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TRAVEL BUDGETS - A REVIEW OF EVIDENCE AND MODELLING IMPLICATIONS

by

Hugh F. Gunn
Institute for Transport Studies, University of Leeds
Leeds LS2 9JT. Tel: (0532) 31751 Ext. 7214

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ABSTRACT

Gunn Hugh F. (1979) Travel Budgets - A Review of evidence and modelling implications. Leeds: University of Leeds, Inst. Transp. Stud.,

This paper reviews the empirical data that has been put forward as evidence for the feasibility of direct forecasts of the average amounts of time and money allocated to travel, and the alternative model frameworks which have been designed to exploit such forecasts.

It is concluded that the evidence for the stability of aggregate travel behaviour from analyses of cross-sectional data has not yet been reconciled with the variations shown over time.

.. ..

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CONTENTS

TRAVEL BUDGETS - A REVIEW OF EVIDENCE AND MODELLING IMPLICATIONS.

1. INTRODUCTION

1.1 In recent years a considerable amount of research has been devoted to the exploration of the total amounts of time and money that the individual spends on travel. The forecasting implications of the existence of constraints on these totals have also received attention in the literature, if to a rather lesser degree. The context of all these studies can probably be found in a recognition of some inherent limitations in current modelling procedures, especially in the face of a fairly general change in emphasis for the areas of concern for transport planning (in developed countries at least) away from issues of road construction and towards more general considerations of personal mobility and the problems of the 'transport disadvantaged'.

> Increasingly,....traditional concerns are being supplemented, or even replaced, by questions about how the use of existing facilities can be redirected to meet air pollution and energy conservation goals, as well as transportation objectives.
>
> Many of the transportation policies currently under consideration seek to make large changes in the relative price of travel in general and in the relative price of competing modes with the objective of substantially altering household travel behaviour.
>
> To evaluate effectively the probable impacts of these policies, an analyst needs to be able to draw on an understanding of the major mechanisms by which households are likely to make adjustments in their travel behaviour. (Oster (1978)).

Some writers have concluded that there are aspects of the demand for travel that simply cannot be accommodated within the conventional structure of an aggregate sequential approach broken down into generation/distribution-modal split/assignment stages. For example, Zahavi (1979) writes

> .....the measurement and analysis of travel demand, as they are done presently by travel demand models, are not satisfactory for two principal reasons; (i) the measurement of travel demand by trips is not compatible with the measurement of system supply service by travel distance; and (ii) travel demand, as defined presently, is not flexible enough to express the possible effects of system supply on travel demand....

In particular, the ability of the individual to alter his or her travel habits by means of re-scheduling trips, amalgamating trips or simply finding alternative ways of operating which involve less or no travel cause problems for the conventional methodology. Changes in individual trip rates can come about without any apparent 'causation' in terms of income growth, vehicle purchase or change in family circumstances simply as a result of adjustment to travel behaviour in the face of changes to the costs of travel. Such adjustments seem likely to be the rule rather than the exception, especially in the long term. Yet the assumption basic to the conventional procedure, that of stable trip rates for various household categories, seems to preclude treatment of such behaviour. (Jones 1977), (Oster 1978).

At the same time, and independently of the arguments about the adequacy of the theoretical underpinnings of the model, there has been increasing disquiet over the statistical inaccuracies of the conventional procedures, and the difficulties of fitting the model components to observed data (Robbins 1978). More recently, the question of forecasting errors has also received attention; Gilbert and Jessop (1977) argue that "due to the increasing instability of the relationships over time it would probably not be worth using this model to provide forecasts more than, say, ten years ahead".

The common conclusion of all these arguments is that there is a need to improve the 'behavioural' basis of the model. It is in this context that interest has recently focussed on travel 'budgets', the amounts of money and time that the individual allocates to travel.

1.2 The suggestion that forecasts of travel patterns might sensibly commence with direct forecasts of total amounts of travel (to be made by different population groups) was first made by Tanner (1961) on the basis of the empirical evidence he assembled which pointed towards a constancy of generalised expenditure (time spent being given an estimated behavioural value and added to money costs) of travel for the inhabitants of different areas, at any time, after allowance had been made for income differences. However, this apparent constancy of travel expenditure did not appear to hold for different individuals, nor even for the same individual at different times or similar individuals at different times. There was clear evidence of large and systematic variations in total travel as between the sexes, different age groups and so on, as well as between different income groups.

1.3 Broadly speaking, two approaches have been investigated as ways of incorporating considerations of the 'budget' dimensions of travel in forecasts. The first approach is to treat the budgets as overall constraints determining the amount of travel, effectively replacing the forecasts of trip ends with forecasts of travel. The constraints may be either fixed at the outset, as demonstrated by Tanner (1961), or allowed to vary in response to changes in the costs of travel, as in the later work of Zahavi (1977), in which there is an explicit recognition of the circularity or feedback between travel costs and travel budgets.

The second approach treats travel patterns within the context of activities in general, inevitably at the cost of considerable extra complexity. Various models have been devised in the attempt to make full and explicit recognition of the importance of the timing and duration of journeys linking activities in different locations; a summary of the different sorts of model within this stream can be found in Morris and Wigan (1979). This approach to modelling travel behaviour makes no assumptions about travel budgets, although assumptions about the allocation of time to more basic activities play a central role. The allocation of time to travel is then deduced from the travel patterns necessary to accommodate the required activities in the chosen locations.

A third stream of recent research which is particularly relevant to the consideration of travel budgets involves the development of idealised representations of travel based on a limited number of simplified assumptions. (Goodwin (1976) and Tanner (1979)).

1.4 This paper sets out to review the empirical evidence about the role of travel budgets as determinants of travel behaviour, together with the development of the ideas about models based on travel budgets. Were such models to be adopted, they would replace such conventional models as address all travel, regardless of mode, purpose or route. In fact no such models exist. If walk trips are ignored, on the assumption that they can be treated separately (Daor and Goodwin (1976)), it is the generation/distribution-modal split/assignment model that would require alteration.

The remainder of this paper will be set out in four sections, which will in turn consider:

i) the evidence for the nature of travel budgets from UK data;
ii) the evidence from data from other 'developed' countries;
iii) the aims theory and implications of the various modelling approaches; and lastly
iv) summarise such outstanding issues as can be identified from the above.

2. EMPIRICAL EVIDENCE FOR TRAVEL BUDGETS FROM UK SOURCES

2.1 Restricting attention to the level of the two available measures of overall travel, total money expenditure and total travel time expenditure, a number of national surveys and case studies of particular individual areas provide evidence for the nature of travel behaviour. The following sources will be used:

a) The National Travel Surveys of 1966, 1972/3 and 1975/6;
b) The County Surveyors' Trip Rate Data Bank, for 1974 and 1977;
c) The Family Expenditure Surveys (1959 onwards);
d) The Reading Activity Survey (1973) (see Shapcott (1977));
e) The Annual Abstract of Statistics (various years).

Total travel time will be taken to be all reported time spent on travel, inclusive of waiting time and walk trips. It is to be expected that there will be differences in the accuracy with which different surveys record the various component parts of travel, as well as definitional differences such as of the shortest trips to be recorded. Any detailed comparison of the different studies requires an extremely careful process of adjustment and allowance for such discrepancies. For the present purpose of drawing together the broad patterns of travel behaviour, the definitional problems have been ignored, and as a result, comparisons of the absolute levels of expenditure of time or money between different surveys should be made only with considerable caution, if at all.

Two different definitions of 'money expenditure on travel' will be considered. Firstly, we can consider the total outlay on transport related items, covering current expenditure on vehicle maintenance and running, bus and train fares and also the net outlay on the purchase of vehicles. This latter item represents the difference between the receipts from sales and the expenditure on purchase. Secondly, we can restrict consideration to the expenditure excluding the net outlay on vehicle purchase on the grounds that by so doing we achieve a definition of a 'budget' which is more directly related to the quantity of travel performed by the households; this is loosely called 'current' expenditure on travel below.

