Department for Transport

Transport Analysis Guidance (TAG)

Unit 2.12
Introduction to Modelling and Appraisal for Road Pricing

February 2007

Contents

1 Introduction

1.1.1 This Unit provides an overview of the modelling and appraisal issues, including scheme design issues, arising in the analysis of road pricing schemes. It also provides an outline of the approaches required to address those issues. Where appropriate, it refers to guidance in other TAG Units, rather than repeating that guidance.

1.1.2 More detailed guidance for analysts is provided in TAG Units 3.12.1, 3.12.2, 3.12.3 and 3.12.4:

- *Designing Effective Road Pricing Schemes* (TAG Unit 3.12.1) discusses approaches to the design of effective road pricing schemes

- *Modelling for Road Pricing* (TAG Unit 3.12.2) provides advice on the modelling of road pricing schemes;

- Guidance on the issues arising when appraising road pricing schemes is provided in *Appraisal of Road Pricing Schemes* (TAG Unit 3.12.3); and

- *Measuring the Social and Distributional Impacts of Road Pricing Schemes* (TAG Unit 3.12.4) provides guidance on the use of social research methods to assess the social and distributional impacts of road pricing.

1.2 Scope and Background

1.2.1 Road pricing offers a means to reduce congestion and/or impacts on the environment through the management of demand for road space. In congested conditions, each road user contributes to the congestion and economic and environmental costs experienced by other road users and the public generally. Road pricing is intended to ensure that road users take account of the impact of their journeys on other road users and the public. Well designed road pricing schemes with appropriate prices should deliver significant net economic and environmental benefits, with reductions in congestion and pollution and improvements in the journey.

1.2.2 Key characteristics of road pricing schemes include the level and structure of the prices, where and when the prices are levied, and the extent to which prices and/or exemptions are allowed to vary by class of users.

1.2.3 Road pricing is a demand management tool and an analysis needs to recognise that reducing demand for road space at congested times can be complemented by mode switching, changes in the time of travel, changes in destination and changes in the route taken. In terms of the impact on the number of trips – and acceptability more generally – these changes will ameliorate some or all of the negative impacts of reducing road traffic.

1.2.4 Road pricing schemes also have the potential to raise revenue. Revenue raised represents a benefit of the scheme, offsetting the disbenefits to road users paying for a charge. It must, therefore, be taken into account when assessing the overall value of the project. However, the benefits arising from expenditure of these revenues can only be appraised if the projects it is to be spent on are identified and appraised in the usual way. It will often be the case that projects funded from revenue will generate benefits that exceed the revenue spent, but it is clearly impossible to estimate what those benefits might be unless the projects have been defined and appraised. Where projects are identified as complementary to road pricing, or as part of a package including road pricing, the overall package may be appraised. In this case, the costs of the complementary and/or other parts of the package would offset some or all of the revenues. Similarly, the benefits of the rest of the package will complement the benefits of the road pricing scheme itself.

1.2.5 Transport models will provide important evidence in the appraisal of road pricing and packages of interventions which include road pricing. The models will assess the impact of road pricing on route choice, modal changes, etc., exploring the economics of road pricing for an area. Further discussion of the economic basis for road pricing may be found in the Annex to this TAG Unit.

1.2.6 Road pricing is expected to be an integral part of the majority of packages and schemes put forward for the congestion entry point of the Transport Innovation Fund (TIF). Further information on the operation of the TIF can be found in *Transport Innovation Fund: Guidance January 2006,* published by the Department in January 2006. Sensitivity tests of the impact of road pricing may also be required as part of the analysis of some major highway and other schemes. This Unit introduces guidance for analysts working on these schemes or in any other circumstances where some part of the proposal includes managing demand on roads using road pricing.

2 Charging structures

2.1 Types of charging systems

2.1.1 Direct charges for road use can in principle be imposed in one or more of the ways set out below. These systems can be specified in terms of the locations in which charges are imposed and in terms of the levels at which charges are levied, covered in Section 2.3.

2.1.2 There is a link between the modelling and appraisal of a scheme and the technological solutions that are considered in an implementation. Scheme design benefits from an early identification of areas where there are interdependencies in these two aspects.

2.1.3 In considering the potential technologies, a useful distinction is between event-based charging systems and distance-based. A distance-based charge imposes a charge related to the distance travelled in a defined area or on a defined road. The charge rate may be uniform across all road types (which is termed “flat-rate”), or may vary by time of day, road type or area type. The German heavy lorry charging regime is an example in which charges are directly based on distance travelled; so are several continental motorway toll schemes, which charge based on distance between two points.

