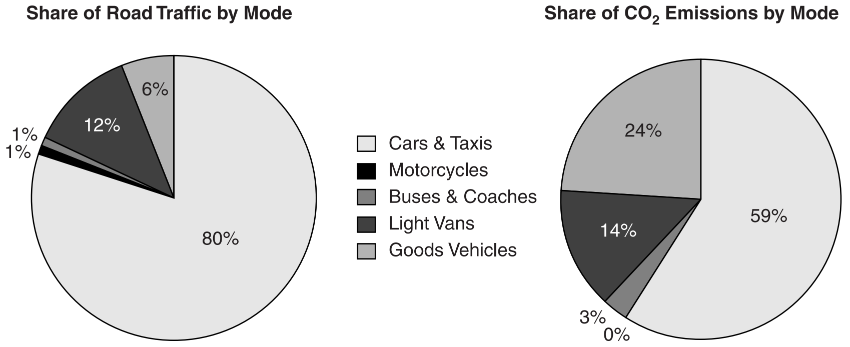

Figure 9.2 *Road transport 2005: modal share and share of CO_2 emissions*

Source: Drawn from DfT (2007b)

– for a diesel motor car, the effect has been to reduce the emission of particles by a factor of just under five, hence highlighting the problem that road haulage share of emissions is increasing.

In terms of comparisons with other modes of freight transport, Short (1995) cites figures from Befahy (1992) who calculated comparative differences in pollution rates per road and rail tonne kilometre moved. For three measures of air pollutants, nitrogen oxide, hydrocarbons and carbon monoxide, the levels of emissions for road were four times higher per tonne moved than by rail in the case of the first, forty-five times higher for hydrocarbons and thirty-five times higher for carbon monoxide. These however appear to overstate the issue, with similar comparisons made by the Strategic Rail Authority in 2005 as quoted by the Freight on Rail campaign (FoR, 2008) revealing smaller differences. Their figures suggest that emission per tonne kilometre of freight moved were 12 times higher for PM10 (particles), ten times higher for carbon monoxide, five and half times higher for nitrogen oxides and 12 times higher for carbon dioxide. The main reason for the considerable differences in the two studies cited however is due to the advances made in controlling the emissions of road vehicles over the intervening periods. These have resulted in a substantial decrease in comparative differences, although differences still remain significant. Schipper and Fulton (2005) however make the important point that the composition of freight drives the modal mix. Hence low-volume high-value commodities tend to go by road, whilst high volume low value commodities by rail. Unlike passenger transport, therefore, where such comparisons are based upon (roughly) the same unit of measurement in the form of passenger kilometres, the different composition of freight tonne kilometres make such comparisons far more problematic. Thus for example a significant modal shift from road to rail would change the freight composition on the relative modes (particularly rail), and this change would in turn impact on emissions per tonne kilometre hauled.

As the impact of transport on the environment is an international issue, we end this short section with a brief international comparison of freight carbon emissions per capita for a number of developed countries. Research by Schipper *et al.* (1997) found that the US had a figure of over twice as many freight carbon emissions per head than seven countries of the European Union. Norway also had around an output 50 per cent higher than the EU countries. This suggests that there exist considerable variations around the world of the impact of freight transport on the environment in relation to the size of the population.

To conclude this short section and bring it into focus with the economics of transport, relating freight transport to Figure 9.1 it would appear that road haulage has a disproportionately high call upon environmental resources highlighted in that figure, and thus the total cost of that mode of transport is relatively more understated than the other freight transport modes. As environmental concerns heightened, this is likely to have a more detrimental impact on the use of the mode. How this might be brought about is considered later in the chapter under policy options for addressing environmental concerns; however, to put some of these issues in perspective we end this section with a case study titled 'is it really road haulage that is bad for the environment?'.

Case study 9.3 Is it really road haulage that is bad for the environment?

We saw above that road haulage is a major contributor to the deterioration of the natural environment, far more so than any other land-based individual transport mode. If road haulage is so bad for the environment, therefore, why don't we just get rid of it? That would, after all, be the ultimate conclusion of such a finding. What this highlights is that what has been presented so far is only one side of the argument, but this issue should not be looked at in isolation. This case study attempts to give some insight into the wider problems that may result as a consequence of significantly reducing the reliance on the mode, as this in turn brings into focus the issues involved in attempting to lessen transport's impact on the environment. What follows however is pure speculation on the author's part; this is designed merely to give some idea of the problems that this would involve rather than act as a highly accurate scientific study. In compilation of this case, thanks are due to Professor Alan McKinnon on whose research some of this case rests (see McKinnon (2006) for further details). That research was a scientific study aimed at developing a scenario for a temporary disruption in road haulage services of a week. In this case, we speculate on some of the issues involved in a more long-term modal shift.

