# BTE Publication Summary

# The Value of Travel Time Savings in Public Sector Evaluation

# **Occasional Paper**

This Paper has been prepared in response to a general concern that value of time in transport analysis, while acknowledged to be important, was not being accorded that importance in practice. At the outset it was hoped that a literature and practice review would enable some useful guidance to be given to practitioners on appropriate values for use in various circumstances. This has not been the case. What has emerged is that there is a wide range of considerations properly governing the valuation of time, and time values will vary widely with context. Existing work allows little confidence to be attached to currently available values or to generalising from prior, case-specific, estimates of values of time. What is now required is a series of rigorous estimates of time values with a view also to determining procedures for generalising and updating as required.







# The Value of Travel Time Savings in Public Sector Evaluation



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### FOREWORD

This paper has been prepared in response to a general concern that value of time in transport analysis, while acknowledged to be important, was not being accorded that importance in practice. At the outset it was hoped that a literature and practice review would enable some useful guidance to be given to practitioners on appropriate values for use in various circumstances. This has not been the case. What has emerged is that there is a wide range of considerations properly governing the valuation of time, and time values will vary widely with context. Existing work allows little confidence to be attached to currently available values or to generalising from prior, case-specific, estimates of values of time. What is now required is a series of rigorous estimates of time values with a view also to determining procedures for generalising and updating as required.

This paper serves as a record of the review leading to these conclusions and is published only as such. While it touches on a wide range of relevant topics it is still not a fully comprehensive treatise on the value of time. It does provide a useful introduction and reference point.

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Bureau of Transport Economics Canberra September 1981

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### **CHAPTER 1—INTRODUCTION**

Time has been explicitly central to analytical studies of transport supply and demand for several decades and probably implicitly so for much longer.

The evolution of transport systems technology over the centuries, and more rapidly over the last decades, has focused on time advantage.

This focus has generally been in the direction of the development of systems which save time but many of which have initially higher costs. The replacement of sail by steam in shipping, the introduction of rail to supersede the horse and wagon through to the development of air transport all follow this trend. A recent example of the use of high speed, high cost technology is supersonic air transport, although in this case the market demonstrated that the time/cost trade-off was insufficiently attractive to justify the total cost involved (see for example Maurice 1980).

Although this underlying trade-off of time for money in transport investment and development has long been recognised, it is really only in the last three decades—and increasingly over the last fifteen years—that the need has emerged for some more precise measurement of the rate at which the trade-off should be made. This has given rise to a whole range of studies on the general theme of the value of time.

Time plays at least three major roles in current analyses of transport:

- travel time as a major determinant of travel demand (including choice);
- travel time as a major measure of the efficiency of transport systems; and
- changes in travel time as principal components of *benefits or losses* resulting from changes in transport supply or demand.

It is the first and the last of these that provide the focus for much of the interest.

Notwithstanding the considerable interest and literature on the subject over several years, transport analysts in practice are still without the benefit of a unified theory or comprehensive yet comprehensible summary of the state of the art. Some countries have solved this problem by adopting a common set of values by convention or edict. This paper has been written to provide some guidance on the subject, covering roles, uses and issues in the value of time in transport demand and economic analysis contexts.

The remainder of the paper is set out in seven further chapters:

- · Chapter 2 outlines the roles of time value in transport analysis and evaluation;
- Chapter 3 outlines some methods which have been used to estimate travel time values;
- Chapter 4 deals with perceptions of travel time and discusses the issue of small time differences;
- Chapter 5 discusses the concept of travel time budgets;
- Chapter 6 considers the effect of taxation on valuation;
- Chapter 7 reports a simple survey of travel time values in practice in Australia;
- Chapter 8 is an overview of some of the considerable literature on travel time values; and
- Chapter 9 gives some general conclusions.

# CHAPTER 2-VALUES OF TIME IN TRANSPORT ANALYSIS AND EVALUATION

Time spent travelling is used as a variable in two broad areas within transport analysis:

- as a supply-side cost variable in the analysis and explanation of transport demand levels and patterns; and
- as a resource cost in the analysis of resource consumption in transport as part of the evaluation of transport changes.

While the economic concepts of supply and demand and of welfare economics provide a unifying framework for both the above roles, the histories of transport analysis and evaluation have not always relied on such a unified framework. In practice, demand analysis methodologies were largely separated from evaluation methods in their earlier development. While in recent years the dichotomy in methodologies has been reduced and almost eliminated, present practices are still dependent on and linked to the history from which they evolved.

On the demand side, many analyses were developed from largely empirical bases and were often founded on mechanical or other analogies (eg Martin et al 1961). In such work, travel time was frequently cast in the role of proxy for some property in the physical analogy—typically 'friction' or 'impedance'. It was not until the late 1960s (eg Wilson et al 1969, McIntosh and Quarmby 1970) that transport demand analysts in the mainstream of practice began to treat travel time explicitly as one component of a 'generalised price' (or cost) of travel, in a context more readily associated with economic concepts of demand and supply.

On the evaluation side, reduction of time spent travelling has long been recognised as a major, desirable objective.

...the capacity criteria must include...speed...It is of little value to know....the capacity..., without knowing the quality of service...(Bureau of Public Roads 1950, pp1-2).

However the translation of that time-saving objective into explicit terms within an overall evaluation framework took several further years to develop. In 1965 there was still considerable uncertainty.

...there is frequently disagreement as to how [time savings] should be valued...(Road Research Laboratory 1965, pp474).

By 1967, British practice at least had firmly adopted the concept of explicit time values in transport evaluation (Ministry of Transport 1967). However, it was not until the late 1960s that value of time in evaluation was linked to value of time as a travel demand determinant (eg Neuberger 1971, McIntosh and Quarmby 1970).

The establishment of this linkage notwithstanding, several major studies neglected it and produced results which were seriously inconsistent. Many demand analysts continued to use only a limited set of 'price' variables in assessing demand levels, patterns and changes. Typically the price determinant of trip destination was taken as travel time alone, while mode choice was taken to be determined by a price which included travel times and fare costs. The choice of route was usually taken to be determined solely by travel time (eg Tressider et al 1968; Freeman, Fox and Associates 1972a, 1972b). Subsequent evaluations of the economic costs of any changes often took account of a different set of cost variables. These were based more heavily on vehicle operating costs, other out of pocket expenses (fares, parking fees) and also but less predominantly—personal time. Such inconsistency in the definition of 'price'

resulted in large errors in assessed values. Travellers, assumed to respond to one set of prices, were subject to evaluation at another, higher set of prices. Benefits of transport improvements were understated (Freeman, Fox and Associates 1972b), although travel time savings were assumed to be one of the major benefits of the transport improvement. Table 2.1 indicates the varying levels of importance attached to time savings in a range of analyses.

TABLE 2.1—TRAVEL TIME SAVINGS EXPRESSED AS A PERCENTAGE OF T	OTAL
BENEFITS FROM TRANSPORT INVESTMENT	

Author	Country	Travel time savings benefits (per cent)
CBR (1969)	Auștralia	29 (working travel time savings)
Roskill (1971)	UK	38 3rd London Airport
Heggie (1972)	UK	80 roads
CBR (1973)	Australia	49 urban roads 20 national highways
Beesley (1973)	UK	80 Victoria Rail Line Study
CBR (1975)	Australia	58 urban roads 44 national highways
Leitch (1977)	UK	80 trunk roads
Heggie (1979)	UK	80 roads
BTE (1979)	Australia	41 rural arterial roads

The actual methodology used for deriving values of time are discussed in Chapter 3.

A further inconsistency in the practices of evaluation and demand analyses is the inclusion of time values in the evaluation of some projects for which the demand levels are taken as insensitive to time savings. This practice was true of the road project evaluation methods used by the former Commonwealth Bureau of Roads (Commonwealth Bureau of Roads 1973). It is also embodied in the standard procedures for trunk road appraisal adopted in the UK (Department of Transport (UK) 1978).

# CHAPTER 3-METHODS USED IN VALUING TRAVEL TIME SAVINGS

Measurement of travel time values has generally relied on one of two broad approaches:

- the marginal productivity of working time; and
- consumer behaviour.

The first of these is most commonly used in valuing travel time savings during working hours. It relies on the thesis that such time savings can be diverted to marginal production, with due allowance for any production during actual travel time.

The second approach has two aspects to it:

- revealed travel preference, in which a choice is exercised between slower, cheaper and faster, more expensive travel options; and
- time allocation among activities eg, the work/leisure trade-off.

In general, analyses of time values relying on the marginal productivity approach have been theoretical. Those relying on revealed preference in consumer behaviour have been empirical, and those on time allocation have been a mixture of empirical and theoretical.

This chapter deals with the methods used in the estimation of time values by each of these methods.

#### MARGINAL PRODUCTIVITY OF WORKING TIME

When valuing working travel time savings, a common practice is to establish a value on the basis of the information obtained from the market mechanism. As there is a market for labour, values of travel time savings during working hours can be related to wages, or earning power.

With few exceptions—Dawson and Everall (1972), DeVany (1971), Gronau (1970a, 1970b), Fullerton and Cooper (1969), useful empirical evidence is absent. The majority of studies are carefully reasoned expository arguments, based on the economic rationale that people will work and employers will hire labour as long as its value to them is greater than its cost. So at the margin, the average wage rate is a useful measure of the value of production lost or gained by changes in the workforce. However imperfections in the economy distort the appropriateness of the wage rate as a base measure. An example of this is minimum-wage and maximum-hours legislation.

Travel time saved by employees in the course of their work can be regarded as a change in productive time, and hence if production remains constant, savings in direct or indirect labour costs will result. Fullerton and Cooper (1969) indicated their unwillingness to accept that, in the figures obtained from their study, there could be any material and quantifiable changes in overheads due to road improvements.

A major criticism of this approach is the difficulty, over time, of separating the unique impact of road improvements from the technological, institutional (eg speed limit) and maintenance trade-off adjustments.

#### CONSUMER BEHAVIOUR APPROACH

The consumer behaviour approach is centred basically on *non-working time savings*. This refers to time outside of working hours and includes all journeys for which no payment is received from an employer. In evaluating these time savings one encounters formidable problems. Investigations of these values attempt to infer a value of time by examining the trip makers' behaviour in situations where a choice between money and time exists. Given the fact that the value of travel time savings partly arises out of the disutility generally attached to travelling, it means that travel time cannot be viewed independently of other trip making is presumably related to the physical and mental effort expended in performing the activity of travelling. It is difficult to separate time spent in travelling from the comfort experienced in travelling, as they are by nature joint attributes.