2.1.4 In an event-based system, the scheme relies on the passing of a particular part on the road network to determine the charge on road use. For modelling and appraisal, event-based systems can be further split into categories which represent where a charge is imposed on road users. This means a typology as follows:

(i) Point-based charges: These impose a charge to pass a point on the road network. Tolls on bridges and tunnels are an obvious example; so are some simpler motorway toll systems. As indicated in the following section, it is possible to consider a set of such points isolated from one another in a network.

(ii) Cordon/screenline charges: These systems impose a charge when a sceenline is crossed, with a cordon differing from a screenline because it forms a closed loop around a defined area. The current Electronic Road Pricing scheme in Singapore is a prominent example of a cordon. Cordons and screenlines are a very simplified way of attempting to approach Marginal Social Cost Pricing, which is constrained by the locations chosen.

(iii) Area charges: An area charge differs from a cordon charge in that vehicles are charged to be within an area rather than to enter (or leave) it. The London Congestion Charging scheme is an example. In such systems, particular consideration needs to be given to residents’ vehicles.

2.1.5 There may multiple cordons or a scheme may allow users to both an event-based system and a distance based system. So some degree of variation can be expected in a proposal that is being analysed. There are other charging structures that have been considered in the past, such as time-based charges where a charge is based on the time spent travelling in a given area. A proposal for such a scheme was developed in London in the 1980s.

2.2 Variations in charge

2.2.1 Any given charging system and structure can be further specified in terms of the charging levels imposed; the more complex the structure the wider the potential range of charging levels.

2.2.2 For any given point, crossing, area or unit of distance, the charge levied can in principle be set at any level. Within this range there will be an optimum charge in terms of welfare benefits. Above this optimal charge level, environmental benefits and revenues are likely to continue to rise, but economic benefits will fall as the charges discourage drivers whose journeys' benefits exceed the marginal social cost. The aim will normally be to identify this optimum and charge a level as close to it as is considered acceptable.

2.2.3 With point and cordon-based systems it is possible to vary the charge by location. In principle it is possible to charge at different rates at different crossing points of the same cordon, and there is evidence that this can increase benefits. Charges can also differ by direction of crossing, though it is most common to consider charges only in one direction.

2.2.4 Distance-based charges can differ by location; the Road Pricing Feasibility Study modelled a variant of this.

2.2.5 Charges can differ by time of day, with travel at some times being free and at others lower than the peak charge. Such variations can be applied to any form of charging system and structure.

2.2.6 Charges can vary by type or class of vehicle – to reflect different vehicles' different contribution to externalities. However, we have focussed here on charges imposed on the private car and have assumed that one charge level is applied to cars.

2.2.7 Finally, charges can be adjusted for different types of user, through exemptions and discounts (as used widely in London), or through caps which limit the maximum charge (as proposed in Edinburgh). The impact of this particular set of variants of charge levels is beyond the scope of the current report, but should be borne in mind as one of the most effective ways of reducing inequities and perceived unfairness.

2.3 Scheme design issues

2.3.1 It may not be possible to model all of the different types of road pricing schemes. The level of complexity will be an issue ranging from a flat price single cordon to a multiple price distance based scheme and the ability to design each type will depend on modelling capability (see Modelling for Road Pricing (TAG Unit 3.12.2)).

2.3.2 It should also be noted that complex schemes are likely to be more expensive to implement and run and harder for travellers to use. There are trade-offs to be made and these will need to be considered at an early stage. For example, cordon based schemes may be easier for the public to understand and a flat price may be more acceptable to the public. However, targeting prices to take account of the location and time of congestion will improve the efficiency and benefits of scheme. Some flexibility may also be desirable as travel patterns will change over time and, consequently, the demand for road space will vary. A relatively fixed system may become inefficient over time.

2.3.3 Whilst it is expected that the type or types of scheme – cordon, area or distance based – is identified at an early stage, the scheme design options in terms of locations, prices, etc. should be formed from an analysis of demand and supply conditions.

2.4 Location of boundaries

2.4.1 The location of boundaries is an important component of scheme design, possibly the most important for cordon and area wide license schemes. An early indication of the options for boundaries would be needed because the significant equipment and other infrastructural costs will largely be determined by the location and operating costs are to some extent dependent on traffic flows. It is may be less of an issue for distance based schemes, where the boundary issues are less of a factor as the price is incurred along a greater part of a route. However, even in these circumstances, it is likely that an initial indication of where the distance-based charge will operate would greatly facilitate scheme design. The issue of location is developed further in *Designing efficient Local Road Pricing Schemes* (TAG Unit 13.12.1).

