ECONOMICS AND THE ROAD PROGRAMME

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INTRODUCTION

Road schemes in the United Kingdom are evaluated by cost benefit analysis (CBA). The supporters of CBA usually characterise it as a simple and logical extension of common sense: "The returns measured on road investment . . . are not of a direct financial nature . . . What . . . is used is called cost benefit analysis . . . The basis of the calculations is not highly technical and appeals to straightforward common sense" ([1], p. 2). Its opponents are more critical: "The general idea of CBA is to express some or all of the factors that are considered relevant to some decision in terms of a common denominator of money so that their magnitudes can be directly compared." However, this requires a number of sweeping assumptions—assumptions which the analyst rarely makes explicit. We must assume "that it is possible to quantify in monetary terms all sorts of factors that normally are not so expressed; secondly that the money terms used in the analysis really do possess the common property which they appear to have . . . ; and thirdly that these figures represent measurements of some concept of community welfare which can or should stand . . . as one important criterion of the best policy" ([2], p. 5).

A lot of criticism has focused on the government's own methods of appraisal, particularly on the National Traffic Forecasts and the computer program COBA, which calculates and discounts the costs and benefits of inter-urban road schemes over an assumed 30 year life to produce a net present value (NPV) for each scheme. The recent Green Paper ([3], vol. 1, p. 72) recognised this "criticism" and promised an independent assessment of COBA (the Department's general method of appraising road schemes), its traffic forecasts and the weights given to economic and environmental factors.

Criticism has generally been of two kinds. Some people have questioned the fundamentals of CBA and its specific application to road works; others have concentrated on points of detail (often of a mathematical or statistical kind) or on the particular empirical values used in the evaluation. Most critics have furthermore been critical of "best practice", not only of the way the Department has translated it into a detailed planning methodology. In the view of many critics, even the best practices of engineering economy are either based on false premises or simply not good enough.

* Director, Transport Studies Unit, Oxford University. This article is a revised version of evidence presented to the Leitch Committee in early 1977. The Department of Transport subsequently commissioned research on car ownership along the lines outlined here.

CURRENT METHODS OF EVALUATION

Each scheme is evaluated on a "with" and "without" basis. The existing traffic flow is measured in terms of its principal components and is forecast for 30 years ahead of the road's proposed opening date. The *benefits* of the scheme are then calculated by subtracting the cost of using the road "with" the new improvement from that of using it "without" the improvement.

Most of the benefits are attributable to time savings. "On average, time savings by value account for about 80 per cent of total benefits."[1] Savings in working time account for nearly two-thirds of the total time savings; the remaining one third represents savings in commuter travel time and in time spent in travel for education, shopping and personal business. Time savings to car drivers account for 49 per cent of the average benefits.

The "other main quantifiable benefit is fewer accidents" ([3], vol. 2, p. 100). Road improvements generally lower the rate of accidents, although the cost of an accident on a motorway is higher than on other roads. On average this accounts for about 20 per cent of benefits.

A road improvement may also give rise to small savings in vehicle operating costs. Fewer delays (due to congestion) result in lower operating costs, although increased speeds, particularly in the range above about 30 m.p.h., result in higher operating costs. The net change in vehicle operating costs may thus be positive or negative, depending on the precise nature of the scheme. They are usually quite small.

COBA finally assumes that inter-urban road improvements do not affect basic trip patterns. It thus takes no account of induced traffic, assuming only diversion, redistribution and changes in mode choice.

The savings listed can now be used to calculate the economic return of the road scheme. COBA does this by calculating benefits over an assumed thirty-year life, discounting them at the test discount rate (TDR)[2] and subtracting from this the discounted investment cost of the scheme. This includes the cost of compensation, of noise insulation to buildings and of the environmental treatment of the road. A simple decision rule is then applied: is the net present value of the road scheme (NPV) greater than or equal to zero? If it is, the scheme is accepted for implementation, subject to further environmental considerations. These are dealt with in a less

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[1] *Benefits from a road improvement scheme on average*

	per cent	
Accident savings	20	
Vehicle operating costs	0	
Working time savings:		
cars	26	
light goods vehicles	11	51
heavy goods vehicles	11	
buses	3	
Non-working time savings:		
cars	23	29
buses	6	

Source: [3], vol. 2, p. 99.

[2] The TDR is currently 10 per cent.

explicit way: "It means making judgements about things on which views may differ widely; and in balancing advantages and disadvantages". The net result is that a positive NPV may be overruled on environmental grounds; a negative one may be accepted if the scheme generates additional environmental benefits. "In some cases, roads which do not pass the economic tests are approved and built if the environmental case . . . is sufficiently strong" ([3], vol. 1, p. 72).

