Transport pricing and investment in Britain

A scoping study

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Introduction

The Independent Transport Commission wishes to commission a study into transport pricing, taxation, and investment in Britain. The study will develop a model that explores the implications of different transport policies on traffic flows and travel behaviour. It will address some of the most fundamental issues in current transport policy, but the intention is also to include an exploratory element, seeking to explore more radical avenues than have received attention in existing work.

The pricing and investment study proposes four outcomes:

- Predict inter-modal behavioural responses to changes in transport policy, recognising the linkages that exist between prices, traffic volumes, journey quality, and the time, direction, and destination of travel.
- Provide a basis for reviewing transport investment decisions.
- Indicate the costs and benefits that arise from changes in transport prices and associated traffic and patronage flows.
- Provide a means to appraise transport pricing arrangements and other relevant policies.

As a preliminary to that exercise we have set out to identify in this paper what can reasonably be achieved given the information there is available. This document is our scoping-study report, describing our suggestions for research and the sources of information that might be used

The scoping study is structured as follows. First, we define the purpose of the research and outline the main objectives that the full study should achieve. We then treat in some detail the method we propose to use. Previous studies and relevant sources are then reviewed, identifying the information available for our study and the level of disaggregation of results we can expect to achieve. Aspects of pricing are discussed in the penultimate section. Finally, we offer a comprehensive bibliography of relevant sources.

Purpose of the study

Our research concerns transport pricing in Britain and how consumers may respond to different pricing measures. The overall hypothesis is that prices are often set on the basis of historical precedent or political expediency and their potential use as a tool of efficient transport management is not being given sufficient attention.

The full study we propose will have the following outline.

(1) Establish an appropriate social, demographic and economic background. This will be as it is now, and also some agreed scenarios as to how it might change in the future. Some of these could be those set out in such official documents as the Government's July 2000 Ten Year Plan.

(2) Address the question: putting aside historical, institutional, legal and technological constraints, what would be the effects if all transport users were to be charged a "full price"?

(3) Then consider the question: what would be the economic, social and environmental consequences of a move from the situation established in (1) to that established in (2)?

(4) Taking account of the realities, how far and by what means might Government be able to move from state (1) to (2)?

In addressing items (1) to (3) this scoping study identifies suitable sources of data and parameter values such as elasticities, values of time and incremental costs. Good sources on the costs of external effects such as pollution will be required and the study advises on the extent to which the recent survey by the University of Leeds (Sansom *et al*, 2001) will be adequate.

In addressing (2), there are at least two distinct interpretations that could be given to the phrase "full price":

- the price that would be established if roads were privately owned and unregulated
- the price (including taxes and subsidies) that would face each user with the total of the costs imposed by their actions on others.

The distinction between the two is partly accounted for by external costs and benefits. The final price paid by the user is composed of the price received by the supplier and any element of tax (or subsidy)[1]. In principle, taxes and subsidies could be manipulated as a matter of public policy in order to bring into balance what individuals pay and what costs are incurred by everybody.

The other reason for a distinction is that a private, profit-seeking owner of a road, or road network would be in a position to exploit a degree of dominance. If the supply

[1] There are some important taxes (such as VED) that do not appear directly as elements of a unit price

of capacity were restricted – either because of planning constraints or because the owner were restricting the rate of expansion of capacity as a means of strengthening dominance (i.e. generating and capturing scarcity rents) – then this would normally be judged to be against the public interest. That is why, when concessions to build private infrastructure are occasionally granted (for example with some toll bridges) there is usually some form of public regulation of the behaviour of the concessionaire. The other side of the same coin is the possibility that a private owner would, in practice, have both the incentive and the financial means to fulfil the need for more capacity, to a greater extent that would a cash-strapped public sector.

The implications of these two philosophies will be addressed, though it is likely that more attention would be given to the second, "public ownership" philosophy.

Items (3) and (4) should provide a basis for a comparison of the current structure of transport taxation against that implied by the analysis.

The study will need to recognise three fundamental linkages:

- varying prices will change volumes which, in turn, will vary important dimensions of quality such as speed, crowding and trip time predictability
- varying prices will affect the time of day, direction, destination and mode of travel
- varying prices, taxes and subsidies will change the burden on the public purse and may change the funding available for new infrastructure from both public sources and from privately funded investment.

Thus, differing pricing regimes will create changes in patterns of demand, and consequential changes in the case for investment in infrastructure. The study should form a basis for a discussion of the merits of present investment intentions and the investment requirements under a reformed pricing regime.

General method

The approach we propose will not develop a model that explicitly represents origins and destination of trips. Nor will it have a geographical representation of the road or rail network. Such a conventional transport demand framework is extremely time-consuming to implement and would add a degree of cost and complexity to the analysis that we wish to avoid. Instead, we propose a method that models demand on the basis of trip rates and traffic density for a variety of defined area types.

The study by Sansom *et al* (2001) forms a very valuable starting point. Accordingly, it seems sensible to adopt the classifications used in that report, for instance, with respect to area types, traffic types and time periods. The specific classifications we intend to use are discussed in the relevant sections below.

Traffic density per unit area

Consider a typical one kilometre square in some defined area type based on selected characteristics. The model will work in terms of the flow rates per hour in that unit square. It will distinguish between peak and off peak. It will have estimates of the volume of infrastructure of various types in the unit area. Therefore it will be possible to estimate traffic per unit of infrastructure and thus crowding and congestion.

Avoiding any attempt to model origins and destinations allows a major simplification in modelling and the requirements for data. It should give enough detail to assist a discussion of high-level transport policy. However, it cannot be expected to give detailed information about any specific place.

Long distance trips

The approach essentially relies on the fact that most trips are short and will stay within the area type. This is clearly not reasonable for long distance, inter-city trips, and there will need to be a separate model for these. This would be a conventional direct demand model, using elasticities to relate the volume of travel and the split between modes to price, journey time, income and, possibly, one or two other variables such as reliability and comfort.