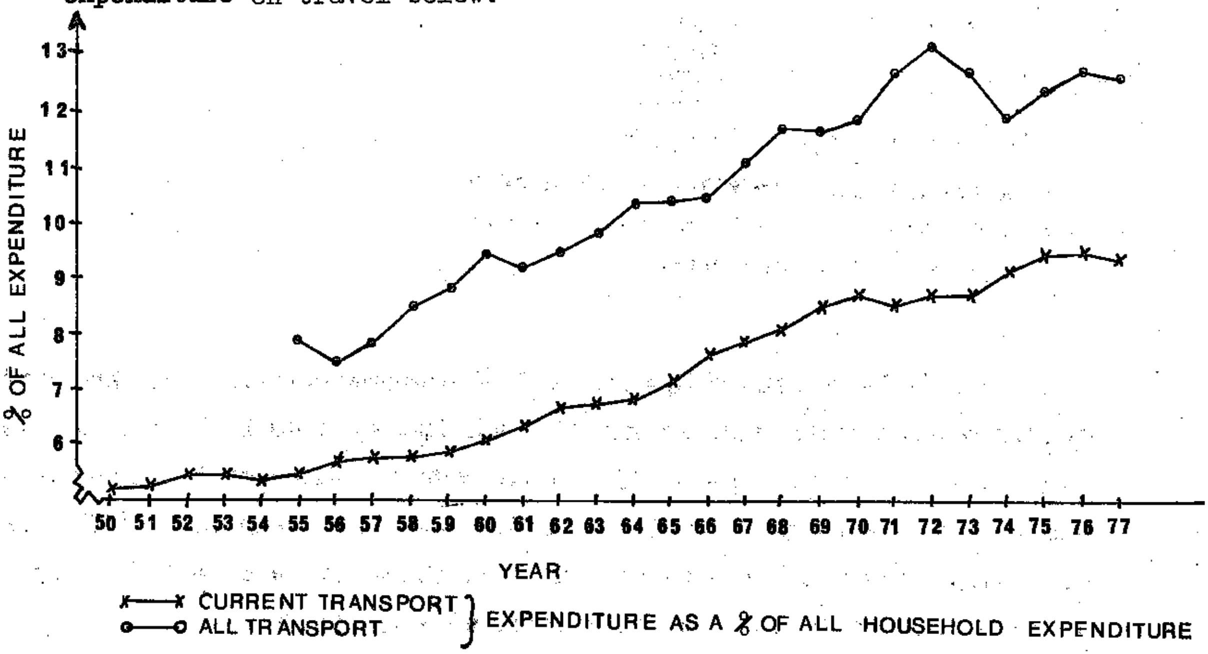

Figure 1. Proportion of Household Expenditure on Transport; 1950—1977

Figure 1 presents the expenditure on both 'current' travel costs and on total travel costs, as a % of all expenditure, from successive Annual Abstracts of Statistics. Both series show a clear upward trend; overall, the 'current' expenditure is less subject to fluctuations about this trend.

2.2 In a detailed analysis of household travel expenditure, based on the Family Expenditure Survey, Mogridge (1967) has demonstrated that the fluctuations in the overall average percentage of total expenditure allocated to transport conceals a remarkably regular pattern in expenditure habits.

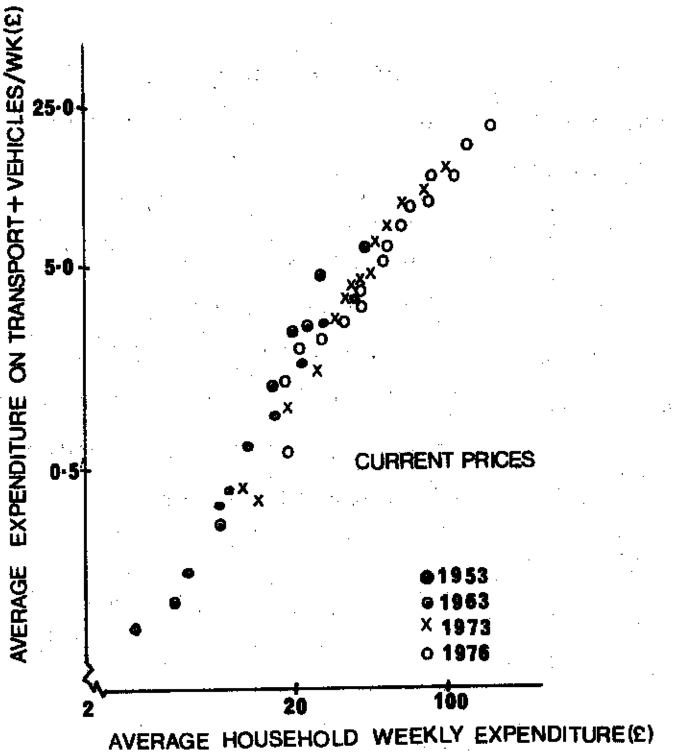

Figure 2 The Relationship between Total Expenditure and Transport Expenditure; F.E.S. data

Using the results of surveys in 1953 and 1963, Mogridge plotted household expenditure on transport against total household 'disposed income', or total expenditure, and demonstrated that the relationship between the two was very similar in each of the years. In Figure 2, the appropriate points for 1973 and 1976 have been added, and it may be seen that the same relationship persists in more recent data.

In a later paper, Mogridge (1977) examined the expenditure patterns of car-owning and non car-owning households separately; over the years 1971 to 1975, during which oil prices rose so sharply, he demonstrated that the % of disposable income allocated to total car operation remained virtually constant, as a result of a compensating reduction in outlay on vehicle purchase offsetting rising running costs.

The proportion of household expenditure allocated to public transport, on the other hand, varied over time "presumably with respect to service and fare levels". The variations and trend illustrated in Figure 1 are thus to be interpreted as the result of changes in the overall proportions of households owning cars together with variations in the costs and quality of public transport.

2.3 A recurring problem for the interpretation of survey data describing travel behaviour is the marked patterns of seasonality and regular day-of-the-week fluctuation for which allowance must be made. In terms of vehicular traffic on roads, the analysis of automatic traffic count data indicates that there is a variation of something like ±5% in travel as between different weekdays, with Fridays exhibiting consistently higher traffic levels. Variation over the year takes a rather more complicated pattern, with urban roads showing little regular variation, but inter-urban roads displaying fairly regular fluctuations, more or less extreme according to the trip purpose mix that the road carries. (Bellamy (1978)).

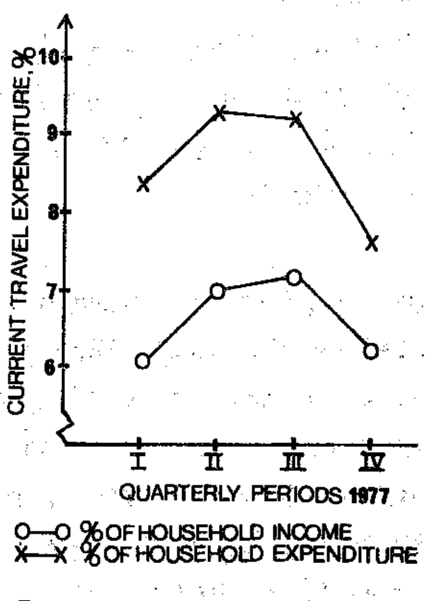

Figure 3 Seasonal Variation

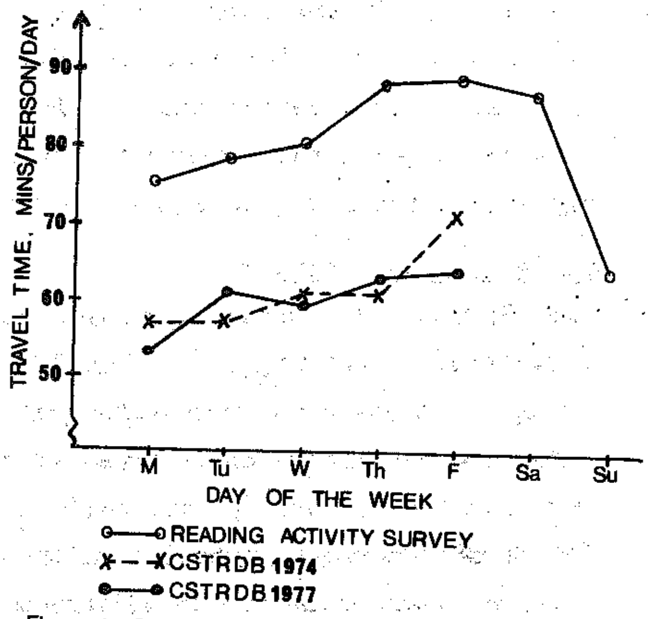

Figure 4. Day of the Week Variation

Figure 3 displays the allocation of household income to 'current' travel expenditure, as a % of income and as a % of expenditure, for the four quarters of 1977, and illustrates the sort of variation that can be expected. Figure 4 displays the reported average travel time, in minutes per person per day from three surveys.

None of these surveys should be taken as nationally representative, since each sampled from atypical populations - however, the overall patterns are probably reasonably typical.