We begin with the basic question that if the reliance on road haulage is to be eradicated or significantly reduced, then how would all of the freight that is currently transported by the mode be moved? Currently within the UK some 1.936bn tonnes of freight are shifted 167 billion kilometres over a road network that is 398,350 kilometres in length. In comparison, 108 million tonnes of freight are moved 22 billion kilometres on a rail network 15,795 kilometres long. In simple terms, therefore, the rail network simply could not cope with a significant increase in freight loads, particularly given that in certain parts the network is already at or close to capacity. To bring these figures more clearly into understandable terms, for each head of population in the UK some 33 tonnes of freight are moved annually by road, compared to just under 2 tonnes on the railways. Whilst railways were described in Chapter 2 as the driver of the Industrial Revolution in the 19th century, road haulage is undoubtedly the mainstay of the economy of the 21st century.

The modal split of freight however is not a straight division between the various modes involved, but rather particular modes tend to specialise in certain sectors which results in an uneven division of freight moved across the whole sector. Road haulage has an almost complete monopoly at the lower levels of the supply chain in the delivery of retail supplies, hence any impact of reduced road haulage levels would be most acutely felt at that end of the supply chain, i.e. by the consumer.

McKinnon (2006) evaluates four forms of substitution that could occur in the face of an absence or reduction of road haulage levels. These are used below to examine the potential longer-term consequences of a major modal shift.

Product substitution

One of the main issues with road haulage is that the greater flexibility that it presents has led to the development of the concept of the whole logistical supply chain, with one direct result being that inventories levels have been considerably reduced. Product substitution would effectively involve a reversal of that position, where greater stocks would be held at all levels from production through to consumption. Simple examples would be the substitution of fresh produce for frozen and greater reliance on electronic communication rather than traditional postal services. Major shifts would have to occur however in consumption patterns towards goods with a longer useable life and a significant shift away from the consumer-orientated society. The impact on production would be considerable, and this is considered further under locational substitution.

Modal substitution

This has been hinted at above where the substitution is in the mode of transport used. Thus road haulage would be replaced by rail and maritime transport, with most of the emphasis falling on rail. In simple terms, the rail network would have to change beyond all recognition in order to cope with any increase in demand. This not only relates to the actual length of the network, which would have to expand in size well in excess of pre-Beeching levels, but also would require considerable enhancements in terms of loading gauges in order to accommodate larger and heavier trains and in signalling to reduce headways in order to accommodate more traffic. Such enhancements would not come cheap.

Vehicle substitution

Vehicle substitution is different from modal substitution in that it involves using the existing road infrastructure, however, with vehicles that are far less polluting. A number of alternatives to fossil-based fuels currently exist, the better known ones being biodiesel, bioalcohol (ethanol, methanol, butanol), electricity and liquid gas. These alternatives however have a considerable way to go before they could substitute fossil fuels. Whilst undoubtedly a biased viewpoint, the AFCG (2003) nevertheless state that only natural gas could compete economically with existing fuels and gain a market share in excess of 5 per cent by 2020.

Locational substitution

As with product substitution, locational substitution involves a reversal of long-term trends. Over time there has been a major shift from high density living to a greater geographical dispersion of the population and a general de-centralisation of activities. This not only refers to the American concept of 'urban sprawl', but has occurred in many other countries where new housing developments have generally been of the low density form. Location also relates to the whole structure of industry, which is very different today to how it was 30 years ago. Logistics play a major part in the whole industrial activity, and this has led to a centralisation of activity. McKinnon (2006) highlights the case of agriculture and the requirement for the distribution of winter feed and the centralisation of slaughterhouse capacity, which now involves both feed and animals being transported far greater distances. This change in industrial patterns is also very true of manufacturing, where there is now a far greater tendency for movement through the logistical chain of component parts. Whilst perhaps not a good example in the current context, motor cars do nevertheless provide a good example of this change; in the past cars were built in a single factory and components sourced locally; however, today different parts are built in different locations, many not even in the same country.

This case study began by attempting to speculate on what life would be like with a significant reduction in road haulage transport driven by environmental concerns, but in many respects it has failed to do so because such a scenario is simply outside of current terms of reference. In other words, it cannot be contemplated. Road haulage will never be replaced; however, any move to significantly reduce the reliance on the mode will have to be done over a very long period of time and will come at a very high cost (in terms of living standards). In many respects it would be akin to returning to the 1930s, the only problem however is that the global population is far larger today than it was then, hence effectively a 1930s transport system could not support today's population, never mind at current living standards.

AN ECONOMIC MODEL OF TRANSPORT AND POLLUTION

The effect that transport has on the environment can be studied by the use of an economic model (see Figure 9.3). In the figure the horizontal axis measures the level of transport activity and its related pollution, which is assumed to be directly related to the level of transport activity. This could relate to an airport and the number of aircraft and passengers who use the airport over a period of time. Since transport can be seen as a derived demand, as outlined in Chapter 3, then transport activity can be firmly linked to the level of economic activity. The vertical axis measures the costs and benefits, both to transport and society.