London

The London area also creates a special problem because it is heterogeneous and attracts a large number of long distance commuting and leisure trips. It is proposed that London is treated as a special case by application and possibly refinement of the existing METS model (Glaister, 2001). This has been set up to represent the year 2000.

The model has also been set up for the remaining English metropolitan areas, for the year 1997. It would be possible to use it for the present purpose, as with London. However, we suggest that a decision to do that be delayed until work on the approach suggested for the rest of the country has progressed, to see whether that approach would be best used for some or all of the metropolitan areas, or whether METS would be better. The Strathclyde metropolitan area presents similar problems to London, yet the METS model has not been set up for that area because of shortage of data; it might be necessary to attempt to set up METS for Strathclyde.

General approach for most areas
The generalised cost to a user of a specific mode, in a particular place at a particular time of day is a measure of the total of all the costs faced per passenger kilometre:

$$g = p + \tau_v (1/s) + \tau_w w + t + \ldots$$

that is,

money cost + value of in-vehicle time x time per vehicle mile + value of waiting time x average waiting time + taxation + any other relevant costs.

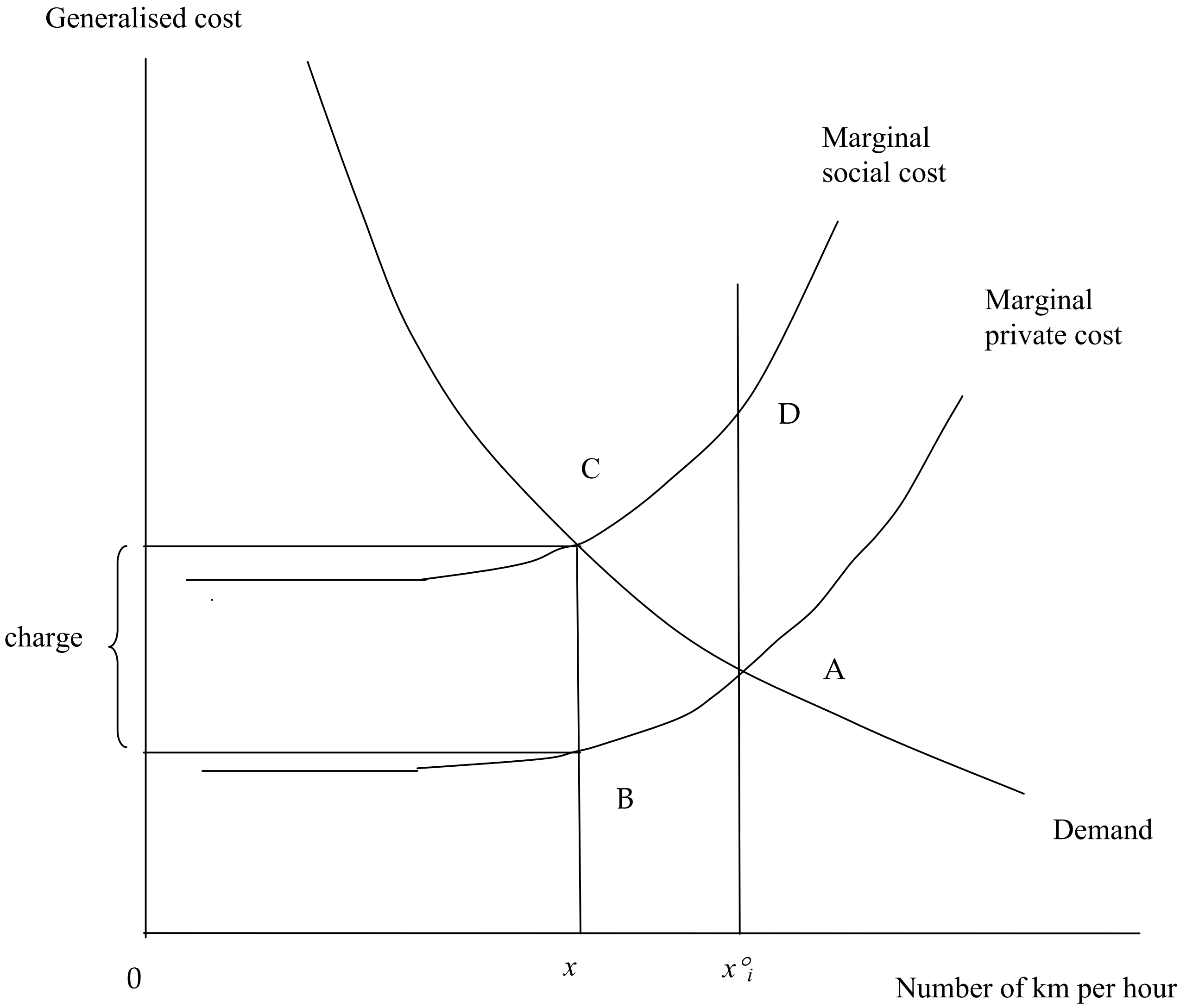

Figure 1

Referring to Figure 1, the vertical axis represents the generalised cost per passenger or vehicle kilometre and the horizontal the flow of passenger kilometres per hour. For any given area type and infrastructure type, Sansom et al essentially provide material to enable an estimate of the marginal private cost and marginal social cost lines illustrated. These are, respectively, the cost to an individual of making one extra trip and the cost to all individuals of one individual making an extra trip. The vertical distance between the lines represents (for any given flow) the difference between the costs borne by the individual user and costs imposed on everybody else.

For example, at the flow x_i^o the cost in terms of the value of time spent and money of an individual travelling one additional kilometre might be £0.10. But the act of making that extra kilometre will cause a little extra pollution cost to others, and slow down all the existing traffic a little. So the total cost to society of the extra trip might be the £0.10 plus £0.03: a marginal social cost of £0.13.