At present, as far as central government is concerned, the simple NPV criterion is sufficient. There are enough funds available to support any road scheme with an NPV $\geqslant 0$. However, the COBA programme also calculates the ratio NPV/C. This is in case too many projects have a positive NPV. If that did happen, the Department would set a minimum NPV/C ratio (a cut-off rate) to exclude the marginal projects.[3]

When benefits are calculated over a thirty-year life, due allowance is made for varying traffic volumes (i.e. the hours of the day are divided into four separate groups; benefits are then calculated separately for each group, using appropriate time values and speed/flow relationships), for general increases in driving speeds over time, and for increases in the volume of traffic using the road. The last factor is of particular importance, since "with growing traffic the benefits from road schemes typically increase over time" ([1], p. 8). The estimates of future traffic volumes are thus crucial. They are based on the national traffic forecasts, which are prepared separately for four types of vehicles: cars and taxis, buses and coaches, lorries, and light vans. However, since cars and taxis account for about 80 per cent of total vehicle-hours, the forecasts of car ownership and use dominate this calculation.

CONFLICTS AND QUERIES

When COBA was first introduced it embodied the best assessment techniques the profession could offer. The authors could therefore claim that "The introduction of COBA is a significant step forward in applying objective assessment tools to the Roads Programme and in the efficient and proper management of public expenditure" ([1], p. 17).

Since then enthusiasm has waned, and more and more people are now questioning the technicalities behind the national traffic forecasts, as well as the fundamentals of cost-benefit analysis and its application to road schemes. This was recognised in the Green Paper, which promised an independent assessment of the present system. It was to be carried out by an Advisory Committee, which was asked:

> "To comment on and recommend any necessary changes in the Department's methods of appraising trunk road schemes . . .
> To review the Department's method of traffic forecasting" [5].

The objections to the methods of appraisal are too numerous to catalogue in detail. The following discussion therefore concentrates on three general issues: the national traffic forecasts, the value of time savings, and the treatment of environmental issues.

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[3]This criterion is not strictly correct. A better rationing device is the marginal benefit-cost ratio, which is often similar to the first-year rate of return (see [4], p. 162).

THE NATIONAL TRAFFIC FORECASTS

Estimates of future traffic volumes are used to identify the need for more roads. They are also used for purposes of engineering design and for project evaluation. The forecasting methods used by the Department were developed at the Transport and Road Research Laboratory:

> "The basic method adopted is first to make forecasts of car ownership per person, then to use population forecasts to give equivalent numbers of cars, and finally to make assumptions about kilometres per car per year to give estimates of car kilometres. Similar methods . . . are used for motor cycles and buses. The lorry figures are based on forecasts of ton-kilometres, which are then split between road and other modes; assumptions about lorry sizes and utilisation rates then lead to forecasts of numbers of lorries and of lorry kilometres. Number of light vans are assumed to be related to numbers of lorries" ([6], p. 2).

The T.R.R.L. is well aware that these methods are not ideal, and accepts that they do not go far towards "producing policy dependent forecasts". It nevertheless prepares the estimates "on the basis of alternative assumptions about energy prices and economic growth" ([6], p. 2) to try to give them some relevance.

Some of the T.R.R.L.'s assumptions about lorry sizes and utilisation rates have been questioned, but the main criticisms concern its forecasts of car traffic. Not only are the forecasting methods used for cars more questionable, but, since private cars make up over three quarters of the vehicle fleet and contribute over three quarters of the vehicle kilometres, they represent the single most important demand for road space.

Car traffic is forecast in two stages. Car ownership is forecast first and is assumed to follow a logistic growth curve. This is followed by a forecast of the annual average distance travelled by each vehicle, which enables total vehicle kilometres of travel to be established for each year.

The car ownership model specifies ownership as a characteristic of the individual. It is calculated as cars owned per head. Income per head (measured in terms of G.N.P.) and the cost of motoring (in terms either of money or of generalised cost) are assumed to "modify" the normal logistic path of ownership by influencing the constant term a:

$$dy/dt = ay(s - y)$$

where $y(t)$ = cars per person in year t,
s = the ultimate saturation level of ownership,
a = the constant.

The saturation level s thus represents the level of ownership expected "when incomes have risen to such a level that neither income nor price of motoring has any further influence" ([6], p. 65). The parameters of the model are estimated from time series and cross-section data and are checked by means of international comparisons.

Average annual vehicle kilometres are estimated from a simple equation in which annual distance travelled is assumed to be a function of increases in G.N.P. and the length of motorway per 1000 cars.

The models are criticised from two points of view. First, there are the statistical

criticisms ([7], pp. 550–4, and [8]). They show that, if the statistical models are estimated in a slightly different way, they result in a different figure for the final saturation level (for example, Kirby argues that the final saturation level may be somewhat less than 0.4 cars per person instead of Tanner's estimate of over 0.45).

Second, there are the conceptual objections. A number of these are implicit in Mogridge's work [9], which seems to show a causal relationship between income, car ownership and car prices (not the cost of motoring as in Tanner's model). The relationship likewise twists with time because it varies across income groups. Mogridge also suggests there might be a direct trade-off between the costs of car purchase and use.