Insofar as 'current' expenditure on travel and total travel time can be equated with quantity of travel, there is indication of variations of ±10% for seasonality and about the same for day-of-week variation. Surveys taken over short periods and unequally as between days of the week could disagree considerably for no other reason, and surveys over longer periods will contain an extra dimension of variability unless explicit allowance is made for these effects.

Another consideration in the interpretation of survey results for implications for overall travel budgets is the evidence that it is common practice to plan travel patterns for the whole week, and that the variability of travel times, for example, is less for an entire week's travel than for a single day. (Goodwin (1978)). All of the large scale surveys that are available to investigate travel behaviour have collected details of total travel for only a single day, yet this may not be the most appropriate period to forecast.

<u>Cross-sectional trends</u>

2.4 Perhaps the first reported investigation of travel budgets is contained in Tanner (1961); based on data for the period 1953/4. Using information on household expenditure, average public transport fares and vehicle running costs, this study assessed the amounts of time spent on travel by households in various different area types. The first and possibly most obvious relationship to be encountered was the correlation of expenditure on travel with income level; for the purposes of area to area comparisons, allowance was made for this factor. The resulting pattern showed that, after allowance for income differences, the money costs of travel in 'large' urban areas were less than those in smaller ones, and that money expenditure on travel was greatest in rural areas. Using the expenditure data in conjunction with fare levels and vehicle running costs, an assessment was then made of the distances travelled in each of the three area types. The conclusion was that the actual average distances travelled by households in each area type were very similar, despite differences in money costs which arose as a result of urban travellers making more use of public transport.

The next step in this investigation was to link the journey distances to average door-to-door speeds to assess time spent in travel. The conclusion from this stage was that rural households expended least time on travel of the three area types, and that the larger urban areas had the lowest journey speeds and hence the highest expenditure of time on travel. It may be noted that by using door to door speeds, such walk trips as were associated with a vehicular trip have been taken into account in this assessment. However, trips using only the walk mode are excluded. This data was combined to measure the overall 'generalised' expenditure on travel, for a range of values of travel time (chosen as zero, then at what is argued is a reasonable estimate, and lastly at twice this level). It was found that at the value of time that is chosen as a reasonable estimate, generalised expenditure on travel in the three area types was virtually constant, after allowance had been made for differences in income levels.

2.5 It is this last result which is presented as being the most interesting and important conclusion of the paper. The similarity of distances travelled, after allowance for income differences, would then follow only for particular combinations of fare levels, journey speeds and modal splits.

2.6 The relationships that Tanner deduced have been broadly corroborated by subsequent surveys. Figure 5 presents the relationship between the percentage of income allocated to 'current' travel expenditure and income levels for the two years 1976 and 1977, taken from the Family Expenditure Survey results. (The first two income groups contain very few households, and the results in these groups should be interpreted with caution). 1976 income levels have been adjusted to a 1977 level using a series for the Retail Price Index (see Appendix). The pattern noted in Tanner persists in the latest figures - an initial rise in transport expenditure as a percentage of income, followed by a tailing off at high income levels.

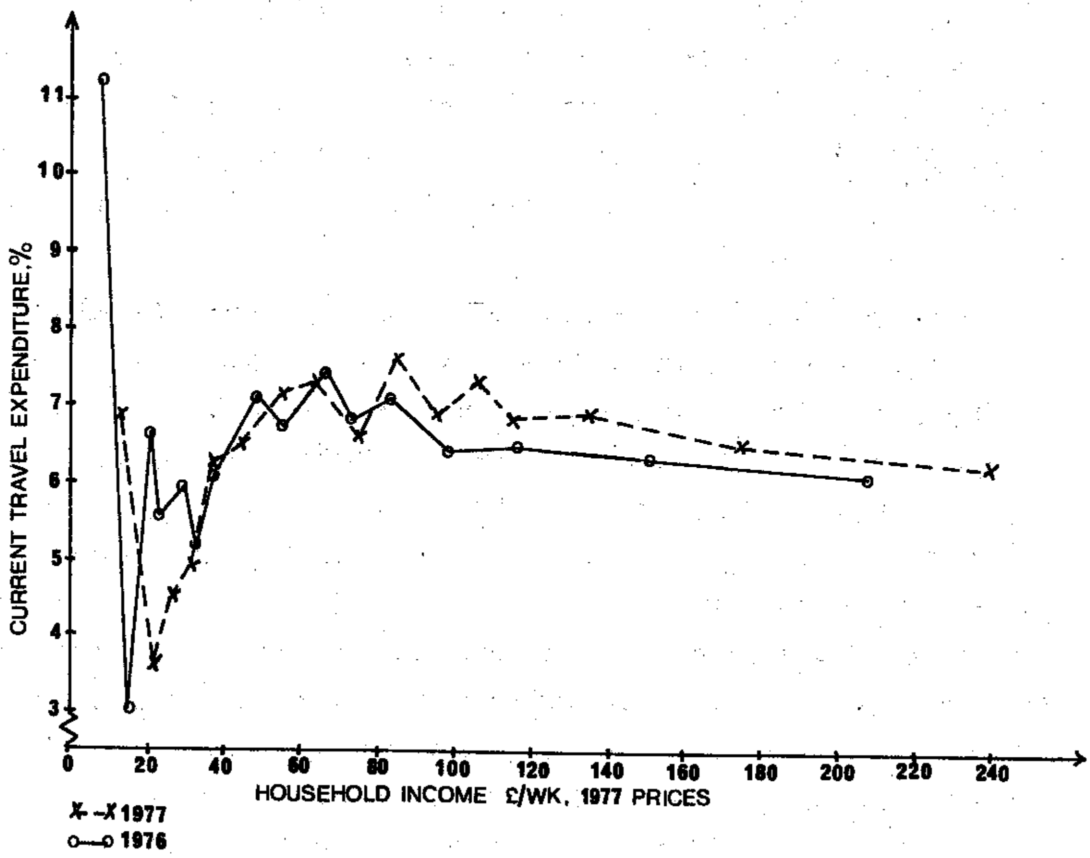

Figure 5. Household Income and Expenditure of Money on Travel

2.7 Figure 6 displays the relationship between total time spent travelling and household income, as found in the National Travel Surveys of 1966, 1972/3 and 1974/5, together with the same relationship from the County Surveyors' Trip Rate Data Bank for 1974 and the Reading Activity Survey from 1973. The actual levels from the last two surveys are not necessarily comparable with each other, nor with the N.T.S. data, in that neither were based on nationally typical samples. (The major difference in each case is the geographic coverage). However, the patterns are generally similar in all these surveys; as might be expected, time spent travelling increases with income level. There is some suggestion of a tailing off at high levels of income, as with the expenditure data in Figure 5.