Straight lines drawn for the cost curves would imply assuming constant marginal costs. This might be appropriate for most items, such as pollution and noise. But it would probably over-simplify congestion costs if the relevant domain of variation of traffic volumes is large, because they inherently exhibit increasing margins. For roads appropriate congestion cost relationships should be derived from the standard speed/flow relationships recommended by the DTLR for specific road types, probably on very similar lines to that already developed by Sansom *et al*.

The present equilibrium

The Figure also shows a demand relationship, representing the way the demand might respond to changes in generalised cost. Sansom et al essentially identify the current flow rates and hence the point D, the total short run social costs of an extra trip at that base flow rate x_i^o. In principle the answer to the question "what would be the best generalised cost and flow, given a free hand to adjust taxes and prices?" is given by the point where the benefit of an extra kilometre (the vertical height under the demand curve) is just in balance with the marginal social costs: point C, with the reduced flow, x_i. This is achieved by imposing a unit charge given by the distance BC. Our aim is to estimate the point C.

The position of point C, and thus the magnitudes of the charges and the volume reduction required, is clearly critically dependent on the shape of the demand relationship. Further, bearing in mind that the Figure only represents one of several interdependent modes, the demand for any one of them will depend upon generalised costs for all the others.

A critical determinant of the shape of the demand curve is the response of demand to changing generalised cost at the base demand level - its slope, and how demand for one mode will be changed by a change in generalised cost for a different mode. These quantities are directly related to the own-price and cross-price elasticities of demand. That is why we have given attention below to the sources of evidence on elasticities.

Shapes of demand relationships

Unfortunately, knowledge of the slopes is not enough to determine the shape of the demand curves for anything other than a very small change. There is little conclusive evidence about the shape of the curves – it is hard enough to obtain evidence on the slopes, never mind the actual shape of the curve for large perturbations. A way to handle this problem is to try the exercise with two or more candidate shapes and see how much difference it makes to the qualitative conclusions. It will be important to write the modelling software in such a way that it will be easy to try different functional forms. This applies also to the cost relationships.

Candidates include the linear and the constant elasticity forms. A particularly useful intermediate form is the semi-logarithmic form: if x_i is the number of passenger trips per hour and x_i^o is the base number of trips, then

$$x_i = x_i^o \exp \{ \Sigma_j \lambda_{ij} (g_j - g_j^o) \}$$

Here the λ_{ij} are the constant parameters determining the responses of demand to changes in generalised cost. They relate changes in demand for any one mode to changes in generalised costs (including prices and taxes) for all modes. There is a simple relationship between the λ's and the respective elasticities which enables the one to be calculated from the other. The form has the intuitively reasonable property that the implied own price elasticity is directly proportional to the respective price: as a price rises the mode becomes progressively less competitive, so the loss of market accelerates as the price continues to rise.

Inter-modal switching

It is not reasonable to assume that the cross-elasticities in a particular area will necessarily be the same as a national average. For instance, if a particular area has very few rail services one cannot assume the national average percentage change in car trips as a result of a one percent change in rail fares. It is a simple matter to modify national cross elasticities to reflect the local market shares.

Also, there may be good reason for thinking that own-price elasticities deviate from the national average. The software should make provision for easy adjustments to elasticities to facilitate the imposition of local variations.

Peak and off peak

It is important to attempt to represent the distinction between peak and off-peak flows, because of the non-linear nature of congestion and crowding. However, it is very hard to obtain reliable estimates of how traffic might interchange between peak and off peak. In the first instance a useful simplifying assumption may be that there is no such interchange.

Freight

Whilst we have identified evidence on price elasticities for passenger markets, much less seems to be known about freight markets. In the first instance it may be necessary to assume that cross-modal freight elasticities are zero. Road freight volumes need to be represented because of their contribution to traffic volumes - probably in terms of standard Passenger Car Units.

The numerical algorithm to search for the best price and tax levels

The steps for computing the movement from point D to point C will be:

- Establish suitable national average own-price and cross-price elasticities.
- Modify these to local conditions using local market shares.
- Convert from the modified elasticities to the respective λ's.
- Change a policy variable, such as a rail fare or a tax on petrol
- Calculate a new, *mutually consistent* set of demands and generalised costs.

Note that this last stage will involve an iterative algorithm because of the interdependencies. This problem is similar to the one solved numerically in the METS model (Glaister, 2001), so we have confidence that it can be made to work.

Having set the system up in this way it will be relatively easy to "search" iteratively to find the set of taxes and charges corresponding to point C in Figure 1. This would also yield estimates of the revised volumes of travel and hence the changes to tax revenues and public transport costs , revenues and subsidies. Therefore, an estimate would be produced of the overall net effect on the public finances.

Commercial charging

The total price that would maximise revenue is, in principle, relatively easy to find. Its position on the figure depends critically on the shape of the demand curve over a wide range of prices. Essentially, one is asking, how far can one go in raising charges before the loss of traffic outweighs the gain in revenue from each unit of traffic? The answer to this is likely to be highly dependent on local circumstances.

For these reasons it will not be possible to be precise about the full commercial price. However, it should be possible to give some indication of where it might be in relation to today's prices. It will then be possible to deduce the approximate magnitudes of the incremental revenues available if a commercial owner expanded capacity.

Programming language
Although simple in concept this is a moderately complex task to set up in software, and the computational task is significant. It is very well within the capabilities of any modern desk-top computer. However, it is probably too large and complex a task to program using a spreadsheet such as Excel. We would recommend using a high level programming language such as BASIC, Pascal or FORTRAN.

It is important that at all stages the software is designed in such a way that it is easy to alter parameters and functional forms for the purposes of experimentation and accommodating data as it becomes available.

Road and rail demand studies

In this section we identify sources that provide information about the elasticities of road and rail demand.