The earliest efforts in evaluating travel time savings during non-working hours have sought answers in consumer-choice theory. This theory was basically designed to explain an individual's preferences among 'alternative baskets of goods'.

#### Revealed behaviour approach

Most investigations of the value of travel time savings have been based on the revealed behaviour of trip makers when faced with alternative situations. Such investigations usually comprise estimation of the trade-off between the time and money cost dimensions of travel 'packages'. A travel package is defined by such dimensions as total travel time, in-vehicle time, walking and waiting required, comfort, safety, and the cost of travel. Alternative routes, or alternative modes to a given destination or alternative destinations represent different travel packages involving different combinations of trip attributes.

#### Time allocation among activities

The more recent developments in economic theory in relation to time have been mainly concerned with its allocation and value. Early attempts to derive values of time were purely theoretical. The theories were basically designed to explain preferences among 'alternative baskets of goods'. Johnson (1966) and Oort (1969) utilised this theory to determine the combination of leisure, work and travel that maximises satisfaction. At equilibrium the theory states that the individual will divide his time between work and leisure so that the rate of substitution between income and leisure will equal the wage rate. A criticism which may be applied to this work is that its conclusions will hold only if there are no standard hours of work or a standard week.

Bruzelius (1978) extended the work of DeSerpa (1973) in this area and argued that consumer demand theory must be reformulated to consider the time dimension of consumption. In DeSerpa's model, an individual's utility is viewed to be a function of the quantities of goods he consumes and the amount of time he allocates to labour, leisure and consumption of each good. The individual is viewed as maximising his utility subject to a money budget constraint, a time budget constraint and a constraint on the minimum amount of time required to consume a unit of each good. Bruzelius demonstrates how other time allocation models based on economic theory are special cases of DeSerpa's model. In the context of his proposed time allocation model, Bruzelius proceeds to discuss how the value of time savings can be defined in terms of the consumer surplus concepts of compensating and equivalent variations. He then demonstrates how these surpluses can be measured from individual and aggregate demand functions. Bruzelius pays attention to the very restrictive conditions which are required to formulate consumer travel demand in terms of constant marginal values of time. Bruzelius concludes that given the limitations of available data and existing econometric techniques, the only feasible approach to obtaining measures of the value of travel time savings is to assume that every individual in a population has the same value of time, and each marginal unit of travel time saved, the same value.

More general theories on the valuation and allocation of time have been developed from the earlier attempts of Johnson (1966) and Oort (1969). In particular, Gronau (1970) and Evans (1972) integrated time used in an individual's activity explicitly into the discussion. In effect, it was argued that individuals and households could be regarded as producers of activities which combine time with goods and services purchased in the market. The utility function in this approach was generalised so that work, leisure and consumption were defined as the activities. As such, they were more consistent with the approaches taken in the empirical studies designed to evaluate time saved in a particular activity, such as travel.

#### METHODS OF EVALUATION

Most approaches to time valuation have been through revealed preferences, where an implied value of time was a by-product of some descriptive or explanatory mathematical model of travel choice. These values were generally implied by the ratio of estimated coefficients in a linear function. Typically these coefficients were estimated with quite large standard errors (albeit that the coefficients were generally significantly different from zero). The standard error of the ratio of such coefficients is only rarely presented in such work, and is typically very large indeed. Any imprecision of individual coefficient estimates yielded by conventional econometric analyses is compounded by the subsequent calculation of coefficient ratios. Consequently the values of time estimated by these revealed preference approaches to real travel choices must be subject to wide confidence intervals.

The types of models developed for these techniques are stochastic and disaggregate. They are stochastic in that the predictions obtained from them are probabilities that individuals will make a specific travel choice. The probabilities are assigned on the basis of the characteristics of the choice environment as perceived and evaluated by the individuals. They are disaggregate in that the basis of the models is the individual trip maker rather than zonal aggregates. The basic hypothesis underlying these models is that decisions are based on the relevant attributes of the available alternatives, evaluated in terms of the trip maker's preference functions. These decisions enable an estimation of the rate of trade-off among various transportation system attributes. More specifically, if measures of both time and cost of alternative transport decisions are included in the model, the rate of substitution of money for travel time can, at least in principle, be determined and interpreted as a value of time.

However there is little agreement on the proper interpretation of parameter estimates obtained in the mathematical models that are used to describe the values of time savings in these cases. Some claim that these parameter estimates represent *marginal* values of time and others that they are *average* values of time (Stopher 1976). Some criticise them because they represent what has been called 'the price of time' (Gronau 1976) rather than the value of time, and still others have doubts about these estimates since they may not be 'pure' (Dalvi and Daly 1976) or 'true' values (Goodwin 1976) or may only represent 'curve fitting parameters' (Mitchell and Clark 1972). Some of this criticism can be interpreted as questioning the validity of these estimates, that is asking whether they really measure what we want to measure. One consequence of this is that although a considerable body of empirical knowledge is available today, there is a great deal of doubt as to the meaning of this knowledge and its relevance to cost benefit analysis (Rogers 1976).

The first step usually taken in developing travel choice models is to determine a mathematical function that represents the basic hypotheses and assumptions underlying the models. Work in this field has utilised discriminant, probit and logit analyses.

#### **Discriminant analysis**

Discriminant analysis (see Beesley 1965, Quarmby 1967) was among the earliest techniques used in developing a behavioural model in this context. It was used to determine a function of user and transport characteristics that best discriminated between sub-populations of trip makers on the basis of the transport 'package' they used. The choices analysed were binary choices, that is the choice involved only two alternative packages. Thus the problem was that of determining a set of discriminant functions  $D_{ij}$  (where  $D_{ij}$  is the discriminate function between travel package i and j) that minimised misclassification by the model, in terms of choice of transport package.

The discriminant function used in transport demand modelling comprises the attributes of the alternative transport packages and the characteristics of the trip makers. The discriminant function in general terms can be expressed as:

$$Z_{ij} = \sum_{k=1}^{n} \alpha_k(f(X_{ki}, X_{kj})) + \sum_{l=1}^{m} \beta_l U_l$$

The solution to this problem will be approached from two standpoints:

- that of minimising misclassification with respect to some predetermined threshold; or
- seeking to find conditions in which the separation between the two populations is greatest in relation to the variation within each population.

The ratio of the weighting coefficient of the time attributes in the travel package to that of cost, indicates the value of time.

Examples of the uses to which discriminant analysis have been put are:

- the willingness-to-pay approach, where a trade-off between a fast toll road and a slower, free, all-purpose road may be observed (Lee & Dalvi 1969, 1971; Thomas 1967; Thomas & Thompson 1970, 1971; Beesley 1974); and
- the choice of speed at which to drive approach, where a trade-off between time spent in travel and the higher costs of faster travel may be observed (Mohring 1965).

Much criticism has been levelled at discriminant analysis as an effective mechanism for explaining modal choice, and hence the value of time (De Donnea 1972, Watson 1972, Hensher 1973). A main criticism relates to the assumption of knowledge of a priori probabilities, where variation in spatio-temporal stability make interpretation of such probabilities difficult. The more refined statistical techniques of probit and logit analyses have subsequently been utilised.

#### Probit analysis

The basis of this approach is that if members of a population are subjected to a stimulus that can range over an infinite scale, the frequency of responses will be normally distributed.

Lisco (1967) and Lave (1968, 1970) have applied this technique in analysis of modal choice. The attributes of the alternative modes in a binary situation and the characteristics of the trip makers are assumed to be stimuli, and the choices made are

the responses. The calibrating technique involves fitting a cumulative normal sigmoid curve to the information on responses and stimulus values for each member of the sample. The probit equation used by these authors was in the following form:

$$Y = \sum_{k=1}^{m} (\alpha_k (X_{1k} - X_{2k})) + \sum_{l=1}^{n} (\beta_l (U_l))$$

where  $X_{1k}$  and  $X_{2k}$ <sup>=</sup> the values of the kth attribute of modes 1 and 2 respectively user attributes U,= = value of the probit Y

The value of the probit represents the number of standard deviations away from the mean of a normal distribution, and the ratio of the coefficient of travel time to that of cost gives the implied value of time.

#### Logit analysis

The basic principle underlying this mathematical technique is that the probability of the occurrence of an event or choice varies with respect to a function G(X) as a symmetrical sigmoid curve, which is labelled the 'logistic curve'. Mathematically the model is expressed as:

$$\mathsf{P}_1 = \frac{\mathsf{e}^{\mathsf{G}(\mathsf{X})}}{1 + \mathsf{e}^{\mathsf{G}(\mathsf{X})}}$$

In transport demand analysis this model is used by defining the choice made by an individual trip maker as an event. In a binary choice situation P, refers, for example, to the probability of trip makers choosing mode 1 in preference to the other. The function G(X) can be expressed in a number of different ways. The model developed by Stopher (1976) was based on the G(X) function expressed in terms of the differences in travel times and travel costs:

 $G(X) = \alpha_1(C_1 - C_2) + \alpha_2(t_1 - t_2) + \alpha_3$ 

Stopher demonstrated that logit analysis is simpler and guicker to calibrate than probit analysis and appears to yield estimates of similar accuracy.

#### **Regression analysis**

Regression analysis is a generally used statistical tool where the relationship between a dependent variable and a set of independent or predictor variables are determined. In transport analysis the problem is usually a choice between different modes of transport (eg private and public transport). In these cases, the dependent variable will be assigned one of two values:

- Y<sub>1</sub> = 1, if the ith person chooses the train; or
- Y<sub>i</sub> = 0, if the ith person chooses the car.

The simplest formulation utilises the linear probability function and computes leastsquares estimates of the co-efficients of the model:

$$Y = X_{\beta} + \epsilon$$

There are many examples of regression analysis in transport planning (see Merlín & Barbier 1962, Stopher 1966, Gronau 1970 and Mansfield 1968), with a number of weaknesses in the abovementioned models. It has been found that errors in the data and particularly time and cost data, will greatly affect the value of time obtained. The implications of such errors in the value of time studies have been examined by Watson (1971, 1974) and De Donnea (1971). Watson found that it was often impossible to determine the direction of bias in the values of time that are caused by errors in the data. He concluded that there is no single correct value of time, as the definition of 'correct' depends on the context within which the model is built.

#### Social and community planning research

Using simulation, Hoinville and Berthoud (1970) developed a model to look at the reconciliation of conflicting preferences and, the identification of relative priorities. Pictorial opportunities were given to each participant to choose between three possible states for each of five factors (journey time, walking distance, journey cost, frequency, comfort and the number of changes required). The implied 'values' at which people are prepared to trade-off between one factor and another may be obtained by relating the expected choices (given a random distribution of the budget which would occur if asserted prices were the trade-off prices) and the actual choices made. The latter choices are measured by the individual allocating points (out of a budget which represents the individuals constrained resources) to those pictures depicting his present modal situation with respect to the five factors.