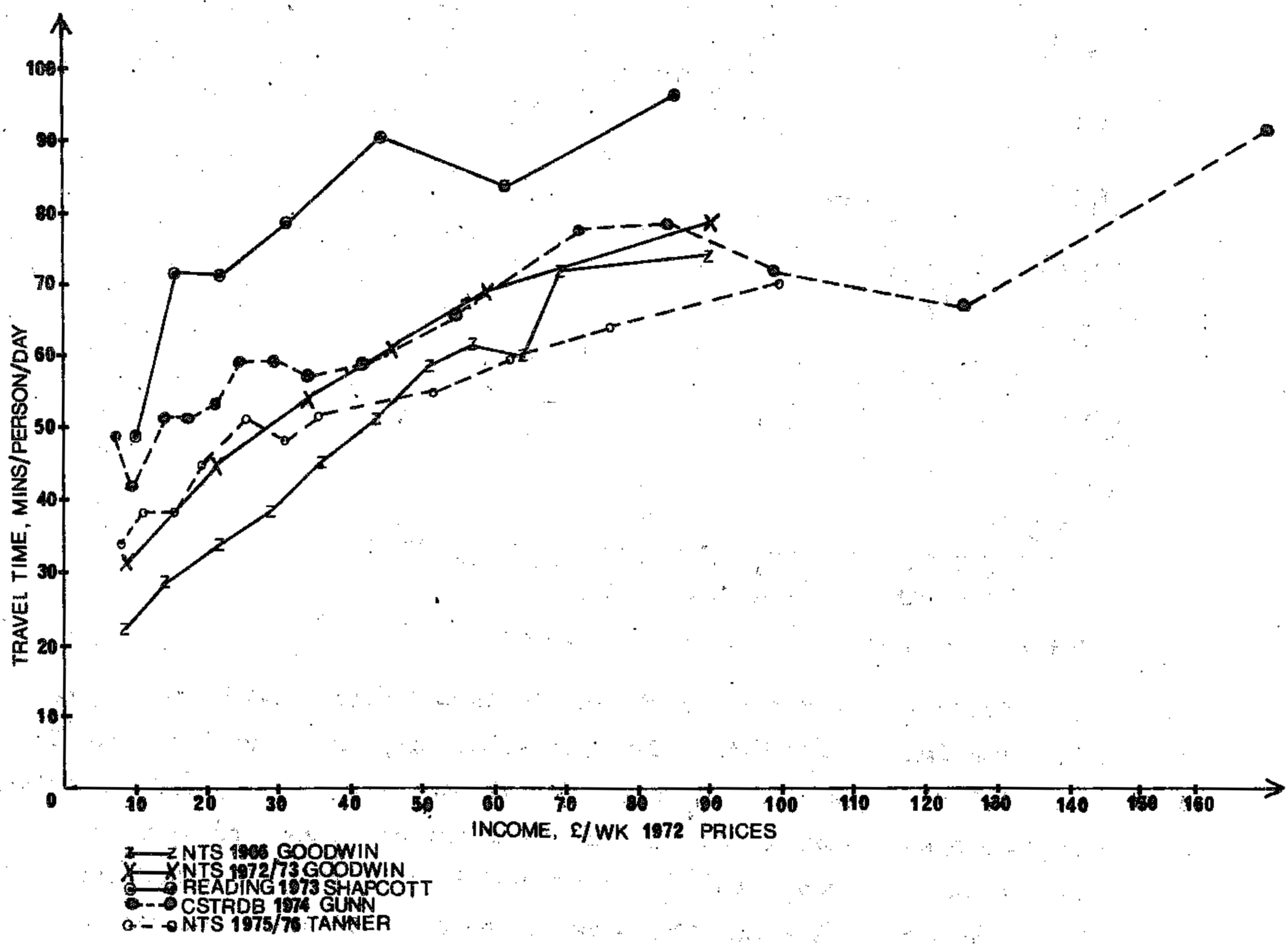

Figure 6. Household Income and Expenditure of Time on Travel

2.8 Figure 7 shows the relationship between time spent travelling and income per head, taken from the CSTRDB for 1974. Excluding the last income point, correcting income for household size seems to strengthen the direct proportionality of travel time with income over the range examined - i.e. up to about 100 minutes per person per day. Taking the last income point into consideration, there is evidence for a tailing off of the average time spent before this level.

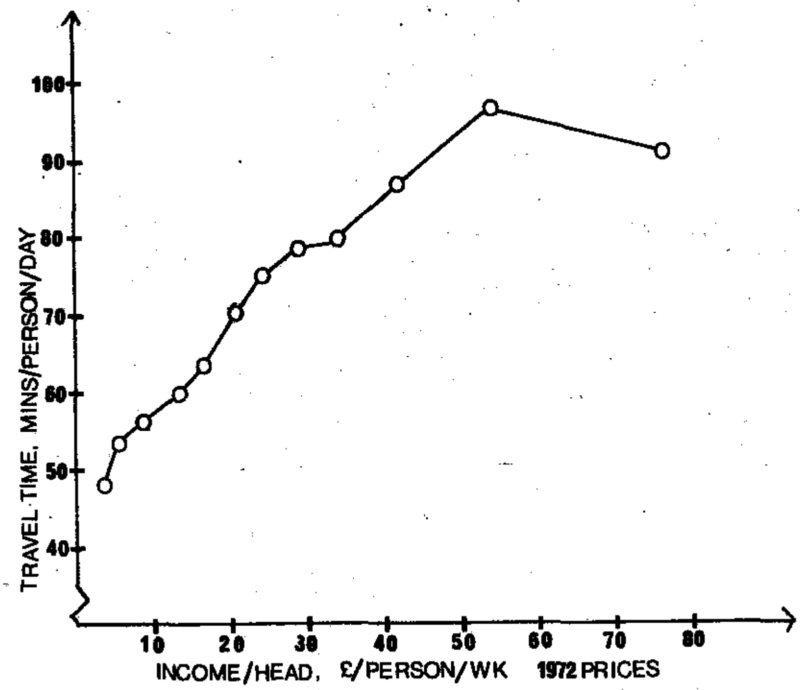

Figure 7. Income per Head and Expenditure of Time on Travel

2.9 The evidence for the variation in travel budgets with area types from the Family Expenditure Survey also broadly agrees with expectation on the basis of the relationships that Tanner deduced. Figure 8 displays the average expenditure on current transport costs as a percentage of income and of expenditure during '76 and '77, for the seven regions distinguished in the FES, and shows a general increase in allocation to travel costs rather less than proportional to mean regional incomes.

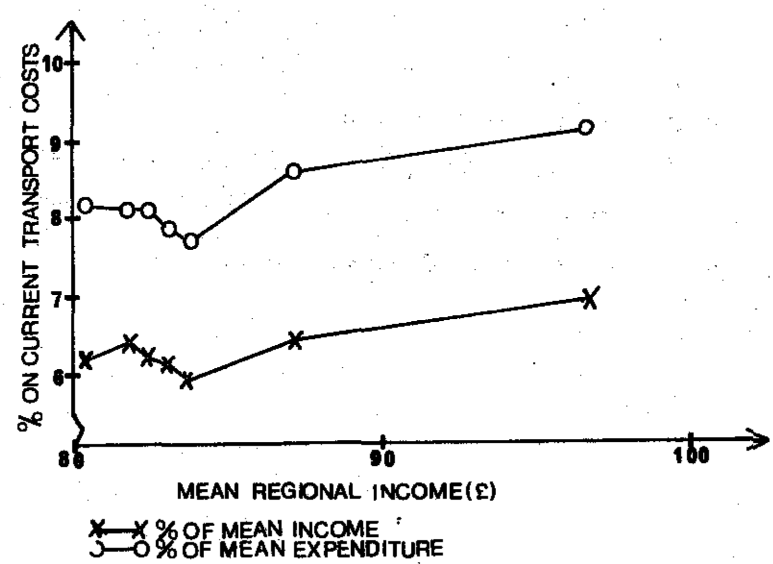

Figure 8 Mean Regional Income and Expenditure of Money on Travel

2.10 Figure 9 uses data given in Tanner (1975) and Goodwin (1975) from the National Travel Surveys of 72/3 and 75/6 to illustrate the relationship that has been found between total time spent travelling and population density (plotted on a log scale). Generally, density does not seem to affect travel time much, although of course no correction has been made for income differences in this data. The trend is one of slight increases in 'time' as density increases, similar to Tanner's results

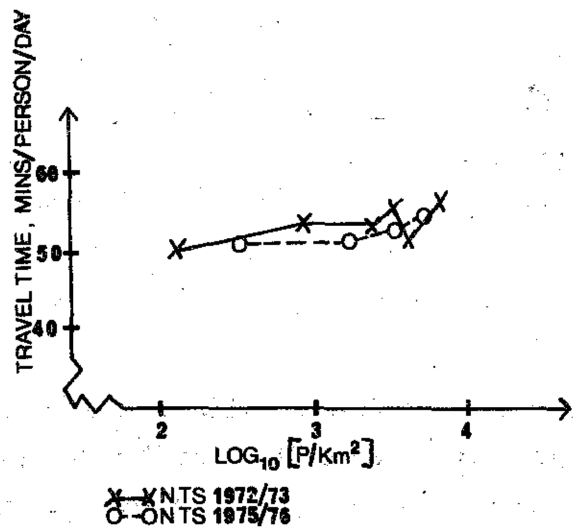

Figure 9. Gross Residential Density and Expenditure of Time on Travel

Figures 10, 11 and 12 use the information from the County Surveyors Trip Rate Data Bank to provide some more information about the variation of travel time between different locations.