Marginal private benefit (MPB) measures the additional benefits, in terms of satisfaction received by the road user or airline passenger from undertaking journeys, or road haulier, cargo

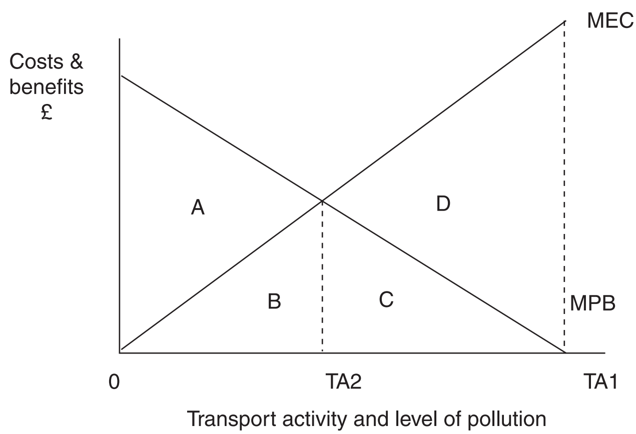

Figure 9.3 *An economic model of transport activity and pollution*

handler or airport authority in terms of profitable activity. The marginal external cost curve (MEC) measures the additional environmental cost of transport activity, in terms of air pollution, noise and so on. If the transport user/sector is not constrained in terms of their level of activity then they will consume or provide an amount equal to TA1. This means that the area under the MPB curve, represented by A + B + C will be maximised. At that level of activity (TA1) however there are external costs in terms of the impact of the emissions detailed above of B + C + D. The optimum level of pollution, therefore, is achieved at a scale of transport activity TA2, where the MPB = MEC. If the transport user operated at a level of activity above TA2 then the additional environmental costs would be greater than the additional benefits accrued from undertaking the transport activity. This represents what is termed a 'welfare loss' to society, whereas at a level of transport activity below TA2 the opposite is true. Here the MPB is greater than the MEC and as such, activity should be allowed to increase to TA2, in order to take account of these additional benefits. Note further, however, that continuous production above level TA2 will result in a significant negative impact upon the environment. As can probably be gathered from Figure 9.3 the benefits accrue to the road user or airline passenger in terms of moving between destination A and B for work or leisure activities, or to road hauliers, bus operators, airport operators or the like in terms of profitable activity. The costs (MEC) in terms of airport pollution and so on are not incurred by the same group. For example, aviation activity is likely to lead to profit for the airport operator, but the costs are incurred by those who live in the vicinity of the airport and who suffer, in particular from the noise and air pollution, not simply from aircraft but also the surface access traffic. These can be viewed as external costs since transport users or organisations do not normally include them in their decisions as to what output level to produce. The costs are actually incurred by third parties who are not involved in the transport activity but who suffer from the 'spill over effects'. In terms of our airport example, the first two parties are the airport operator (the producer) and the airline and airline passengers (the consumers).

There are a number of policy options which can be considered as a means of addressing the issue of the environmental impact associated with road and air transport.

It is important to state that the options detailed below are by no means exhaustive but provide an indication of possible measures, namely a bargaining solution, a tax-based solution, the role of tradable permits, the setting of standards, technological change and the encouragement of alternative modes of transport that can be considered. These options need to be considered as part of a package of measures, although note that we have already seen some of the impacts such actions may have in Case study 9.3.

Bargaining

The basis of this particular approach is that if property rights are assigned then bargaining will occur naturally between the various parties that suffer from or are the source of external cost, the externality, and the optimum level of pollution will be the result. Based on Figure 9.3 the two parties are airline operators and the airport who generate environmental pollution and those who suffer in terms of that pollution, namely those who live close to the airport. The notion of bargaining is based on the idea that if property rights are assigned to either of the two parties, thus giving the airline operators or airport the right to pollute or to those who are affected by the pollution to clean air, then via bargaining agreement will be reached so that pollution is reduced.

If the property rights were assigned to the airline/airport operator then in terms of Figure 9.3 the level of transport activity would be TA1, with profit maximised and no account given to those affected by emissions. It would however be in the interest of those suffering from the emissions to pay the polluter if they agree to reduce their level of activity and thus their level of pollution. In this situation the sufferers would pay as long as it was less than the value of the pollution from which they would otherwise suffer. The bargaining solution states that payment would be made to the airline/airport operator by those that are suffering so long as it is below the valuation of the damage they incur. In terms of Figure 9.3 therefore the sufferers may be willing to offer the polluters a maximum amount of C+D, which represents the total external cost incurred by the sufferer as a result of the transport activity TA2–TA1. The airline/airport operator would have been prepared to reduce their scale of activity from TA1 to TA2 for an amount no less than C, an amount which represents the total profit gained from activity undertaken TA2 to TA1. As such, there is a basis for 'bargaining' between the two parties. For this option to work, the amount paid by the sufferers would be somewhere between C and C+D, and as might be expected the amount actually paid will depend on the relative strength of the two parties involved.

If on the other hand the 'property rights' were to be assigned to the sufferers, who therefore have a right not to be affected by aviation pollution, that is a right to clean air or no noise, then the airline operators and thus the airport would have to cease operation, thus being at point 0 in the figure, with no airline or airport activity or related pollution. In such a situation the polluters may find it to their advantage to offer the sufferers compensation that allows them to undertake activity and its related pollution. The polluters would offer compensation so long as it is less than the private benefits they receive from undertaking their activity. In terms of Figure 9.3 it would be worth the polluters offering the sufferers an amount equal to B or a little more, so that they could operate and obtain profit of A, or a large portion of A. Any activity beyond TA2 would not be sensible since the amount of compensation paid would outweigh the satisfaction received. The result would therefore be the optimum level of pollution, at TA2. Under either scenario economists such as Coase (who developed the idea of bargaining) reveals that assigning property rights can result in bargaining which brings about an optimum solution.