Hensher (1976a) points out though, that the analytical and data collecting procedures are complex and costly to implement. Another of his criticisms is that the respondents were not forced to consume their chosen travel situation, as they were in real life choices. This might then distort the results towards an idealised picture which might not be translated into practice if the opportunity arose (Mansfield 1970). In commuting, marginal time savings were found to be relatively unimportant in comparison with convenience, reliability and overcrowding. The weights attached to the variables varied between modes, making investment priorities mode specific. An implication of this is that the value attached to an improvement in travel would vary according to the mode involved.

A similar study was initiated by the Director General of Transport WA (1976) where a 'Priority Evaluator' was used to analyse public transport journey attributes. The concept is similar to that of Hoinville and Berthoud's and respondents were confronted with the problem of being able to spend a limited amount only for transport improvements. As a result they had to trade-off among various choices. The journey attributes that were evaluated were:

- in-vehicle travel time;
- the possibility of a seat;
- length of walk to bus stop or railway station;
- type of bus or train;
- cost of ticket;
- waiting time at bus stop or railway station; and
- number of transfers.

The results were similar to that of Hoinville and Berthoud's in that the 'Priority Evaluator' indicated that commuters appear to be less concerned with travel time reductions and instead place more emphasis on other travel attributes relating directly to comfort and convenience.

#### CONCLUSION

The foregoing discussion indicates that the use of mathematical models to describe and summarise complex patterns of travel behaviour assists in the identification of the relative weights to attach to those factors which determine that behaviour. But a model which can reproduce existing behaviour patterns will not necessarily provide an understanding of unfulfilled individual consumer preferences. Moreover, these convenient mathematical summaries can only go a certain way towards representing the full complexities of choice. It is much easier to describe the aggregate behaviour of the community with these models than it is to explain the individual preferences which contribute to that behaviour.

## CHAPTER 4—CONSIDERATIONS IN TIME SAVINGS VALUATION

Apart from measurement issues dealt with in Chapter 3, there are a range of other considerations affecting the valuation of travel time savings. Of these, the concept of travel time budgets (the notion that individuals behave as though a fixed proportion of their time each day or week were to be allocated to travel) is dealt with separately in Chapter 5. This chapter deals with the principal remaining considerations:

- the perception of time savings;
- the value of small time savings;
- reliability and time savings;
- stability of values over time;
- effect of income and location;
- opportunity cost of time savings; and
- equity considerations in value of time.

These issues are dealt with separately, although several of them have overlapping considerations, both among themselves and with issues raised in Chapter 3. These overlaps are also dealt with in the following sections.

#### THE PERCEPTION OF VALUES OF TIME

Factors such as convenience, flexibility and context may affect the perception of time. Fouvy (1974) suggested that perceived values of five minutes of walking, waiting and in-vehicle time may all be different. Walking and waiting times may have greater perceived time costs than in-vehicle time.

Horowitz (1978) found that the environmental conditions of a trip may have significant effects upon the trips perceived time ratings. This work was based on a psychological scaling method, where from an interview situation respondents subjectively valued time spent in travel. The greatest influences were weather conditions on walk trips, traffic congestion on car trips and seat assurance on bus trips. One result highlighted the variability of perceived values of time where it was found that time spent in a car trip to work in heavy congestion was rated three times greater than the same time length of trip in moderate traffic. The greatest difficulty seems to occur when people try to value the times for different activities in money terms or anything else but time itself. They are not able to match their irritation with a corresponding payment for a provided service.

Time savings are not necessarily perceived in a linear manner, but may be subject to thresholds related to the size of the saving and to the occasion in which it occurs. In this way, the function may not be wholly continuous but contain discrete time periods, eg one day. In another interview situation, Heggie (1976) found that for business travel a step seems to occur after a journey time of five hours. This is probably related to the ability to complete a return journey in one day.

The foregoing discussion may be summarised as follows: perceived values of time are dependent on the purpose and condition of the journey. Time is not viewed independently of what one endures and consciousness of time becomes apparent usually when there is disutility associated with it. As a result, it tends to be overestimated. Therefore, perceived values of time may be unreliable because they can vary greatly from situation to situation.

#### The effect of cost on perceived time

Perceived values of time can hinge on perceived costs. Perception of travel costs seem to be related to both the purpose and mode of a journey and include experiences of discomfort and expenditure of time and money. Figure 4.1 shows a relationship between distance travelled and the perceived time of journeys for car travellers. Car trips were the hardest to evaluate (Heggie 1979) because car users obtain a smaller amount of savings in time in return for extra costs incurred (Hensher 1977b). This may then lead to an overestimation of the value of travel time savings.



Percieved time (minutes)

Source: Hensher (1977)



This overestimation of values is revised when frequent journeys are made (as in the journey to work) but it is postulated (Hensher 1977b) that this does not outweigh the disutility effect associated with a journey (which may raise the values placed on time saved).

Generally, in repetitive trip making, evaluation of routes and modes lead to a ranking of choices by commuters and a resultant 'preferred' route. Because the individual is familiar with his mode of travel, this enables him to deduce fairly accurately the costs involved. Often the commuter will not be familiar with the alternative modes available or aware of the changes occurring within a system. Travel habits for repetitive trips may thus be hard to change. Changes must therefore be *brought* to the notice of the trip makers. This perception gap, according to Hensher and Hotchkiss (1971a), can be related to the 'habit period'.

In the 'habit period' individuals view travel time savings and other aspects of travel in isolation. That is, in a perceptual space independent of any changes occurring. Therefore, the state of the mode is important. If it is changing then the perceived state of alternatives in relation to the preferred mode become relevant. When the cost of the usual mode is perceived to be greater than an acceptable maximum, then the traveller looks for alternatives that vaguely meet his defined criteria. However, if the cost of the alternative mode is perceived as being greater than the preferred mode, the individual will switch back. Non-repetitive trips however, tend to be made in an 'ad hoc' manner using the most convenient mode available and travellers are less likely to accurately perceive and assess the costs involved. Hensher (1977b) found that except for the distances of one and forty-four miles, commuters' perceived evaluation of the costs involved were less than manufactured cost estimates.

What is perceived as 'costly' by an individual may also be related to the individuals income and their own perceived status. The value placed by the user on each 'cost' can be correlated to a number of 'user characteristics', such as occupation, income, age, sex and number of persons in the household earning a living. The frequency with which a journey is made may also be expected to affect one's attitude towards the amount spent upon the journey. This difference in attitude stems from the combination of the effects upon one's discretionary income (resulting from price/journey x frequency of journey) and habit.

Linder (1970) claimed that for an individual the costs of obtaining information on modal alternatives may increase more rapidly than the advantages when their income rises. This is because the number of alternatives available increase as well as the number of needed decisions. An implication of this is that as income rises, one's perceptions of items that are of immediate interest to the individual will become less related to actuality.

#### Evaluation

Lisco (1976) has suggested that in any economic analysis the relevant factor is how much one spends on a good. It does not matter how much he thinks he is spending. If basic prediction and cost/benefit questions are at issue for particular transport options, the analysis should be based on people's actual market behaviour and the data should describe the situation objectively and accurately. Searle and Clark (1976) point out though that value of time studies seek a causal explanation of behaviour without regard to its suitability for predictive purposes. Perhaps, as Lisco points out, transport analysts should use only the 'real' cost involved, because consumers are apt to misperceive and overestimate different facets of the costs associated with valuing time. However, comparative studies of real and perceived values of time may help to determine the 'time equivalence' of some aspects of attractiveness. These comparative studies may be of paramount importance to help establish a clear understanding of the relationship between the real value of time and cost and those perceived by the consumer.

While it is relatively easy to indicate the benefits of those transport improvements which result in higher speeds and levels of service (not only reductions in travel times, but the extension of travel horizons and increased convenience) calculations of their money values as benefits is considerably more complex.

#### Committed and uncommitted time

It is feasible to construct a classification of types of time within the 'typical' 24-hour period which encompasses most peoples' routine activities. Richardson (1978) suggested that time can be regarded as being of one of two types:

- committed time, devoted to essential activities (sleeping, eating, working etc); and
- *uncommitted time*, devoted to discretionary activities (recreation, travel, personal business, shopping, etc).

Uncommitted time, can be further subdivided into two categories:

- travel time; and
- non-work (or discretionary) activity time.

The boundaries between these time classes are not rigid. In particular, depending on the time horizon considered, committed and uncommitted time can be exchanged. For instance, in the short run, time 'committed' for sleep can be foregone to pursue other activities. In the longer term time committed to work can be varied by seeking employment for a greater or lesser number of hours per week. Nonetheless this taxonomy of times provides a useful conceptual framework in this context.

Because total discretionary time equals non-work activity time plus travel time, the utility of recreation time will be at a maximum when travel time is zero and zero when all discretionary time is spent travelling. This is displayed diagramatically in Figure 4.2. (The exception to this is where travel itself is a form of recreation.)



Figure 4.2. Recreation time utility function

Richardson assumes that:

- the value of time in trade (ie 'pure' value of travel time) is considered and not the value of time in use (ie 'situational' value of travel time where, for example, utility might be derived from travel); and
- that the distribution of recreational activities is uniform spatially and that no increase in the utility of recreation time would occur by travelling further to increase the quality of the recreation activity.

Obviously these two assumptions are violated in practice, and Figure 4.2 can be redrawn to include the realisation that increasing travel time usually does not bring increasing utility, rather decreasing utility (Figure 4.3).



Source: Richardson (1978)

Figure 4.3. Travel time disutility function

From the figures it may be shown that the disutility of travel time depends not only on the amount of travel time involved, but also on the total discretionary time available. Thus a certain amount of travel time will have greater disutility if the amount of discretionary time available is smaller. Also, the marginal value of travel time increases as the total amount of time spent travelling approaches the total available discretionary time. That is, saving time becomes more important as one nears the limit of the amount of available time, for example as one becomes late for an appointment.

As Heggie (1976), Richardson (1978) and others have pointed out, the proportion of discretionary time available to spend on travel varies among individuals, and depends upon such things as status, income, occupation and stage in the life cycle (see also Chapter 8). A change in any of these factors changes the amount of discretionary time available to spend in travel. This will in turn affect the value, both average and marginal, of that time.

Changes in the value of time may thus occur because of changes in either transport or non-transport factors. The direction of the change in travel time will affect the level of disutility associated with it. Some changes will reduce the amount of travel time and will lead to a time and utility gain for individuals. However, a time loss will increase the amount of travel time and disutility for some other individuals. Generally, as time lost reduces discretionary time, time losers will value their loss more highly than time gainers.