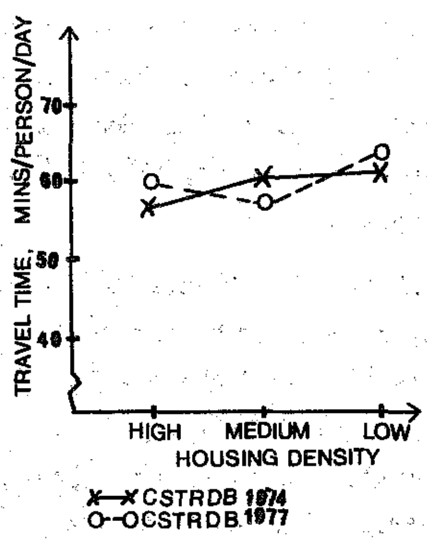

Figure 10. Housing Density and Expenditure of Time on Travel

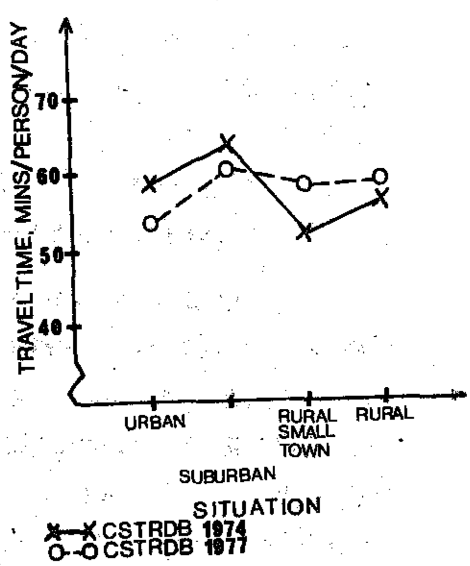

Figure 11. Area Type and Expenditure of Time on Travel

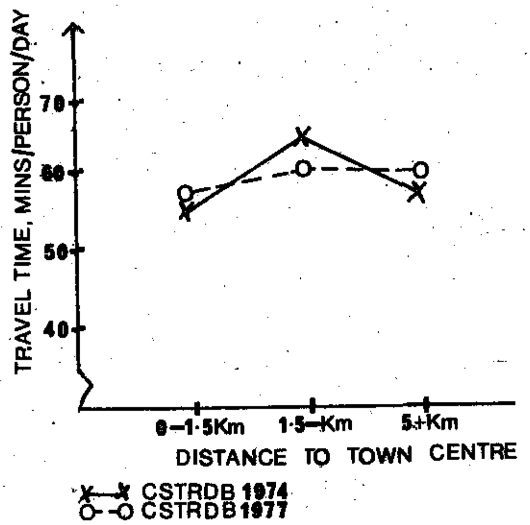

Figure12 Distance to Town Centre and Expenditure of Time on Travel

Once again, conclusions are difficult without correcting for income levels; however, ignoring this difficulty for the moment, Figure 10 could be taken to confirm that grouping areas by housing density, like grouping by population density, has little effect on average travel times with the high density group exhibiting the highest travel times and the low density group the lowest. Figures 11 and 12 on the other hand, suggest that a grouping on the basis of 'de-facto' area type might have more effect in showing up a systematic variation of average travel times with area type.

2.11 The process of linking the evidence for travel costs from national statistical sources to the information about travel from large surveys such as N.T.S. has been used by Tanner and Goodwin to allow the estimation of the money expenditure and the generalised expenditure on travel by individuals within different area types, where residential density is used to differentiate area types.

In brief, the trends exhibited in the 1953/4 data examined by Tanner persist in later surveys. There is a slight increase in travel times in areas with higher residential densities, whereas the trend is reversed for money expenditure. Weighting time spent by a 'reasonable' estimate of a behavioural value of time, and combining these two costs to a generalised expenditure suggests that the average generalised expenditures on travel of people in areas of different residential density are approximately equal. (Tanner (1979) and Goodwin (1975)).

Trends over time

2.12 Other than the evidence from the various large scale national surveys such as N.T.S., for which comparisons are made dangerous as a result of incompatabilities of definition and approach, virtually the only evidence for the trends in travel budgets over time has been produced by Tanner (1979), on the basis of estimates of expenditure, travel mileages and speeds by different modes. Figure 13 demonstrates the fairly steady increases that have taken place in the amounts of time, 'current' transport expenditure and total transport expenditure over a 23 year period.

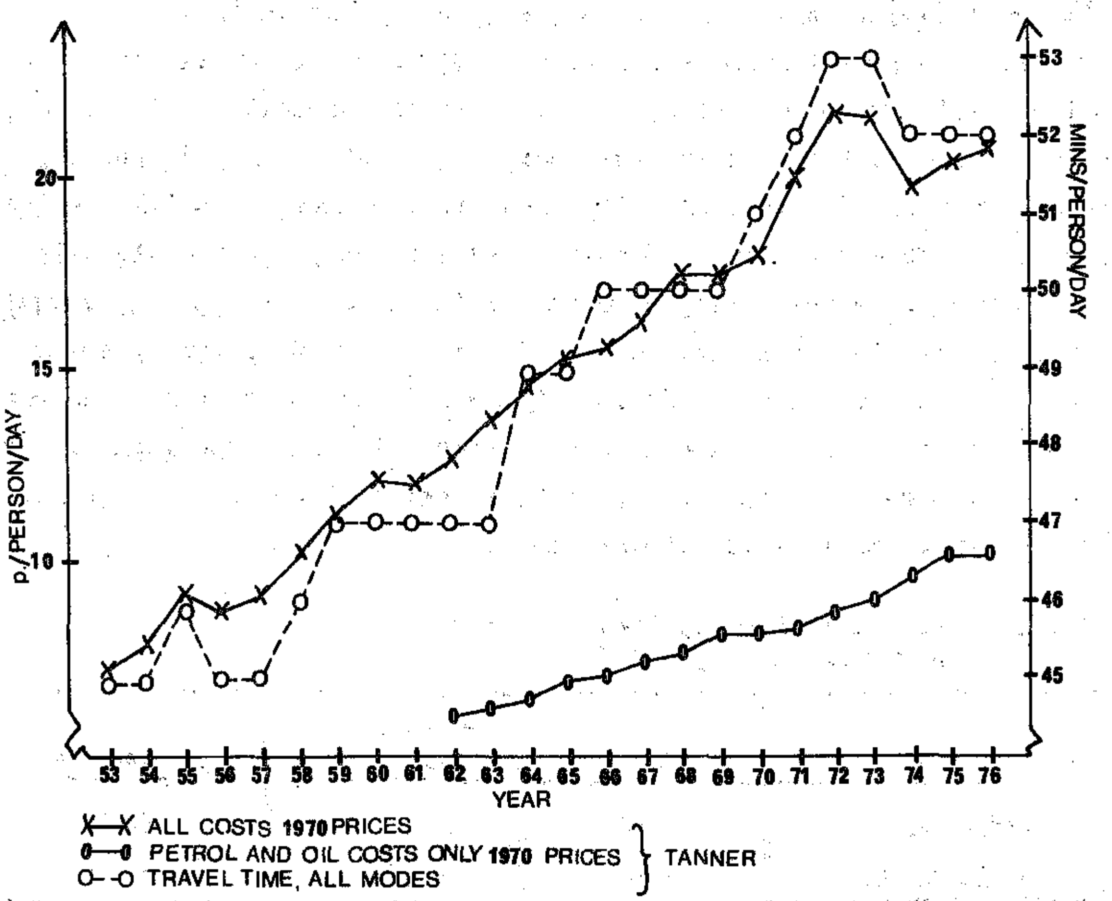

Figure 13, Trends over Time

The effect of grouping by person and household characteristics

2.13 Previous sections have presented the main body of evidence about overall variations in time and money expenditures on travel, as between areas of different residential density, between different income groups and over time. Analysis of the large scale travel surveys has revealed that there are many other factors which affect travel budgets. Most analysis of the influence of personal and household characteristics on travel behaviour has concentrated on time expenditure, principally as a result of the sparseness of evidence for money outlay on a 'per person' basis. As far as time expenditure is concerned, cross-tabulating survey results reveals large and systematic variations in travel time as between different age groups, different socio-economic groups, men and women and so on. (Shapcott (1977), Prendergast (1978), Williams (1978)). Heggie (1978) has suggested that an important consideration in determining individual travel behaviour is the 'stage in the family cycle' of the household to which the individual belongs. There is some conflict in the evidence for the effects of different factors, perhaps due to real differences in the areas to which the data refer in different surveys. Goodwin (1976) interpreted the NTS data from 1972/3 as demonstrating a variation in travel time for individuals in households with different levels of car ownership, after allowing for the effects of income. Bullock (1979), on the other hand, presents a table relating to the Reading survey (Table 1) which shows that, for this data, car-ownership appears to have little effect on time spent, although employment status clearly does.

Table 1 Total Hours Per Day Spent In Travel (survey in Reading, 1973)

	Men	Employed women	Housewives
With car	1.59	1.47	0.81
Without car	1.51	1.42	0.93

2.14 A difficulty with the interpretation of these results is that many of the background variables, such as income, age, car-ownership and household size, are closely interlinked and thus that it is necessary to consider all of the possible influences simultaneously in order to avoid attributing a single effect to each of a number of connected background variables.