Road traffic demand elasticities.
Elasticities of demand for road transport are well documented in the literature. Recent surveys can be found in Glaister & Graham (2000), Graham & Glaister (forthcoming), Dahl (1995), Goodwin (1992), Sterner et al (1992), and Sterner & Dahl (1992). For the purposes of the present research we can identify four types of study that are relevant.

General road traffic studies

The general studies provide information on road traffic demand elasticities in aggregate, and estimate how the demand for road use responds to changes in national income or GDP, and price. There is generally no disaggregation for different vehicle types in these studies. There is, however, good information on the distinction between short and long run price and income effects.

Private car specific studies

These are generally based on models using individual household demand data and provide elasticity values specific to private car users (DTI 2000, DETR 2000a, Dargay & Vythoulkas 1998, 1999, Romillly *et al* 1998, Eltony 1993, Rouwendal 1996, Blum *et al* 1988, Henshner *et al* 1990, Puller and Greening, 1999, Johansson and Schipper 1997).

Bus demand elasticities

Dargay & Hanly (1999) and (2000), Clark (1997), Fairhurst & Edwards (1996), and Goodwin (1992) provide evidence on bus fare elasticities for Britain emphasising differences in magnitude between short and long run effects. Preston (1998) has distinguished price elasticities of demand between the peak and off-peak, while

Wardman (2000) and Dargay and Hanly (1999) provide geographical and socio-economic breakdowns for Britain. Variation by user groups, including concessionary fare passengers, is covered in Preston and Mackie (1990). This bus fare elasticity literature is reviewed in Bristow *et al* (2001) and Bristow and Shires (2001).

Freight traffic demand elasticities

We have not found studies containing direct evidence of road freight traffic demand elasticities. The assumption employed in many studies is that road freight activity is price inelastic, for instance ROCOL (2000) and Glaister (2001).

Rail travel demand elasticities.

The most authoritative source of rail elasticities is contained in the *Passenger Demand Forecasting Handbook* (PDFH). This was first developed by the Policy Unit of British Rail and has been continually updated. It is now held by the Association of Train Operating Companies (ATOC). Because of the commercial significance of some of the information the document is not generally available. We have spoken to officials at ATOC who have indicated that they would co-operate in releasing relevant data under appropriate restrictions.

PDFH provides information about aggregate and differential rail fare level elasticities for Britain. Separate elasticities are given for different journey purposes such as commuting, business, personal and leisure travel, for different areas of the country (London, non-London urban, non-London inter-city, non-London other), and by type of trip (i.e. inter-city trips, short, medium and long-distance trips). Further work in the PDFH includes the treatment of cross-elasticities between full fare and cheaper restricted tickets, differential pricing between train operators, and some advice on other products such as First Class, railcards, multi-journey tickets, and zonal fares.

We understand that AEA Technology have carried out an extensive study into rail elasticities in an attempt to derive a comprehensive set of values. Dr. Mark Wardman of the Institute for Transport Studies at the University of Leeds is in the process of reworking this analysis and he expects to have a report available in the autumn of 2001.

Cross price elasticities

A number of recent articles exist that provide information on cross price elasticities for transport in the UK:

Acutt & Dodgson (1995) provide a set of cross-elasticities of demand at the national level for travel in Great Britain. The elasticities consist of cross-elasticities between car travel and the fares on six different public transport modes, and between travel on these six modes and the price of petrol.

Clark (1996) reviews cross price estimates from studies that employ aggregate models based on collective behaviour, such as market share or travel volumes.

Whelan (1997) provides a review of cross-price elasticity estimates in relation to car ownership modelling and forecasting.

Wardman *et al* (1997) provide evidence about rail and car cross elasticities in the inter-urban leisure travel market in Britain.

Wardman (1997a) reviews urban cross price elasticities estimates for rail and car, rail and bus, and car and bus.

Wardman (1997b) reviews estimates from inter-urban studies of Great Britain using disaggregate mode choice models. His review covers rail and car, rail and coach and considers the demand for both business and leisure travel.

Accent Marketing *et al* (1989) provide evidence on inter-city business travel cross price elasticities for Britain.

Glaister (2001) and Grayling & Glaister (2000) provide geographical information for the conurbations for intra-urban cross price elasticities, including values for the London underground.

Inter-urban travel

ATOC (1997) provide elasticities of demand for inter-urban rail travel and DETR (2000c) provides elasticities of demand for air travel for the purposes of air traffic forecasting.

The report of the Monopolies and Mergers Commission (1994) into the Midland Main Line case summarises a quantity of evidence on inter-urban elasticities that was available at that time.

Values of time.

Values of time for road, rail and underground users are given in DETR (1997), Glaister (2001) and DETR (2001). Specific values for bus passengers are in Bristow and Shires (2001), MVA *et al* (1987), WS Atkins & Polak (1997), Wardman (2000), Wardman (2001) and Bristow *et al* (2001). General information on the evidence for values of time on British transport modes can be found in Wardman (1997c), (1998a), (1998b), and (2001).

Service quality values

Road

Insofar as road service quality is captured by achieved road speed, the generalised cost formulation implies a direct relationship between price elasticity and the speed elasticity through the respective value of time.

There appears to be relatively little reliable evidence on elasticities with respect to reliability. Although this is an important factor at the level of the individual trip, it may be less so at the level of this study, where it would be hard to represent changes in average reliability in a meaningful way.

Rail

The PDFH contains comprehensive information about how rail passengers respond to service quality changes.

More to be added on crowding, and waiting time effects

Transport supply studies.

Road and rail cost studies

It may be hard to obtain reliable estimates of operating and capital costs, especially in the case of railways in view of the current turmoil in the industry.

A number of recent studies have examined costs and revenues associated with road and rail transport in Britain. British road costs are analysed by Madison *et al* (1996) and Newbery (1998). Madison *et al* consider total road costs but do not disaggregate by vehicle type, while Newbery focuses mainly on total social costs but does provide information for different vehicle types.