#### Perception of time changes

Psychological studies (eg Horowitz 1977, Thomas and Thompson 1971) have clearly shown that people do not necessarily fully perceive small changes. It follows that people may not perceive small changes in time spent travelling. The proportion of a population perceiving a time change will increase as the size of the saving increases and then increase at a decreasing rate as the proportion approaches unity (see Figure 4.4).

Thomas and Thompson (1971) found in their empirical work that the nature of their data precluded statistical estimates of a value for 0-5 minutes range. For time saved of less than five minutes and greater than zero minutes there were very few reported data points because of the tendency to report in multiples of five minutes. Their data also had problems in this range because a small perceptual error could turn real positive time savings into perceived time losses. They concluded, therefore, that it was difficult to focus an empirical analysis on small amounts of time saved.

While those who do perceive a small change will probably value it (Richardson 1978), most people will not perceive the change and hence will not be able to assign any value to it. The value of the change to them will be zero. The average perceived value of a small time change over the entire population will thus be very low. Richardson (1978) suggested that the perceived value of any change could be assessed by:

 $PDU = \%P \times (DU_2 - DU_1)$ 

where: PDU = perceived disutility of travel time change

%P = per cent perception of change

DU<sub>1</sub> = disutility of original travel time

 $DU_2$  = disutility of new travel time.

#### SMALL TRAVEL TIME SAVINGS

Savings in travel time are generally non-accumulative, at least when treated case by case in the short run. Time saved in small units, unlike money, cannot be easily transferred from activity *i* to anything other than activity *i*+1 (Richardson 1978, Sharp 1973, Heggie 1976). This is particularly so, when in many instances constraints require



Source: Richardson (1978)

Figure 4.4. Perception of travel time changes

certain activities (eg work and shopping) to take place in certain hours. Similarly, time saved by one individual cannot generally be transferred to another individual's use.

Although small time savings cannot be easily transferred to alternative uses, larger ones may be (Heggie 1976 and 1979, Fouvy 1974, Evans 1972, Sharp 1973). Larger time savings do not always have to merge with time spent on adjacent activities, and may often permit the re-scheduling of a sequence of activities to obtain a more optimal distribution. This enables time saved to be transferred to activities with high values. Thus the size of a time saving may determine the extent to which an individual may use that saving for alternative uses.

#### Valuing small time savings

Some authors, eg Tipping (1968), and Heggie (1979), have contended that small time savings should have zero value allotted to them. Despite a low level of perception of small travel time savings, many authors (Zachary 1975; Thomas and Thompson 1971; Earp, Hall and McDonald 1976; Hensher 1976a and Leitch 1977) have suggested that travellers implicitly pay to save small amounts of time, and consequently small travel time savings must be examined and valued. Sharp (1973) and Hooper and Rimmer (1978) argue that even if time can only be used in individual 'lumps', then some travellers must have unusable 'surpluses' of time (eg the office worker who arrives early). Each small time saving may convert some of these surpluses into usable segments of time. As a result, the small saving may still have an effective value in excess of 'first order' values.

However, the Commission on the Third London Airport (Roskill 1971) found that in practice, the effect of ignoring small time differences in their evaluations was small. For example, the exclusion of time differences of less than five minutes reduced the net benefits of inland airport sites in comparison with the Foulness site by less than 1 per cent. The exclusion of time differences of less than ten minutes reduced these benefits by a maximum of 2.5 per cent.

The Leitch Report (1977) on trunk road assessment in the UK pointed out that interurban roads are generally improved on a piecemeal basis and that the time saving gained on a typical journey comprises an aggregate of small piecemeal savings. It would then be inconsistent to value the overall time saving differently from its component parts. This is a powerful argument, and if rejected could lead to a major shift in thinking on the economics of stage construction as the net benefits from a total project could be less than those from the same project developed in stages, with small time savings being ignored at each stage.

If however, the practice of attributing the same unit value to all time savings is incorrect, the rates of return from urban road investment (where small time savings may be enjoyed by a large number of travellers) could be overestimated when compared with the returns from interurban road investment where traffic flows may be lower but individual time savings greater because of the greater journey length.

In a number of standard operational evaluation procedures, the methods of calculation do not permit the separation of small time savings per traveller. This happens where such procedures analyse a system as an aggregate of network links. Total travel times in the original and modified systems are calculated by multiplying link usage volumes by link travel times and then aggregating over the systems (eg see the CoBA system, Department of Transport (UK) 1978). In such analyses the distribution of travel time savings is not known, so small savings cannot be separated. The travel time saved on any specific journey is the sum of travel times saved on the links used. In such analyses this is generally not known. It is only in complete origin-destination based methods of analysis (eg McIntosh and Quarmby 1970) that such exclusions and small differences can be made.

The evaluation methods for roads developed by the former Commonwealth Bureau of Roads (Commonwealth Bureau of Roads 1969) and those adopted for non urban roads by most State Road Authorities (eg NSW Department of Main Roads 1981) are among the methods which prevent exclusion or separate treatment of small time savings.

#### Valuing small savings in different activities

Daly and Zachary (1975), Evans (1972) and Roskill (1971) argue that one pays not so much to save time *per se* as to save time *in a particular activity* and therefore the valuation of the differences in time spent in different activities is not a meaningful concept. They suggest that to look at small savings seriously, one must look at the small time differences between travel choices for each separate activity involved.

#### Summary

In general, travellers may only be aware of larger time savings; many savings will be too small to be used for economic activity. Such savings may still have considerable value though if the disutility of some 'unpleasant' form of travel is reduced.

The critical feature then of small travel time savings theory is that small time changes are not necessarily fully perceived. As a result, the perceived value of small time changes is less than would be predicted by a linear utility function. The inclusion of small travel time savings in evaluations (say, less than five minutes) could then lead to erroneous results and an overestimation of the benefits or losses to existing demand.

There is also the issue of the effect of small time savings on the *demand* for transport. Where time savings are so small as to be generally unperceived, then demand will be unaffected. However the range of perceptions and responses apparently leads to a continuous demand curve. While small changes may not be consciously perceived on an individual basis, in aggregate they may lead to small behaviour changes implying a benefit.

#### RELIABILITY AND MODE CHOICE

Transport system characteristics, and in particular reliability, are critical features in the allocation of time to trips and in the disutility associated with travel. The journey to work highlights this where a particular time of arrival is usually desired by the commuter.

Reliability is made up of two elements. One is a *schedule* delay and is a function of service frequency. This is where a desired time of arrival is different from the actual time of arrival because a service is not scheduled to arrive at the 'target' time. The second element arises from the lack of predictability of journey times and leads to such expressions as 'unpunctual' and 'unreliable'. Whereas schedule delay is basically a matter concerning public transport, *unpredictability* affects both private and public transport alike. Reliability in public transport is particularly important when one or more changes of mode must be made in order to complete the journey. To encompass these two aspects of reliability, the term 'idle-time' has been coined (Starkie 1971).

Commuters will tend to budget their time so that schedule delays and unpredictability of journey times may be allowed for. In a majority of journeys, the commuter may arrive before the desired time and thus associated travel costs are higher (Thomson 1968 and Smeed 1968).

While journeys to work (and other activities which have fixed arrival time) will have reliability constraints, other journeys (eg from work) will not be subject to such considerations, or at least not to the same degree.

Where public transport shares the same track as private transport, Starkie (1971) pointed out that idle-time would be greater for public transport, as it is not only subject to the same conditions of uncertainty as private transport, but has the added element of schedule delay. Since schedule delay is a direct function of service frequency, it will vary according to circumstances.

One of the principal benefits of improving transport networks is nominally a decrease in travel time. However the disutility of this time could probably be changed without changing the average travel time, simply by changing the variability of travel time. This concept is illustrated in Figure 4.5.



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Figure 4.5 illustrates three stages in an 'improvement' of a travel situation:

- (i) the original case where mean travel time is 35 minutes with a standard deviation of 5 minutes;
- (ii) an 'improved average' case where the mean travel time has been reduced to 30 minutes, but the standard deviation has increased to 7.5 minutes;
- (iii) an improved performance case where the mean travel time is held at 30 minutes and the standard deviation has decreased to 2.5 minutes.

An improvement in the urban network may reduce travel time but not necessarily increase reliability. In the change from case (i) to case (ii) the average trip saving would be 5.0 minutes. However for a traveller committed to arriving on time (or earlier) on at least 95 per cent of occasions, the saving is less. In case (i) the appropriate (95th per centile) travel time is 35+1.96x5=44.80 minutes. In case (ii) the corresponding time is 30+1.96x7.5=44.70. The saving is a mere 0.10 minute (and in terms of the earlier discussion of small savings is certainly insignificant). In case (iii) there is no average improvement over case (ii) and 5.0 minutes over case (i). However the reduced variance in travel times allow the scheduled (95th per centile) time to be 30+1.96x2.5=34.90. This is a saving of almost 10 minutes over both cases (i) and (ii).

It is likely then that reliability as well as the mean of travel time will affect the disutility associated with travel.

#### THE STABILITY OF VALUES OVER TIME

As wage and salary levels increase in real terms as economic growth occurs, it can be assumed that values of time will also increase. This has generally been the most commonly held view (eg Heggie 1972, Roskill 1971 and Fouvy 1974).

Although this assumption has been made by many investigators, very little supporting evidence is available. Mansfield and Wade (1974) partially confirmed the assumption in an analysis of male commuters into Central London, where they found that between 1951 and 1961 the importance of time in relation to the costs of travel had grown.

Phillips (1969) suggested though that changes in the wage rate can yield useful pointers to changes in the value of travel time savings. Phillips says that on certain (unstated) reasonable assumptions, changes in the value of time will increase faster than the wage rate (but this is a conclusion that cannot be proven).

Beesley (1977) discussed the question of how time savings change over time in relation to leisure time values, and concluded that one could not adopt a value of time strongly increasing in line with GDP while other measures of real income change. As a result he suggested that a stable value for leisure time be adopted.

Surveys and analyses of the values of travel times have typically been based on individual cross-sectional analyses and not repeated over time. Nonetheless, the conclusions derived from such analyses are generally assumed to apply to the future as well as the past. The attention that has been given to the problem of 'improving' cross-sectional estimates has not been accompanied by concommitant attention to analyses of changes in the value of travel time savings over time. As repeated cross-sections of behaviour become available from transport studies, some attention could perhaps be given to investigating and explaining shifts in the implied values of time and their relationship to changes in income.