There is however an issue of equity, which varies greatly depending on which of the two scenarios is adopted. In addition whilst the theory of bargaining seems relatively straightforward it may not be possible to adopt such an approach when addressing traffic-related pollution. There are a number of issues raised when considering the bargaining solution which would seem to favour the 'polluter pays principle'.

- Those affected by pollution will often find it difficult to organise themselves. This is certainly the case in terms of those who suffer from transport-related pollution, since there may be so many individuals they will find it difficult to coordinate their activities and thus may not be able to offer the appropriate monetary amount in order to induce polluters to reduce their level of activity.
- Those who suffer from pollution may not have sufficient funds to compensate those who pollute for the cost of reducing pollution. As such, the optimum level of pollution consistent with a level of activity TA2 will not be attained.
- Certain individuals who suffer from transport-related pollution or noise may be reluctant to contribute to the monetary payout to the polluter, not because they are unconcerned about

the situation, but because they assume others will take responsibility and they will reap the benefits without paying a penny. They can be termed 'free-riders'.

- If polluters were aware of the fact that they would have to make payments to sufferers then it is likely they would curb their activities or would encourage research and development into more environmental friendly technology, such as quieter aero engines.

The success of the bargaining solution depends in part on the numbers involved, and even with two parties an agreement is not automatic. As such, the government may resort to alternative methods of dealing with the problem.

A tax-based solution

This would involve setting a price which places a monetary value on the environmental costs of transport using taxation and imposes these upon the polluter. Such a solution is likely to reduce the demand to travel and therefore the environmental impact.

In terms of the economic model in Figure 9.4, then, if an environmental tax of t (known as a Pigouvian tax, which is a tax imposed upon an externality) is imposed on the transport user/operator/polluter it has the effect of shifting the MPB curve to MPB–t. The tax would be paid on each unit of pollution and the transport operator would now maximise their marginal private benefits at a level of activity equal to TA2. If the transport operator undertook a level of activity between TA2 and TA1 then the benefits received (in terms of profit) would be less than the amount of tax paid.

Using an environmental tax is a way of internalising the external cost and the tax of t can be viewed as the optimum tax.

The use of this kind of measure is based on the notion of the 'polluter-pays principle', with the polluter being responsible for the cost of measures to reduce pollution.

There are a number of advantages and disadvantages with the use of an environmental tax on the transport user/operator.

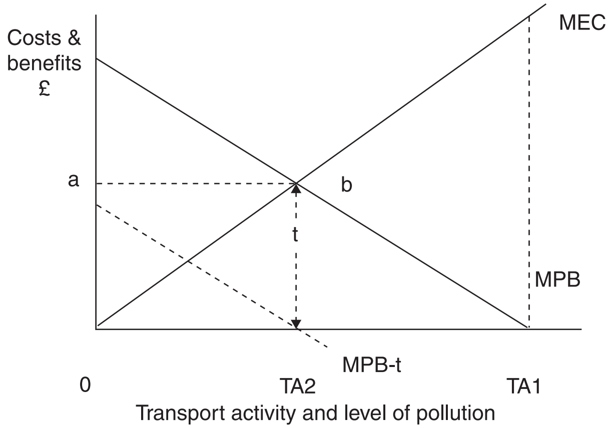

Figure 9.4 Imposition of an environmental tax

Advantages

- With an environmental tax, then, the road or air transport user or airport/airline operator has to pay a price for the pollution caused. As such, the polluter has an incentive to reduce their level of activity to the optimum level of TA2 in Figure 9.4.
- The introduction of an environmental tax allows the transport user/operator to decide how they will respond, unlike the use of a standard which sets a particular limit.

Disadvantages

- There may be difficulties in establishing the optimum tax of t, although in reality the aim may be to get as close to the optimum as possible. If the tax is underestimated then it may lead to a problem as illustrated in Figure 9.5 below.
- There are often political difficulties when introducing a new tax, say with a passenger tax on airline users. There may be resistance in that the belief is that the tax will be raised above t in Figure 9.4 once it is introduced – the tax being seen simply as a revenue-raising measure.

  In Figure 9.5, if the optimum tax rate t is established then there is no problem. This may not however be the case. The tax rate could have been set too low, say at t_1 and this could be problematic. At a tax t_1 then the level of transport activity would be TA3 and this would equate with an external cost of b which is higher than that at the social optimum of c. This may be acceptable, but if the MEC were to rise more sharply as with MEC2 then the MEC would be significantly larger at a, which may be far more problematic. What this scenario illustrates is that small miscalculations can result in far larger deficits.
- It could be argued that the transport user is penalised twice. First by virtue of the fact that the level of transport activity has been reduced from TA1 to TA2 in Figure 9.4 with the resulting loss in profit given by the triangle TA1TA2b, and second by having to pay tax equal to the area TA20ab.