A variety of other studies analyse both road and rail costs, however the geographic coverage tends to focus on case study areas rather than Britain as a whole (Peirson & Vickerman 1997, Bickel *et al* 1998, Sansom *et al* 1999, Proost & Van Dender 1999, Roy 2000). All these studies give information on the marginal costs of transport for their case study areas, and with the exception of Bickel *et al*, the undertake modelling optimal prices. In most cases, it is difficult to generalise the geographic case study results to the national level.

Possible other sources include a recent study by NERA on cost recovery in highways, We understand that Professor Chris Nash of the University of Leeds is currently undertaking a relevant study for the Institute of Logistics and Transport.

The cost study by Institute for Transport Studies, University of Leeds
Perhaps the most comprehensive recent study of road and rail transport costs in Britain is by Sansom *et al* (2000). They undertake a study of surface transport costs and charges for the UK. Their interest is in understanding the possibilities offered through charging, taxation and subsidy for the development of transport policy.

This work provides highly disaggregated cost and revenue calculations by geographical area and by vehicle type. Insights from this study are likely to prove extremely valuable in the research we intend to undertake, and it is worth outlining the scope of this work in more detail.

In support of their objective Sansom *et al* provide two sets of information about the costs of road and rail transport:

The efficiency perspective

identifies *marginal costs and revenues*. As regards pricing, the interest lies with the additional cost not directly borne by the user that arises with an additional passenger or freight tonne kilometre (externalities). Private marginal costs are not relevant.

The cost coverage perspective

describes *fully allocated costs and revenues*. For pricing the interest is in the cost imposed by a group of users on the rest of society. The cost imposed by individual users on users of the same mode is not relevant.

To incorporate the main factors underlying variation in cost the authors disaggregate their analysis by location of travel, road or rail infrastructure type, vehicle or train type, and the time period of travel.
The disaggregations for the road framework are:

- 11 area types (3 for London, 2 for conurbations, 5 other urban, rural)
- 3 road types (motorway, trunk and principal, other)
- 5 vehicle types (car, light goods vehicle, rigid heavy goods vehicle, articulated heavy goods vehicle, public service vehicle)
- 2 time periods (weekday peak from 0700-1000 and 1600-1900, other times)

For rail they use three disaggregations relating to passenger service types and two for freight:

- Inter-City passengers services
- Regional rail passenger services
- London commuter catchment-based passenger services
- Bulk freight
- Other freight

Results for the road sector are shown in Table 1.

Table 1: Comparison of 1998 road sector costs and revenues (pence per vehicle km), Great Britain, 1998 prices and values.

Cost or revenue category	Fully allocated cost		Marginal cost	
	low	High	low	high
Costs:				
Cost of capital for infrastructure	0.78	1.34	n/a	n/a
Infrastructure operating costs and depreciation	0.75	0.97	0.42	0.54
Vehicle operating costs (PSV)	0.87	0.87	0.87	0.87
Congestion	n/a	n/a	9.71	11.16
Mohring effect (PSV)	n/a	n/a	-0.16	-0.16
External accident costs	0.06	0.78	0.82	1.40
Air pollution	0.34	1.70	0.34	1.70
Noise	0.24	0.78	0.02	0.05
Climate change	0.15	0.62	0.15	0.62
VAT not paid	0.15	0.15	0.15	0.15
Sub-total of costs	**3.34**	**7.20**	**12.32**	**16.32**
Revenues:				
Fares (PSV)	0.84	0.84	0.84	0.84
Vehicle excise duty	1.10	1.10	0.14	0.14
Fuel duty	4.42	4.42	4.42	4.42
VAT on fuel duty	0.77	0.77	0.77	0.77
Sub total of revenues	**7.14**	**7.14**	**6.17**	**6.17**
Comparison of costs, revenues:				
Difference (cost - revenue)	**-3.79**	**0.07**	**6.15**	**6.17**
Ratio: revenues / costs	**2.13**	**0.99**	**0.50**	**0.58**

Marginal cost and revenue analysis for road

- The ratio of marginal revenue to marginal cost is 0.50 given the low cost estimate and 0.58 given the high. Thus, road transport charges would have to rise if they are to be set on economic efficiency grounds.
- The report identifies a need for a far higher degree of differentiation in road user charging than current instruments allow for. However, the report does not assert that these mechanisms are justified on cost-benefits grounds.

- The excess of marginal costs over revenues does not contribute to the case for wider economic benefits from transport investment.
- Subsidy to the bus industry is not justified on an economic efficiency basis.

Fully allocated cost analysis for road

This approach is less relevant for the present study. The results are:

- Total social costs for the road sector range between being broadly covered by revenues (high cost estimate) to being more than twice covered by revenues (low cost estimate).
- Cost coverage occurs for all vehicle types except PSVs for low cost estimates, but only for cars with high cost estimates.

Results for the rail sector are shown in Table 2 below:

Table 2: Comparison of 1998 rail sector costs and revenues (pence per train km), Great Britain, 1998 prices and values.

Cost or revenue category	**Fully allocated cost**		**Marginal cost**	
	low	**high**	**low**	**high**
Costs:				
Infrastructure	5.33	3.41	0.42	1.19
Vehicle operating costs	7.07	9.28	7.07	9.28
Electricity	-	-	0.23	-
Congestion	n/a	n/a	0.18	0.00
Mohring effect	n/a	n/a	-1.05	n/a
Air pollution	0.46	0.68	0.46	0.68
Noise	0.16	0.37	0.16	0.37
Climate change	0.12	0.33	0.12	0.33
VAT not paid	1.32	n/a	1.32	n/a
Sub-total costs	**14.46**	**14.07**	**8.91**	**11.85**
Revenues	**7.52**	**13.41**	**7.52**	**13.41**
Comparison of costs, revenues:				
Difference (cost - revenue)	**6.94**	**0.66**	**1.39**	**-1.56**
Ratio: revenues / costs	**0.52**	**0.95**	**0.84**	**1.13**

Marginal cost and revenue analysis for rail

- If set to achieve economic efficiency transport charges would need to rise for passenger rail and fall for freight.