2.5 Level of price

2.5.1 The level of price is clearly important in determining the efficiency of a scheme both because it acts to change road user behaviour and in terms of value for money. Careful scheme design will allow more informed decisions to be made about this trade-off. More details are given in *Designing efficient Local Road Pricing Schemes* (TAG Unit 13.12.1).

2.6 Other components of scheme design

2.6.1 The class of vehicle will determine, in part, the impact on congestion and the environment. This would suggest that, in an idealised road pricing scheme, prices should vary between classes of vehicle with those causing more congestion or environmental costs paying more. However, it could also have an impact on the cost and complexity of a scheme. If scheme promoters are proposing to vary prices according to vehicle class this should be based on evidence that this would improve the overall efficiency of a scheme. For example, discriminating between commuter traffic using cars and motorcycles may be justified by the lower congestion impact of motorcycles. Setting a lower price on environmentally friendly vehicles would be a response to an environmental objective but might lessen the impact on congestion.

2.6.2 When to price will depend on the actual level of congestion and the variability of the price will depend on the functionality and costs of the available technology. For instance, in most urban settings, congestion generally peaks in the morning commute period where arrival times are a constraint for many users. In addition there is likely to be an evening peak that is more spread out as arrival times are less important. On inter-urban roads traffic could be fairly constant throughout the working day.

2.6.3 Discounts or exemptions to road pricing schemes will reduce benefits but may be desirable to meet certain objectives or requirements. For instance exemptions might be given to certain classes of users such as the registered disabled or classes of vehicle such as motorcycles, taxis and buses. Here there is a trade-off between efficiency and public acceptability. For motorcycles there may be also a recognition issue with some technologies or the difficulty of mounting on-board detection units and modelling motorcycle trips will be challenging. National guidance may be issued on discount and exemptions. Whatever exemptions are deemed reasonable the impact of exemptions should be included in any analysis when it proves significant. For example, if exemptions mean that 10% of traffic is not priced the impact of this on scheme efficiency needs to be analysed. The number of exempted users and their patterns of road use will help in any analysis of the impact of exemption on the value for money of the scheme. With area based license schemes there is the issue of residents within the zone and whether or not they would be eligible for any discount.

2.6.4 Each type of scheme will involve enforcement issues largely concerned with non –compliant behaviour. There will be a trade-off here between the cost of encouraging compliance and debt management. The local costs of compliance need to be added to scheme implementation and running costs in scheme appraisal.

3 Study Process

3.1 Scheme Design

3.1.1 Scheme design, that is, where and when prices apply and the level and structure of the prices will be critical in developing schemes that are effective and provide good value for money.

3.2 Study Process

3.2.1 Analysis should be part of a wider study process, designed to ensure that schemes address the issues they are aimed at, reflect stakeholder views and represent the best way forward

3.2.2 The study process discussed in *The Overall Approach: The Steps in the Process* (TAG Unit 2.1) is suitable for studies including road pricing schemes. In summary, the process recommended is as follows:

- establish what problems need to be addressed and/or what (local) objectives are to be achieved;
- identify a range of options that address the problems and/or help achieve the objectives;
- sift the options, using appropriate modelling and appraisal tools and taking account of stakeholder views;
- refine the preferred option (or shortlist of options), using appropriate modelling and appraisal tools and taking account of stakeholder views; and
- implement and evaluate the chosen option, thus learning from experience.

Clearly, there may be a need to iterate through this process before a satisfactory solution emerges.

3.3 Road Pricing in Packages

3.3.1 Road pricing will often be associated with other measures. In some cases, road pricing will be one element of a package of measures, such as public transport investment. In others, road pricing will be explored as a sensitivity test as part of the analysis of a conventional scheme or package of schemes. Where road pricing is the main component of the proposal, it may be necessary to explore the impact of complementary measures designed to ameliorate distributional or other impacts of the road pricing scheme itself. In these circumstances, it will be important to assess the contribution of each element of the package to the overall value for money.

3.3.2 In essence, these tests should demonstrate that the incremental benefits of each element provide good value for money relative to the incremental costs. Guidance on these tests in the context of benefits to transport users (transport economic efficiency benefits) is provided in the COBA Manual. However, it should be noted that the tests should not be restricted to analysis of benefits to transport users – all sources of benefit and disbenefit (including benefits and disbenefits that cannot currently be monetised) should be taken into consideration.