2.15 A convenient solution to this problem is to use a dummy variable (least squares) regression to select the most suitable grouping by fitting only such effects (i.e. including only such background variables) as can be demonstrated to be statistically significant in the sense of being distinguished from zero at some chosen level of significance. There are still some difficulties with this approach, in particular in the measurement of standard errors being based on an assumption of constant variance in each group and consequently being more or less approximate, and also in the choice of model specification, in that it is difficult to fit all possible interaction terms so that a choice must be made as to which to leave out. However as a tool for exploratory analysis these are not serious problems.

2.16 Such an analysis has been performed on the CSTRDB for 1974. The total travel time reported by 10280 individuals was modelled as a function of sex, age, job, household situation, household car-ownership and household income per member. Table 2 sets out the groups that were defined using these variables - a star indicates the group relative to which the effects of other groups were measured, so that the constant in the regression is the fitted average travel time for males, aged 25-59 years, in a non-professional occupation, in households with income per member between £750 and £1,500, located in central urban areas and owning one car. The various alternative grouping to this were judged to be 'favourable' or 'unfavourable' in terms of having higher or lower average travel times; these are labelled 'F' or 'U' as appropriate. The model specification then included all first and second order interactions, the 'F' group, and the 'U' group; dummy variables were also included to measure the effect of day-of-the-week variation. The final model was as set out in Table 3.

Table 2 Basis of Model

Variable													
	Sex		Age		Occupation		Income/ person		Location		Car-ownership		Day
*	Male	U	5 - 16	*	Non-prof.	U	Low	*	Urban	U	0 Car	*	Mon.
U	Female	F	17 - 24	F	Prof.	*	Med/low		Suburb	*	1 Car		Tues.
		*	25 - 59	U	Other	F	Med/high		Small town	F	2+ Cars		Wed.
		U	over 60			F	High	U	Rural				Thurs.
													Fri.

(For exact definitions, see Gunn (1979)).

Table 3 Fitted Coefficients (all statistically significant at 95% level).

Variables		Co-efficient	Interactions	Co-efficient
Sex	Female	-8	17.24 x Prof.	-17
Age	5 - 16	-8	2+ cars x Prof.	+11
	17 - 24	+15	2+ cars x high income	+3
	over 60	-11	Female x (old or young)	+6
Occupation	Prof.	+13	Female x rural	-5
	Other	-13	17.24 x Prof. x 2+ cars	-35
Location	Suburb	+3		
	Small Town	-7		
Income	Med/high	+8		
	High	+20		
Day	Wed.	+5		
	Thurs.	+6		
	Fri.	+14		

Constant = 66 R^2 = .083 S.E. of estimate = 57.7

(Thus, for example, the expected Monday travel time of a 23 year old professional male from a suburban household with medium/high income per head (income levels as defined in Gunn (1979)) and less than 2 cars, can be calculated as

$$(66 + 15 + 13 + 3 + 8 - 17) = 88 \text{ minutes})$$

The CSTRDB refers to a sample of households which was specially selected in areas of particular interest for trip generation reasons, and as a result is atypical of the national distribution of households by area type. (Coverage also omits virtually all of the South Eastern region of England). However, if it can be assumed that the bias is solely due to area type, and that area type can be reasonably described by the classification into urban central, suburban, rural small town and rural, then this atypicality of the sample frame will not invalidate the results as stated, since explicit allowance is made in the model for area type.

Table 3 indicates the relative importance of the effects that have been listed above. Age group, income level and occupation type emerge as the most important categorisations, all producing ranges of variation of about 20 to 25 minutes travel per day as between the most active and the least active group in each category. There is an interaction term between age and occupation; individuals who are members of the most active groups on both categorisations do not travel appreciably longer than members of just one or other group, all other things being equal. The largest coefficient in the model refers to the fairly small group of individuals in the most active age group and occupation type who also are members of households which own two or more cars; this group exhibited higher travel times than the base (assuming that they all also belonged to the high income group) but only an amount higher roughly comparable to members of any one of the most active groups, all other things being equal. This effect is equivalent to a 'saturation' phenomenon; Goodwin (1973) has suggested models of travel time based on s-shaped curves between the upper and lower 'saturation' levels.

Apart from these effects, the regression equation also indicates that women travelled for less time than men, on average, and that women in rural households travelled lesser amounts again. In general the effects of location were much smaller than the effects of personal or household characteristics, with the pattern of figure 11 above persisting even after the removal of the other effects. Travel per head was least, on average, in small towns, and most in suburbs; there seems a simple interpretation in terms of accessibility.

No firm conclusions can be drawn on the basis of this exploratory analysis alone, but the general results are in agreement with similar exercises, and it is interesting that there is no justification for a categorisation into car-ownership groups, after allowance has been made for the other effects, as appeared to be the case for Reading. (However, it is likely that a categorisation by actual car availability would be more effective. Similarly there is scope to explore different definitions of the income and occupation categories. These modifications are the subject of current research).

The time series estimates of travel time per head derived by Tanner show a steady increase from 1953 to 1976, to about 15% above the 1953 level. The simple cross-sectional model could only accommodate such a trend *if there were corresponding changes in the percentages of* the population in the groups which have been identified as having distinct different average travel time characteristics, with a net movement into the more active groups.

It is clear that some changes have taken place which might tend to produce higher average travel times under the simple cross-sectional model - growth in real incomes being probably the most important, with changes in the percentages of population as between occupation groups and between different age groups also quite marked.

Table 4 sets out the changes in percentages of UK population in the male/female, age, income and employment categories that were distinguished for the preliminary analysis of the CSTRDB, as between 1961 and 1976, together with the weights or co-efficients which would determine the effect on average travel times according to the model.

Table 4 Percentages of Population in Different Categories: 1961 and 1976

United Kingdom	1961	1976	% ('61-'76)	Weight	Effect
Sex					
Male	48.3	48.4			
Female	51.7	51.6	-0.1	-8	+0.8
Age					
5-14	16.6	17.5	+0.9	-8	-7.6
15-24	14.5	15.5	+1.0	+15	+15.0
over 60	18.6	21.2	+2.6	-11	-28.6
Income					
Med/high*	7.2	19.7	+12.5	+8	+100.0
High*	1.3	3.7	+2.4	+20	+48.0
					+127.3

*Converted to the equivalent of £1,500-£2,500 and > £2,500 in 1974 prices by deflation by the RPI.

It may be seen that the three factors considered here would imply an increase in average travel time of just over one minute, if all other factors were equal. This is much lower than Tanners estimate of a 5 minute increase in average travel times over the same period, but it should be noted that it is likely that the income effect is considerably under estimated; the CSTRDB is biased towards suburban households. The four broad income bands chosen to analyse income effects within this data set are clearly unsuitable for national purposes; the medium-high and high categories contain together only 9% of the 1961 households, and 23% of the 1976 households. It is unclear what effect trends in occupation type would have, but here again the three categories used for the exploration of the CSTRDB would certainly not be the most suitable for a national analysis.

However, this exercise does serve to illustrate some interesting trends in the national average travel time, if the CSTRDB weights are at all reasonable. Firstly, the variations in the percentages of males and females in the population are trivial at a national level. Secondly, the aggregate effect of the shifting proportions in the different age groups has tended to <u>decrease</u> average travel time, mainly as a result of the increased proportion of over-sixties in the population. Lastly, even with the evidently sub-optimal choice of income groups (for this purpose) it may be seen that the most important changes by far have been in the levels of real incomes, and that the net effect of all these changes has been to produce an increase in average national travel time.

There may be scope for exploring models similar to the one described above, and perhaps for considering incomes relative to travel costs rather than to the Retail Price Index, or even allowing changes in real travel costs to have an effect distinct from changes in real incomes.

3. EMPIRICAL EVIDENCE FROM OTHER COUNTRIES

The data from countries other than the UK derives mostly from specific case studies, rather than from large national surveys. As such, virtually all the data relates to small regions, and usually to cities. Although there is no scarcity of such case studies, very few record all travel; most are concerned with 'mechanised modes' (i.e. excluding walk and cycle trips) and many deal only with private vehicle trip making. Goodwin's analysis of the N.T.S. has demonstrated that walk and cycle trips account for something like 50% of all travel time in the UK, and further that there are systematic differences between the amounts of time allocated to such travel as between areas of different residential density. Even though it seems that there have been no important trends in time spent walking and cycling in the UK, at least at the national level (Tanner (1979)), the Reading data analysed by Downes and Wroot (1974) do suggest that it is necessary to consider these modes for the interpretation of time series data as well as for cross-sectional data, in that there was evidence of a compensating reduction in time spent walking and cycling which offset apparent increase in travel time based on mechanised modes alone.