Some transport analysts have assumed, at least implicitly, that savings in travel time attributable to road improvements are transferred to the next activity (ie travel time saved on a journey to a recreational destination is typically credited to the recreational activity). However temporal analyses have shown, particularly in the case of commuting, that an increase in travel speed may not necessarily save travel time; in the short run the available saving may be traded-off for a combination of more non-work trips and/or longer trips, while in the long run it may mostly be traded-off for shifts in location (see Zahavi 1976).

#### THE EFFECT OF INCOME AND LOCATION

Hotchkiss and Hensher (1971b) suggested that there are two pre-determined constraints on the value of travel time savings. These are distance (a willingness constrained variable) and income (an ability constrained variable).

Thomas and Thompson (1971) have suggested that the effects of geographic region (urban v rural and north v south) appear to be accounted for by variations that appear in income levels for each region.

One problem associated with income and individual specific time values is how to include non-income earning sectors of the community (such as housewives and children) into explanations of travel behaviour. A way in which this problem may be overcome would be to treat households as a decision unit in travel time equations, rather than to use individual specific values.

#### THE OPPORTUNITY COST OF TRAVEL TIME SAVINGS

When extra units of time are acquired through savings in travel time, the value of each additional unit of time will depend, at least in part, on the use to which these savings may be put. The opportunity cost of time lost is the benefit foregone by not being able to utilise it in the next best use. This cost will differ among persons and for the same person in different circumstances. For example a five minute saving on the journey to work generally provides a more limited range of substitute activities than a five minute saving on the journey from work. Opportunity cost will also vary with the size of the saving.

Road improvements may particularly benefit goods movement, especially for owner drivers. Tipping (1968) suggested that for truck drivers more journeys or longer, different journeys may be undertaken. Thus there is a possibility of extra mileage and hence revenue for the additional unit of time.

Similarly, Hooper and Rimmer (1978) have pointed out that road improvements may benefit goods movement by affecting the operating efficiency of labour and commercial vehicles and by improving the quality of the transport service itself. The latter benefit component is instanced when goods are delivered at the point of demand sooner than they would have been prior to the change. In some instances this may add value to the delivered good. Another example would be where the variability of the journey times is reduced and delivery times can be more reliable or consistent, although Pelensky (1972) considered this cost saving to be negligible.

Hooper and Rimmer (1978) suggest that it is always assumed that it is possible to determine whether or not time savings take effect during working hours. This is not always the case. Vehicles classified as being 'commercial', might also be used for private purposes and it then becomes important to distinguish between these purposes. This is especially so in the case of the owner driver where hours of operation are largely self determined, and a time saving may be realised at any stage of the day and used appropriately.

#### EQUITY CONSIDERATIONS IN THE VALUE OF TIME SAVINGS

Searle and Clark (1976) suggest that the value of time is likely to vary among socioeconomic groups of the community. In particular, the value of time seems to be positively correlated with travellers' incomes. The use of income related values of time could lead to inequitable results. An extreme but possible result, they suggest, might be the creation of exclusive express lanes on a highway for high income travellers. One way around such problems is to define an 'equity' value of time that reflects the average value of time for all travellers, which takes into account the variations occurring among the different socio-economic groups.

# CHAPTER 5-TRAVEL TIME BUDGETS

#### THE CONCEPT OF TRAVEL TIME BUDGETS

In recent work (Wigan and Morris 1979: Earp, Hall and McDonald 1976; Goodwin 1976; Searle and Clarke 1976; and Zahavi 1973, 1976) it has been suggested that individuals exhibit 'travel time budgets' for travel in urban areas. Usually this is taken to mean that a certain fixed amount of time each day is devoted to travel.

A travel time budget is not a *consciously* allocated amount of time set aside for travel. Rather it may be considered as an acceptable cumulative allocation of time—whether by trip purpose or in total—which when consistently exceeded or not reached, would be noticed by the traveller and result in travel practice changes to vary it.

Few authors have indicated whether this travel time 'budget' applies over the whole day, or only to repetitive trips such as commuter trips. For example, Goodwin (1976) and Earp, Hall and McDonald (1976) merely suggested that travel time budgets exist. Fouvy (1975) was more specific and suggested that the budget was between one and two hours of travel per day. Zahavi (1976) measured budgets of between 1.09 and 1.13 hours and indicated that these were stable over time (these values were derived from a number of household interviews for various cities).

Although Zahavi established travel time budget values from analysis of household interviews, most other authors have generally *inferred* the presence of travel time budgets by linking urban sprawl with the decreasing average work trip time—a result of improved travel networks. The development of higher speed networks leads to average work trip time decreasing and this is then traded-off against increased average work trip distance. Spatial separation of home and workplace increases, while time separation remains relatively constant (see for example Vorhees et al 1970, Ogden 1970). In this way a commuter optimises the costs of a housing location decision (Alonso 1964).

#### FACTORS INFLUENCING TRAVEL TIME BUDGETS

#### Travel budget and public transport

Zahavi found that public transport users had a greater variation in their travel time budgets than did private transport users.

As commercial speeds of buses are generally 40 to 60 per cent of car speeds on the same network, if bus users wish to have the same travel time budget as private transport users, they need to economise on other travel components. This is done by reducing trip rates, or trip lengths, or both. If, however, trip rates had already been reduced to a minimum, the trip maker would be forced to increase his travel time budget or use an alternative mode of transport (Zahavi 1976).

#### Travel time budgets and income

Work by Goodwin (1974), Zahavi (1976) and Mitchell and Town (1976), has shown that travel time budgets are relatively stable and vary only slightly with income. The reverse is true for travel cost budgets which vary greatly with income. As Zahavi points out, this is to be expected, since all trip makers, regardless of income, have the same 24 hours per day for their activities and, therefore, travel time budgets would have less scope for

change than would travel cost budgets. However, recent work on UK data by Prendergast and Williams (1981) has cast doubt on the stability of travel time budgets across socio-economic groups. Rather, they report, large variations among subgroups indicating that '...time varied both with and between population groups'.

#### The value of time and travel time budget

The value of time is influenced by the presence of travel time budgets (Fouvy 1974, Zahavi 1976, Manning 1978, Searle and Clark 1976). The time of day may greatly influence the prevailing value of time. During the morning, at the start of travel and time budget, the value of saved travel time would be very high because of the potential to transfer savings to subsequent activities on a preference list. However, in the afternoon or evening the value of saved time would be significantly less for an individual, as there would be less opportunity to expend time on their as yet incomplete activities.

Zahavi (1976) also mentions the notion that the value of 'saved' travel time when measured for certain trip purposes should not be allocated to the purpose from which it was measured, but to the additional activities that may be achieved with the saved travel time during the same day and according to the ranking of trip preferences.

#### Travel time budgets and access to opportunities

Higher travel speeds made available through improved transport services are not only used to reduce travel times. Individuals may extend their opportunities for work, education, shopping and recreation as these facilities are more able to be reached within a given time span (Fouvy 1974, Manning 1978, Searle and Clark 1976 and Ogden 1970).

#### Comments on travel time budgets

The abovementioned discussion highlights a duality in the concept of travel time budgets. Time saved as a result of transport network improvements may be treated by an individual in one of two ways:

- he may transfer the time saved to the next most important activity on his preference list; or
- he may maintain the same travel time budget while moving to a more distant housing location.

From this it may be inferred that travel time savings would realise an increase in travel activity, that is more and/or longer trips.

It could perhaps be suggested that two or more separate travel time budgets are operating simultaneously in decision making processes for trip makers.

Long run travel budget decisions may be made for repetitive trips, (eg commuting) where the trip maker has an awareness of travel time budgets. A saving in this trip time would enable re-evaluation of housing location decisions and would then lead to the urban sprawl that has resulted from network improvements.

Savings in time for other trips would, in the short run, be transferred to the next most preferred activity. By considering travel time budgets in this light, some of the conflict that results from variations in travel time budgets could, perhaps, be resolved.

Hensher (1976c) has suggested that time budgets combined with a travel diary approach (which provides necessary complementary information on the extent of planning of activities, obligation of allocated time, habit and dominance of activities) can help to develop hypotheses that are more appropriate for modelling the nature of travel and travel time budgets than traditional approaches.

# CHAPTER 6—THE EFFECTS OF TAXATION ON TRAVEL TIME VALUES

With the significant exception of Beesley (1976) and Forsyth (1980), few authors have explicitly considered the effects of taxation on values of travel time savings. Beesley postulated that changes in tax, and especially income tax, will affect the leisure/work trade-off and thus measured values. He suggested that if past tax trends continue, one might expect an increase in the values of leisure time because the ways to use it pleasurably will proliferate.

However, how much work/leisure trade-off is there in real life? It could be suggested that few really effective trade-offs exist. Most people are constrained to work fixed hours and must fit leisure activities around working hours. Flexitime workers do have some effective work/leisure trade-off, but flexitime only allows for manipulation of working hours, and a fixed minimum number of hours must be worked.

Forsyth points out that leisure/work trade-offs are available, in that an individual may choose to carry out part-time work rather than full-time work. Again, the extent of choice available to any individual may be heavily constrained.

The main thrust of Forsyth's work was that even in an optimally organised economy the wage rate would not equal the leisure time rate. In practice, a significant role in explaining the difference between the two values must be accorded to taxation, and in particular income tax. Marginal income tax rates are high in many countries, and the marginal net wage rate is often much lower than either the pre-tax rate or the average rate. Thus it is often the case that over half the difference between the 'value' of leisure time and the wage rate is accounted for by taxation. However, although this may be enough to explain observed differences in the two valuations, it does not indicate which values should be used and under what circumstance.

It is recognised that taxes pose problems for the proper shadow pricing of resources. The clearest recognition of this arises in discussions of public sector investment criteria (see Marglin 1963, Feldstein 1964, Harberger 1969, Dreze and Sandmo 1971, Layard 1972, Boadway 1975). The general conclusion is that when deriving the shadow price of a resource (eg for cost-benefit purposes) it is incorrect to use either a 'resource' (or individual valuation) or a 'market' (or productivity) valuation alone. It is necessary to combine the two, with the tax rates and supply and demand elasticities entering as parameters into the shadow price equation. The same reasoning should apply to savings in travel time, whether in work or leisure hours.

Forsyth's conclusions indicate that simple conventional procedures, such as using a behavioural value of leisure time for evaluation of savings during leisure hours or a wage rate for savings which occur during working hours are inappropriate. It is necessary to derive shadow prices which depend on both. In the paper a social valuation of time is derived which is appropriate for use in welfare analysis and normally lies between behavioural time values and the wage rate. Where this value lies depends on the nature of the time saving, and its impact on the taxes raised.

