

ECONOMIC RESEARCH CENTRE



**ROUND
TABLE
30**

VALUE OF TIME

EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT

PARIS 1976

ECONOMIC RESEARCH CENTRE

**REPORT OF
THE THIRTIETH ROUND TABLE
ON TRANSPORT ECONOMICS**

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on the following topic :

VALUE OF TIME

EUROPEAN CONFERENCE OF MINISTERS OF TRANSPORT

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* * *

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VALUE OF TIME

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SUMMARY

Current techniques of economic evaluation of transport projects require money values for savings and losses in travel time. The derivation, justification and use of these values are discussed, concentrating on questions relating to behavioural accuracy in prediction and equity in evaluation. It is argued that what is sometimes interpreted as a value of time should more properly be regarded as a utility of money.

It is recommended that the procedures at present adopted by the United Kingdom Department of the Environment are broadly satisfactory and should be widely applied, but some modifications are suggested. In particular:

(a) For prediction, generalised time (time plus money costs, expressed in units of time) is appropriate, but walking time should be used as a base instead of in-vehicle time. Relative weights for time spent in working hours based on observed behaviour should be found and used.

(b) For evaluation, income from sources other than wages should be carefully excluded when using wage-related values of time spent travelling in working hours. These values themselves should be the subject of empirical research, and possibly eventually replaced. Time spent in travel associated with housework should be valued as working time rather than leisure time. An "equity" value for non-working time should be used as at present, but with an international rather than a national base. Lower discount rates should be used. Cost benefit studies should identify in more detail the separate incidence of savings and losses of time and money to different sections of the population; if required, behavioural values of time can be used to provide distributional weights for money costs and benefits.

A number of areas are judgedd to be particularly suitable for new research, including: values of working time; disentangling the effects of the duration and the unpleasantness of travel activities; the perception of time spent travelling; the importance of the amount of "spare" time people have at their disposal, and public transport mode choice.

1. INTRODUCTION

1.1 Aims of this Report

The object of this report is to identify and discuss a number of the problems associated with putting a money value on time spent travelling. The areas selected are chosen because, in the judgement of the author, they raise important questions which affect practical decisions, are capable of solution, and have been inadequately researched.

It will become clear that many of the questions raised have a direct or indirect relevance to problems of distribution, i.e. the incidence of costs and benefits among different sections of the population. These questions are as far as possible treated quantitatively and with a view to making practical recommendations. Some of the recommendations may be controversial, and it should be emphasized that they do not necessarily represent the views of anyone other than the author.

A second recurrent theme is that of behavioural accuracy. Individuals do of course vary, and any attempt to portray their behaviour in a mechanical way is likely to be misleading. Nevertheless, the approach adopted in most studies of travel behaviour, and explicitly endorsed here, is that broadly speaking people do act rationally enough and consistently enough to make it possible to predict general patterns of behaviour for large numbers of people with a useful degree of accuracy. In other words, this is a field appropriate for scientific investigation.

Linking these two aspects are the currently accepted procedures recommended for use in the United Kingdom and summarised in section 1.3. Some of the suggestions made here would be quite substantial modifications to these procedures, but they do not really attack the basic framework, which, it is argued, is intellectually and practically satisfactory. The procedures could usefully be applied more widely than is in fact the case. In part, therefore, this report might be interpreted as a defence

of important elements of current practice against criticisms that the entire structure is invalid, that generalised cost has no meaning, or that problems of statistical method render all quantitative results suspect.

1.2 Definitions

Travel decisions may be thought to bring benefits to the traveller at the cost of certain disbenefits involved in making journeys. Little work has been done on the measurement of the benefits, but the disbenefits may be described as a weighted sum of a number of different kinds of "cost", for example:

$$g = k_1 t + k_2 m \quad (1)$$

where t is travel time and m is the money cost, and g is the total disbenefit or disutility. The variables included are those which are found empirically to be related to travel decisions, but which also are thought to influence behaviour directly, rather than those (for example population density, size of a bus fleet, routing system in a town) which exert their influence indirectly via effects on travel time, cost, etc.

In the context of transport economics, the "value of time" may be merely a coefficient used to convert a quantity of time into a quantity of money which is in some appropriate sense "equivalent", although it is often given a wider meaning than this. It has dimensions money/time. In the above expression, we can calculate a generalised cost g_m which is in units of money by putting

$$g_m = m + \lambda t \quad (2)$$

where λ , the value of time, is k_1/k_2

Such a coefficient is useful in two connected areas; prediction, and evaluation.

First, it may be used in explaining the decisions travellers are observed to make in allocating money and time to travel, and hence in estimating the total amount of travel, its distribution over a network, the relative demand for different

transport modes, and so on. An appropriate definition in this case is "the amount of a change in the money cost of travel that would result in the same travel decisions as a unit change in the time of travel". Note that in this definition no assumption is made linking the value of time with utility or benefit, a distinction that will be further discussed in section 3.

Second, it may be used in taking decisions on the quantity and nature of the resources to be allocated by public authorities for the provision of transport facilities. An appropriate definition here is "the money value of the resources which it would be socially worthwhile to allocate to transport facilities in order to make a unit saving in travel time."

The first definition requires of the coefficient only that it shall correspond most accurately with behaviour, the second that it should guide public authorities' decisions; there is no inherent correspondence between these two objectives. The same value or set of values may be used for both, but in that case a number of more or less drastic assumptions have to be made, and distributional implications accepted, that are discussed in section 3 and 4.

An alternative representation of equation (1) is to calculate g_t , sometimes called "generalised time", with units of time instead of money:

$$g_t = t + \mu m \quad (3)$$

where μ is k_2/k_1 , or the reciprocal of the value of time, with dimensions time/money. It can be called a "value of money" with definitions corresponding to those given above for the value of time.

1.3 The Procedures used by the United Kingdom Department of the Environment

The values used by the DoE are based on recommendations in a note by McIntosh and Quarmby (1970) which closely follow the line of argument in a paper presented by Harrison and Quarmby (1969) to the Sixth Round Table of the E.C.M.T.

The recommendations may be summarised as follows:

- (1) Values of time should be used in the context of a generalised cost of travel, incorporating as separate components time spent in a vehicle (t_1), time spent walking (t_2) and time spent waiting (t_3) and money cost (m). In general form this would be:

$$\begin{aligned} g = & b_1 t_1 \\ & + b_2 t_2 \\ & + b_3 t_3 \\ & + b_4 m \end{aligned} \quad (4)$$

- (2) For prediction, this should be put in units of in-vehicle time by dividing each coefficient by b_1 . Each of the coefficients should preferably be calculated empirically using data relevant to the particular area and type of project concerned, and the components may be combined or altered if it is found useful. National figures suggest that b_2 and b_3 will normally be about twice as great as b_1 , and the value of time λ (i.e. b_1/b_4 , although the coefficient would not actually be used in this form) will normally be about 25 per cent of the wage rate. It is normally assumed that time spent travelling in working hours is valued more highly, and the figures suggested for evaluation purposes are often also used in prediction.
- (3) For evaluation of time spent travelling during working hours ("work time"), a coefficient is sought which is thought to measure the value of output to be gained from savings in travel time. The measure used for this is the gross wage rate plus overheads, employers pension contributions, and national

insurance contributions(1). This should be calculated separately (as far as possible) for each group of travellers.

- (4) For evaluation of time spent travelling outside working hours ("leisure time") standard values should be used for all travellers, and all regions, whatever their incomes or behaviour, but distinguishing in-vehicle and out of vehicle activities. These values are approximately those suggested by an average of values found in empirical studies.
- (5) A number of modifications and adjustments are suggested to distinguish between transfer payments and resource costs, and to evaluate the time allocated to marginal journeys that are generated or disappear as a result of a change in travel costs. These are not discussed here.

Mid-1974 figures provided by the DoE for evaluation purposes are shown in Tables 1 and 2. The figures are updated annually. Local figures are preferred when available, but only for working time.

(1) The assumption here is that the marginal unit of labour is the employee. If it is considered more appropriate to take an hour's overtime as the marginal unit, then the wage rate will be replaced by the overtime rate, and only wage-related overheads (e.g. some forms of pensions) added. The resulting total would in general be very close to the values calculated by the DoE method, but might be significantly different in some particular cases, e.g. employees who do not get paid extra for overtime.

Table 1

VALUES OF WORKING TIME FOR EVALUATION	
	pence/hour
All workers	215
Car Drivers	246
Car Passengers	214.5
Rail Passengers	265
Bus Passengers	127.5
Underground Passengers	233
Heavy Goods Vehicle Occupants	118
Light Goods Vehicle Occupants	109
Bus Drivers	122
Bus Conductors	111

Table 2

VALUE OF LEISURE TIME FOR EVALUATION	
	pence/hour
In-vehicle time	28
Walking and waiting time	56

2. TIME SPENT TRAVELLING IN WORKING HOURS

2.1 Objections to wage-related values

Some 17 per cent of car mileage is carried out during working time, and if this time is valued according to Table 1, it becomes substantially more important than the 83 per cent done outside working hours. Moreover, the order of priority for transport projects which will save an equal quantity of working time, other things being equal, will be approximately:

- 1st International air travel
- 2nd Domestic air travel
- 3rd Inter-city high quality rail services or motorways
- 4th Urban motorways
- 5th Urban buses.