- The excess of revenues over marginal costs for freight contributes to the case for wider economic benefits from rail freight investment

Fully allocated cost analysis for rail

- Rail freight almost covers its social costs but passenger services only cover about half of social costs.

Other vehicle and mode-specific studies
The following sources provide information on mode or vehicle specific costs:

Bus operating costs

for Britain are reported in Bristow and Shires (2001), Preston (2000), and White (2000).

Heavy goods vehicle traffic costs

NERA *et al* (1999) consider the external costs of HGC traffic in Britain including information on total costs and fully allocated costs.

Investment in infrastructure
The cost relationships derived by Sansom *et al* are explicitly short run. That is, they take the basic volume of infrastructure available as a given. The result of the analysis just described would therefore indicate how to use taxes and charges to make best use of the *existing* infrastructure. It will also give a general indication of the extent that it would be justified to spend new resources on expanding capacity.

Further, to the extent that the move towards optimum pricing would reduce demand by increasing prices (and Sansom *et al* indicate that this will generally be the case) this will imply a reduced need to expand capacity in the future. In situations where increasing capacity is, in practice, an option this will give a guide to when and in what circumstances and to what extent that capacity should be provided. For this purpose it will be necessary to have estimates of the incremental costs of infrastructure capacity.

An alternative way of increasing capacity is by making more effective use of existing infrastructure. The Appendix by Vodafone Group Research and Development gives some indications of the considerable scope that new communications technology may offer for this. The final study will need to consider the ways in which these new opportunities may alter the methods of increasing capacity, and the incremental costs of doing so.

Transport data for Britain

Our study will draw a variety of official published data:

National travel data

Official published travel data are derived from a variety of sources including the National Travel Survey (NTS) - a household survey of personal travel carried out by the DTRL, with a sample of almost 6,000 households completing a seven day travel diary. Transport statistics are available for Great Britain (DETR 2000b), for the metropolitan areas (DETR 1999), and for Greater London (DETR 1998)

Socio-economic and demographic data

The basic data on social, economic and demographic trends will be obtained from the Censuses of Population and Employment via the National Online Manpower Information System (NOMIS). Up-to-date regional and sub-regional socio-economic data can also be obtained directly from the Office for National Statistics (ONS) and is regularly published (e.g. ONS 2001a).

Consumer expenditure data

Household expenditure on travel is reported in the family expenditure survey (ONS 2001b). This source indicates how much is spent on various components of transport by different types of household. It is particularly useful in allowing one to identify the relative impact of price changes across different categories of consumer (e.g. Glaister & Graham 2001)

In addition to these published sources the DTLR have made available more detailed data for use in our study:

The National Road Traffic Forecasting (NRTF) data

This data comprises counts of road traffic from over 50,000 sites in the UK. The data provides information on the volume of traffic flows by vehicle type, by a variety of geographical areas, by time of day, type of road, speed, and level of congestion.

Traffic costs database

Provides information on a variety of road transport costs including infrastructure costs, and costs associated with air pollution, noise and accidents.

Trip rate data - the DTLR have conducted runs of their demand model to provide us with trip rate data for our areas of interest. The trips are disaggregated into combinations of origin area type, destination area type, distance, mode and purpose.

Disaggregation of outputs

Many of the data to be used in our research are identical to those used by Sansom *et al* (2001) and results from their study will form inputs in our model. Sansom *et al* found that data availability placed constraints on the level of dissagregation they could achieve in their study. For these reasons, it makes sense for this study to match closely the disaggregation of its outputs with those of the earlier study.

In this section we review the Sansom *et al* classifications and suggest ways of matching them given the available data. Many more classifications are specified in the study for road than for rail. This is due to limitations on train operating company data imposed because the SRA or ATOC can only release such data with the consent of each individual TOC. Accordingly, for rail transport, the overall disaggregation has been effectively limited to five types of service:

- Inter-city passenger services
- Regional rail passenger services
- London commuter catchment area services
- Bulk freight, freight for which trainloads comprise one commodity
- Other freight.

Below we focus on the disaggregations used for road sector outputs.

Geographical disaggregations
For road transport Sansom *et al* (2001) define 11 area types covering England only - 3 London, 2 conurbation, 5 urban, and 1 rural. The choice of this particular disaggregation was determined by the National Road Traffic Forecasting (NTRF) data that was used for congestion cost calculations. They used this classification in preference to more detailed location information.

The specific area type classification from the NTRF data area as follows:

i. **Central London** - area covered by the City of London and the London Borough of Westminster.

ii. **Inner London** - area covered by the boroughs of Camden, Hackney, Hammersmith & Fulham, Haringey, Islington, Kensington & Chelsea, Lambeth, Lewisham, Newham, Southwark, Tower Hamlets, and Wandsworth

iii. **Outer London** - area covered by the boroughs of Barking and Dagenham, Barnet, Bexley, Brent, Bromley, Croydon, Ealing, Greenwich, Harrow, Havering, Hillingdon, Hounslow, Kingston-upon-Thames, Merton, Redbridge, Richmond-upon-Thames, Sutton, Waltham Forest

iv. **Inner Conurbations** - defined either in terms of administrative district or in terms of a circle of radius five kilometres drawn around a central point

Conurbation	*Coverage*
West Midlands	Birmingham
Greater Manchester	Manchester
Merseyside	Liverpool
West Yorkshire	5km radius circles of Leeds and Bradford
Tyne & Wear	5km radius circle of Newcastle

v. **Outer Conurbations** - are either areas surrounding inner conurbations, or separate spreads of urban areas where individual boundaries are distinct