3.3.3 In some cases, these tests may suggest that the scale of some other elements of the package should be different with and without road pricing. For example, including road pricing in the package might suggest that a road widening can be limited to one additional lane where more than one might be required without road pricing. In an urban area, introducing road pricing might suggest that significant extra public transport provision would be required to cope with mode shift. Where these findings emerge, they should be fully explored within the study process outlined above, to ensure that the most appropriate package of measures is taken forward. The exploration of these issues should include a robust analysis of the consequential cost of provision or savings in costs, any impacts on revenues, and impacts on user benefits.

3.4 Preliminary Analyses

3.4.1 The analysis of road pricing schemes is likely to require the use of relatively sophisticated modelling tools. These models take time to develop. Where no appropriate model exists, it will often be necessary to start the study process before the necessary models become available. Sifting and preliminary design of road pricing schemes can be carried out using simpler models. However, where this is done, it will be important to confirm key decisions and to refine designs when more suitable modelling tools become available. Further advice on this is given in *Designing Effective Road Pricing Schemes* (TAG Unit 3.12.2).

4 Modelling for Road Pricing

4.1.1 Many of the requirements for the modelling of road pricing are the same as those for modelling any other transport policy. As a general guiding principle, models should be fit for the purpose, in that they should be capable of reflecting the outcome of road pricing schemes in a way which allows their impacts to be satisfactorily assessed.

4.1.2 Taken overall, with regard to road pricing, the model structure should be able to make allowance for all important responses (these include change of trip frequency, mode, time of travel, destination and route) to pricing, and to allow for differential response by purpose, person type and so on, as far as is useful and practical. It should also deal with secondary effects such as changed speeds for all classes of highway user (including buses), plus the likely effects on other modes of significant increases in demand (bus and rail overcrowding, for example).

4.1.3 Apart from modelling road pricing as a distance-based charge, cordon or area based charge, models can also be run with prices varying on parts of the road network, with that variation reflecting the marginal social cost of congestion. This kind of pricing structure may not be feasible in practice, because, for example, of high implementation costs. However, it could provide some important benchmark results about what prices, benefits and revenues might be achievable were such prices feasible.

4.1.4 Depending on the details and the scale of the schemes or policies being appraised, it may be appropriate to relax the requirements. The detail of the scheme appraisal needs to be appropriate – and proportionate – to the nature and scale of the scheme itself. Detailed modelling of variable or distance-related prices is unlikely to be appropriate for a small-scale area or cordon charge scheme. The larger the scale (e.g. in terms of geographical coverage, nature of complementary measures) the greater the need is for a fully specified model.

4.2 Data Requirements

4.2.1 Good data is an essential requirement for robust modelling. Maximum use should be made of existing data sources, subject to their being fit for the purpose. However, data that is obsolete should not be used, and existing data sources may be insufficient for robust model development. There may, therefore, be a need to collect new data to support the modeling and analysis of road pricing.

4.2.2 Key determinants of people's response to road pricing have included the value of traveller's time, the purpose of a trip, the availability of a car and the costs of various modes, including public transport options. For the first, various individual and household characteristics, such as occupation, education level, housing tenure, have been used as proxies. The most direct indicator is traveller income but this has not usually been collected for transport modelling, on the grounds that interviewees were likely to be reluctant to answer questions about their income. However, evidence suggests that this is not the case. It is, therefore, recommended that income questions be included in travel surveys.

4.2.3 Travel is subject to seasonal variation. Studies have shown that, as well as being biased, travel behaviour in summer and winter also tends to be subject to greater variability. Thus, it is standard practise to carry out transport surveys in either spring or autumn. It is important, therefore, to ensure that data collection is considered and planned early in the study process, to avoid holding up model building.

4.2.4 Data will also be required to facilitate analysis of the social impacts of road pricing. Wherever possible, these data needs should be fully integrated into the data collection planned for transport modelling purposes. This may mean the inclusion of additional questions in interviews designed to support modelling, for some or all of the sample. Note, however, that the scope to add questions to roadside interviews is very limited, due to the need to keep these as brief as possible: the key requirement is therefore to ensure the right balance of questions is included.

4.3 Networks and Zoning

4.3.1 On the supply (network) side, a key requirement is for the models to be capable of predicting the effects on congestion of significant changes in traffic flows at different places in the network. This is because the calculated journey times are critical for a) the calculation of transport user benefits, and b) as inputs to the calculation of the consequent (second round) induced changes in demand. In addition, for most types of pricing schemes, changes in routeing will occur and need to be accurately forecast.