This order of priority does not altogether accord with current political thinking on transport priorities, and it is worth looking more closely at the assumptions underlying it.

The practice of valuing working time by reference to wage rates has little empirical basis, and arises from a tenet of economic theory rather than behavioural investigation. To quote Harrison and Quarmby:

"The most usual approach has been to estimate value by reference to wage rate....the most obvious theoretical backing for this is the marginal productivity theory of factor rewards."

Harrison and Quarmby list eight possible objections to the successful application of such a theory, each of which they answer with an assertion that the objection is of dubious validity, may be offset by another objection, or is unlikely to be important in the long run. They go on to say that the problems of working time values are:

"not amenable to research..."

and they are not included in a list of recommended research themes.

In general the objections may be summed up in one; that real economies differ substantially from the perfect competition model in which the marginal productivity theory is derived. The existence of monopoly, unemployment, a large state sector, taxation, fixed working hours, rigid prices or wages, inflation, time lags in the adjustment of the economy to changes, a non-optimal (however defined) distribution of wages, other incomes and wealth, make this objection so obviously true that it would seem to make a *prima facie* case for empirical investigation to see how much difference these departures make.

Such investigations do not necessarily depend on finding satisfactory comprehensive theoretical explanations for the macro-economic problems listed. Two fields of investigation in particular would be reasonably self contained and potentially rewarding.

- (a) Standard behavioural models of mode-choice, route choice etc. can be applied to trips made during working hours, with exactly the same degree of confidence as applied to the journey to work which has been extensively studied. The use of resulting values of time for prediction must be better than the use of values derived from a theory that may or may not be true. Comparison of these values with carefully collected data on the wage rates, earnings, type of work, and overhead expenses associated with the traveller concerned would also make a valuable contribution towards testing the theory itself.
- (b) More detailed study of the behaviour of firms and the behaviour of non-profit making institutions (whose employees also travel) should help to test a number of key assumptions; to what extent is time saved from travelling in fact used for productive activity? To what extent does this vary for different types of employee or journey? To

what extent is the traveller making a travel decision in fact in contact with or controlled by those with management responsibility for production expenditure?

Very little work has been done on these problems. An Australian study by Hensher (1974b) of air travel in working time, which attempted to take account of firms' decision taking processes, the proportion of business travel time in fact done in the employee's own time, etc., suggested values of time of less than the wage rate - an average of 69 per cent of average gross wage rate for domestic and 30 per cent for international air travel (compared with findings in the same study of around 15 per cent of the wage rate for leisure time). Because of the shortage of such studies it is not possible to assess whether these results are of general validity or merely reflect the special circumstances and particular analytical methods used.

In the judgement of the author, further studies of this kind are a priority for research into values of time. There seems little point in further elaborating theoretical structures for working time until some degree of empirical work has been carried out to reject, modify or support the hypotheses presently used.

2.2 Non-wage Sources of Income

Until empirical results are available, it seems likely that wage-related values will continue to be used, and there are still a number of smaller points that need to be tidied up.

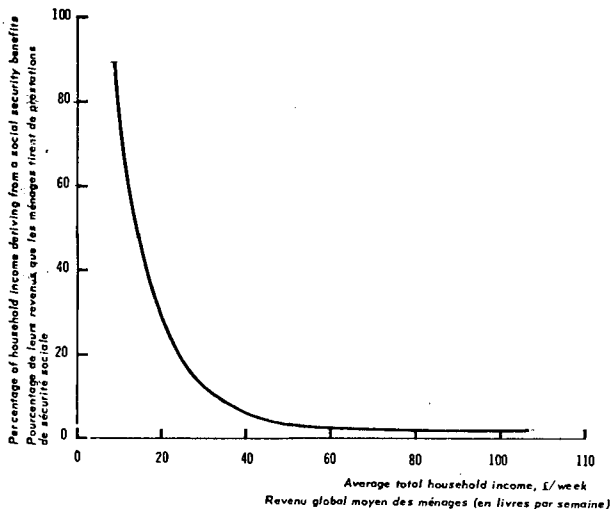
The source of money income is likely to be irrelevant to a behavioural trade-off between time and money, and for this reason (and also because questions in excessive detail about income may have an effect on the response rates to surveys) most transport studies collect information about total household income from all sources, not just wages. However, the source of income is relevant to a theoretical value of time based on the idea that the time saved from travel will be used for the production of goods and services. It is necessary for this purpose to make an

adjustment on the basis of the proportion of household income that comes from wages. This is attempted in the national DoE figures, but little guidance is available on how to do it in the context of specific studies.

The proportion of household income from sources other than wages varies substantially for different income groups. There are two main categories of income that do not correspond with payments for productive work and therefore cannot be used to measure the value of working time savings; social security benefits, and income from various kinds of investment and property. These affect opposite ends of the income scale.

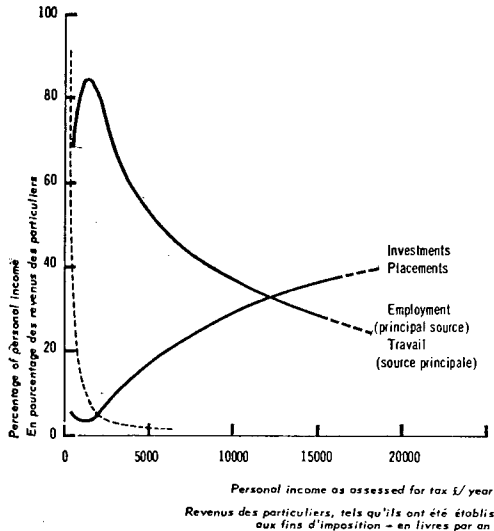
Figure 1 shows the incidence of social security benefits for households of different incomes. This may be compared with Figure 2, showing the incidence of investment incomes and employment income for individuals of different incomes. The two figures are shown separately because of differences in definition but the dotted line on Figure 2 approximately corresponds with the social security income of Figure 1.

Figure 1
INCOME FROM SOCIAL SECURITY BENEFITS
REVENU TIRE DES PRESTATIONS DE SECURITE SOCIALE



Source : Family Expenditure Survey, 1972.

Figure 2
INCOMES FROM INVESTMENTS AND EMPLOYMENT
REVENUS DES PLACEMENTS ET REVENUS DU TRAVAIL



Source : The Survey of Personal Incomes 1970-71.

It may be seen that social security benefits are a very high proportion of the income received by the lowest income categories, whereas incomes from investment and property are a high proportion of the incomes received by the highest income categories. In this context, it may be that the investment income is more important, since its recipients are more likely to be making trips during working hours.

Most households in the central range of incomes have substantially less variation than at the extremes, and an adjustment of 15 per cent - 25 per cent subtracted from household income would be approximately right for a large amount of ordinary urban travel. However, in some circumstances this would be misleading, when projects are being considered that affect different income groups to substantially different extents. This may be true, for example, of projects affecting differently

households with no, one or two cars; Tulpule (1974) gives figures for these groups (but with under-representation of very high income households) as shown in Table 3.

Table 3

WAGE INCOME FOR HOUSEHOLDS OF DIFFERENT CAR OWNERSHIP

Households	Wages as a proportion of total income (%)
No car	70.6
One car	77.9
Two cars	70.2

In addition, it is not strictly valid to use household income as the base for calculating earned income for households when there are two or more employed persons; trips made in working time but a relatively low paid second earner should not be valued at the same rate as the more highly paid second earner. The difference can be substantial, as is shown when comparing the wages of men and women in the next section. There may also be regional variations; for example, half of all the individuals in the United Kingdom whose incomes fall in the highest category used in Inland Revenue published statistics, live in London and the surrounding region.

Whether such effects are important will depend on national and local circumstances, and the characteristics of the projects under consideration, but the fact that working time is valued so much more highly than leisure time means that the results of studies may be sensitive to these adjustments. As a guide to action, the best course would seem to be that at an early stage of the investigation of major projects, a certain amount of preparatory groundwork should be done to test the magnitude of these features; it will then become clear whether detailed adjustments are necessary.

2.3 The Working Time of Housewives

It has invariably been assumed that all the travel done by housewives(1) fits into the category of leisure travel, whether the journeys are undertaken for the purposes of shopping, taking children to school, etc., or for more genuinely leisure activities such as visits to friends. Following this assumption, it then becomes normal to use the values of time based on behaviour rather than based on theory. There is some evidence that behavioural values of time are lower for women than for men, but studies have not distinguished in general between employed and non-employed women. Also, the wage levels of women in employment are lower than those of men, as shown in Table 4.

Table 4

WAGE RATES FOR MEN AND WOMEN		
	Men	Women
Gross weekly earnings	£35.0	£16.20
Gross hourly earnings	£ 0.82	£ 0.51

The data relate to April 1972 and are taken from the New Earnings Survey 1972. Part-time workers are included, but men under 21 and women under 18 are excluded.

For prediction, it would be useful to know more about how travel behaviour varies separately for men and women, and separately for housewives and employed women, since these categories are likely to affect life-style, access to private cars and the balance of trips for different purposes.