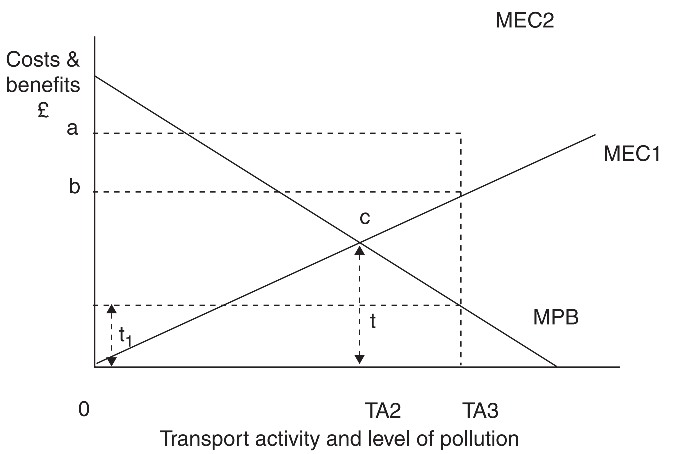

Figure 9.5 *The problem with underestimating the optimum tax rate*

Case study 9.4 Fuel tax

A fuel tax increase can be seen as a somewhat crude method for dealing with the problem of the environmental fall-out from transport. Their impact in the short run may be slight other than provoking a very short-term knee-jerk reaction to the increase in price. In the longer term however it could influence the choice of vehicles with a smaller engine capacity and a reconsideration of either the place of employment or residential location. In terms of Figure 9.6 following a rise in the price of fuel from P1 to P2 in Figure 3 the demand in the short run may reduce from Q1 to Q2, a movement from point a to point b along the short run demand curve (D_{SR}), as motorists use their car less. In the long run demand could reduce further to point c on D_{LR} with a quantity Q3 through the purchase of vehicles with smaller engines or because of the relocation of households to be nearer their work.

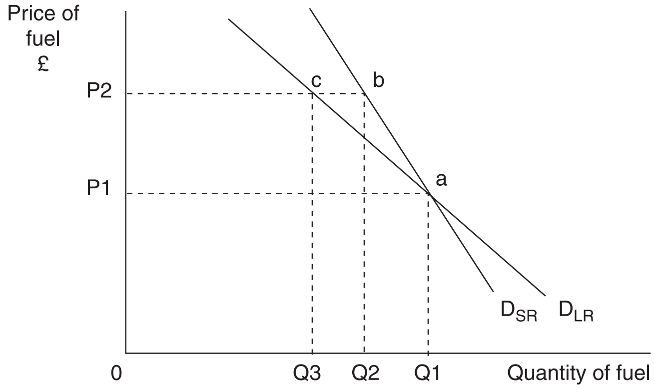

Figure 9.6 *The potential impact of an increase in fuel prices*

Clearly, the objective of fuel tax is not environmental even though as stated by the Royal Commission on Environmental Pollution (1994) that:

- The amount of tax paid varies with the environmental cost with the amount of fuel duty used in the main proportional to the amount of CO_2 emitted and (for any given vehicle) is closely reflected in the quantities of other substances emitted.
- It is simple to administer, it costs little to collect, is difficult to avoid or evade, and can easily be modified.
- Road users have discretion about how to respond: road users may respond either by reducing the number or length of their journeys or by reducing their use of fuel in other ways, such as switching to a smaller or more fuel-efficient vehicle or driving in a more fuel-efficient way.

Tradable permits

The idea behind tradable permits is that polluters are presented with a number of 'permits' which allow them to emit a particular level of CO_2. The number of permits which exist clearly limits the amount of emissions. The permits are tradable in that they can be bought and sold to other polluters who are participating in the particular tradable permits scheme. The basis of such a scheme is that those organisations who are able to achieve a lower level of emissions are then able to sell their superfluous permits to organisations that are not able to meet the emissions target set and are therefore forced to buy permits to emit if they do not want to curtail their activity.

The tradable permits market is illustrated in Figure 9.7. The body responsible for setting the level of pollution will issue a number of permits in line with a predetermined level of pollution, such as Qp, which at the level of demand would give a market price of Pp. If there is an increase in demand and thus a shift in the demand curve to the right then clearly the equilibrium price will increase. Figure 9.8 illustrates how the market operates in a hypothetical situation, with two airline operators A and B. In the figure airline operator A emits 100 thousand tonnes of CO_2 annually, and airline operator B emits 80 thousand tonnes of CO_2 annually. MAC refers to the marginal abatement cost curve and represents the additional cost to each airline operator of abating pollution. As can be seen operator A's curve is flatter than operator B's, thus abatement is more costly for B than it is for A, and as such there is a basis for trade in permits to take place between the two operators.

Without the existence of the permit scheme, then, 180 thousand tonnes of CO_2 would be emitted, namely 100 thousand tonnes from operator A and 80 thousand tonnes from operator B. If the body responsible for setting CO_2 emission targets wanted to see a 50 per cent reduction then this could be achieved by issuing 90 tradable permits. Allocation of those permits is an issue, but if they were issued based on previous emission levels, then operator A would receive 50 (one for each thousand tonnes) and operator B would receive 40 (also one for each thousand tonnes). Clearly the merits of allocation can be debated, but if this were the case then operator A would reduce its emissions to 50 thousand tonnes, and operator B to 40 thousand tonnes.