3.2 Clearly the proportion of overall travel time spent walking or cycling varies from country to country, and from area to area within any country. In some countries it may be perfectly reasonable to neglect these modes altogether. However, it seems dangerous to assume that trends and relationships based on travel by mechanised modes alone can be given any general 'behavioural' interpretation. For the purpose of drawing comparisons between travel in different countries, or even different regions, it seems necessary to include all modes; this drastically reduces the amount of data that are available for consideration.

Travel expenditure

3.3 Individual differences in income levels and distribution, and the 'costs' of travel by different modes, as between different countries make detailed comparisons of money expenditure on travel difficult. The data presented by Morris and Wigan (1978) for Australian households, for example, illustrates that expenditure on travel is directly related to household income, but as a percentage of either income or total expenditure is lowest in the lowest income groups and highest in the middle income groups. This is the same pattern as is revealed by the data analysed by Tanner and Goodwin for the UK; however, the absolute levels of expenditure are very different, with Australian households spending a far larger proportion of their income on travel than UK households.

3.4 Oi and Shuldiner (1962) report an analysis of household expenditure on travel based on three surveys of US cities made in 1917/19, 1935/6 and 1950, which discovered the same pattern described above in the relationship between percentage expenditure on travel and overall expenditure. Interestingly, they also demonstrated that there was evidence for a time trend of increasing travel expenditure over and above that to be expected on the grounds of increasing real wealth, and strengthened this conclusion by further analysis of time series data relating to the period between 1929 and 1957; this is in agreement with Tanner's conclusions for the UK.

3.5 Oi and Shuldiner then examined the variations in travel expenditure between different cities, and different areas. By analysing travel expenditures in conjunction with housing expenditures, they conclude that there is evidence that an 'adjustment process' takes place, in which 'higher income families move to locations where the rent per unit residential space is lower. Such an adjustment usually entails a considerable increase in travel demand...' They also concluded that residents of 'small' cities spent a larger proportion of their income on travel than did residents of 'large' cities, even when expenditure on public transport was similar. (This would also be true of overall 'travel consumption' since vehicle operating costs per mile did not vary much between cities).

Travel Time

3.6 Godard (1978) reports an extensive analysis of data from repeat surveys carried out in French Cities. The data relates to all travel, excluding travel by children under 5 years old, on weekdays, and comprises a single days travel for each respondent. The timing or duration of the surveys is not recorded, unfortunately. Figure 14 displays the overall variations in Travel Time per person for each of 7 cities taken from the report. Godard concludes that there is no constancy of travel times as between different cities (as had been suggested by Zahavi (1977)) and further, that for any given city "the Travel Time Budget can hardly be regarded as stable over a period of time, unless a margin of 10% to cover possible survey errors is considered acceptable".

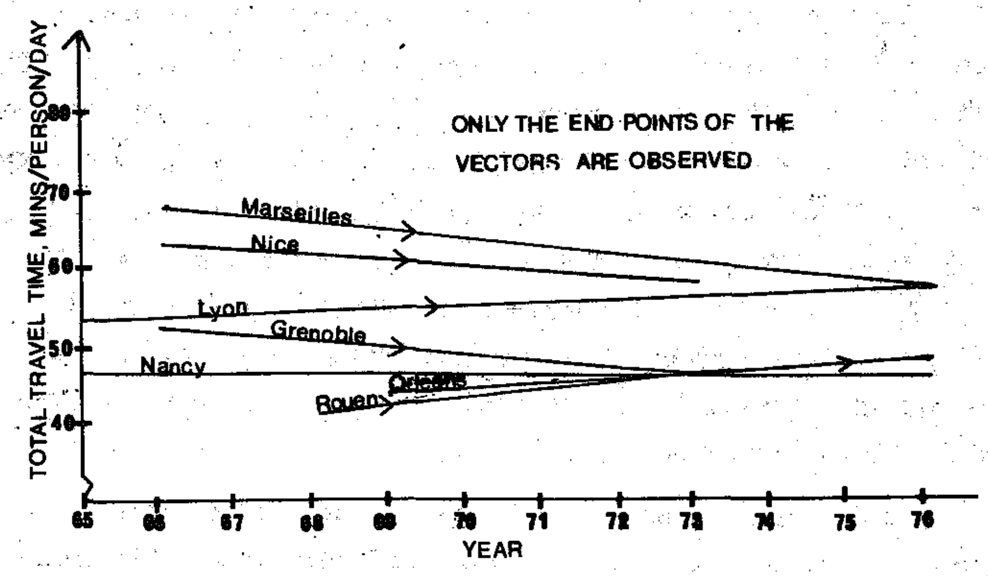

Figure 14, Changes in Average Travel Time in Various Cities between Different Periods

10% may well be a realistic 'survey error' if the surveys were carried out at different times of the year, given the evidence for the considerable seasonal variations that characterise travel. However, the actual variations in the trends for the cities are about 10%, some increasing and some decreasing, one remaining virtually constant. This could result from a 5% survey variation, not 10%, since the error would attach to both surveys. This seems to lessen the force of this evidence as counter-example to the temporal stability hypothesis. At any rate, no allowance has been made for changes in real incomes, or any of the other background variables which affect travel behaviour, so nothing can be inferred about the stability or otherwise of personal travel budgets, defined as the average travel times of homogeneous groups of individuals.

3.7 The variations in two of the cities, Marseilles and Rouen, are analysed in more detail, with some surprising results. In Rouen the overall average travel time in 1973 was virtually identical to that in 1968, although there had been sizeable (and offsetting) changes in trip rates and average trip times. There had also been some increase in the % of respondents who make trips on the day of the survey; (in fact the travel time budgets of travellers, as opposed to all respondents, varied even less). However, when the data were grouped by such background variables as age, sex, employment status and household size, offsetting trends and variations as between personal travel time budgets in the two years became apparent. The different car-ownership groups, on the other hand, had retained individually constant time budgets. The need to treat the mass of related background variables simultaneously has already been noted, but there does seem to be indication of a lack of stability in personal travel time budgets which might suggest that the resulting 'constancy' of the overall average is co-incidental.

3.8 In Marseilles, on the other hand, average travel times in 1976 were markedly different from those in 1966. A 15% decrease was observed in the overall average, and the decrease in travel time amongst trip-makers was even more pronounced. The decrease in travel time coincided with slight increase in trip rates and a marked reduction in average trip times. Interestingly, the reduction in average times was not linked to improved network speeds, but to the combination of a shift from public transport to cars and a reduction in the numbers of workers returning home for lunch. Godard concludes that the evidence of the Marseilles surveys "raises serious doubts as to the validity of the stable Travel Time Budget concept.."

3.9 Further analysis of these two cities reveals relationships very similar to those found in UK data sources. Travel time is closely related to income level, but at the highest income levels there appears to be a reduction. Age, sex and occupation differences have similar effects to those found in UK surveys; in general, Godard found that personal characteristics were more strongly correlated with travel time than were household characteristics. The different car-ownership categories also showed clear differences in travel times, with average times increasing with the number of vehicles owned. However, as Godard notes, car-ownership is strongly correlated with income, and it may be that a single effect is being attributed to each. It is interesting that the category of people in households owning three or more cars in the Marseilles survey showed lower travel times than those in the two-car-owning group. This may correspond to the down-turn in travel times at the highest income levels.

3.10 Collecting the results of a number of other recent surveys in French cities, Godard concludes that there is no evidence of any constancy of travel times for different cities, and that in general the Travel Time Budget tends to increase with urban size. Oi and Shuldiner had concluded that the distances travelled were greater for citizens in the smaller of the American cities that they studied; this trend may simply not hold in French cities, or the effect of city size on congestion and thereby speeds may offset the reduced distances travelled. The time spent walking or cycling would also complicate the comparison since Oi and Shuldiner were considering only mechanised modes. Godard rejects the hypothesis that travel time budgets vary with distance from the city centre, based on the evidence of the Marseilles and Rouen surveys.

3.11 The differences in average time allocated to travel between different cities is further illustrated by the results of surveys held in two Australian cities, Melbourne and Albury/Wodonga in 1974. These surveys are discussed in Morris and Wigan (1979); at the level of overall daily average travel times, Table 5 may be compared with Table 1 to illustrate the similarity of the patterns, inasmuch as men travel for longer periods than women, and employed women travel for longer than housewives, for both of these cities and for Reading. However, the average times are all much lower in the smaller city, Albury-Wodonga; in fact they are only about $\frac{2}{3}$ to $\frac{3}{4}$ of the average times in Melbourne. This is the same trend as was found in the data relating to French cities.