-
- (1) The word "housewife" is used to include both men and women engaged in unpaid work such as cooking, cleaning, bringing up children, shopping, etc. The word "houseperson" has recently been coined, and may be thought less misleading, since it is the economic function rather than the sex which is relevant here.

However, a more fundamental problem is whether a low behavioural or a high theoretical value is appropriate for the evaluation of housewives travel time. The existing approach assumes simply that housework is not a productive activity, and is without an economic value. The only justification for this assumption is that (with minor exceptions) there is not an organised labour market with known rates of pay for housework. There is, on the other hand, an organised labour market and known rates of pay for, say, civil servants, and for this reason their activity is assumed to have an economic value.

It may be noted that this distinction has been explicitly rejected, in theory and practice, in at least one other area of transport assessment, namely the economic evaluation of road accident measures.

Dawson (1967) for example based the economic value of the work of a housewife on the wage rate of women in employment. A.D. Little, Inc., (1968) argued:

"the death of a housewife creates a demand for household services and entails removing another woman from some other productive labour to provide these services. The proper valuation of the housewife is then according to the alternative costs of the provision of household services."

There are various problems associated with this approach, which are not discussed here. But the point is not whether the approach is correct, but that it has been used, and its use raises principles which are relevant here.

The case that travel time associated with housework is "economic" may be argued from two alternative bases:

- (1) Housework is a service in itself, contributing to human wants in exactly the same way (and perhaps more effectively) as employed cooks, shoppers, nurses, teachers and home-helps

contribute. Time saved in travelling is available to be spent on providing more, or a higher quality, of these services. Insofar as the wage rate provides a useful guide to the value of the output of any worker, then to that extent a value of housework may be found by looking at the wages of employees doing comparable tasks.

- (2) Time saved or spent by housewives will affect the participation by women in paid part-time and full-time employment - in the long run, one of the most flexible components of the total supply of labour. At the margin therefore, time saved from housework (including the travel associated with it) can be spent in "proper" economic activity, and its value can be found by looking at the average wages of women in employment.

The adoption of one or other of these arguments would justify slightly different values, and both would lead to a value which was less than that of men travelling in working hours. The value would be about 3-5 times as high as that used at present.

The change would be large, but operationally easy, probably socially acceptable, based on a plausible and already accepted theoretical precedent, and would result in a shift of resources towards providing improvements for a category that has less access to transport facilities than many others. It is recommended here.

A further consequence might be some alteration in leisure values of time where values based on behaviour are used for evaluation, since a large category of travel would be removed as no longer relevant to the estimation of a behavioural average.

3. BEHAVIOURAL ASPECTS OF THE VALUE OF TIME

3.1 Generalised Cost or Generalised Time

In classical consumer theory, the cost or disutility of purchasing a commodity is given by its money cost, and this is offset against the utility provided by consuming the commodity.

One important difference between this classical case and the analysis of transport demand is that the disutility is multi-dimensional - i.e. it is composed not only of the money cost, but also the expenditure of time, and possibly the experience of stress, discomfort and inconvenience, and the expenditure of effort.

It would in principle still be possible to use a whole family of classical demand curves, relating demand to money cost separately for each outlay of journey time, etc., but this is difficult to handle if there are more than two components of disutility, and the calculation of benefits by some sort of consumer surplus does not enable easy comparison of alternative situations.

Using some suitable definition of generalised cost provides an easy solution to these difficulties. A "demand curve" can be presented with a combination of all the relevant disutility variables on one axis, expressed in a common unit. We need only one such demand curve for a given problem, and a consumer surplus, or more precisely a change in consumer surplus, may easily be calculated. This consumer surplus no longer inevitably has units of money, as it will in the classic case; it will take on whatever units are chosen for the generalised cost, i.e. the units of one of its components. It is for this reason that generalised cost is a very flexible tool of economic analysis.

Suppose that generalised cost in money units is chosen:

$$g_m = m + \lambda t \quad (5)$$

Now most studies have indicated that the amount of money a traveller is prepared to pay to make a unit time saving is some sort of increasing function of money income, M . For simplicity we will assume a simple linear function:

$$\lambda = kM \quad (6)$$

Then for a given journey, with money cost m_t and time t_i we get the relationship:

$$g_{mi} = m_i + kMt_i \quad (7)$$

As income increases, so the generalised cost of that journey to that traveller increases. This result will be quite general - it applies to a particular journey, and to travel as a whole.

We would want to use a demand relationship empirically measured to predict travel demand either over the years, as incomes rise, or for different sections of the population whose characteristics including income vary.

Since the quantity of travel undertaken is generally seen to increase as real incomes increase, using both cross-section and time-series data, we seem on the face of it to have an increasing generalised cost of travel associated with an increasing demand for travel. This is not a plausible result.

We may overcome this difficulty in one of two ways:

- (1) Assume, and subsequently try to measure, relationships such that the marginal utility to be gained from travel increases with income - and increases so sharply that the increasing generalised cost is outweighed. This seems implausible, and would in any case be difficult or impossible to test.

- (2) Specify the generalised cost expression in such a way that it is still consistent with observed behaviour, but is a decreasing instead of an increasing function of income. The simplest possible version of this approach (and one that has, by Occam's razor, considerable advantages) is the use of generalised time, namely:

$$g_t = t + \mu m \quad (8)$$

which enables us to replace the implausible equation (7) with:

$$g_{ti} = t_i + \frac{m_i}{kM} \quad (9)$$

The disutility of making the journey (or travel in general) now decreases as income increases, which is entirely consistent with observations that the amount of travel increases.

What we have done is to use our observed values of time in a different way. Using generalised cost, λ inflates or deflates the time component according to how much money it is worth. Using generalised time, μ inflates or deflates the money component according to how much time it is worth.

The two approaches use the same observed relationships between the allocation of time and money to travel, but differ in their interpretation of these relationships. Given an observed increase in values of time as incomes increase, is this more likely to be attributable to an increase in the utility of time savings, or a decrease in the utility of money savings?

In the form used in equation (9), the assumption is made that the marginal utility of time savings is constant for different income groups, but the marginal utility of money savings declines. Such an approach may be justified from a number of different standpoints:

- (1) It works.
- (2) The money assumption is consistent with classical welfare theory, for example Marshall (1890) who argued:

"the richer a man becomes the less is the marginal utility of money to him."

- (3) There are some a priori reasons for expecting constant marginal utility of time to be a more plausible assumption than constant marginal utility of money. Time is, by its nature, equitably and unalterably distributed, not subject to the accidents of inheritance, theft, chance, inflation, social system, or government decree. Clark (1973) has used this interpretation to provide a means of measuring the marginal utility of money directly.

On the other hand, the amount of "free" or spare time undoubtedly varies, and this would undermine the plausibility of an approach that assumed the marginal utility of time to be constant. Some empirical evidence on this may be examined.

Table 5 shows the gross weekly and hourly earnings of adult employees in 1972, compared with the average hours worked.

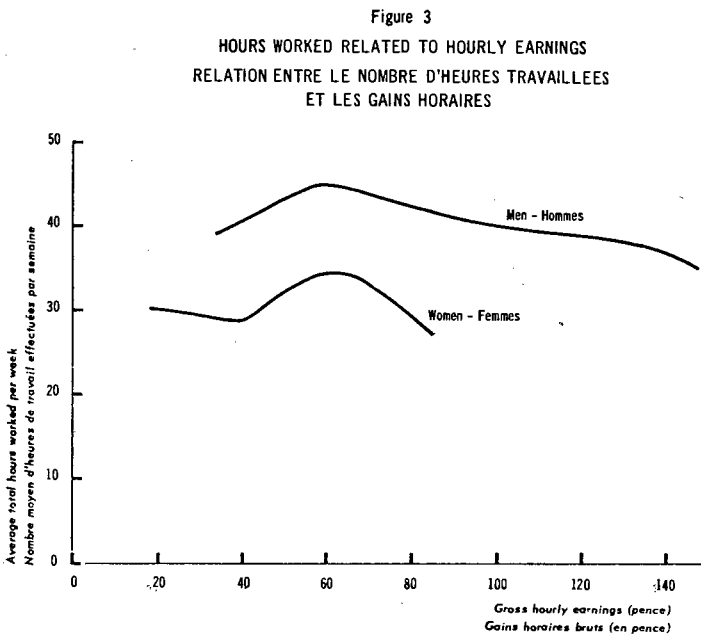
Table 5

RATES OF PAY AND HOURS OF WORK

	Men			Women		
	Earnings		Hours per week	Earnings		Hours per week
	£/hour	£/week		£/hour	£/week	
Mean	0.82	35.0	42	0.51	16.2	31.2
Standard Deviation	0.32	14.8	9.1	0.22	9.3	10.2
Coefficient of Variation	0.39	0.42	0.22	0.44	0.57	0.33

Part-time employment - a major source of variance in working hours - is included. It is seen that for both men and women the coefficient of variation of hours worked is substantially smaller than the coefficients of variation for weekly or hourly earnings.

It is not only the existence of a variance, but also the direction of movement that counts here. Figure 3 shows the average total hours worked for employees in each wage-rate category, based on data from the New Earnings Survey (1972).