Conurbation	Coverage
West Midlands	Coventry, Dudley, Sandwell, Solihull, Walsall, Wolverhampton
Greater Manchester	Bolton, Bury, Oldham, Rochdale, Salford, Stockport, Tameside, Trafford, Wigan
Merseyside	Knowsley, St Helens, Sefton, Warrington, Wirral
West Yorkshire	Calderdale, Kirklees, Wakefield
Tyne & Wear	Gateshead, North Tyneside, South Tyneside, Sunderland

vi. **Urban areas greater than 25 square kilometres** -

Size	*Urban area*
120 - 130 kms^2	Stoke
110 - 120 kms^2	none
100 - 110 kms^2	none
90 - 100 kms^2	Nottingham
80 - 90 kms^2	Bristol
70 - 80 kms^2	Leicester
60 - 70 kms^2	Bournemouth, Hull
50 - 60 kms^2	none
40 - 50 kms^2	Luton/Dunstable, Norwich, Reading
30 - 40 kms^2	Blackpool, Brighton, Derby, Grimsby, Ipswich, Peterborough, Plymouth, Southend on Sea, Swindon, Telford
25 - 30 kms^2	Cheltenham, Frimley/Farnborough/Aldershot, Middlesborough, Southampton, Woking, York

vii. Urban areas of 15 to 25 square kilometres

Size	*Urban area*
20 - 25 kms²	Basingstoke, Blackburn, Chatham, Chester, Colchester, Eastbourne, Gloucester, Hartlepool, Northampton, Preston, Slough, Stockton-on-Tees, Torbay, Watford, Worthing
15 - 20 kms²	Bath, Bedford, Cambridge, Carlisle, Chelmsford, Cheshunt/Hoddesdon, Chesterfield, Crawley, Darlington, Exeter, Guildford, Harrogate, Hemel Hempstead, High Wycombe, Lincoln, Maidenhead, Mansfield, Oxford, Portsmouth, Scunthorpe, Shrewsbury, Stafford, Staines, Walton/Weighbridge/Sunbury, Warwick/Leamington Spa

viii. Urban areas of 10 to 15 square kilometres - 45 areas

ix. Urban areas of 5 to 10 square kilometres - 128 areas

x. Urban areas of 0.05 to 5 square kilometres - 1,096 areas

xi. Rural areas - all area types not included in i. to x.

Road infrastructure type

For road transport three infrastructure types are defined - motorway, trunk & principal, and other. This particular classification was constrained by the specification of the infrastructure cost database (NERA 1999) and the traffic cost database used (DETR 2000b).

Road vehicle type

The road vehicle types used by Sansom et al are defined by the NRTF database. These are:

- Car
- Light delivery vehicle (LDV)
- Heavy goods vehicle (HGV) - rigid
- Heavy goods vehicle (HGV) - articulated
- Public service vehicle (PSV)

Time period

Two levels of time period were used by Sansom *et al*

i. weekday peak (07.00 - 10.00, 16.00-19.00)
ii. all other time periods in the week

In fact the NRTF data that was used in the study would have allowed for a disaggregation into 19 time periods. The choice of only periods was made on the basis of manageability.

Other, related studies

We have become aware that there are several studies underway, or about to start, that have some overlaps with the work proposed in this paper.

The Department of Transport, Local Government and the Regions (DTLR) continue to develop their own modelling and forecasting work, as used in the development of the Ten Year Transport Plan. We have met officials from DTLR and discussed these proposals with them. They were extremely helpful and indicated that they would render such assistance as they could.

The Commission for Integrated Transport has been asked to monitor the progress of the Ten Year Plan and in that connection they have commissioned work from NERA, Oscar Faber. We have spoken to these consultants and taken the impression that their work is confined to the roads sector and is not "multimodal". There is overlap on the roads side, but the two studies would provide an interesting crosscheck on one another. They indicated an interest in exchanging ideas, to the extent that they are able to within the constraints of confidentiality.

The Royal Automobile Club has started a consultation exercise, relating to many of the same issues as we are proposing to address. (NERA drafted an initiation report for them.) We have spoken to Professor Sir Christopher Foster who expressed a strong interest in co-operating with this work.

The Rees Jeffreys Road Fund is about to invite proposals to carry out research, directed particularly towards the future quality of the travel experience, how it can be improved and by how much, and the extent to which people's expectations could be fulfilled.

There is work under way at the Transport Research Laboratory into the marginal costs of various modes under the direction of Neil Pauly.

Unidentified aspects of transport pricing

The scoping study has turned up little solid information on certain aspects of our original research proposal. In particular, we believe that it will be difficult to provide in depth analyses of the following issues:

Interactions between transport costs, pricing and land use

We have not found suitable sources of information or relevant studies to convince us that any real modelling of these interactions can be included. Where appropriate, we may be able to give a qualitative and speculative view about likely consequences.

The role of new technologies

Our scoping study has not identified a substantial body of research concerned with the role played by new technologies or new methods of charging for travel. It is likely that any contribution in this area will be ancillary to the main pricing study and of a qualitative or speculative nature.

It has been pointed out to us that the elasticities and other parameters that we discuss above have, of necessity been generated from current or past observed behaviour. In practice, if much more sophisticated pricing regimes were to be introduced, the responses might differ from that in the past. This issue must be addressed, but it may be hard to bring reliable evidence to bear.

The Appendix by Vodafone Group Research and Development gives a clear indication of the extent to which pricing, service delivery and information are likely to increase in complexity and sophistication in the near future. The study will need to respond to these changes in framing its final recommendations.

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APPENDIX
Mobile Communications in Future Integrated Transport

Vodafone Group Research and Development

The Problem of Traffic Congestion

Road traffic congestion increases travel time, energy consumption and pollution. It is indiscriminate, disrupting leisure, business and emergency traffic regardless of its social or economic priority.