4.3.2 This calls for a generally high level of network detail, including representation of the delays at junctions as well as speed/flow relationships on links. Zoning systems should be consistent with the level of network detail. Congested assignment models, which allocate traffic to multiple routes so that network costs are consistent with traffic loadings, should be well converged, to avoid errors due to poor convergence. It should be noted that this implies relatively long run times, since congested network assignment is generally one of the most “expensive” parts of the model system computation.

4.4 Variable Demand Modelling

4.4.1 On the demand side, there is a need to have a quite detailed representation of the different kinds of response (changes in trip frequency, time of travel, choice of mode and choice of destination), as well as a detailed representation of purpose and person types, primarily because of different sensitivity to prices, but also to assist with equity considerations. These responses are usually included in a variable demand model. The Department has recently published guidance on variable demand modelling for highway schemes – see *An Introduction to Variable Demand Modelling* (TAG Unit 2.9.1) - and for public transport schemes – see *Introduction to Modelling for Major Public Transport Schemes* (TAG Unit 2.10).

4.4.2 For road pricing, a key issue is to establish enough segmentation of journeys so that responsiveness can be adequately modelled. Transport demand models segment the journeys using characteristics of the particular trip and differences in the personal attributes of the traveller. It is critical that the heterogeneity of actual journeys is adequately represented in the modelled estimation of the behavioural choices where there is a change in travel costs or journey times. The most important attributes are journey purpose, car availability, journey length and socioeconomic characteristics of the traveller, such as social group, employment status, and income. Most conventional models should have trips segmented by journey purpose, but it is important to check that a particular model has an adequate level of segmentation and so responsiveness.

4.5 Land Use Models

4.5.1 Road pricing schemes could affect the attractiveness of certain locations for business, residential or other activities. For example, an urban road pricing scheme could reduce congestion and thus make the central business district of the town more attractive to businesses. Current land use models increase or decrease the numbers of jobs and/or households in a zone in response to increases or decreases in the zone’s accessibility, which is itself calculated by the transport model.

4.5.2 Land use models will not be needed for most road pricing studies. However, they may be appropriate for major schemes which are intended to have land use and/or economic impacts, or where there is concern that schemes may have unintended land use and/or economic impacts. They may also be useful for determining the changes in employment location required as inputs to estimates of the impacts of road pricing (and other measures) on productivity. In these circumstances, because there is only limited evidence of the impact of road pricing, modelling may be the best way of assessing these impacts. [Para amended to reflect DCS's comments]

5 Appraisal

5.1.1 The modelling requirements for the appraisal of road pricing schemes are not inherently different from those for any other transport scheme. Guidance in *The Appraisal Process* (TAG Unit 2.5) should be followed when appraising road pricing schemes (or packages including road pricing). In particular:

- impacts on environment, safety, economy, accessibility and integration should be assessed using standard methods and recorded on standard Appraisal Summary Tables.

- the effectiveness of options in addressing problems and/or addressing local objectives should be assessed and reported.

- supplementary analyses of distributional and equity impacts, financial sustainability and affordability and practicality and deliverability should be carried out and reported.

5.1.2 Much of the Department's guidance on appraisal was written on the basis that road pricing might be an option to be considered, and the established approach has been applied to projects involving road pricing (multi-modal studies, estuarial crossings). Appraisal methodologies used for conventional transport schemes are generally directly applicable to road pricing schemes. In particular, the Department's standard TUBA software, used to estimate transport user benefits, is designed to accommodate road pricing schemes. Nevertheless, road pricing schemes do call for some new elements of analysis.

5.1.3 The Department expects well designed (and cost-effective) road pricing schemes to provide significant economic benefits in congested areas, and this will translate into real world benefits for households and businesses. It will be appropriate to carry out analysis of the wider economic impacts of road pricing schemes, on productivity and economic development. The impacts of road pricing on economic performance will be highly dependent on scheme design and the assumptions made about other trends, including policies outside the proposed road pricing scheme area.

5.1.4 Road pricing schemes are likely to have differential impacts on different socioeconomic groups. Understanding these impacts during the study process will be important, since they are likely to affect scheme design. Therefore, it is recommended that sensitivity tests be carried out using separate values of time by income band, as used in modelling. Analyses based on the Department's standard values of time will also be required, to enable comparisons between road pricing schemes and other transport investment proposals.

5.1.5 While modelling and appraisal will, with the sensitivity tests outlined above, provide a coarse assessment of distributional and equity impacts, more detailed social analyses will usually be required to complement those results. Social analysis is likely to be required to explore impacts on particular social groups, especially vulnerable groups. Good, objective social analysis requires considerable skill and good data. Further guidance on the use of social research methods to assess the social and distributional impacts of road pricing is given in *Measuring the Social and Distributional Impacts of Road Pricing Schemes* (TAG Unit 3.12.4).