The relationship is rather complex, due in part to the combined effects of different tendencies affecting part-time and full-time employees, and manual and non-manual employees, which it would be useful to investigate separately. What seems clear however is that people earning higher rates of pay do not consistently work longer hours; indeed the highest wage rate groups of both men and women seem to work about 20 per cent shorter hours than the groups earning around the median

wage rate. This may in part be due to an under-reporting of unpaid overtime for senior non-manual employees, but that effect is most unlikely to be strong enough to reverse the apparent trend.

Thus the availability of spare time does not seem likely to be strongly negatively correlated with income, and is therefore unlikely to be a cause of the observed tendency for values of time to increase with income.

The figures also suggest that considerable care is necessary when calculating hourly rates from gross earnings statistics. A simple 2,000 hour/year rule, while a convenient approximation, may blur important deviations from average working hours.

Limited but interesting evidence is also available from a survey of time spent in different activities by men and women, published in Social Trends (1973) and summarised in Table 6.

Table 6

HOURS PER WEEK SPENT WORKING BY MEN AND WOMEN				
	Men	Women in full-time employment	Women in part-time employment	Women not in paid work
Employment	49.5	40.2	26.3	-
Household	9.9	23.1	35.3	45.5
Total work	59.4	63.3	61.6	45.5

The travel to and from work is included for employees, but "housework travel" is not included for women. The survey only included married men and women aged 30-49, and hence probably underestimates the work load of women not in paid work, because of an under-representation of women with very young children. It is interesting to note how close together are the first three categories.

It is clear that, while the variations in "spare" time are likely to be less than the variations in money income, especially when income from other sources is included, nevertheless the amount of time people have at their disposal for allocating to travel does vary, and this seems likely to be an important, and as yet uninvestigated, cause for the variation in values of time. A simple extension of equation 9 suggests that a suitable form of generalised cost or time might be:

$$g = \frac{t}{f_1(T)} + \frac{m}{f_2(M)} \quad (10)$$

where T is the total amount of time available after fulfilling basic needs such as work, sleep, eating etc. The form of $f_1(T)$ could be investigated by comparison of groups with different amount of spare time, just as the form of $f_2(M)$ has been chosen by reference to travellers with different incomes.

An advantage of this approach, if successful, is that the debate about units of measurement would become less important.

Meanwhile, the assumption of constant marginal utility of travel time seems likely to be a closer approximation to the truth than the assumption of constant marginal utility of money, especially when changes in money income are the expected source of variations in travel behaviour. Generalised time seems therefore a more useful tool in prediction than generalised cost.

3.2 Time Spent in Different Travel Activities

In the previous section distinction was not made between the different travel activities to which time may be allocated. It has been found that making such distinctions, at least for the major activities, increases the understanding and predictive power provided by behavioural models.

We have to ask what is the theoretical justification for these different coefficients, quite apart from the question of the extent to which they may increase the statistical goodness of fit of an equation. Three alternative approaches may be mentioned.

(1) We could say that time has a value only because time saved can be used for some alternative, preferred, activity. From this point of view it does not matter from what part of the journey the time has been saved, and we would expect a single value.

(2) Harrison and Quarmby (1969) argued that:
"the value of time savings depends not on the use to which time saved will be put, but on the disutility attached to the travelling time saved"

where different travel activities will:

"Convey different amounts of utility because of the basic conditions under which time is spent."

With this approach we would expect the coefficients of what Harrison and Quarmby called "different types of time" to be in the ratio of the disutilities associated with those times.

(3) A slight but important modification of the second approach is contained, for example, in Mitchell and Clark (1971):

"The 'values of time' obtained are only curve fitting parameters...(reflecting)...the comfort of the mode as well as the value the traveller actually places on his time."

The implication here is that while it may be convenient to incorporate other factors such as comfort in a time coefficient, these factors are in principle separate and distinguishable, were we able to devise a suitable unit system for measuring them. We would still expect to observe different coefficients, but these would need to be recalculated if any change other than duration occurs which affects the attractiveness of the activity.

It is the last of these three approaches which seems to offer most. This leads us to assume that time savings have a basic value determined by the alternative use to which time may be put, augmented by an extra value which arises from incorporating in the time coefficient an importance truly attributable to other factors.

The object is to disentangle these factors, which will require a reformulation of the definition of generalised cost.

The sorts of variables which we expect to be incorporated into the time coefficients are comfort, irritation, physical and mental stress, overcrowding, fear of accidents, protection from the weather, and so on. At the moment, we shall simply assume that it is in principle possible to identify a quantity of what we shall call "effort", not yet precisely defined, which represents the combined influence of the factors mentioned.

Let t_i = time spent in activity i (walking, in-vehicle, etc.)
 e_i = effort spent in activity i
 M = money spent
 g = generalised cost function
 a_i = rate of expenditure of effort per unit time
 b_i = observed coefficients of different components of g
 k_t = true coefficient of time
 k_e = true coefficient of effort
 k_m = true coefficient of money.

Assume that a particular journey consists of only two activities 1 and 2 (say, walk and ride) and that the true generalised cost is defined as:

$$g = k_t (t_1 + t_2) + k_e (e_1 + e_2) + k_m M \quad (11)$$

However, effort is not measured and we adopt the "different types of time" approach, thus observing:

$$g = b_1 t_1 + b_2 t_2 + b_3 M \quad (12)$$

Our values of b_1 and b_2 are influenced by the values of k_e and a_i since:

$$e_1 = a_1 t_1 \quad (13)$$

$$\text{and } e_2 = a_2 t_2 \quad (14)$$

$$\text{Therefore } b_1 = k_t + a_1 k_e \quad (15)$$

$$b_2 = k_t + a_2 k_e \quad (16)$$

However, if the data are well behaved, our estimate of b_3 should be unaffected, i.e.:

$$b_3 = k_m \quad (17)$$

So our observed equation can be reformulated:

$$g = (k_t + a_1 k_e) t_1 + (k_t + a_2 k_e) t_2 + k_m^M \quad (18)$$

From (15) and (16):

$$k_t = b_i - a_i k_e \quad (19)$$

Thus the single true coefficient of both time components, k_t , is less than the observed coefficients b_1 and b_2 by an amount depending on the effort expended per unit time and the importance to travellers of that effort. The true value of time will be less than the smaller of the two estimated values. If values of b_i and a_i are known, k_t and k_e can be calculated, since, from (19):

$$b_i = k_t + k_e a_i \quad (20)$$

Thus there should be a linear relation between b_i and a_i , where the slope represents the true weight to be given to effort and the intercept the true weight to be given to time.

The argument from which these conclusions are derived depends on a definition of the estimated generalised cost of a journey in which one can have reasonable confidence in the size of the coefficients. In practice an extra problem may be caused by the form of demand model used, where the costs and times associated with two alternative ways of making the same journey are often included in the same equation, either as absolute quantities or in the form of differences. In this case the quantities of effort associated with the use of competing modes may bias the observed coefficients. For this example we can

ignore money cost and the time outside the vehicle, and consider only time spent in a car t_c and time spent in a bus t_b , where $t_b > t_c$.

Then we estimate a coefficient for in-vehicle time difference as an approximation to the two coefficients for differences in in-vehicle time and in-vehicle effort, i.e.:

$$b_1 (t_b - t_c) = k_t (t_b - t_c) + k_e (e_b - e_c) \quad (21)$$

$$\text{So } b_1 = \frac{k_t (t_b - t_c) - k_e (a_c t_c - a_b t_b)}{(t_b - t_c)} \quad (22)$$

Then

$$b_1 = \begin{cases} < 0 \\ 0 \\ > 0 \end{cases} \quad (23)$$

Depending on whether:

$$k_t (t_b - t_c) - k_e (a_c t_c - a_b t_b) = \begin{cases} < 0 \\ 0 \\ > 0 \end{cases} \quad (24)$$

The estimated in-vehicle time coefficient b_1 will be negative if the effort involved in travelling by bus is less than that by car, and if for that reason bus has been chosen in spite of its time disadvantage. It is clear that in some circumstances zero or even negative time values will arise quite naturally if "effort" components are ignored. Such results, implying at face value that time using is an end in itself, are generally explained in practice by "statistical accident" or imperfections of data or analytical technique.

The argument thus implies that ignoring effort will in general lead to an overestimate of the value of time, but in some circumstances will lead to an underestimate or even apparently negative values of time. The importance of these effects will depend on the form of model chosen, and the specific conditions on the transport systems available to the sample of travellers considered.

It may be noted that we would therefore expect results of studies carried out in different towns or relating to different people to show differences in estimated coefficients even

if the utility of time savings is the same for all of them. It also follows that when choosing one of the components to provide a "base" time, the one chosen should preferably be as homogeneous as possible, with characteristics that vary between individuals and over time as little as possible. The component "in-vehicle" time does not qualify well on this counts, and it would appear sensible to use walking time as a base.

There are various techniques of measuring scientifically the physical and/or psychological reactions of individuals to different conditions, some of which are mentioned in the Appendix. Table 7 indicates two possible measures, suggested by Goodwin (1974b).