Congestion may be caused by breakdowns, road repairs and accidents, but the most significant cause is simply traffic overload – or demand outstripping supply. By nature congestion occurs as hot spots distributed both in location and time.

Approaches to the Problem of Managing Traffic Congestion

A solution to the problem of traffic congestion may include measures to:

- increase supply – for example by road building or improvement, or by making public transport an attractive alternative;
- reduce demand – for example by hot-spot sensitive road pricing;
- manage traffic flows – for example by being able to manage the routes taken by individual vehicles in real-time.

These measures would benefit from continuous real-time communications with individual vehicles to gather traffic statistics and model traffic behaviour, to charge for road usage that reflects demand, to plan and manage journeys – including timing, routing, parking, payment, breakdown prediction and management, and switching to alternative transport.

The Potential for Mobile Communications in Traffic Management

A mobile communications system, and in particular one using GPRS and 3G, has the potential to provide an ideal means for communicating traffic management information, and for providing the heart of a system for road usage charging. It offers the potential for traffic management and road usage charging based upon knowledge of the behaviour and eventual control of individual vehicles. Three main features of mobile communications make this possible:

A real-time, always-on, packet communications to individual vehicles – which can be used to manage traffic at the level of individual vehicles, for example through:

- vehicle identification, location and speed monitoring – enabled by a GPRS/3G device implanted in the vehicle;

- monitoring of local environmental conditions – the information being provided by vehicles enabled with pollution sensors, weather sensors, cameras, etc;
- real data for traffic modelling from vehicles and fixed locations;
- communication to individual drivers and their vehicles for journey management;
- emergency and breakdown management – including communication with engine management systems to predict malfunction.

A charging and payment system – that can be adapted and used for individual demand based road charging and payment.

An infrastructure that is already in place – there is no need to build another communications and billing system for traffic management.

Functions of Transport Management Provided by Mobile Communications
There are a number of specific functions needed by a transport management system that could well be catered for by mobile communications, particularly if individual road usage charging is to be introduced. These functions are outlined below.

For road and rail traffic management
1. Data gathering from distributed sources – cars, lorries, trains, infrastructure and people.
2. Tracking of vehicles, goods and local environmental conditions – through location and sensor technology and on-board processing, integrated with mobile communications in road vehicles, trains, freight containers, etc.
3. Modelling traffic flows and predicting traffic conditions – using data that mobile network operators gather in order to provide service to their customers and manage their networks.

For reducing road traffic by improving public transport
4. Communications for public transport management – to match the local demand, or pending demand for public transport, with availability.
5. Passenger information, help and reservation services – including fares, timetables, train delays, seat reservations, queues at bus stops, etc.
6. Inter-modal payment – mobile commerce techniques to allow payment for road use to be transferred to payment for railway tickets and parking.

For traffic reduction and restraint
7. Heavy vehicle control – informing lorries of when and on which routes they are authorised to use for delivery and monitoring violation.
8. Access and route control – informing drivers and monitoring violation of current access controls to cities based on travel priority, pollution levels, parking availability, etc.

For charging and payment

9. Road usage charging – based on temporal and spatial conditions such as the nature of the road, popularity of the route, current traffic levels provided without the need to build additional roadside infrastructure of billing systems.
10. Road pricing information - sent to a vehicle to enable it to continuously track its position and the charges that will made by using certain roads, so that the driver can mange the cost of the journey in real-time, taking breaks to allow traffic levels and costs to go down.
11. Parking space management – using mobile communications devices to reserve, gain access to and make payment for parking.

For improving safety

12. Road safety – communications to individual vehicles to warn of accidents, to advise on road conditions and recommended speeds, with the possibility of automatic speed control of individual vehicles if socially acceptable.
13. Transport security – monitoring and tracking of vehicles transporting hazardous materials.

For managing the consequences of congestion

14. Congestion information – providing relevant and timely information and services (including entertainment and access to business data) to those caught up in traffic jams.

Research into the Use of Mobile Communications for Traffic Management

A number of the functions outlined need to be researched further before being implemented in a mobile network. Indeed if mobile systems are to be used as the basis for communications and payment for traffic management, then there is considerable need for research into how this is to be best achieved. In addition there are several special topics that would merit research. Some of these are outlined below.

1. Ad-hoc networking for traffic management – ad-hoc networking uses mobiles as base stations to relay data; the potential to use the car in front of or behind you to relay traffic data should be looked at seriously as a mechanism for traffic management, including collision avoidance.
2. Packet switched vehicles – investigate adapting the Internet Protocol for data packet routing to real traffic routing of cars controlled through a mobile link; for example cars could be remotely controlled, for certain periods of the day and certain routes, and assigned slots on roads.
3. Location based services for car sharing and pooling – investigate the design of an application of mobile location services to enable people to come together for car sharing or car-pooling.

4. Adaptive road management – investigate the possibility of traffic lights and traffic lanes being managed in a way that is sensitive to the priority of the traffic.
5. Parking space management – investigate the use of mobile communications for a complete parking space management system, including reservation, arrival time dependent allocation, access and payment.

A comprehensive list of research and development tasks, that is intended to provide a complete picture of the application of mobile communications to traffic management, and which complements research being undertaken in other research programmes within the European Union and the UK, is being prepared by Vodafone Group Research and Development.

Vodafone Involvement in Traffic Management

Vodafone Group Research and Development is already engaged in several traffic management projects:

1. UK: Urban and inter-urban road charging; project DIRECTS (DTER)
2. Germany: Heavy goods vehicle charging
3. Netherlands: Road runner – a project to research different road management systems

In addition, Vodafone Telematics already operates traffic management systems:

1. Passo operates a road traffic sensor network in Germany – providing a system to collect speed and vehicle type, covering 80% of German motorways
2. Passo operates a traffic data acquisition system
3. Passo operates the location based BMW assist service

Vodafone Group Research and Development
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