6 Further Information

The following documents provide information that follows on directly from the key topics covered in this Unit.

For information on:	See:	TAG Unit number:
More detailed guidance on the design, modelling and appraisal of road pricing schemes	Designing Effective Road Pricing Schemes Modelling for Road Pricing	Unit 3.12.1 Unit 3.12.2

	Appraisal of Road Pricing Schemes Measuring the Social and Distributional Impacts of Road Pricing Schemes	Unit 3.12.3 Unit 3.12.4
Study process	The Overall Approach: The Steps in the Process	Unit 2.1
Analysis of packages	The COBA Manual (Design Manual for Roads and Bridges Volume 13)	
Variable demand modelling	An Introduction to Variable Demand Modelling Introduction to Modelling for Major Public Transport Schemes	Unit 2.9.1 Unit 2.10
Appraisal	The Appraisal Process	Unit 2.5

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8 Document provenance

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9 Annex - Economic Basis for Road Pricing

9.1.1 This annex briefly set outs the economics of road pricing. More detail about these principles may be found in Alasdair Smith's *A Mathematical Introduction to Economics.* Kenneth A Small's *Urban Transportation Economics'* may also be useful.

9.2 Demand and supply

9.2.1 In standard demand and supply analysis, the supply line represents the costs of producing one extra unit and the demand line represents the benefits of one extra unit of consumption. The demand curve shows how much consumers are willing to pay for a good or service and that more people will be willing to buy a good or service as the price falls. The supply curve shows how much producers are prepared to supply at different price levels.

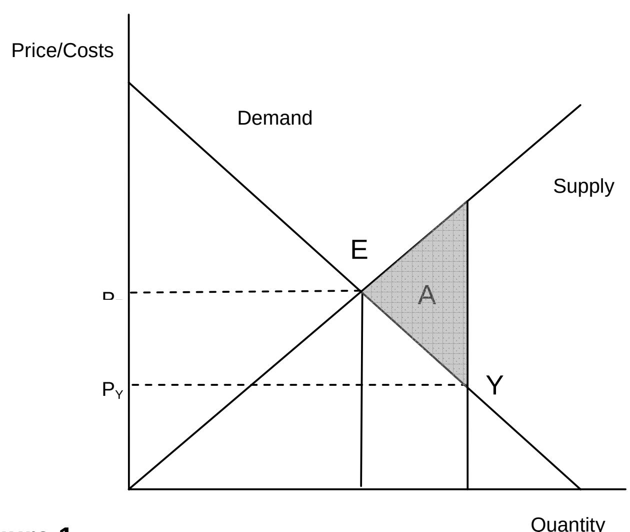


Figure 1

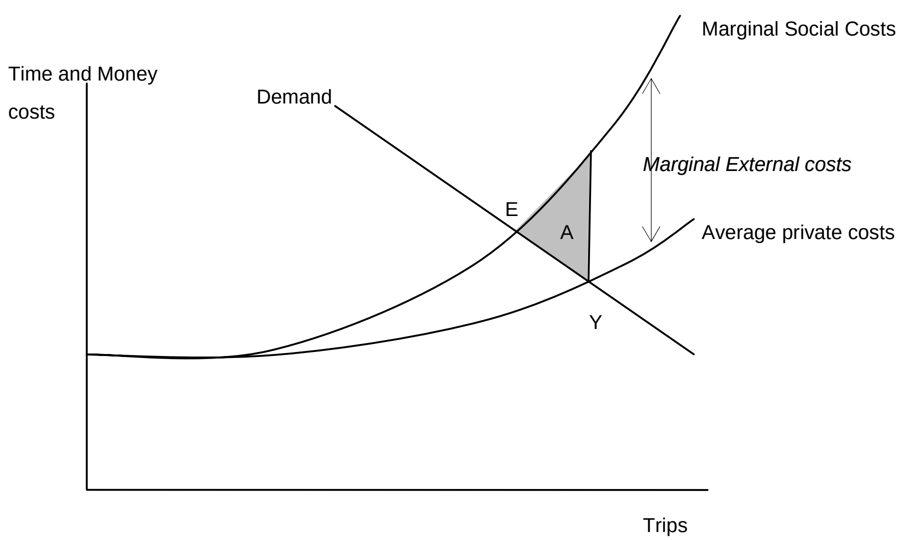
9.2.2 If enough quantity was supplied to satisfy demand at point Y in Figure 1 above, the cost of supply would exceed the benefits and there would be a misallocation of resources or loss of social welfare. (This could happen if the good or service was subsidised). The loss of social welfare is the area of the red triangle. The efficient level of production and consumption would be at point E. At this point prices would be higher and less quantity would be demanded. Clearly some consumers would lose out but this is an issue of distribution rather than the efficient allocation of resources.