Table 7

APPROXIMATE AVERAGE ENERGY EXPENDITURE AND HEART RATES
OF PEOPLE ENGAGED IN TRAVEL ACTIVITIES

Activity	Energy expenditure (excess over base rate) kcal/min	Heart Rate (excess over base rate) Beats/min
Sitting on bus or train	0.5	5
Standing waiting	1.0	16
Driving	1.8	18
Walking on level	3.5	25
Climbing stairs	7.0	50

Physical energy expended would account for sitting being preferred to standing, walking being preferred to climbing stairs, etc., and it would also be a convenient way of explaining differences in the choices made, for example, by the exceptionally over weight or those burdened with heavy luggage. It may be noted however that waiting is not associated with a very high level of energy expenditure; heart rate, which is closely

related to energy expenditure but is also influenced by stress, anxiety and discomfort, appears to have some advantages here. It is also more easily measured. Figure 4 compares coefficients given to in-vehicle, walking and waiting time in studies mentioned in the Appendix, with the heart rate figures outlined. The crosses indicate most common or most probable values, and the likely range of estimates from different sources is indicated by the areas enclosed.

There is some evidence of a slope in the right direction, although little reliance should be placed on its exact position. The figure gives support to the idea that there is a case for further investigation.

The importance of this sort of analysis is that it should be able to extend understanding of decisions which do not easily fit into a "time and money" framework; the "costs" of a bus trip experienced by a parent, standing, with shopping, pushchair and child, for example. The penalties associated with transfer from one vehicle to another, or while crossing a road by footbridge or underpass, or with using an irregular (as distinct from infrequent) service, and the increased problems of travel faced by the elderly or infirm in mounting a bus, or the claustrophobic in using an underground railway could, if required, all be more systematically handled by an appropriate measure of effort than by multiplying different special values of time. To have a large number of different "types of time", each with its own value, inevitably focuses attention on the duration rather than the pleasantness of activities, and will give little guidance, and misleading predictions, concerning the effects of changing the pleasantness of travel.

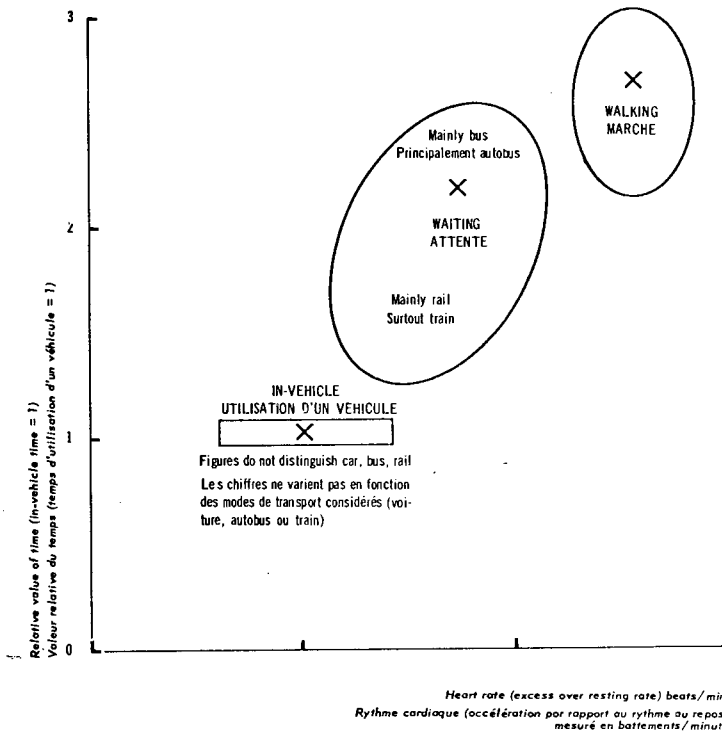
3.3 Perception

The problem of perception affects the interpretation and use of time values in a number of different ways.

(1) People are not, in general, able to estimate exactly the duration of an activity. There will certainly be errors in either direction, and there may be bias - that is,

Figure 4

RELATIVE VALUE OF TIME COMPARED WITH A MEASURE OF STRESS AND EFFORT
VALEUR RELATIVE DU TEMPS COMPAREE A UN INDICE
DE TENSION NERVEUSE ET DE L'EFFORT



the errors may be larger or more common in one direction than the other. This matters because demand studies and behavioural modelling usually calculate values of time from survey information about what people say their travel times are, while cost benefit studies are normally carried out with engineering estimates of the real changes in journey times. If the two are consistently incompatible, the results will be biased.

(2) The errors and biases may be different for different activities; most plausibly, people may overestimate the duration of unpleasant activities and underestimate the duration of pleasant activities. This will affect the reliability and use of weights attributed to in-vehicle time, waiting time, etc.

(3) Travellers may not be able to detect time savings below a certain threshold level at all, in which case their behaviour will not be affected and it is unclear that any real benefit is provided. This will affect those projects providing very small time savings for very large numbers of people.

(4) Travellers may be imperfectly informed about the costs and times of the travel choices they have rejected; this is especially so since the costs and times of all journeys are values drawn from some sort of probability distribution, and travellers whose experience of one mode is confined to a small number of journeys are likely to have a misleading impression of the average journey time.

(5) While ordinary public transport fares present little problem, the money cost of car travel is more difficult, since travellers perception of the cost to be attributed to a particular journey may vary between travellers and be difficult to estimate for any of them. That this is important for values of time is shown in Table 8, indicating a range of values of time derived by Rogers Townsend and Metcalf (1970) from the same data set but with different assumptions about car costs. Measures of statistical explanatory power were little affected by the variation in assumptions.

Table 8

EFFECT OF ASSUMPTIONS ABOUT CAR COSTS ON VALUES OF TIME	
Car cost assumed (old pence per mile)	Value of in-vehicle time (% of wage rate)
0.5	12.4
1.0	15.0
1.5	17.3
2.0	21.6
3.0	36.5
4.0	58.0

Empirical evidence on all these questions is scanty, and mostly based on inference from results of studies carried out for other purposes. O'Farrell and Markham (1974) give results comparing estimates made by car owners of the times of trips to and from work by train and bus. Table 9 summarises the results.

Table 9

PERCEIVED TIMES OF TRAIN AND BUS JOURNEYS			
		Average actual time min.	Average perceived time min.
Train time to work	car users	23.0	21.9
	train users	22.8	24.0
Train time from work	car users	23.8	22.6
	train users	23.2	23.8
Bus time to work	car users	20.3	24.2
	bus users	21.8	25.2
Bus time from work	car users	23.4	29.0
	bus users	24.5	28.2
Bus waiting time, to work	car users	4.0	7.5
	bus users	3.9	5.7
Bus waiting time, from work	car users	5.9	17.3
	bus users	5.1	13.9

There is little indication that, on average, users of the mode make substantially better estimates than non-users, or that estimates are seriously wrong except for waiting times which appear greatly overestimated, more so by car users than bus users (although the "actual" times are themselves estimates calculated by application of a formula that appears not to take into account the arrival of full buses).

Work has been done by Liivamagi (1974) comparing the estimates made by people of the time to be specified journeys that they do not undertake regularly, compared with the actual time subsequently taken in actually performing those journeys. The estimate of times made in advance of a journey is important since this is the stage at which a mode choice is made.

Table 10 shows the actual time for 25 specified journeys in London (a total of about 100 miles of travel) by each mode, with the actual trip time subsequently taken.

Table 10

ESTIMATED AND ACTUAL TIMES OF CAR, BUS AND TUBE JOURNEYS					
	Actual time for 25 journeys min	Estimated times for same journeys			
		Mean min	Standard deviation min	Lowest estimate min	Highest estimate min
Car	352	610	147	435	885
Bus	1,047	1,042	250	725	1,973
Tube	1,052	912	217	655	1,223

The figures indicate substantial errors, but surprisingly good average estimates for bus and tube journeys. The car times were substantially and consistently overestimated to an extent which suggests that people were expecting peak period conditions even though off-peak conditions were specified.

Various methods have been proposed for solving these problems, some of which are mentioned in the Appendix. The whole area is one which deserves more research emphasis. It is also an area where a number of quite simple experimental research projects would be rewarding. In particular:

- (a) It would be useful to find experimentally what systematic relationships there were between the perceived and clock duration of time, for people engaged in various travel activities. An approach which relates the distribution of actual times to the distributions of perceived times would appear preferable to one relying on a simple comparison of means, but either way sophisticated demand modelling would be unnecessary. The results would illuminate subsequent modelling and the use to be made of values of time in investment appraisal.
- (b) The problem of car costs might be advanced best, paradoxically, by concentrating modal choice demand modelling more on the choice between two or more public transport modes where money costs are usually more explicit. This would result in more reliable coefficients for the money component of generalised cost, hence more reliable values of time and a better understanding of how then to treat money costs in general including those of cars.

4. EQUITY AND THE INCIDENCE OF COSTS AND BENEFITS

When incorporating such items as petrol savings, construction costs, etc. in a cost benefit analysis, the assumption of constant marginal utility of money enables the costs and benefits expressed in money terms to be simply added, transfer payments to be eliminated, and the distribution of costs and benefits among different sections of the population to be ignored.

However, the assumption of constant marginal utility of money also implies that in maximising society's welfare, schemes saving travel time for the rich should be preferred to those saving travel time for the poor.