More fundamental are the objections implicit in a recent pilot survey of car restraint in Oxford ([10], sections 5.3 to 5.5). This characterised the car as a joint household asset, emphasising its widespread value in use, and interpreted its value as a function of the household's social and economic circumstances. Car ownership was not therefore characterised as an attribute of the individual, but as a predisposition felt by a household group faced with certain "needs", a given pattern of land use, and specific endogenous and exogenous constraints (income being one of them).

It may thus be a serious mis-specification to characterise car travel as a function of car ownership, which in turn is specified as a characteristic of the individual. It may be more appropriate to represent it as a direct function of the value of the car in use, and to base this on the social and economic characteristics of the main categories of car owning households, that is, households owning 0, 1 and 1 + cars. In this scheme, decisions on ownership would relate to the car's value in use and would be a function of the separate characteristics of each group. Changes in ownership would likewise be related to those changes in the social and economic circumstances of each household which predisposed it to change to another group. The acquisition of a first car, for example, would be related to changes in the social and economic circumstances of members of the 0 group which either encouraged, or permitted, them to transfer to the 1 group.

By focusing on car use, this model would expose the mechanism behind the car's value in use and would go some way towards answering questions like: Which car journeys are essential? Which could be made by other modes? Which could be reorganised to involve less travel? Which are discretionary, and which are trivial? If these could be answered, even in descriptive terms, the model would have direct relevance for policy and would give more insight into possible long-term adaptations when other things were unlikely to remain equal.

The characteristics which separate the three categories of car-owning households are not too difficult to discover. The Oxford survey emphasised the following:

Category 0

Households without cars are mostly small households of single persons or couples without children (that is, either parents of no children or of adult children who have left home). Elderly members of the group often do not "need" a car because younger members of the extended family take them on trips whenever necessary. Married couples with small children very often live in areas which are very accessible and live relatively self-contained lives in established neighbourhoods where the giving and taking of lifts is common. When these conditions are not fulfilled, the family feels

very deprived and is often striving to acquire a car. Income is then usually the constraint which prevents transition to category 1.

A lot of households in this group not only do not need a car, they positively do not want one:

Respondent: "It doesn't bother me to that extent . . . not having a car."

Interviewer: "You don't find not having a car . . ."

Respondent: "I don't like the responsibility of a car, let's put it like that" ([10], p. 29).

Category 1

Many one-car owning households are entirely dependent on car use (that is, their present life style and pattern of activities is dependent on it). The car is often a necessary adjunct to work (and is often provided by the employer), or is an essential means of getting to and from work. In some cases this necessity is related to the relative location of work and home, in others it is related to the nature of the employment (e.g., for jobbing carpenters, building workers, electricians and other tradesmen).

Car-owning households also seem to live in less accessible residential areas, and must use the car to make a number of shopping journeys and nearly all discretionary ones. Buses are nevertheless still used, particularly for school journeys and some shopping. Loss of the car can have a traumatic effect on such households. "I would be forced to change my job—and move into an area where the doctor, dentist and food shops could be reached on foot" [11].

Category 1 +

Households owning two or more cars have the same general characteristics as category 1, except that they seem to contain more employed persons. Indeed, the causal link between household characteristics and multiple car ownership seems to be multiple employment. Of course there are exceptions. Some households are in transition and appear as only temporary members of this group: for example, single persons, both owning cars, who get married, or working couples—both using the car for work—who retire. Since multiple car ownership seems to be related to multiple adult employment in the household, it is also correlated with income. Income is nevertheless not *the* determining factor, though it may be a permissive one.

This pattern of car ownership is implicit in the 1971 Census [12]. Figure 1 shows the percentage of households in each group by household size. It shows clearly how many small households there are in category 0, and that the multi-car-owning households are mainly three- and four-person households. The detailed characteristics of these households again confirm the apparent importance of multiple employment: 73 per cent of the three-person households in the 1 + group have members who are all over 16 years of age; 37 per cent of the four-person households likewise have all members over 16 years of age, while 56 per cent have three members over 16 years of age ([12], Table 2).