9.2.3 The analysis of road use can be made in the same way, the only difference being that supply costs are determined by demand – speeds will fall and journey times will increase as the level of traffic increases. Road users will demand trips up to the point where demand equals the average costs they face at point Y in Figure 2. These include out-of-pocket expenses and journey times that will depend on the volume of traffic.

9.2.4 The costs they face do not include the congestion costs they impose on other road users, the marginal external congestion costs: they take account of the level of congestion in their own costs but not the impact their choice has on others. The efficient level of traffic or efficient usage of road space will be where the benefits equal all the costs that road users face plus those they impose on others. This is shown as point E in Figure 2 below. As in Figure 1 above there is a loss of welfare denoted by the triangle A.

9.2.5 This can be considered as a subsidy from society to road users, because the cost of motoring is less than the full costs, i.e. private costs and costs to society.

Figure 2

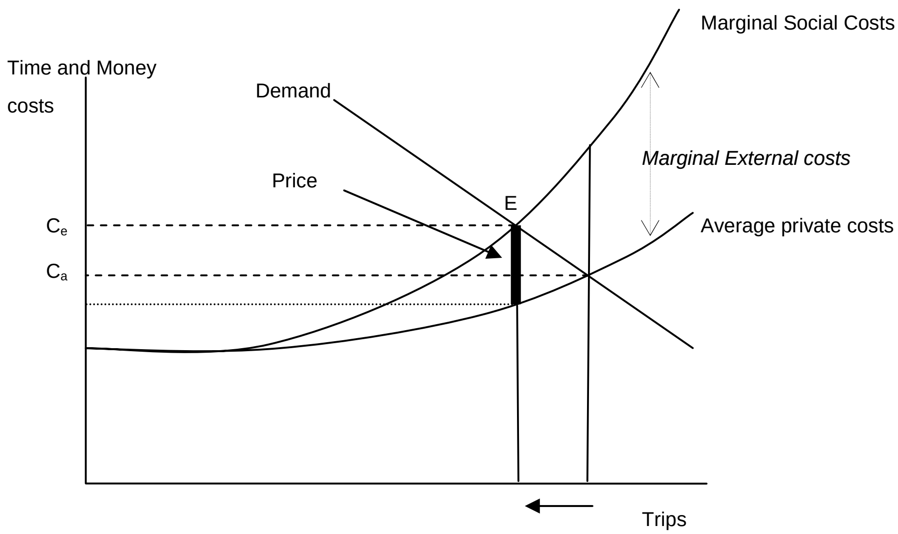


Note: For simplicity fuel duty has been ignored

9.2.6 The most efficient way of reducing demand is via prices, in this case imposing a price C shown below in Figure 3. If set at the optimum it will result in an efficient use of road space at point E.

9.2.7 As demand falls so do congestion costs and there will be journey time savings. The impact of the charge on costs is offset to some extent by journey time savings. Thus the time and money costs rise from C_a to C_e, less than the price. How much of an offset will depend on the value of time. See below.