The Department of the Environment decided that this would result in an unacceptable shift of resources for the benefit of the rich without any corresponding increase in payments by them, and, for non-working time only, recommends a single average value, the "equity" value, of time savings. It will be seen that this is consistent with the use of generalised time for prediction, although its justification is political rather than behavioural.

There are a number of problems associated with this approach, of which three will be discussed.

- (1) If the approach is valid, it applies as much to inter-regional and international comparisons as to urban transport projects. Agencies which are concerned with (or provide finances for) transport projects in a number of countries ought to apply the same equity value for savings in leisure time in all those countries. It follows that the equity value chosen should not be calculated as an average of data relating to one country, but should apply to both underdeveloped

and advanced countries. To do this will result in a much wider variation in incomes in the data from which values are estimated, and would almost certainly involve an increase in the comparison of unlike schemes. But the main alternative in practice would be to use a separate equity value for each country, and this value would itself be income based. Hence it would appear that allocating resources for travel time savings is more justifiable in rich countries than in poor countries in a way which has been explicitly rejected when applied to rich or poor regions within a country, and this seems unacceptable.

- (2) McIntosh and Quarmby (1970) justify the use of generalised time in prediction with the argument that:

"time has much the same value in terms of personal utility to people of different incomes, and to people living now and at some future date."

The discount rate to be used, which will affect the distribution of costs and benefits between present and future generations, then becomes relevant. The higher the discount rate, the less importance is given to the time losses and savings of future travellers. The quotation above would seem to justify a zero discount rate, although consideration of possible increases in the amount of spare time might modify this. In any case, it seems very unlikely that a useful guide will be provided by market interest rates⁽¹⁾, which to

(1) A case can be made that the real market rate of interest, i.e. interest net of current rates of inflation, is a useful base. At present in the United Kingdom this would suggest a negative discount rate. The implications of this are profound, and confusing.

some extent must include expectations of future inflationary rates, and are therefore compatible neither with the constant prices assumption of cost/benefit analyses nor with the assumption that the utility of time savings is approximately stable over the years. From this point of view, substantially lower discount rates are indicated, perhaps of the order of 2-4 per cent.

(3) While the equity value of time in evaluation is consistent with the use of generalised time in prediction, there are other less consistent features:

- (a) different units are used for prediction (time) and evaluation (money);
- (b) constant marginal utility of leisure time is assumed for prediction and evaluation of leisure time;
- (c) constant marginal utility of money is assumed for evaluation of all other costs and benefits.

Either (b) or (c) might be true, but they cannot both be true if the value of time increases with income.

The author has suggested (Goodwin, 1974a) that it would be possible to resolve these inconsistencies by the use of generalised time in evaluation as well as in prediction - i.e. use observed money values of time as weights applied not to the time, but to the money costs and benefits accruing to different groups. Such a procedure has the advantage that the provision of transport facilities would be judged by criteria consistent with travellers' observed behaviour.

All techniques of evaluation have some implication for the distribution of costs and benefits, even those techniques that ignore questions of incidence. This may be illustrated

in the following example, where three schemes are being compared, which cost the same to implement, have similar life-spans, have effects only on costs and leisure time, and affect two income groups differently. The figures chosen for the example are shown in Table 11.

Table 11

INCIDENCE OF BENEFITS OF THREE TRAFFIC SCHEMES

Income Group	Value of time pence/hour	Schemes					
		A		B		C	
		hours	pence	hours	pence	hours	pence
Low	25	1	20	2	40	2	10
High	50	2	40	1	20	0.5	80
TOTAL	37½	3	60	3	60	2.5	90

Each scheme is then evaluated by converting cost and time to a single unit, by each of the three procedures discussed, as shown in Table 12.

Table 12

TOTAL BENEFITS MEASURED BY THREE PROCEDURES

Procedure for estimating total benefits	Scheme		
	A	B	C
Generalised cost	£1.85	£1.60	£1.65
Generalised time	4.6 hours	5.0 hours	4.5 hours
DoE method	£1.72½	£1.72½	£1.83½

Using generalised cost, scheme A is preferred. Generalised time indicates that scheme B is preferred. Using generalised cost with an equity value of time, scheme C is preferred - that is, the scheme in which money savings accrue to the rich, and time savings to the poor. This is not to imply of course that the method always chooses such schemes, but merely that it can choose such schemes, whereas either of the alternative procedures will reject them.

The issue here is whether it is appropriate to incorporate in the comparison of costs and benefits information about the incidence of those costs and benefits.

If it is considered appropriate, the main change in practice would be that the incidence of costs and benefits of schemes should be separately estimated for major social groups such as employees/non-employed, men/women, income groups, car owners/non-owners, users of different modes, travellers of the present/travellers of the future. Other categories (urban/rural, children/adults, etc.) might be relevant in particular cases. For each of these groups, weights can be applied to the costs and benefits; the aspects of current transportation practice discussed above suggest that the reciprocal of the value of time provides a suitable set of weights for costs and benefits which accrue in terms of money.

It could be argued that the question of incidence and distribution is not a question for economic analysis, but solely for political judgement. If this is so, it still follows that information on the incidence of costs and benefits has to be estimated and made available, preferably in their "raw" units, i.e. hours, pounds, etc.

5. RECOMMENDATIONS

The suggestions discussed in preceding sections are drawn together here in two categories; suggestions for practice, and suggestions for research.

(a) Practice

(i) The present framework used by the Department of the Environment in the United Kingdom is generally satisfactory, and should be more widely applied.

(ii) For prediction, generalised time should be used, with the components (at present four in number, although this can be adapted for particular circumstances) separately identified. However, walking time should be used as a base instead of in-vehicle time, and in-vehicle time should itself be separated out when two or more substantially different types of vehicle are involved. Behavioural values of working time should be found and used.

(iii) For evaluation, wage-based values for working time and equity values for leisure time should be used as at present, except that time spent in travel associated with housework should be treated as working time and the equity leisure value should have an international not national base. It may be that wage-related values for working time will not be a long lasting assumption, and there should be a readiness to replace it if empirical research results so indicate. Meanwhile, care should be taken when converting annual or weekly wages, or household income from all sources, to individual wage rates.

(iv) A substantially lower discount rate for discounting time savings should be used than would be indicated by market interest rates.

(v) Cost benefit exercises using values of time, however defined, should specify in more detail the incidence of costs and benefits among different sections of the population.

(b) Research

(i) A substantial research effort should be put into testing the empirical validity of wage-related values of working time, investigating both the behaviour of travellers and the productive value of the time saved.

(ii) Investigation of possible other components of generalised cost should concentrate more on identifying suitable measures other than duration, rather than on devising a great number of different types of time.

(iii) There should be experimental work on the relationships between clock time and perceived time for travel activities, and analysis of the importance of the variance in both.

(iv) An investigation into the possible usefulness of "spare time" as a source of variation in the utility of time savings to different groups should be made.

(v) More attention should be placed on deriving values of time from the behavioural modelling of choices between public transport modes.

APPENDIX

RECENT THEMES IN RESEARCH ON THE VALUE OF TIME

In Harrison and Quarmby's report to the Sixth Round Table, short summaries were provided of work by Beesley (1965), Institut d'Amenagement et d'Urbanisme (1963), Lee and Dalvi (1969), Lisco, (1968), Local Government Operations Research Unit (1968), Barnett and Saalmans (1967), Quarmby (1967), Stopher (1968), Bevis (1965), Claffey et al (1961), Dawson and Smith (1959), Thomas (1967) and Mohring (1960, 1965). These studies were pioneering works in the field.

Since that report, there have been several papers and theses that have adopted a similar approach of separate summaries of each major study to date. Readers are particularly referred to summaries by Barber and Searle (1973) and by Hensher (1974a) which provide particularly good summaries of work done, and bibliographies.

It is not intended to repeat those summaries here.

A number of themes have recurred in the work carried out, and those that are relevant to the subjects of this report are highlighted here.

(a) The effect of income

Most studies have investigated the effect of income on values of time, usually by separate estimation of values for each of several income bands. Figures in the range of 20-50 per cent of an estimated wage rate have been found by Mohring (1960), Becker (1965) Beesley (1965) Barnett and Saalmans (1967) Quarmby (1967), Stopher (1967), Lee and Dalvi (1969), Wabe (1969), Mansfield (1969), Hansen (1969), Lave (1968) Hensher (1972), Kraft and Kraft (1971) and others.

Values rather greater than this, often with considerable variation, have been found by Thomas (1967), Rogers Townsend and Metcalf (1970) Davies and Rogers (1973) Ebdon and Hall (1971) and Dawson and Everall (1971). (This study also found

very high values of work time, though with very approximately estimated wage rates) Watson and Stopher (1974) and Watson (1972).

Values rather lower were found by Goodwin (1974a) (in a study that included children's travel) and Hensher (1974).

Most of these studies have found that the values of time increase with income, although the evidence is stronger in some (e.g. Quarmby) than others (e.g. Davies and Rogers). One study by Heggie (1974) seemed to indicate an apparently negative relationship between gross income and marginal value of time, though the sample was small.