There is thus *prima facie* evidence to suggest that car use is incorrectly characterised as a function of individual car ownership (explained in terms of an exogenous logistic

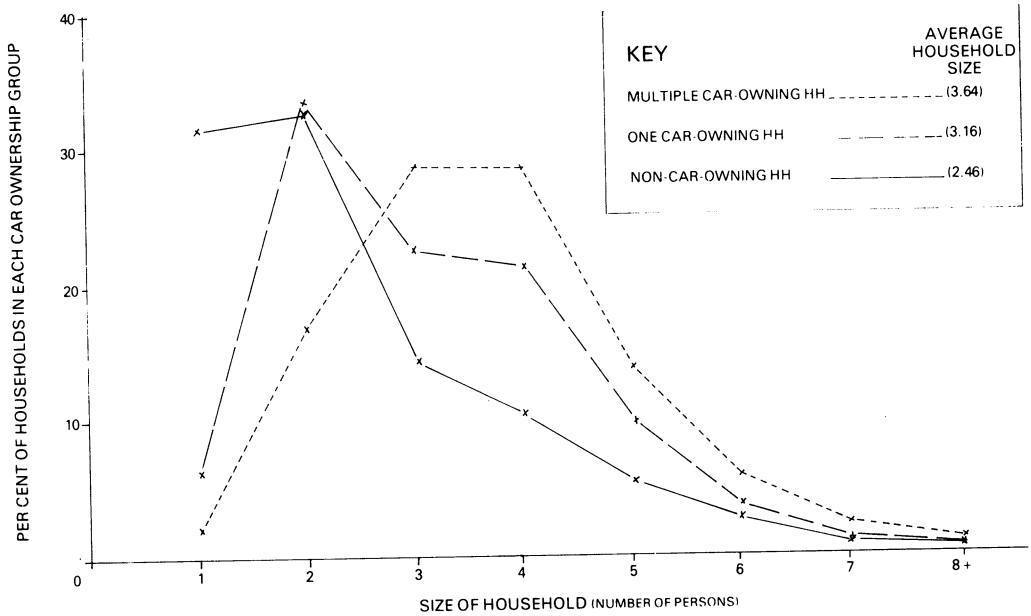

FIGURE 1
Characteristics of 0, 1 and 1+ Car-owning Households
(Source: 1971 Census)

growth curve influenced by income per head and the cost of motoring) and individual car use, which is also related to income and mileage of motorway per 1000 cars. The analysis above suggests that it might be better characterised as a group phenomenon in the context of multi-nomial choice. Certain characteristics of the household—including stage in the family life cycle, number of employed adults, and residential location—would clearly form part of this characterisation, with income entering as a permissive constraint which may enable the household to acquire a first or an additional car.

Such a model should clearly produce better forecasts, and would be more relevant for policy. It could take account of changing population structure (the declining birth rate in particular), of long-term employment prospects and of housing and land-use policies. For example, if there were a decline in new house building in suburban estates and on the urban fringe, the "need" to own a car would decline. Car use would also be specified as a more direct function of basic "needs", enabling the effects and implications of various policy measures, e.g. restraint, to be more readily explored.

THE VALUE OF TRAVEL TIME SAVINGS

On average, 51 per cent of the benefits attributable to a road improvement consist of savings in travel time during working hours. A further 29 per cent consist of savings during non-working hours.[4] The following discussion focuses on savings to business travellers and drivers of commercial vehicles and on savings in non-working time.

"For travel undertaken in the course of work, time savings are valued at the cost to the employer of employing the traveller, i.e. wages and overheads." This is based on the assumption that "a saving in travel time will on average allow production to take place that would not otherwise have been possible" ([3], vol. 2, p. 99). No account is taken of the increased utilisation of commercial vehicles following road improvements. Only savings in drivers' time are counted as a benefit.

This argument is fairly simplistic. It assumes that all time savings, no matter how small they are or under what circumstances they occur, can be instantly translated into productive output. This is not always true. The Gas Board, and most distribution companies, can quickly respond to savings in travel time by reducing the number of drivers and vehicles required to deliver and install household appliances. Other organisations, and road hauliers in particular, cannot always respond in this instantaneous way. The long-distance haulier, travelling for six hours on an inter-urban route, may be quite unable to make use of a half-hour saving, since his units of account may consist of indivisible journeys occurring in 4, 5 or 6 hour blocks. The Department offers little, if any, empirical evidence to support the claim that travel time savings can be readily translated into productive output.

In the case of business travellers, there are further worries. Not only may their tasks be indivisible (i.e. they may not be able to take advantage of small time savings); recent research has questioned the basic assumption that all travel time is "lost" time [13]. It seems clear that air travellers at least make use of their travel time by working in transit, and often travel out of normal working hours. Their travel time thus includes some productive effort, and, since some travel is done out of hours, is not automatically convertible into additional output. Indeed, in [13] the average value of travel time savings, taking these factors into account, was found to be only 62.9 per cent of the traveller's gross salary rate. This compares with the 150 per cent used by the Roskill Commission in its study of the Third London Airport ([13], p. 181).