The important distinction, Forsyth argues, is not between time savings in leisure or work hours, but whether the saving is integral to the production process. If it is, the time saving will lead to greater taxes being raised through more production being undertaken, since there will be a substitution effect in the direction of goods rather than leisure. Thus the external effect of the saving is greater, and the social valuation is also greater. It is possible that the social valuation exceeds the wage rate, if the change

results in less leisure being taken. The size of the correction, to be made to either the behavioural value of time or the wage rate, will depend on the shadow price of taxation revenue.

Income and commodity taxes provide the main source of corrections that need to be made in order to obtain the social value of time. Thus, the criterion for relevance is the extent to which the tax alters the real wage to the individual for giving up his time.

Discussion on the social value of time has depended on an individual being able to choose the amount of time spent in leisure and in work. The most obvious constraint is the requirement to work a set number of hours, the most common working contract.

An employee may be constrained to a minimum or maximum number of hours of work (by legislation), and if bound by a minimum, then time saved may be spent in additional work. The individual might prefer to have more leisure and thus will spend a time saving entirely as leisure. If the individual is subject to maximum hours constraints, a time saving outside of working hours will necessarily be spent as leisure and will be valued accordingly. A time loss however, will probably be covered by taking less leisure and not less work. In these cases, Forsyth indicated that no adjustments need to be made to the behavioural value to derive the social value of time.

From the point of view of the firm, hours constraints make for complications. The firm will not be constrained in the number of hours it hires in total, but it may be constrained in terms of the number of hours of each individual hired. If production depends not only on total hours but also on the hours of each employee, the valuation of work time savings will also be affected.

#### SUMMARY

Increases in taxation affect the work/leisure trade-off. Corrections to the value of time savings to include taxation will increase the social value of leisure time savings but may increase or decrease the value of work time savings depending on the context. However, these corrections are to be made when values are being used for normative purposes only. If time values are being sought for use in a behavioural model, such as a travel choice model, the social time values remain the relevant ones to use.

### CHAPTER 7-A PRACTICAL REVIEW OF AUSTRALIAN TRAVEL TIME VALUES

#### BACKGROUND

In 1980 the BTE requested a number of Australian transport agencies to advise of their practices in valuing time in preparing demand analyses or economic evaluations of proposals. The aim of the survey was to establish whether any consensus existed among such agencies in methods of valuing and applying travel time savings. In addition, an attempt was made to assess the extent of any research being undertaken into the value of time by agencies to establish their own viewpoints, as opposed to adopting some 'common' set of values.

#### **RESULTS OF THE SURVEY**

Of the thirty five agencies surveyed, thirty responses were received. Thirteen of these agencies indicated that they had had no call to utilise values of travel time in their assessments and as such did not have any values. This left seventeen 'workable' responses.

These responses have been separated into three tables:

- Table 7.1 shows the results for five State Road Authorities;
- Table 7.2 shows the results for five Urban Transport Agencies; and
- Table 7.3 shows the results for six Planning and Other Transport Agencies.

				Commer	cial vehicles	
Year	SRA	Private	Business	Bus	Truckª	Scope
1978	А	1.40	14.65		5.30-5. <b>80</b>	rural
		1.13	12.80	14.50	5.30-5.80	urban
1978	В	1.32	13.42		4.87-5.32	rural
		1.05	11.74	13.37	4.87-5.32	urban
1979	С	1.20	12.40		4.50	na <sup>b</sup>
1980	D	1.50	15.75		5.70-6.25	rural
<u> </u>		0	00	0	0	urban°
1980	Ed	1.50	15.75		5.70-6.25	rurai
		1.20	13.80	15.60	5.70-6.25	urban

#### TABLE 7.1-VALUES OF TIME USED BY STATE ROAD AUTHORITIES

(Dollars per hour for each time category)

a. The range in truck values differentiates for a variety of truck types.

b. Scope not available.

c. This State Road Authority indicated the use of zero values of time in urban situations for two reasons:

it did not alter their cost/benefit ratios; and

• there was too much controversy for a value to be used.

d. Country Roads Board values of time.

	(Dollars per hour for each time category)									
Year	Agency	Private	Business	Bus	Commercial	vehicle Truck	In- vehicle	Walk- ing	Wait- ing	Public transport
1977	A	4.20	8.70	4.92						
1977	Bª	2.30-3.20				·				2.30
1978	В	2.30	2.30	2.30	2.30	2.30				2.30
1979	₿ª	2.30-3.20	2.30-3.20	2.30-3.20	2.30-3.20	2.30-3.20				2.30-3.20
1980	C			1.50				3.00	3.00	1.50
1980	D	1.20	1.20	1.20		1.20				1.20
1980	E	1.02	1.02				1.02			1:02

TABLE 7.2-VALUES OF TIME USED BY URBAN TRANSPORT AGENCIES

a. The agency gave no explanation for the range in values except that it was assumed to 'apply over time'.

### TABLE 7.3-VALUES OF TIME USED BY PLANNING AGENCIES AND OTHERS

(Dollars per hour for each time category)

					Commercial	vehicles					
Year	Agency	Private	Business	Bus		Truck	ick In- vehicle	Walking	Waiting ti	Public transport	Scope
1974	A	0.50			2.00					0.50	naª
1975	БВ	0.70	2.70								urban
1977	′С	0.90		12.99		4.40			0.60		naª
1977	D⊳	· .			0-31.50						both
1978	3 E	6.50					1.28	2.56	1.77		naª
1978	B F°	1.05 1.32	11.74 13.42	13.37		4.87-5.32 4.87-5.32					urban rural

a. Scope not available.

b. These are the SWATS freight values and have a wide range to account for the different values of goods. c. These are the BTE updates of the Australian Road Survey (1978) parameter values. The range in truck values accounts for different types of trucks. The majority of respondents indicated that they used the set of parameter values which were originally developed in 1971 for the Commonwealth Bureau of Roads (Hensher 1971).

Those values were last updated by the BTE in 1978 (BTE 1978). These updated values are presented in Table 7.3, together with 1980 values prepared on the same basis by the Country Roads Board (CRB) of Victoria (Both 1980).

The dominant use of these values is most clearly seen in Table 7.1. State Road Authorities used these values almost exclusively. The variations in the results are accounted for by the methods of updating; some State Road Authorities use the Consumer Price Index while others use average weekly earnings.

Tables 7.2 and 7.3 show less consistency. Two agencies indicated that they used the CBR/BTE values of time but 'took account of overseas studies' as well, and varied their values accordingly (but not necessarily rigorously).

One agency had no system for valuing savings in travel time. Until recently it had employed values of \$1.20 for both private and commercial time savings. Discussions indicated that the analysts 'occasionally updated these values using the Consumer Price Index'.

One urban transport agency considered that 'plug in' values of time were generally inappropriate. As such, the factors that were relevant to each specific case were 'taken into account, where possible,' in decisions on the values to be placed on time. Because of this, specific details on 'the value' used for time in different situations could not be given. However, no work had been carried out to value time specifically.

Western Australian agencies (shown in Table 7.3) indicated values of time for freight transport derived in the Southern Western Australian Transport Study (SWATS) (1977). The values are based on the opportunity cost associated with the value of the goods which are, in some ways, temporarily unusable while being transported.

Most agencies indicated the use of either the CPI or average weekly earnings to update their values of travel time to current prices when necessary.

In addition to providing actual values used, respondents were asked to indicate if they used different values for different travel conditions or traveller characteristics. Only one agency related value of time to income, one other used different values for different unit amounts of time saved, three agencies used different values for different trip purposes and four used different values by mode. None had an empirically proven analytical base for their practice.

#### CONCLUSIONS

The results of the survey indicate a reluctance on the part of most agencies to make independent estimates of value of time for use in analysis. In general they lack the appropriate resources or technical skills. Consequently these agencies seek some standard, 'off the shelf' set of values. Most agencies are willing to carry out simple analysis to update such standard values to current price levels, but there was no uniformity among respondents in the method of update adopted, with both consumer price and average wage rate indices being popular.

The large number of agencies (13 out of 30 responding) which indicated no use for a value of time is an interesting reflection on current transport project analysis in Australia. One of the principal outputs of any transport improvement project is a time saving, that is accomplishing the same transport task in less time, yet this output is not valued by several major agencies.

# CHAPTER 8-A SUMMARY LITERATURE REVIEW

The foregoing chapters and associated references furnish descriptions of investigations which have been carried out in various countries (mainly Australia, UK and USA) in order to obtain estimates of a money value of travel time savings. In most research, values of time have either been derived theoretically or deduced from survey material. An effort was made to try and establish some trends in these values and a number of tables were collated for this purpose. However some points should be borne in mind when reviewing them.

Most results were presented by authors in the currency of their respective countries. Owing to variations in exchange rates, inflation, wage rates and taxation systems, the values are not easy to compare. Where possible, the values presented are given as percentages of the average wage rates of the respective country to permit some comparison among countries.

When considering comparisons among countries, uncritical use of time values may lead to serious errors. For example, Kain (1976) drew attention to the special shape of American cities. He suggested that traditional racial separation in residential location repeated itself in job location and one consequence was much cross-travel that would otherwise be eliminated. The burden of Kain's remarks was that one should be very careful when attempting to use American data for transport planning in other countries.

Four sets of tables have been constructed as a time series from 1959 to the present, showing the values given for business (Table 8.1), leisure (Table 8.2) and commuter (Table 8.3) travel time savings as well as the relationship between walking, waiting and in-vehicle time savings (Table 8.4). Whilst bearing in mind the points mentioned in the preceding paragraphs, it can still be seen that there is little consensus within countries and even less among countries.

Table 8.1 is the only example where some sort of agreement is evident. Prior to 1965 the value of business time savings was assumed to be equal to the average wage rate. However between 1965 and 1970 these values were questioned. The result was a range of values from 20 per cent to 149 per cent of the average wage rate. In 1971 a value of 110 per cent (the extra 10 per cent allowing for overheads) was derived. This seems to have been seized upon (perhaps with a measure of relief) and has been widely used since then in Australia.

From Table 8.3, it can be seen that much activity has occurred in the efforts to value commuter travel time savings. The result has been a wide range of values from zero to 184 per cent of the average wage rate. However, no consensus has been reached either within countries or among them. Some clustering of values does occur between 20 and 34 per cent of the average wage rate and between 42 and 45 per cent of the average wage rate.

Similarly, from Table 8.2 it appears that considerable work was carried out between 1968 and 1971. Once again a wide range of values have been cited from zero to 105 per cent of the average wage rate. However the value of 75 per cent of the average wage rate occurred fairly frequently in the table signifying at least a popular value.