There is some evidence that, although values of time increase with income, they do so at a less than proportional rate. Lee and Dalvi found this, as did Goodwin, and many of the other studies are not inconsistent with it. A possible explanation would be that the progressive tax rates themselves cause a less than proportional relationship between gross pay and take home pay. This might also explain an apparent drop in the value of time for the single highest income group found by Watson and Stopher, and Hensher.

(b) Time spent in different activities

Quarmby, combining all time not spent in a vehicle into "excess time" found a coefficient 2.3 times as great as that for in-vehicle time with one group, and 2.6 for another. The SELNEC study (Wilson et al, 1969), used a weighting of 2.0 for public transport waiting time, but gave in-vehicle time, parking time and walking time weights of 1. The Tyne-Wear study (Costinett, 1973) gave walking time a weight of 1.7 and waiting time 2.3. The London Transport Executive (National Board for Prices and Incomes, 1970) found for underground trains that waiting time and in-vehicle time had the same weights, but walking was 1.5 times as much and a fixed extra penalty of 4 minutes should be added for each interchange. The Local

Government Operations Research Unit has published a number of studies in each of which a very wide range of different results are given. Preferred results include those of Rogers et al (1970) giving waiting 1.7 and walking 2.4 compared with in-vehicle time, Davies and Rogers (1973) giving waiting 3.2 and walking 2.5, Steele and Rogers (1973) giving waiting 2.1 and walking 2.8. Mitchell and Clark (1971) indicate that bus time is valued lower than walk time and car and cycle time more highly. Heggie (1974) suggests that values of walking time are higher in winter than in summer, as are values of waiting time except where protection from the weather is provided.

Attempts to separate out the effects of the pleasantness of activities from effects of their duration have largely concentrated on psychometric techniques, e.g. building up points systems based on consumer surveys, for example by Ackoff (1965) Lave (1969) Litchfield (1969) Demetsky and Hoel (1972), Wagon and Collins (1973) Hensher et al (1974), Stopher (1974). Measurements of the physical or psychophysical reactions of people engaged in travel activities have been recorded as a result mainly of interest in medical and safety problems, rather than travel choice; the physical expenditure of energy has been widely studied and is summarised in surveys by Passmore and Durnin (1955, 1967). Heart rates are recorded by Anderson et al (1971) Carruthers (1974), Carruthers and Taggart (1971), Falls (1968), Kryter (1970), Rutley and Mace (1970), Taggart et al (1969). Galvanic skin response, an alternative measure of emotional reactions, has been studied in a driving context by Taylor (1964) and Babkov (1973). The application of this work to values of time has been discussed by Goodwin (1974b).

(c) Perception

In addition to the work by O'Farrell and Markham, and Liivamagi discussed above, work has been done on small time savings by Thomas and Thompson (1970), Jennings and Sharp (1974) and Heggie (1974); all of these tend to suggest (though not in entirely consistent ways) that smaller unit time values might be

appropriate for very small time savings. Heggie (1974) infers from discrepancies between car users' and bus users' estimates of bus travel times that "ex-post justification" biases car users estimates. He also notes that although drivers' estimates of car running costs are on average fairly close to a sensible definition of marginal cost, the average conceals an inexplicably wide variation. The problem of imperfect information is discussed by Hawkins (1974), and suggestions made for modifications in modal split equations to take account of it.

(d) Analytical methods

As the number of studies from which values of time can be inferred have increased, the range of values found has also increased. In a discussion of the conditions which determine whether reliable values can be found, Beesley (1973) argues that "the apparent increase in variance of measured values has coincided with a shift towards much less favourable conditions for making useful observations and estimates". Conditions which should be observed include the normal statistical requirements on data sample size, independence of variables, distribution of errors, etc., and conditions relating to the specific features of travel decisions, e.g. making sure that people actually do have a sufficient degree of choice to make analysis meaningful. These are also discussed by Harrison and Quarmby.

Some attention has been paid to the question of mathematical form and curve-fitting techniques. Modal choice models have generally used some sort of S-shaped curve asymptotic to zero and one to estimate the probability or proportion of travellers using each mode, with its parameters estimated most commonly either by discriminant analysis to find a function that optimally separates two populations, (e.g. Quarmby) or a linear regression on a transformed form of the logit curve (e.g. Dawson and Everall). A procedure used initially by Beesley (1965) and more recently by Davies and Rogers is that of limiting time values; each chosen situation reveals information not about the value of time, but about a maximum or minimum limit to the value of time, and the problem is to find some suitable central value between the two.

Most studies have based their analyses on information about travellers' observed (or at least, reported) behaviour and travel costs and times. One major variant (e.g. Lee and Dalvi, Hensher) is to replace this with questions about what travellers would decide if faced with different specified costs and times. The advantage of this procedure is that it is possible to bypass the problem of taking ratios of coefficients, which are not necessary best estimates of the true ratio; the disadvantage is that hypothetical and actual behaviour may not correspond.

The above methods relate mainly to binary choices, i.e. between modes or routes, which have formed the bulk of value of time studies. However, work has also been done on trip distribution (e.g. Gronau, 1970), housing and travel choices (e.g. Wabe 1971), and choice of car operating speed (Mohring 1963).

Various other more or less ingenious methods have been devised, e.g. the identification of journey distances where an equal number of travellers use two modes, which therefore have equal generalised costs (Mitchell and Clark, 1971) and taking derivatives of continuous functions relating cost and time spent on travel to income and distance travelled (Goodwin, 1974a).

Considerable attention has been focussed on the statistical and theoretical implications of these various methods, without a general consensus. The popularity of discriminant analysis seems to be on the wane, whereas logit models and limiting time values each have their champions. The author's view is that, at the present stage, heterodoxy in technique is a strength rather than a weakness, and more is to be gained by devising new methods and different directions of approach than by attempting to define a single "best" method which will replace all others.

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SUMMARY OF THE DISCUSSION

A. PRESENT USE OF THE CONCEPT OF THE VALUE OF TIME

1) For prediction (traffic forecasts)

A practical point, made clear from the outset, was the lack of refined data which made it impossible to distinguish between leisure and work, and between time passed in or out of a vehicle. It had accordingly hitherto been necessary to make do with gross figures for the evaluation of time on future systems.

Broadly speaking, it appeared that, for purposes of prediction, time savings had been given too much weight. Hence the need for a cautious approach in appraising the implications of investment designed to produce higher speeds.

More knowledge was needed on certain considerations (reliability and safety) which conditioned the choice of transport users. For some categories of passengers (especially the elderly) vehicle design was plainly an important factor.

When considering improvements to transport services, due regard should be paid to accessibility. This was not so much a question of "accessibility indices" in a traffic engineering sense, but rather the measurement of access to those activities which transport users had, or wished, to reach.

Urban growth has produced concentration, but without this leading to a corresponding general economy of scale in the organisation of transport systems. Economies of scale are encountered only in specific cases. Journey lengths and frequencies in areas of concentrated activity give rise to several questions:

- What makes people decide to use transport instead of going on foot?
- Over what distances are people prepared to travel?
- How much time are they prepared to spend on such journeys?

There is an inclination at present to overestimate the possibilities of public transport. But public transport clearly cannot cater for all users and every kind of trip, and is best suited to cases where trips are concentrated in corridors.

This point is particularly relevant in cases where encouragement of public transport is coupled with restraints on the use of cars, for the results are seldom convincing. In the light of experience in some quarters, public transport should be encouraged only in those cases where it fulfils a specific function; the mistake lies in trying to make it serve every purpose.

2) For the calculation of benefits

The value of time may be taken into account in the calculation of benefits both at the decision-making level and when evaluating possible improvements or innovations. In multi-criterion analysis the value of time is necessarily among the factors which have to be appraised.

In any event, and even for relatively isolated projects, multi-criterion analysis should be preferred to straightforward cost-benefit analysis. In practice, the subject of the exercise embraces a series of long-term behavioural patterns and thus falls within a context involving large-scale structural changes. Multi-criterion analysis is the only way to encompass all the relevant factors, in particular the social and urban planning considerations that have a bearing on the decision-making process.

Within a given urban area, the optimum solution consists in obtaining a complete set of figures for the period ending five to ten years hence. For inter-city services, where the time factor has a greater impact, application of a discount rate to benefits may be useful.

Adoption of a single assumed equity value for the evaluation of benefits evidently implies that costs must be treated in the same way.

The aggregation of preferences, which is the essential feature of multi-criterion approach, is all the more warranted because "perception" is seldom entirely distinct from "evaluation". Perception of journey time is blurred by the pleasantness of travel. Time measurements are frequently bound up with degrees of comfort, since the fastest means of travel are often also the most comfortable.

As regards appraisals of user behaviour (it being also borne in mind that present and future behavioural patterns are not necessarily the same) "willingness to pay" is only a clue

for accounting purposes. It is helpful for evaluating potential revenues but has little significance in relation to value in the true sense; one simply needs to have money to be willing to pay. Too much emphasis on "willingness to pay" ultimately leads to an evaluation of spending patterns and tells us nothing about the value of time.

B. CONCEPTUAL PROBLEMS

The discussion in this respect was mainly centred on the definition of equity value, how it varied with income and the pure value of time.