The method of valuing other time savings (i.e. savings in non-working time) is just as dubious. The Green Paper assures us that they "are valued at a much lower level, derived from studies of how much people are actually prepared to pay to save time" ([3], vol. 2, p. 99). This is a little far-fetched, since the studies referred to do not examine how much people are "actually prepared to pay". The studies are all based on studies of mode choice and, to a lesser extent, on patterns of route choice, and *assume* that certain travellers choose one mode of travel (or route) rather than another because of relative differences in speed and cost. A growing body of research is increasingly showing how nonsensical this is [14, 15]. Most people know very little about the attributes of competing modes; how then can they be assumed to be

[4] See footnote 1.

comparing them with their selected mode in order to choose the one they prefer? The psychology of choice simply does not work in this way ([15], section 3.5). It is equally absurd to assume that the husband in a car-owning household uses the bus because he "prefers" it to his car (i.e. he is a "trader"). Other family members also exercise claims on use of the car and these often override the husband's claim to use it for going to work ([10], section 5.3). The wife, who uses the car to go shopping, likewise does not always do so because it is "cheaper and faster" than by bus. It may be slower and more expensive, but it enables her to manage the children and push chair more effectively.

Recent research [16] appears to confirm that existing time values are incorrect. It also shows how unimportant small time savings can be. A study in Leicester showed that a typical medium-sized road improvement scheme produced time savings of less than 3 minutes per vehicle. These comprised the only conventional benefits. [17].

One of the most important results of this research is the suggestion that the value of time savings is not linear; i.e., the unit value of a small time saving is less than that of a large one. This is not a new idea, and was suggested some years ago by research workers in the U.S.A. [18]. Recent research seems to confirm it. An experimental commuter express bus service to London Airport generated far less patronage than the predictions produced by London Transport's mode-choice model(daily patronage was 40 instead of the predicted 149) [19]. When a 10 minute time threshold was introduced, the predicted patronage dropped to about 85 passengers per day. Indeed, the time threshold had "a greater effect than all the other alterations combined". A diagnostic survey [20] of urban journey-to-work behaviour in Vancouver, Canada, likewise suggested that there were distinct thresholds, that the marginal value of the time saved increased as journey lengths got larger, and that the unit value of time saved was not directly related to the traveller's gross income (it seemed to be more closely related to discretionary income, and hence to family circumstances).

Evidence confirming these thresholds is implicit in some of the recent bus priority schemes. Most of them reduce bus running times by about 2 or 3 minutes, although some (e.g. the Reading bus lanes and the Bitterne Bus priority scheme) reduced them by nearly 5 minutes [21].[5] When valued at the Department's current time value of 35p per hour (1975 prices), these time savings are equivalent to a relative fare reduction of between 10 and 15 per cent. It is generally accepted that the average price elasticity of demand for bus travel is about −0.3. The effective fare reductions should therefore have led to an increase in patronage. The increase would have been slight, but should have amounted to about 3 to 4.5 per cent of existing patronage.

It is significant that most monitored bus priority schemes have had a negligible effect on patronage. Indeed, in Reading and Bitterne, where the time savings were largest, the effects on patronage were nil. People simply do not seem to value time savings either at the rate or in the way implied by the Department's current time values. What is even more ironic is that most of the benefits associated with bus

[5]In Reading, the service which gained most from the priority scheme saved 1.21 minutes in the a.m. peak and 4.58 minutes in the p.m. peak. In Bitterne, travellers perceived a relative improvement of 6 minutes on a final average bus journey time of 23 minutes.

priority schemes are attributable to passenger time savings ([22], pp. 141, 147, 174). However, hardly any schemes can show—at least in the context of rigorous monitoring—that bus lanes lead to a significant increase in patronage. If passengers do not respond to an equivalent reduction in fares, has any genuine reduction been made?

There seems little doubt that the large and often overwhelming benefits attributed to time savings have been consistently inflated by giving small time savings the same unit value as large ones. In a world full of indivisibilities, a non-accumulative resource like time must have an opportunity cost that is directly related to the position it occupies in an overall sequence of events. Time, unlike money, cannot simply be saved in one activity and freely transferred to another. Becker's statement that "households would minimise costs by setting the ratio of the marginal product of goods to that of time equal to the ratio of their marginal costs" (see p. 513) is not generally true. Time, particularly in small units, cannot easily be transferred from activity i to anything other than activity $i + 1$, particularly when institutional constraints require, or only permit, certain activities (e.g. work or shopping) to take place during certain hours. It may be transferrable to activity $i - 1$ (if knowledge of the saving is available in advance), or even to activity $i + 2$ if $i + 1$ is a flexible activity that can be easily re-scheduled. In general, however, individuals cannot re-deploy small time savings, but must let them merge with the next or previous activity in a predetermined sequence. Unless the time spent in the sequential activity has a high shadow price, its opportunity cost (and hence its value) will be low.

Large time savings are different. They do not always have to merge with time spent on adjacent activities; they often permit re-scheduling of a sequence of activities so that time saved can be transferred to activities with a high shadow price. This is implicit in some of the adaptations observed in a recent study of staggered school hours in Burford, Oxfordshire [24]. For most families, the revised school timetable meant that children arrived home up to one hour earlier than before. This resulted in extensive re-scheduling of late afternoon and evening activities. In some cases it meant that activities previously carried out at weekends could now be fitted into the late afternoon; in others it meant that new activities (e.g. social and recreational) could be introduced into the family's routine. There was always re-scheduling to (apparently) transfer the time saved to an activity in which the household derived greater utility.