In order to conform to the reduced emissions levels, there will be a cost involved for both airlines, and this is known as the marginal abatement cost. This would include all aspects involved

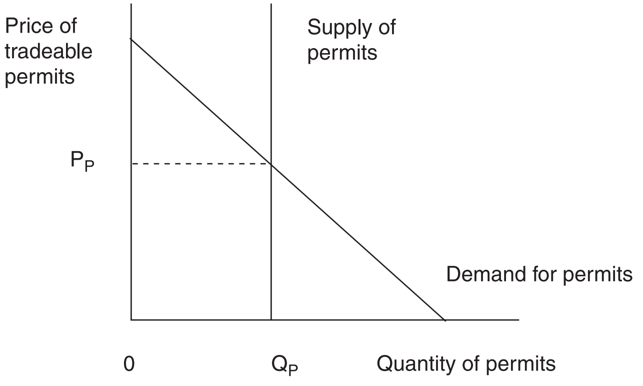

Figure 9.7 *The market for tradable permits*

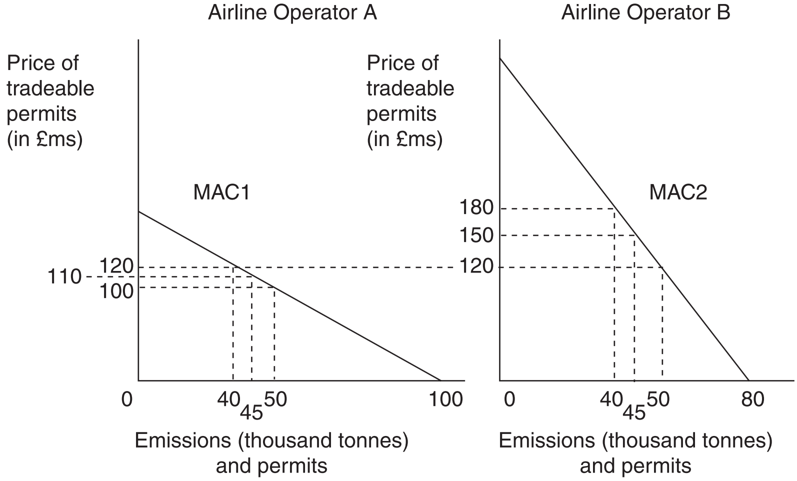

Figure 9.8 *The operation of a tradable permits scheme*

in conforming to the new standards as a consequence of the tighter restrictions placed on pollution levels. Say therefore that for airline operator A the total cost of cutting its emissions from its previous level of 100k tonnes to its 'new' level of 40k tonnes was £100m, then that would represent its marginal abatement cost (MAC). Furthermore, if we know the level of emissions at a zero MAC and at a level of 40k tonnes, then assuming a linear relationship we can sketch out the marginal abatement cost curve (MACC) for firm A. This is done on the left of Figure 9.8. Note however that in practice this would be a curve, and concaved towards the origin – hence as the level of pollution needed to be reduced by ever greater amounts, the relative increase in the marginal abatement cost would increase by far greater relative values. However, to return to our example, if we assume that the cost to airline operator B to reduce emissions from its current level of 80k tonnes down to its allocated permits of 40k tonnes to be £180m, again this represents its marginal abatement cost. By applying the same logic as above then again we can draw the marginal abatement cost curve for operator B, which is shown on the right of Figure 9.8 as MAC2. Due to the difference in the marginal abatement costs facing the two firms, there would thus be a basis for trade between the two operators. For example, say in the following time period operator B wished to increase its emissions (due to the profitability attached to them – see Figure 9.1) by 5k tonnes to 45k tonnes, then reading off the MACC it would be willing to pay up to £150m in order to do so. At that level, however, the MAC to A is £110m in order to bring its emissions down by 5k from the previous time period. It is therefore worthwhile for A to cut its emissions to 45k as the revenue they would earn from the sale of the excess permits (in this case 5k) to B would be in excess of what it would cost them in additional abatement costs. This is because B will buy these permits because the price will be lower than its own abatement costs at that level of emissions. The net difference between the two values therefore (£150m v £110m) represents the basis for the trade. This process of exchange will continue until the two MAC's are equal to each other. Referring to Figure 9.8 this would occur with the price of permits at £120m, hence operator A would emit 40k tonnes of CO_2 and operator B 50k tonnes of CO_2.

There are a number of issues that require careful consideration when developing a tradable permit scheme. First, how are the permits allocated? In terms of the hypothetical situation outlined above the allocation of permits was undertaken on the basis of current emission levels, each receiving 50 per cent of those levels. Companies however may have successfully reduced their levels of pollution, by investing in new technology and as such they are penalised for this by receiving a lower number of permits. An alternative measure could be equal numbers of permits to each participant, but the weakness of this is that they may differ in terms of the amount of CO_2 they currently emit. Second, should permits be freely allocated or should they be auctioned? Third, what should be the overall number of permits in circulation? It could be the case that the supply is greater than would be ideally liked simply so that company acceptance of the scheme is gained. Fourth, it is possible that a number of participants may corner the market in permits, making it difficult for new companies to enter a sector. If this situation developed it would act as a barrier to entry and could be seen as anti-competitive. Fifth, there are administrative costs involved in a scheme of this type, registering and monitoring ownership of the permits. Finally, a tradable permit scheme allows the owner of the permits the right to pollute, a permit to emit pollutants and this is possibly a strategy that can be questioned.