Figure 3

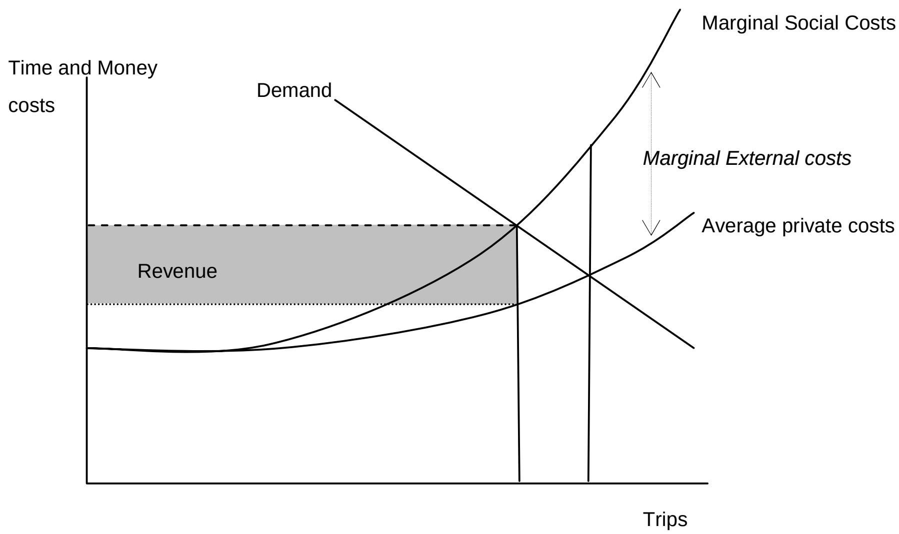


9.3 Welfare analysis

9.3.1 In terms of society as a whole the consequences of imposing a charge C are:

(i) a transfer of revenue from road users to government shown in the oblong “Revenue” in Figure 4 below;

Figure 4

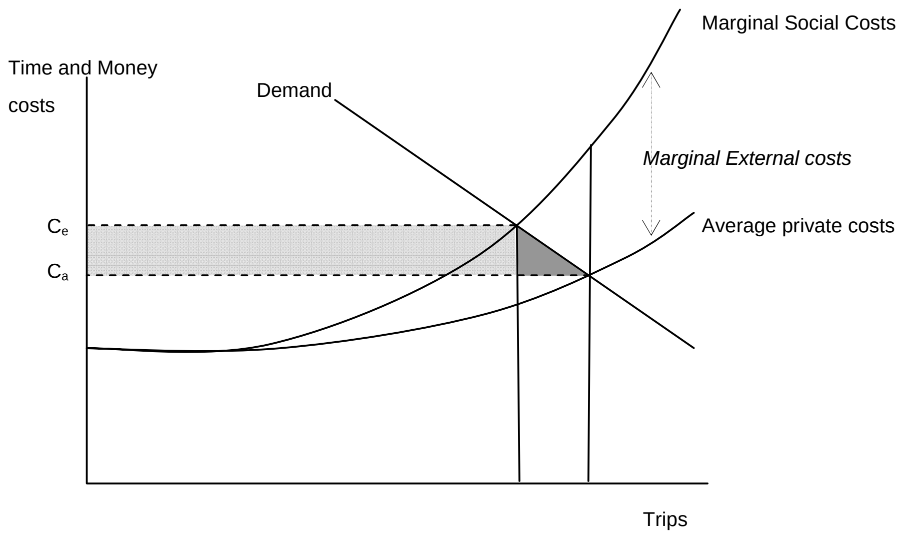


(ii) a reduction in travel times as traffic falls which results in a fall in time and money costs excluding the price, and

(iii) a net increase in time and money costs when the price is taken into account, assuming the price is greater than the value of the reduction in travel times, leading to

(iv) a loss of consumer surplus to those road users who do not change their behaviour and pay the charge (shown in light grey in Figure 5 below). In addition, there will also be a loss of consumer surplus for those who change their behaviour (change route, mode, destination or time of travel) shown in dark grey in Figure 5.

Figure 5



9.3.2 The combination of changes in consumer surplus and revenue is a measure of economic welfare – how much better off individuals collectively are as a result of the scheme. There may be further benefits from modal shift in terms of environment and safety and there may be productivity gains and other wider economic benefits. Of course, the road pricing scheme which delivers the highest benefits may not be the most efficient one, as simpler schemes with lower benefits may also have lower scheme costs. Any appraisal should take account of all of the New Approach to Appraisal (NATA) costs and benefits such as environmental benefits, townscape benefits, reliability benefits, etc.

9.4 The impact on different income groups

9.4.1 For those road users who do not change behaviour, the impacts will depend on whether individual benefits outweigh the price and this will largely depend on their values of time. Those attaching a high value of time could benefit, while those with a low value of time will lose out (this is before any redistribution of revenues or revenue spend).

9.4.2 For example, if the charge was £2, and average time savings were 15 minutes, the high value of time was 20p/min and the low value of time was 10p/min, the high value of time user would see overall costs fall by £1 while the overall costs for the low value of time user would rise by 50p.

9.4.3 Thus we would expect fewer trips to be made by those with low values of time and more trips made by those with high values of time (who may have suppressed trips as a result of the high costs of congestion).

9.4.4 Because there is a strong correlation between income and values of time it is important to segment demand by income. This is primarily for two reasons.

The first is that it is important to know the impact of a pricing scheme on low income road users. The second is that because there are substantially more households with values of time below the average than above, any analysis that uses an average value of time will underestimate the number that change behaviour and overestimate revenues.

9.4.5 Note that low values of time are not just related to income. They are related to journey purpose as well. For example the values of time of shoppers are expected to be lower than those of commuters.