The opportunity cost of time is best illustrated in the context of the household activity travel simulator (H.A.T.S.) of the University of Oxford Transport Studies Unit [24]. The simulator consists of a piece of apparatus combining a physical representation of an activity diary (which records the temporal pattern of entire activities —including travel—instead of travel by itself) with a spatial representation, in the form of a map, of the area where these activities take place. Each household member has a separate simulation board (but all boards are identical) and starts off by filling in his, or her, activity patterns during a previous 24 hour period. This is done with coloured blocks of varying size, each colour representing a separate activity code, to show: (a) how much time was spent on each activity, (b) whether it was done at home or somewhere else (if somewhere else, it appears on the map as well), and (c) the mode and time spent on travel between the in-home and out-of-home activities.

The simulation boards make the household's decision rules quite explicit. They furthermore emphasise the importance of constraints and the way in which the

household operates as an adaptive organism. The most important constraints are related to household structure (i.e. whether there are any children in the household, and if so, of what age), together with the routines and linkages that these impose (e.g. school journeys, joint journeys, journeys undertaken on passengers' behalf).

Once set up, the simulator enables the investigator to examine what happens when the household's travel links are changed: e.g. what happens when journey time is reduced. The Burford study, although primarily concerned with changes in school hours, illustrated the importance and stability of the household's basic routines. For example, the joint journey on which the father runs children to school on his way to work is often a fixed point in the household's daily routine. A road improvement which reduces the husband's journey time to work may thus have little value, since the time of leaving home may be fixed by the relevant school hours. All the road improvement does may be to get the husband to work a little earlier, and this may be something he does not value.

On the other hand, the Burford study also illustrated how some time savings, provided they were large enough and occurred at the right time, enabled the household to reorganise its basic routines to consolidate the time savings and give them some value.

The Department's present method of valuing time savings, together with its recommended empirical values, is unduly simplistic and is based on assumptions (about choices between modes) that are patently not true. Recent research is increasingly pointing to the existence of thresholds (or non-linear time values), while HATS seems to provide an ideal tool for exploring the kind of functional relationships that should be embodied in any genuine theory of the allocation of time.

THE ENVIRONMENT

No one knows how to deal satisfactorily with environmental effects. A lot of things can be measured in physical terms—often with considerable accuracy—but we still do not know how to value effects on the environment, or to balance them in any simple environmental balance sheet to enable unequivocal decisions to be reached. Nowhere is the environmental conflict clearer than in the case of urban by-pass schemes.

In the original booklet describing COBA the D.O.E. gave an example of how COBA might be used to evaluate an urban by-pass scheme. It was called the XYZ scheme ([1], pp. 4, 6, 7). It involved the construction of a three-mile by-pass, B, to an existing three-mile town centre route, A. The volume of traffic using the original route A was 28,000 vehicles per day, and this was expected to fall to 7,000 vehicles when 21,000 had diverted to the more attractive route, A. The estimated annual costs of the scheme were as shown in Table 1.

The extraordinary thing about this calculation is that it completely ignores the environmental arguments in favour of the by-pass, and views the scheme only in terms of benefits to traffic. Presented in its crudest form, the scheme is trying to "bribe" motorists to voluntarily give up route A in favour of route B. What would happen if route B was three miles longer than route A? Would the scheme no longer be justified?

TABLE 1

Three-mile by-pass—COBA estimate

	Original route A	*After by-pass construction*	
		Route A	*Route B*
	£	£	£
Time costs	450,000	80,000	210,000
Vehicle operating costs	300,000	60,000	130,000
Accident costs	90,000	20,000	40,000
Total Costs	840,000	160,000	380,000
		£540,000	

Net benefit = £300,000 p.a.

The cost of using the original town centre route was £30 p.a. per vehicle. The cost of using the new route is £18.1 p.a., while the cost of continuing to use route A, at the reduced traffic volume, is £22.86 p.a. (assuming that drivers include accidents in their perceived motoring costs). If route B were 3 miles longer, it would cost roughly £36.2 p.a. to use. Traffic would therefore redistribute between A and B (under standard diversion curves) and the result would be roughly that 7000 vehicles per day would use route B, at a unit cost of £36.2 p.a., while 21,000 v.p.d. would continue to use route A at a unit cost of £27.72 p.a. This causes the gross cost of using both routes to rise to £835,520 p.a., which makes the annual net benefits practically disappear, and the scheme becomes unjustifiable.