There are a number of advantages however with a scheme of this type:

Advantages

- A tradable permit scheme affords the companies that participate flexibility in terms of the way in which they address the reduction in their emissions. Do they reduce emissions by the manner in which they operate or do they purchase permits?
- Environmental taxes require polluters to pay for emissions, something they once undertook for free. As such, it might be politically easier to get companies to agree to a tradable permit scheme, since a new 'marketable' permit has been created.
- A tradable permit scheme is cost effective in that incentives are provided to address emission levels since lower abatement costs will allow permits to be sold whereas higher abatement costs require permits to be purchased.
- Unlike a Pigouvian tax which needs to estimate the cost of the pollution, with tradable permits it is the market (in tradable permits) that will find the optimum price.

The EU is operating what it calls an Emissions Trading Scheme (ETS), a scheme which is seen as a major economic instrument in addressing greenhouse gas (GHG) emissions. The scheme seeks to make sure that companies operating within specific sectors which are responsible for GHG emission, reduce their emissions or buy permits from other participants within the scheme with lower levels of emissions. The scheme commenced in January 2005 initially covering carbon dioxide (CO_2) emissions. The first phase ran from 2005 to 2007 covering companies of a certain size in sectors including energy (with activities such as oil refinery and coke ovens), production and processing of ferrous metals, the mineral industry (including cement, glass and ceramic bricks), pulp and paper. Overall in the region of 10,000 installations are included covering in the region of 50 per cent of the EU CO_2 emissions. Participants, or what are called installations, obtain their allowances (or permits) for free from the EU member states. The second phase began in 2008 and runs until 2012 and a number of non-EU member countries have joined. It is expected that the UK Treasury will auction off a percentage of their ETS permits rather than is currently the process of issuing them to companies based on their current emission levels. To date aviation has not been included in the ETS even though it represents 3 per cent of carbon dioxide emissions in the EU. The reason for this has been concern over the impact inclusion would have on the sectors' ability to compete in international markets. Aviation is however going to be included in the EU ETS from 2012.

The setting of standards

Whilst not an economic instrument, it is important to introduce the notion of setting standards, since these form a major part of environmental policy and can have a considerable impact on the economics of transport. Polices such as the requirement for an annual vehicle inspection for road trucks and private vehicles (with the latter known as the MOT test in the UK) and vehicle exhaust emissions tests or limits on noise from aircraft come under this category.

Setting a standard of S1 would achieve the optimum level of transport activity TA2 in Figure 9.9. If achieved this would result in the optimum level of pollution. Clearly as with taxation it could be the case that the standard has been incorrectly set. It could be too harsh, thus a point to the left of S1, or too lenient, a point to the right of S1. Not only does the standard have to be set correctly but the penalty for not meeting the standard has to be established. The optimum penalty will be Penalty 1, for if a penalty such as Penalty 2 were to be set then the polluter would be tempted to pollute up to TA3 because the penalty (if ever administered) would be less than the level of additional satisfaction obtained between TA2 and TA3.

Technological change

This can take a number of forms. First, transport emissions of carbon monoxide have been reduced through technology-related initiatives such as cleaner fuels with reduced carbon content, cleaner, more efficient car engines and electrified public transport. Catalytic converters fitted to petrol-driven cars have reduced emissions in pollutants such as nitrogen oxide and benzene and in the UK new cars are 10 per cent more fuel efficient, on average, than they were 10 years ago. In addition,

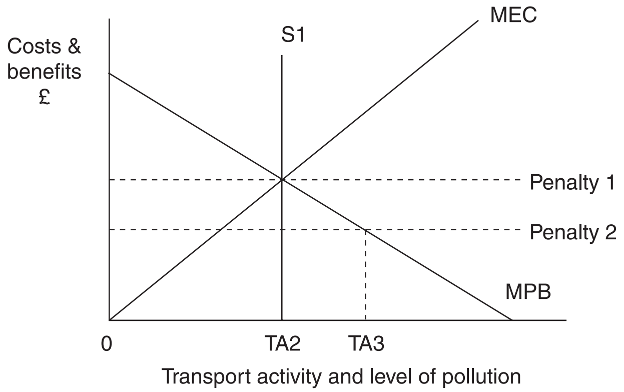

Figure 9.9 *Setting a standard*

in the UK, by 2010 as part of the Renewable Transport Fuels Obligation 5 per cent of fuel sold in the transport sector will have to come from renewable sources.

Second, technological advances have improved the ways in which individuals can make choices about transport modes, through in-car information and real-time information at public transport stops.

Third, through video conferencing meetings can be undertaken without the need to travel. This is also another aspect of technological change which leads to a reduction in transport emissions.