Statistical studies, show no clearly established relationship between income and value of time. This is probably due to inadequate data on, and analysis, of user behaviour. On this last point, it was observed that the constraint of fixed working hours weighs most heavily on those with low incomes. Such people must be on time and have no possibility of adjusting their working hours; this would seem to be the reason why there can be no straight relationship between income and value of time.

As this finding more particularly applies to journey-to-work trips, the question arises whether the relationship referred to does exist, on the other hand, for leisure or inter-city trips. However, research has hitherto been mainly directed to journey-to-work trips and, in many countries, research on other trips needs to be carried further.

It would also be useful to establish a clearer distinction between time spent at work and time spent outside work and see how they are related. Similarly, it would be interesting to arrive at integrated approaches to the linking of the value of time spent at work and that of time devoted to leisure activities.

As regards what income is relevant for these purposes, the most valid criterion is that of disposable income for each member of the household. This criterion needs to be supplemented by factors reflecting the impact of changes, in particular the reduction of working hours, on the evaluation of journey time and leisure time.

Higher incomes are however coupled with price increases, a fact which inevitably weighs against the emergence of noticeable gaps between the two. In any event, the participants considered that a relatively long period of time was necessary in order adequately to assess any changes in behaviour.

In this analysis, distinctions between occupational and age groups should be considered. Another distinction which should be borne in mind is that which exists between the effects of increased earnings on travel and on modal choice. The latter may also be influenced by the lengthening of journeys.

Broadly speaking, two possible effects of income on travel decisions are conceivable. The first assumption is that travel is a good like any other, and that people travel more as their income rises. The second is that increases in income alter the cost of travel and influence modal choice.

For business travel, it could reasonably be inferred that there is a relationship between value of time and income. The participants at the Round Table did, however, point out that there was no scientific proof of this assumption which, at first sight, seems quite plausible.

As regards the use of "generalised time" it must be realised that the choice of method has important consequences in terms of distribution of income.

Another point which was raised was that of the decreasing utility of money as income increases. This may coincide with increased marginal utility of time. Moreover, it may be supposed that more time will be available as incomes increase.

The concept of generalised time implies options of a political nature. Time and money both necessarily vary; if only one factor varies then (at least in theory) the use of generalised time is the proper course.

In the course of the discussion on these concepts, some participants considered that neither generalised cost nor generalised time were really indispensable. Flexible parameters could just as well be used for prediction, provided that elasticities are adequate.

Others considered that evaluation was not sufficiently developed to distinguish between generalised time and generalised cost. It was necessary to introduce finer distinctions between types of time.

The question then arose whether a "weighting" process such as this might be rather in the nature of a political decision. To this it was objected that the value of time was not a matter of economic research or political decision-making. This value was appraised by users themselves; what really mattered

therefore was to find out how users made such assessments and what was their behaviour in consequence. In practice, people make calculations mainly on the basis of expectations; time savings were thus taken into account beyond a certain threshold (this part of the problem is given more ample treatment in the next section).

By way of conclusion on the subject of the concepts of generalised time and generalised costs it might be fair to say that they can be used for prediction, but for decisions there will also be an element of political choice.

The concept of the value of time includes many unavoidably arbitrary factors. It is therefore necessary to spell out the weak points clearly and then rely on political decision-making. Even so, the result is not fully satisfactory as it means that political judgements are being made on points where scientific knowledge is lacking.

The evaluation of time savings in terms of money units is a hazardous procedure and it is debatable whether, everything considered, it would not be better to measure time in minutes. As so many assumptions can be taken as a basis, evaluations of time must inevitably vary.

There are also differences relating to individual cases and changes brought about by long-term trends. Some participants went further than this: they considered that there was flagrant discrimination in the appraisal of time savings depending on the mode concerned. Values taken into account for road-building projects were arbitrary and could in fact be used to justify anything. Public transport projects, on the other hand, were often judged by reference to consideration of profitability alone.

In the final analysis, money is the determining factor, it being pointless to evaluate time that cannot be paid for. However, to assist the decision-maker it is useful to present the various factors in terms of a common denominator and to avoid the juxtaposition of disparate elements. The main advantage of analysis expressed in money units is not so much that of precision, but rather of drawing the attention of decision-makers to those factors which were not previously taken into account, thus providing them with a much clearer picture than before.

To express time savings in minutes would not be a simplification, for it would preclude certain comparisons. Moreover the aim is to show what users are willing to pay and then show the benefit which they obtain without payment (the cost borne by the Community).

Every decision involves a choice between conflicting aims; it is therefore necessary to have rules which clarify those aims. The introduction of pure "willingness to pay" presupposes redistribution of incomes. On this point it is objected in some quarters that "pricing" must not be confused with "cost-benefit". The solution to these differences of approach doubtless lies in making a distinction beforehand between investments that are warranted in the interests of the community and those that must be paid for by users themselves. But the problem would then be to know whether people are "willing to pay" at the time when the investment is made, for behaviour patterns can be subject to fairly rapid changes.

One last point raised in this section was that of the interaction between time savings and certain disbenefits stemming from the fact that the imperfect functioning of the price mechanism often gives rise to hidden transfers and hence to consequences which were not intended at the outset. Thus, time savings may encourage longer journeys and extensive urban development and so give rise to heavy social costs which are included on the debit side. There may also be social objectives such as the reduction of fatigue (e.g. subsidies to elderly persons taking taxis). These considerations indicate a need for better integration of the different factors and a more detailed analysis of the long-term developments, some of which may work "in reverse"; by implication this is an argument in favour of multi-criterion approaches.

C. THE DIFFERENT VALUES OF TIME

For time during working hours, it seems appropriate to adopt a socio-economic approach which makes it possible to evaluate the importance of the journeys undertaken in different cases. In this way, one can make use of the orders of magnitude obtained from traffic surveys: time savings can then be broken down according to wage groups for all trips taking place within a certain area.

However, certain problems arise in relation to "non-wage" occupations and in these cases it is not always easy to evaluate journeys of varying lengths, nor to determine clearly what constitutes "time during working hours".

Research should be more closely directed to behaviour of individuals and firms as regards travelling time saved during working hours. In a number of cases, a series of other considerations (e.g. reading, writing, eating or relaxation during a journey) has a bearing on the issue. It is often not simply a question of saving time, hence the need for more refined approaches in order to see in closer focus what individuals want and what they actually get.

The Round Table dealt at some length with particular aspects arising in connection with the working time of housewives; in this field, there is an undeniable trend towards a large increase in female employment.

The housewife's time can scarcely be treated from purely economic angle since her job is mixed up with other activities of an educational, domestic or more specifically feminine nature. In theory, a distinction can be made between housewives' "work" time and "leisure" time but, in practice, the dividing line is more difficult to trace because the life of a working mother is made up of interlocking activities which do not always fit into a tidy pattern of time and trips.

Some participants accordingly considered that opportunity costs are better suited to the case of the housewife than alternative costs. It was also proposed that total income of the household should be taken as a base because, in an economic context, the household functions as a form of firm.

Again with reference to the general problem of time during working hours, one of the basic distinctions to be made when assessing savings of time is that between savings which benefit the job and other forms of savings. The problem then mainly concerns trips during working hours.

The question was also raised whether "work" time was quite distinct from "leisure" time or whether they were not inter-related to some degree, in particular, by reason of the "recuperation" aspect of leisure time.

Another important question which affects methods of approach is to distinguish persons with a direct interest in a time saving from those who benefit automatically from it; it appears that this distinction can have a considerable influence on decisions. Individual points of view are taken into account for purposes of prediction, so in order to plan future investment correctly, it seems better to take average values.

As a conclusion to its discussions on "work" time and "leisure" time, the Round Table proposes that behaviours from which values can be derived should be studied as well as average wage-related values; the results obtained from these two approaches should to some extent converge.

With reference to perceived times and costs, the Round Table considered various cost elements, more particularly those concerning indirect costs. The latter are often underestimated and, in consequence, time is overvalued.

A well known phenomenon is the new car owner's overwhelming inclination to go by car. This can doubtless be regarded as a transitional stage and it may be assumed that those concerned will subsequently make somewhat more objective appraisals. But the fact remains that car ownership does in itself considerably sway certain judgements: for example, the evaluation of time spent waiting or travelling by bus differs according to whether the person concerned has a car or not, i.e. according to whether or not he is used to waiting.

Given such a systematic bias in the perception of time, it is of some interest to establish a direct relationship between behaviour and the value of time. However, although as a general rule time is perceived somewhat subjectively, some participants considered that the aggregation of individual figures did in the end produce a fairly objective average.

For medium-distance public transport services, signs of a change in the frequencies desired by users are at present taking shape. In some cases this goes no further than trying to make low frequency services fit the times when there is most demand, thus contributing to the growth of traffic peaks. In other cases, services are provided at regular intervals of 60, or even 30 minutes, it being found that travellers are no longer prepared to wait.

Ideally, evaluation should not merely take account of time and cost, but also of a series of factors which require effort or imply uncertainty (e.g. waiting, delay or accessibility), but this type of evaluation plainly involves formidable problems.

As to the question whether perceived values are not unduly blurred by aggregation of data, it was concluded that the need to have instruments that are operational keeps disaggregation within fairly narrow limits; on the other hand, research requirements aiming at increasingly refined measurement incline towards the disaggregation of time values into categories.

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