The nonsense of this analysis is that the through traffic imposes considerable costs on the town centre. This is completely ignored in the XYZ example. Imagine that the cost of this nuisance is valued at £500,000 per annum (based on a value judgement made by local councillors) and is directly related to the traffic flow. Each vehicle driving through the town centre therefore spends £30 p.a. on its own journey and imposes a further £17.85 p.a. of traffic nuisance on people in the town centre.

If the cost of this traffic nuisance was recovered from the motorist (perhaps by a cordon licence, a supplementary parking charge, or traffic management measures) the cost of using route A would rise to £45.57 p.a., i.e. (27.72 + 17.85). Most of the traffic would therefore divert back to B (at £36.2 p.a.) and the distribution of traffic would again revert to something like the 7,000 and 21,000 originally specified. The benefit calculation would then become as shown in Table 2.

The net benefits from the XYZ scheme therefore justify a by-pass of twice the length when the calculation is properly done. It is clear that the existing assessment method embodied in COBA is quite wrong and significantly underestimates the desirability of building urban by-passes.

This example nevertheless only represents the tip of an iceberg. We simply do not know how to evaluate environmental effects in monetary terms, or how to translate

TABLE 2

Six-mile by-pass—with environmental costs

		After by-pass construction	
	Original route A	*Route A*	*Route B*
	£	£	£
Time costs	450,000	80,000	420,000
Vehicle operating costs	300,000	60,000	260,000
Accident costs	90,000	20,000	80,000
Environmental costs	500,000	124,950	—
	1,340,000	284,950	760,000
			£1,340,000

Net benefit = £295,050 p.a.

them into an equivalent NPV. We likewise lack an institutional framework that would enable environmental costs to be recovered through an efficient pricing mechanism. Environmental considerations therefore raise enormous problems of both valuation and implementation, and there is really nothing in our present evaluation framework to suggest how they should be tackled. The COBA example simply makes matters worse by not even recognising that the case for an urban by-pass often rests on environmental grounds alone. It merely emphasises the argument in favour of traffic efficiency, and fails to recognise the important misgivings that both the public and the profession have about this narrow objective.

IMPLICATIONS

These queries have serious implications for the way we evaluate road schemes. It appears that existing methods grossly over-estimate the tangible benefits of road improvements, by (perhaps) overestimating future traffic volumes, over-valuing time savings and under-estimating indirect environmental effects.

In urban areas, the main quantifiable benefit, the value of small time savings, seems to be grossly inflated. The principal benefits from urban road improvements probably consist of accident savings, environmental benefits and, on occasions, reduced vehicle operating costs.

In rural areas, time saving benefits probably remain important. Indeed, because the savings are usually quite large (e.g. 10 minutes or more) and are related to longer journeys, they may even be of greater importance. Environmental costs/benefits are probably also greater, at least for urban by-pass schemes. Accident benefits will probably remain the same, and so will the small (often negligible) savings in vehicle operating costs.

Overall, the emphasis should move from reliance on *apparently* precise time values towards accident costs (which include a value judgement on the cost of pain, suffering

and bereavement), less certain time savings and environmental costs/benefits. This, in turn, raises questions about the value of discounting. As long as most benefits are readily quantifiable and can be identified with resource savings, it seems sensible to use a discounting framework and merely qualify the resultant NPV by reference to any unquantifiable or non-monetary effects. Once the balance shifts the other way, and the overall investment decision becomes more a matter of judgement than of ranking a series of precise net present values, the value of discounting is less clear. Discounted future pounds cannot be added to, or even compared with, physical measures of noise nuisance or scores on some scale of dissatisfaction. Society's communal evaluation of the intangible costs of noise nuisance and of pain, suffering and bereavement may also change markedly over time.

Existing methods of road appraisal may thus rest on a fairly shaky foundation. It seems quite likely that the tight welfare-economics framework upon which cost-benefit analysis is based is not appropriate for road investments. Too few costs/benefits are quantifiable in strict monetary terms, while too many involve non-monetary or unquantifiable benefits which can only be evaluated as a political value judgement. These conditions favour a less rigorous approach based, perhaps, on a planning balance sheet [25] or on what one author calls "multi-variate cost-benefit analysis" [26]. This emphasises the multiple objectives involved in road appraisal, together with the technical, if not conceptual, problem of summing their disparate effects into a single, meaningful index of priority. It may thus mix its units by measuring each effect in a different way: time savings may be measured in minutes per vehicle, accidents in number and severity of occurrence, vehicle operating costs in cash savings, and so on. The results are displayed in a table on which those responsible must base their ultimate decisions.

The planning balance sheet clearly lacks the scientific precision usually associated with cost-benefit analysis. A less formal decision-making process, utilising multiple objectives and simple criteria, may look less scientific, but may lead to better decisions by not postulating firm relationships where none exist.

CONCLUSION

The preceding discussion suggests that the present framework for evaluating road schemes may not be satisfactory. The method of forecasting car traffic has given reasonable predictions in the past. It nevertheless relies on the extrapolation of past trends, and is therefore not particularly relevant as an instrument for policy formulations; nor is it likely to produce accurate predictions when other things are no longer equal.