Table 8.4 presents relationships between values of time for walking, waiting, in-vehicle and transfer times. The figures are factors of the base value (of one) for in-vehicle time. Early work (see Hogg 1970) indicated that waiting and walking times were valued

### TABLE 8.1—BUSINESS VALUES OF TRAVEL TIME

Country	Year	Author(s)	VTTS as per cen of AWR	s Other remarks t
	1959	Charlesworth, Paisley	100	Assumed values
ŬK	1960	Revnolds	100	Assumed values
ŬK	1960	Reynolds, Beesley	100	Assumed values
USA	1963	Moses, Williamson	100	Estimated values
ÜK	1963	Foster, Beeslev	100	Assumed values
Aust	1964	Delaney, Fouvy, MTC	20-100	Empirically determined for cars—20 per cent value at 64 km/hr
France	1965	Merlin, Barbier	60	
USA	1965	Mohring	55(av)	Empirical-0 per cent at 48 km/hr to 155 per cent at 113 km/hr
UK	1965	Beeslev	31	Empirical-for clerical workers
		,	38-50	Empirical-executives, CBD work
UK	1967	Quarmby	20-25	Empirical-CBD work trips
Italy	1968	Dawson	100	Assumed values
UK	1968	Roskill	149	Assumed values
Aust	1968	CBR	110	Estimated values
UK	1968	Millward	100	Assumed values
ŬK	1968	Earp, Hall, McDonald	62-88	Measured in UK
ŪK	1970	Earp, Hall, McDonald	70-76	Measured in Europe
UK	1971	Roskill	100	Estimated average
			303	Measured for medium car
			225	Measured for large car
USA	1971	Thomas, Thompson	40	Empirically determined; maximum at 14 mins saved
Aust	1971	Hotchkiss, Hensher	20	Empirical determined
Aust	1971	BTE	110	Updated from 1968 CBR results
UK	1972	Heggie	89	MI Study
			80	Vic line study
			38	3rd London Airport
UK	1973	Coopers, Lybrand		\$7/ton/day (1978 prices) empirically
				derived for containerised freight
Aust	1974	Hensher, Delofski	80.8	Route choice; tollway; door-to-door
Aust	1976	Both, Bayley	110	Updated BTE dollar values
UK	1977	DOE	131	•
Aust	1978	BTE	110	Updated BTE dollar values
Aust	1978	Hodgkin, Starkie	-	\$0.27/day/ton for average \$1000/ton freight value
Aust	1979	Both	110	Updated 1976 BTE dollar values
Aust	1980	Both	110	Updated 1979 BTE dollar values

a. Value of travel time savings as percentage of average wage rate.

#### Chapter 8

#### TABLE 8.2-LEISURE VALUES OF TRAVEL TIME

Country	Year	Author(s)	VTTS as per cen of AWR	s Other remarks t a
UK	1959	Charlesworth, Paisley	0	Assumed values
UK	1960	Reynolds	0	Assumed values
UK	1960	Reynolds, Beesley	41	Assumed values
USA	1960	AASHO	34	Assumed values
UK	1963	Moses, Williamson	100	Theoretical values
UK	1963	Foster, Beesley	69	Assumed values
USA	1965	Mohring		\$2.80/vehicle; choice of speed, a trade-off of leisure time with operating costs
France	1965	Merlin, Barbier	75	Revealed preference; mode choice
USA	1965	Mohring	55	Trade-off of leisure savings and
		Ū		operating costs
UK	1965	Beesley	35	Revealed preferences
UK	1967	Quarmby	20	Revealed preferences
USA	1967	Lisco	50	Revealed preferences
UK	1967	Barnett, Saalmans	14	Revealed preferences; mode choice
italy	1968	Dawson	75	Assumed values
UK	1968	Roskill	25	Assumed values
UK	1968	Stopher	52	Revealed preferences
UK	1968	Smith	25	Assumed values
Aust	1968	Pelensky et al	51,69,86	
USA	1968	Gronau	 10	
Aust	1900	CBR Milword	75	Assumed values
UN Italy	1060	Dawson Everall	75	Assumed values
	1909	Watson	67.5	Mode choice—social: car_train
Aust	1970	Thompson	105	Derived for car trips
UK	1970	Boskill	25	Assumed values
ŬK	1970	Mansfield	22	
•••			24	Based on household income
Aust	1970	Pelensky	45-74	Assumed values; car trips
Aust	1971	Hotchkiss, Hensher	9	Empirically derived; personal business; ferry, hydrofoil
Aust	1973	Hensher	23	Revealed preference; mode choice
USA	1973	Ben-Akiva	55	Excess travel time; direct estimation;
			84.6,18.7	shopping trips Excess travel time; indirect estima- tion: shopping trips
			14.1	Invehicle time; direct estimation; shopping trips
			5.1,40.2	Invehicle time; indirect estimation; shopping trips
Aust	1974	Hensher, Delofski	35	Route choice; tollway
			81	Personal business
UK	1975	Watson	68	Mode choice; car, train
UK	1977	DOE-DTP	25	
Aust	1978	BTE	9	

a. Value of travel time savings as percentage of average wage rate.

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# TABLE 8.3-COMMUTER VALUES OF TRAVEL TIME

Country	Year	Author(s)	VTTS as per cent of AWR <sup>4</sup>	s Other remarks t
UK	1959	Charlesworth, Paisley	0	Assumed values
UK	1960	Reynolds	0	Assumed values
UŞA	1960	Mohring	22-43	Car, public transport; trade-off between site costs and travel costs
ЦΚ	1960	Revnolds, Beeslev	82	Assumed values
France	1962	Merlin, Barbier	75	Public transport, car: mode choice
USA	1963	Moses, Williamson	100	Theoretical; this value will be more for leisure time and less for working time
UK	1963	Foster, Beesley	69	Assumed value
UK	1964	Quarmby	20,25	Car, bus; mode choice
UK	1964	Barnett, Saalmans	14-33	Mode choice
USA	1965	Becker	42	Car, public transport, mode choice; theoretical
USA	1965	Mohring	55	
UK	1965	Beesley	30-50	Mode choice
UK	1966	Stopher	25,26	Mode choice; car, public transport
Aust	1966	MTC	55	Mode choice; theoretical CBD trips
UK	1967	Quarmby	20-25	Mode choice
Aust	1967	Thomas	61	Car; route choice
USA	1967	Lisco	52	Mode choice; public transport car
UK	1968	Coon	33	Assumed value
UK	1968	Dawson	75	Assumed value
ŬK	1968	Beesley	31 <sup>1</sup> ,25 <sup>2</sup>	(1) 8 shillings/hr; (2) 10 shillings/hr train
			44,35	Train/bus
			44,35	Walk/wait
			63,50	Car
UK	1968	Mansfield	31	Mode choice; male
			33	Mode choice; female
Aust	1968	CBR	75	
USA UK	1968 1969,	Lave /	42	Mode choice; bus, car
	1971	Lee, Dalvi	2 <del>9</del> -37	Mode choice
Italy	1969	Dawson, Everall	75	
UK	1969	Stopher	52,42	Mode choice; car public transport
Norway	1969	Hansen	26	Mode choice; car public transport
Aust	1970	Hogg	30-75	Public transport
			20-100	Private transport
			50-100	Public and private transport
UK	1970	LGORU	61	Mode choice; average for all areas
			61	Liverpool
			47	Manchester
			132	Leicester
			30	Leeds
Aust	1971	Hensher	27 32	Mode choice; non-local area trips Mode choice; local area trips

Country	Year	Author(s)	VTTS as per cent of AWR <sup>a</sup>	Other remarks
Aust	197-	1 Hensher, Hotchkiss	19	Ferry
			22	Hydrotoll
UK	197	1 Roskill	75	Overall
			60	Small sized car
			80	Medium sized car
			89	Large car
USA	197	1 Thomas, Thompson	50	Theoretical values
UK	197	1 Ebden, Hall	69	Ferry
			184	Hovercraft
Italy	197	1 Dawson, Everall	128	Route choice; car
Aust	1972	2aHensher	27,32	Mode choice; car, bus
Aust	1972	2bHensher	16	Overall value mode choice
			13.4	Invehicle
			26	Waiting
			20	Walking
			20	Weighted mean
Aust	197:	3 Hensher	27	Mode choice door-to-door; car, train
Aust	1974	4 Delofski, Hensher	39.2	Route choice; tollway
Aust	1974	4 Hensher	20	Mode choice; car, train
USA	197	4 Kraft, Kraft	41	Mode choice; bus, train, air
Aust	1974	4 Hotchkiss, Hensher	2.7	Mode choice; hydrofoil, ferry
Aust	1970	6 Hensher	11-27	Willingness-to-pay; transfer price
Aust	197	7 Hensher, McLeod	21	Mode choice

#### TABLE 8.3-COMMUTER VALUES OF TRAVEL TIME -continued

a. Value of travel time savings as percentage of the average wage rate.

around twice in-vehicle times as they were the more 'distressing' activities for an individual. This notion has prevailed through later work (eg Beesley 1974, Richards and Ben-Akiva 1975) and generally only slight variations to these factors occur, although their adoption is only rarely confirmed by empirical analysis before use.

Little agreement has been reached concerning what values should be used in valuing travel time savings. Perhaps it can be said of the variation in values, particularly for commuters and leisure values, that these point to the context specific applicability of time values. While a consensus may be fairly easily reached for values to be placed on business travel time savings, where simple time cost considerations are involved, it has proved more difficult to evaluate time savings in other uses.

Valuing travel time savings has led to a proliferation of values. Authors have found that a number of factors greatly influence the values that are obtained in empirical work, and the main ones are mentioned here.

Among these are the quality of the trip, sex, age and income, the length of the journey and whether the trip was of a recreational, commuting or other type. A number of points have been drawn together from the empirical studies and are presented in summary form. Some empirical work has led to conflicting results and while one set of workers stress one factor, another will stress a diametrically opposed result as being of equal importance. For example some researchers such as Skunk & Bouchard (1974) feel sex, age and income to be most important in determining mode choice, others such as Hensher (1971) see travel time and travel cost to be most important. This highlights the confusion that exists in theoretical discussions on the value of time savings.