In the figures illustrated above it is hoped that technological change will have the effect of reducing the gradient of the MEC curve.

Promotion of alternative modes of transport

This policy option involves encouraging alternative modes such as public transport, walking, cycling, rail freight and shipping. The private car has the advantage of convenience and flexibility whereas public transport tends to be confined to fixed routes. As will be seen in Chapter 12, much the same applies with respect to road haulage in the carriage of freight in comparison to the other available modes. Measures can be undertaken in order to make public transport more competitive through things like dedicated bus lanes; however, as we have seen the options with regard to freight transport alternatives to road haulage are far more limited and problematic.

Trams are in many respects a more environmentally-friendly, although expensive, alternative to the private car. In recent years a large number of UK towns and cities and other European cities have invested in the tram, such as Croydon, Manchester, Nottingham and Sheffield in respect of Britain and Karlsruhe, Grenoble, Bordeaux and Genoa on the European continent. Improved cycling and walking facilities are also seen as an important alternative to the private car. The aim of providing alternatives to the private car is to reduce the gradient of the MEC curve in the figures above.

CHAPTER SUMMARY AND REFLECTION

The aim of this chapter has been to highlight the link between the macro economy and the environment and the impact of transport on that relationship. It has detailed a number of transport emissions and the effect that they have in terms of individual health and on a more global scale. The chapter has used economic theory in order to analyse the relationship between transport and the environment. This has allowed various policy options to be studied. In terms of the bargaining solution, although theoretically attractive, it raised a number of issues in terms of the practicalities of implementation. The tax-based solution also raised issues not least in terms of establishing the optimum tax although it would allow the transport operators/users to decide how they respond. Tradable permits also allow flexibility and may also be politically easier for the market to accept. The measure too has issues not least in terms of the allocation of merits, whether they should be issued free or auctioned, their supply and administration. Alternatives, namely the setting of standards, technological change and the promotion of alternatives, have also been examined.

CHAPTER EXERCISES

Exercise 9.1 The use of an environmental tax

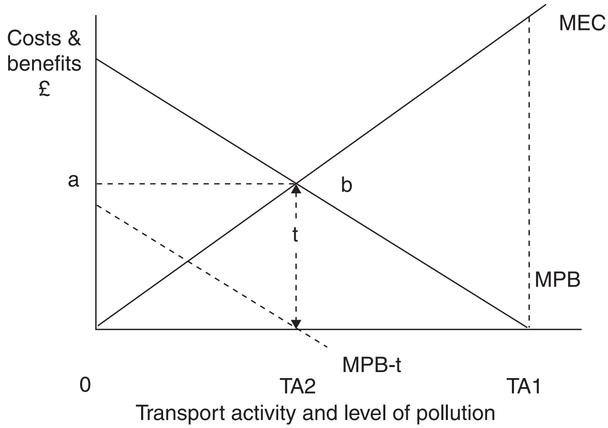

Figure 9.10 *The use of an environmental tax*

Use Figure 9.10 in answering the following questions:

a) If the transport activity carried on at TA1 following the imposition of a tax equal to t, then how much tax would be paid by the polluter?
b) Why will the polluter reduce their transport activity level to TA2 from TA1 following the imposition of an environmental tax?
c) What is the external cost saving to be made by reducing transport activity from TA1 to TA2?
d) What will be the implication if tax is set at a level greater than t?
e) Why is zero output unacceptable from an economic perspective?

Exercise 9.2 Trends and implications

Based on Tables 9.1, 9.2 and 9.3:

a) Outline the trends in terms of traffic at airports, the forecast for air traffic demand and pollution emissions from transport and other end users.
b) In terms of Tables 9.1 and 9.2 what are the likely implications both at the local and global level?
c) Based on the information to be found in Chapter 13 on forecasting the demand for transport services, outline the difficulties inherent in forecasting air traffic demand.
d) Referring to Table 9.3, outline what you think are the reasons for the trends presented in terms of road transport and civil aircraft.
e) What do you see as the advantages and disadvantages of the various options for addressing the environmental impact of transport.

Exercise 9.3 Is it really road haulage that is bad for the environment?

Reconsider Case study 9.3 and then attempt the following questions:

a) Who is responsible for the large increase in road haulage transport that has occurred over the last 50 years?
b) How would we start to estimate the costs involved in reducing the level of road haulage by:

   i 20 per cent of its current level
   ii 50 per cent of its current level
   iii 80 per cent of its current level
   iv Who would have to pay for these reductions?

c) In terms of the policy options for addressing the environmental impact of transport on the environment outlined in this chapter, how would these be applied to road haulage? Note in addressing this question, you should consider that what you do not want to produce is an overnight collapse of the road haulage industry!
d) Of all of the substitution effects listed in the case study, probably the most far reaching would be locational substitution. Outline the full implications of this effect, both in terms of society and the economy.
e) This case only considered the impact of addressing a long-term modal shift at a national level; however, in today's global economy such unilateral action is simply not feasible. How might long-term change be brought about internationally? (Note: you may wish to briefly view the first part of Chapter 12 on the internationalisation of freight transport before considering this issue.)