The present way of dealing with travel time savings is even more unsatisfactory. Recent research, and the results of several monitored bus priority schemes, question the time values currently used by the Department. Most important is the question of thresholds; if thresholds exist, our current methods of evaluation may give far too much emphasis to small time savings and hence to minor road improvements in urban areas.

Finally, the Department's computer program, COBA, deals incorrectly with urban by-pass schemes. It completely ignores the environmental case for by-passes and focuses on the narrow benefits to traffic.

These queries have a further effect on our present methods of evaluation. As soon as the tangible monetary effects of a road scheme become less important relative to the non-monetary ones, the value of discounting is called in question. The usual criterion of NPV is only relevant when *most*, if not all, costs and benefits can be expressed in monetary terms. When this is not so it may be more appropriate to use a less formal method of evaluation, based on a planning balance sheet or on some form of multi-variate cost-benefit analysis.

REFERENCES

[1] Department of the Environment: *Getting the best roads for our money: the COBA method of appraisal.* HMSO, London, 1972.

[2] Self, P.: *Econocrats and the Policy Process: The Politics and Philosophy of Cost-Benefit Analysis.* Macmillan, London, 1975.

[3] Department of the Environment: *Transport Policy: A Consultation Document.* HMSO, London, 1976.

[4] Heggie, I. G.: *Transport Engineering Economics.* McGraw Hill, 1972.

[5] Circulated Terms of Reference drawn up for the Advisory Committee on Trunk Road Assessment.

[6] Tanner, J. C.: *Forecasts of Vehicles and Traffic in Great Britain: 1974 Revision.* T.R.R.L. Report 650. Transport and Road Research Laboratory, Crowthorne, 1974.

[7] Adams, J. G. U.: "Saturation Planning". *Town & Country Planning*, 42 (12), 1974.

[8] Kirby, H. R.: "The Saturation Level of Car Ownership: Estimation Problems, and a Regional Time-Series Analysis". *P.T.R.C. Annual Conference*, Paper N.14, 1976.

[9] Mogridge, M. J. H.: *Traffic Forecasting.* Evidence submitted to the Advisory Committee on Trunk Road Assessment, March 1977.

[10] Heggie, I. G.: *A Pilot Survey of Urban Travel Behaviour in Oxford.* Working Paper No. 21. Oxford University Transport Studies Unit, 1976, sections 5.3–5.5.

[11] Comment written on one of the T.S.U.'s Activity Diaries, administered in Banbury during the autumn of 1976.

[12] Census of Population: *Availability of Cars.* HMSO, London, 1971.

[13] Carruthers, R. C., and Hensher, D. A.: *Resource Value of Business Air Travel Time.* In I. G. Heggie (ed.): *Modal Choice and the Value of Travel Time.* O.U.P., Oxford, 1976.

[14] Earp, J. H., *et al*: *Modal Choice Behaviour and the Value of Travel Time*: *Recent Empirical Evidence.* In [16].

[15] Heggie, I. G.: "Putting Behaviour into Behavioural Models of Transport Choice". *J. Operational Res. Soc.*, 29/6), 1978, pp. 541–50.

[16] Heggie, I. G. (ed.): *Modal Choice and the Value of Travel Time.* O.U.P., 1976.

[17] Sharp, C., and Jennings, A.: *The Value of Travel Time Savings in Transport Investment Appraisal.* In [16].

[18] Thomas, T. C., and Thompson, G. I.: "The Value of Time for Commuting Motorists as a Function of their Income Level and Amount of Time Saved". *Highway Research Record*, no. 314, Highway Research Board, Washington, D.C., 1970.

[19] Heraty, M. J.: *The Skyport Special*: *An Experimental Personalised Bus Service.* In [16].

[20] Heggie, I. G.: *A Diagnostic Survey of Urban Journey to Work Behaviour in Vancouver.* In [16].

[21] Heggie, I. G.: "Consumer Response to Public Transport Improvements and Car Restraint: Some Practical Findings". *Politics & Policy*, 1977.

[22] T.R.R.L.: *Bus Priority Systems.* Nato CCMS Report No. 45. T.R.R.L., Crowthorne, 1976.

[23] Becker, G. S.: "A Theory of the Allocation of Time". *Economic Journal*, 75, 1965, p. 513.

[24] Jones, P. M.: "H.A.T.S.: A Technique for Investigating Household Decisions". *Environment and Planning*, forthcoming, 1979.
[25] Lichfield, N.: "Evaluation of Methodology of Urban and Regional Plans: A Review". *Regional Studies*, 4, 2, 1970.
[26] Stern, G. J. A.: "SOSIPing, or Sophisticated Obfuscation of Self-Interest and Prejudice". *Optical Research Quarterly*, 27, no. 4, 1976, pp. 915–929.