# TABLE 8.4—RELATIONSHIP BETWEEN VALUES OF TIME FOR IN-VEHICLE, WALKING, WAITING AND TRANSFER TIMES

Author	Source	Year	In- vehicle	Walking	Waiting	Transfer
Merlin and Barbier	France	1965	1	1.75	3	2
Quarmby	UK	1967	1	2		
Hogg	Aust	1970	1	2	3	2
Veal	UK	1971	1	1.7		1.7
Hoinville and Johnson	UK	1971	1	2	2	1
Hensher	Aust	1971	1		2	1.5
Hensher	Aust	1972	1		2	1.5
LGORU	UK	1973	1 /	2.9	1.6	
			1	2.6	3.6	
			1 '	2.5	2.5	
			1	3.5	3	
Ben-Akiva	USA	1973	1	0.25	0.25	
			1	0.26	0.26	
			1	0.47	0.47	
Beesley	UK	1974	1	2	2	
DOE	UK	1974	1 '	2	2	
Richards and Ben-Akiva	USA	1975	1	2		
Algers, Hansen	USA	1975	1		12	
and Tegner			1		3	
LGORU	UK	1975	1	2	3	
			1	1.5	2	
Train and McFadden	USA	1976	1	1.4	8-11	
DTP-DOE	UK		1	2	2	
BTE	Aust	1978	1	2	1.5	

#### General observations

At least 30 per cent of all urban travel involves journeys that entail more than two trips of which more than one purpose is not common (Hensher 1976).

Parking availability could be the main determinant of whether a car is used for a particular trip purpose (Hotchkiss and Hensher 1971b).

It has been found that some drivers 'filter out' certain roads (normally defined by the class of road, ie freeway or local road) either for all journeys or for certain journey purposes. In these cases drivers would never consider using a specific type of road regardless of the time saving available (Oxford University Transport Study Group 1980).

Generalised cost functions have been calculated for different journey purposes, eg journeys to work, in the course of work and for leisure. However it has been found that many drivers classify their journeys on a different basis according to whether there was a fixed time of arrival or not (Oxford University Transport Study Group 1980). Richardson (1978) found that a time gain (saving) will be valued less than a time loss of the same amount.

#### Quality of the trip

Reliability of services is high on individuals' lists of priorities. There seems to be a marked disutility associated with unreliable services (Hoinville and Johnson 1971, Wallin and Wright 1974, Richardson 1978). Similarly convenience (and fewer interchanges) together with reliability, are two key factors motivating present travel behaviour (Johnson 1966; Hensher 1973, 1975; Wallin and Wright 1974).

Savings in overcrowding are valued very highly. Train users suffered more frequently from all the defects of overcrowding, such as lack of seats and the need to change modes. Long distance commuters were seen to suffer particularly from the effects of overcrowding (Hoinville and Johnson 1971).

Private transport users have higher standards of travel than public transport users. Their journeys are less complicated, more comfortable, involve little walking and waiting time and hence are more convenient (Wallin and Wright 1974, Hoinville and Johnson 1971). This aspect of travel has been summed up conveniently by Wallin and Wright, who stated that 'a person would rather creep along in his car in heavy traffic than wait for a bus' (p278).

Waiting time is seen to be 'distressing' to travellers; much more so than in-vehicle or walking time. This has often been valued at twice the rates for in-vehicle or walking time (Jennings and Sharp 1976, Hogg 1970, Wallin and Wright 1974, Hoinville and Johnson 1971, Hotchkiss 1973, Goodwin 1976, Horowitz 1978, Hensher 1972). Hoinville and Johnson found that waiting time varied inversely with total journey time.

It has been suggested that an 'unpleasant' (congested, slow) journey can have a subjective time cost of up to two or three times the standard rate (Heggie 1979).

#### Sex, age and income

There is no agreement on the importance of sex, age and income as influences on the value of time in travel.

Some workers have suggested that sex, age and income are the principal characteristics that influence mode choice decisions (Skunk and Bouchard 1974, Wallin and Wright 1974, Hensher and Hotchkiss 1971a). However some of these analyses may be descriptive rather than explanatory.

Relative travel time, relative travel cost and relative travel comfort, were seen by Hensher (1971) and Hotchkiss and Hensher (1971b) to describe choice of travel mode adequately.

Lee and Dalvi (1969) found that the sex of a respondent did not alter results, but that age did—a 1 per cent increase in age in their regression analysis was associated with a  $\frac{1}{2}$  per cent reduction in travel time. They concluded that 'young people would appear to value travel time saved and lost more highly than older people' (pp222-223). Lee and Dalvi felt that as age was not significant when included with household income, it was possible that age was acting as a proxy for household commitments. As age increases, household responsibilities increase and willingness or ability to pay to effect a travel time saving decreases.

It is generally agreed though that values of time are higher for travellers with higher incomes (Thomas and Thompson 1972, Hotchkiss 1973, Hotchkiss and Hensher 1971a, Hotchkiss and Hensher 1971b).

Earp, Hall and McDonald (1976) and Wallin and Wright (1974) suggest that the status and prestige associated with some form of travel may determine choice of mode.

#### Length of journey

Many workers have found that choice of mode was based on major differences in speed and not on marginal time savings (Hoinville and Johnson 1971; Thomas and Thompson 1972; Wallin and Wright 1974; Earp, Hall and McDonald 1976).

Hotchkiss and Hensher (1971) found that the value of travel time savings varied between modal pairs.

Some researchers found that different values of time were obtained for different time intervals. For example, 0-5 minutes, 5-15 minutes and over 15 minutes (Thomas and Thompson 1971, Hensher 1973).

Those who travel longer distances by slower methods value travel time savings more highly than those who travel shorter distances (Lee and Dalvi 1969, Hensher 1973, Richardson 1978).

#### **Commuter and recreation trips**

Whilst values of working time are related to wage rates, no direct market values exist for non-working time. Non-working time encompasses a wide range of activities from travel to work, personal business (such as shopping) to pure leisure travel. The values adopted have been based on observations of behaviour, on the view that day to day decisions implicitly reveal a valuation of time.

Many workers have found that different values of time are associated with different activities (Thomas and Thompson 1978, Phillips 1969, Hotchkiss and Hensher 1971).

Similarly, Hotchkiss and Hensher (1971a) in an analysis of recreation trips have shown that transferring results from one form of activity to another may lead to inaccuracies.

Mansfield (1970) stated that the value of travel time savings for recreation trips is not dissimilar to the value of travel time savings for commuting trips.

Roskill (1971) and Hensher (1974b) have found that persons accompanying travellers to airports do derive benefits from time savings.

Commuters have been seen to select their main mode on the basis of directness and speed (Hoinville and Johnson 1971; Earp, Hall and McDonald 1976).

Businessmen may have their choice of mode determined by company policy and as most emphasise savings in travel time, air has been the most common mode of transport for intercity travel (Wallin and Wright 1974; Earp, Hall and McDonald 1976; Hensher 1974b).

#### SUMMARY

As can be seen from the discussion, a multiplicity of factors influence values attributed to travel time savings. No one clear-cut direction or trend has been established other than the valuing of business travel time savings at the average wage rate with an added percentage to account for overheads. It is little wonder that confusion exists in the values, as no real consensus has been reached on the attributes to be included in the valuation process.

## **CHAPTER 9—CONCLUSIONS**

The role of this paper has not been to specify values of time to be used in the evaluation of transport proposals. Rather it has aimed at drawing together a number of issues that must be addressed when valuing time, to present the practitioner with some information and perhaps guidance.

Estimates of the values of travel time savings have usually been sought in the prescriptions of marginal productivity theory and in the theory of consumer behaviour. The former is the most commonly used basis for valuing time savings during working hours, while revealed behaviour of travellers has been the usual basis for non-working time values.

A review of the literature confirms that there is little agreement about the proper interpretation of the parameter estimates obtained in the analytical models that are used to obtain values of time. Some claim that these parameters represent marginal values of time and others that they are average values; some criticise them because they represent what has been called 'the price of time' rather than the value of time while still others have doubts about these estimates since they may not be 'pure' or 'true' values or may only represent 'curve fitting parameters'. Some of this criticism can be interpreted as questioning the technical validity of these estimates, that is, asking whether they really measure what we want them to measure. One consequence is that although a considerable body of empirical knowledge is available there is a great deal of doubt as to the meaning of this knowledge and its relevance to cost-benefit analysis.

Hensher (1979) has suggested a number of reasons why travel time values have been misspecified, and probably over-valued in practice:

- (a) Inadequate account has been taken of the composition of travel time savings. Not only should policy makers be concerned about the extent of travel time savings but also the characteristics of such savings. Perhaps an appropriate objective would be the move towards a smooth flow of traffic rather than necessarily an increased average speed.
- (b) The values of time savings estimated from mode choice models usually are confounded by inadequately specifying the set of explanatory variables, thereby producing values that represent both the opportunity cost of time and the circumstances under which time savings are spent, the latter commonly referred to as the disutility...of travel. When relatively few journey attributes are included in a model then it is not difficult to conclude that time is the major user benefit. With only two (and sometimes four) variables (overall time or walk, wait and in-vehicle time, and money cost), the relative unimportance of money cost reflects the weak bind of the money budget across all alternative transport options. In the case of individual choice models, however, where all alternatives in the choice set are defined to be within the feasible money budget set, money cost would not be expected to be as significant. With time budgets given consideration, a further narrowing of the alternatives in the choice set may result, although this may be reversed if the broader perspective is adopted, since it will introduce a greater range of alternative ways of achieving a given end.
- (c) Values of travel time savings (when derived) from route and mode choice studies, (are) applied to all travel choices (frequency, destination, timing, etc). It is hence assumed that the marginal rate of substitution between time and money is constant across choice sets. This is a tenuous assumption, especially when the disutility cost varies, but one used for simplicity. How time savings vary over choice sets is unknown. However, whatever the relationship, it seems more appropriate to vary both the possibility for rearrangement of all travel and non-travel activities in the study of accessibility to opportunities (*sic*).

(d) The demand for travel is a derived demand but is not treated as such. This has led to situations where the concepts of efficiency applied to transport networks produce anomalies, such as in a situation where an increase in overall travel time is associated with increased benefits to the users; for example, extension of a suburban bus line could generate trips which were not previously made due to poor transport service previously provided. The overall transport time would increase (for existing users because of rerouting), but so would benefits to residents' (p125-126).

Lack of consideration of these factors may not only lead to a misspecification of time in the models but also to an over-valuing of the importance of time in the evaluation process.

The significance of the above comment is highlighted in cost/benefit studies where there is a highly detailed and precise body of measurement and techniques on the cost of implementing a project. At the same time, the evaluation of time savings and other benefits are dealt with on the basis of assumptions which admit wide margins of measurement, and hence error.

From the subject-matter covered in this paper, there is an evident need for research into the less clear-cut facets of time valuation. A wide variety of transport network improvements may be implemented and a number of travel time saving values may need to be derived to describe each likely situation. One value could not adequately describe the range of transport improvement processes which may occur. Few Australian transport agencies attempt to do this. As a result the usual entreaty is for further research to provide an adequate variety of time savings values that may be easily adopted to meet the improvements under consideration.

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