Total daily travel (minutes)			
	Employed males	Employed females	Housewives
Melbourne	91	83	53
Albury-Wodonga	62	54	41

Table 5 Travel Times by Sex and Occupation: Australian Data.

3.12 Information on travel budgets within the context of overall activity time budgets was collected for the Netherlands in 1975 (NVI (1978)). During the month of October, approximately 1100 people recorded their activities over an entire week. Using the resulting data, the NVI estimated the overall average daily travel time at approximately 70 minutes. It was concluded that car-ownership or availability was not an important influence on travel time budgets in this data set. This result was based on an analysis using a technique designed to select groupings on the basis of maximising explanatory power at each stage of a number of binary splits (A.I.D.). This technique selected divisions which broadly correspond to employed/not-employed as the first stage, and then division of the unemployed into schoolchildren and others, and of the employed into occupation type. The degree of urbanisation was also an important grouping variable. Having removed these effects, car ownership did not affect travel times. The relationship between travel time and city size which has been found in French and Australian cities also holds in Holland; in general, travel times are longer the larger the city. The authors of this report also attribute this result to congestion effects.

3.13 Up to this point, we have deliberately excluded from consideration all information on travel times and expenditures which did not relate to all people, whether or not they reported any travel, and to all modes, whether or not they entailed money expenditure. This was due to the difficulties in the 'behavioural' interpretation of a theory which postulates predictable travel per traveller whatever changes might take place in the proportion of the population which travels on any given day; it simply seems so much more likely that a restriction on the number of days in the week on which travel is undertaken will result in a desire for more travel on the remaining days, and that the decision or ability to spread activities involving travel over more days of the week will tend to produce less travel per traveller per day. The difference between the travelling population and the total population is slight in many cases (depending on the time period considered and the definition of travel used, as Goodwin (1978) has observed), but in general restricting attention to the travelling population alone does seem somewhat arbitrary. At the same time, if the proportion of non-travellers is fairly stable in the population, the distinction becomes unimportant.

3.14 The highly original modelling work of Zahavi has been based on the assumption of predictable time budgets per traveller and predictable money budgets per household (given information on incomes and vehicle ownership). In view of the importance of this work, it is interesting to compare the nature of the relationships that Zahavi has discovered for these budgets with those displayed by the budgets per person described above.

3.15 Firstly, it is to be noted that Zahavi restricts his theorising and modelling to perceived time, not to actual time. Working with this definition, from an analysis of travel in Washington and in Twin Cities in each of two years, he has deduced that travel time (per traveller per day, and by mechanised modes only) is inversely related to door to door speeds, flattening out to around 61 minutes travel per day at high speeds. Distance from the city centre did not significantly affect average travel times, nor did household size or car availability. Evidence from a 'before-and-after' study of a region in which a high speed freeway was provided is used to suggest that the main change in travel patterns to result from improved speeds is that distances travelled rise in proportion to the speeds - as would be suggested by the approximate constancy of the travel time budgets at high speeds found in Washington and Twin Cities. In contrast to the UK experience (Figure 1), Zahavi has found that the % of disposable income allocated to travel, at a country level, has remained virtually constant for both the USA and Canada, over a 15 year period; this constancy concealed a compensating variation in the allocation of money to 'running' costs and 'standing' costs of vehicles following the oil crisis - a phenomenon subsequently confirmed to have occurred in the UK by Mogridge. Zahavi emphasises that considerations for travel money budgets should distinguish car-owning households from non-car-owning; he finds that both exhibit stable travel budgets as between different income groups, locations and years (which Mogridge did not, for UK data) but that the absolute levels are very different, as is true in the UK.

4. AIMS, THEORY AND METHODS

4.1 A brief sketch of the various areas of research which directly concern the use of travel budgets was given in section 1.3, where three sorts of area were distinguished. Firstly, it has been suggested that direct forecasts can be made of the 'amounts' of travel (in distance, time, cost or generalised cost terms) and that these forecasts could be used as control totals, overall constraints determining travel patterns; secondly, in direct contrast, many writers have concluded that it is not realistic to attempt to forecast travel behaviour in isolation from activities in general, and that all features of travel should be considered simultaneously with the activities with which they are associated. Godard (1978) writes "any attempt to develop explanatory systems will need to include mechanisms for determining activity schedules and the interaction between opportunity and trips undertaken". Morris and Wigan summarise the point, "Almost all transport movement is a derived demand, as comparatively little movement is undertaken simply for its own sake. The activities at the end of - and in some cases during - travel are the causal factors which determine the direction, intensity, pattern, timing and demand for travel of different types". (Morris and Wigan (1979)). To some extent, travel budgets are only incidental to such a modelling approach, although there would be implications for the feasibility of different travel patterns in any regularities that could be established in the budgets, and the overall activity analysis would have to consider these. The activity analysis approach illustrates clearly the complexity of the causes and constraints which determine travel behaviour at the level of the individual trip-maker, and highlights the limitations of direct forecasts of travel demand in terms of 'stable' trip rates (Jones (1974)); however, the price of the additional realism that the approach offers is that it is extremely difficult to devise model frameworks that can be made to work in practice. (Hautzinger and Kessel (1977)). An interesting attempt to link activity analysis considerations to conventional modelling procedures is reported by the N.V.I. (1978). This exercise linked forecasts of time spent in activities to time spent travelling associated with activities, and then forecasts of trip frequencies to total travel times;

however, it was discovered that each stage in the chain of linkage was fairly weak (and of course the resulting product of the stages even weaker).

4.2 The third area of research that was identified in section 1.3 concerned the development of idealised theoretical representations of travel, based on a few simplified assumptions; the interpretation of the implications of these theories for travel budgets casts interesting light on the nature of the processes by which 'stable' travel budgets could come about. The remainder of this section will deal with the first and third of the areas mentioned above; the activity analysis approach will not be considered further here, since it has not been developed to exploit the possibility of direct forecasts of travel budgets.

4.3 The first reported model structure to be based on forecasts of amounts of travel was put forward by Tanner (1961), using the regularities he had found in average distances travelled by urban and rural dwellers (section 2.4). The result was effectively a singly constrained gravity model, in which the constraints usually provided by a trip generation sub-model on the numbers of trips produced by each of a number of zones were replaced by a direct assessment of the distances travelled by the residents of each zone. (In fact, this was taken as a constant mileage per head times the zonal population). In the form stated in the early paper, Tanner restricts himself to population as a measure of zone 'size' or attractive power, and distance as measure of separation, but points out that these may be varied if necessary with little or no change to the basic model; thus time, cost or generalised expenditure could replace distance if direct forecasts of these quantities were available, for example. The assumptions underlying Tanner's model were that a) the flows from one zone to another could be represented as the product of a unique origin zone factor, a unique destination zone factor (taken as population size in the example) and a deterrent function based on some measure of the separation of the two zones (taken as distance in the example) and b) that the total distances travelled by trip-makers leaving the origin zone were determined outside the model. These assumptions were sufficient to determine a form for the number of trips taking place between any two zones in terms of the populations of the set of zones under consideration and the distances between each zone pair.

4.4 Another model based on forecasts of 'amounts' of travel rather than numbers of trips was suggested by Halder (1970); in this paper it is assumed that the appropriate measure of zonal separation is the cost of travel between zones and that the 'amounts' of travel that are determined outside the model are the total costs of trips leaving each zone, and the total costs of trips attracted to each zone. These two quantities are given economic interpretations. The first is associated with "the demand for transportation" and the second with "a measure of the power ... to satisfy the primary needs of the community". Given these two sets of forecasts, the final assumption which produces the model is that any set of individual trips which is compatible with the total expenditure on travel that is forecast is equally likely; every set of individual trips produces some matrix of trips between zone pairs, and a given matrix of trips may arise from more than one set of individual trips. On this assumption, the modeller should choose the 'most likely' matrix of trips, i.e. the matrix which arises from the greatest number of feasible sets of individual trips, on 'entropy-maximising' grounds. This criterion allows Halder to produce a particularly simple model of flows between zones which, he argues, will be very similar to those produced by a conventional doubly-constrained gravity model - were the trip ends known. Thus it is suggested that there will be little differences between this model and conventional models when fitted to base year data; the main difference is that the forecasts which must be made outside the model are of different quantities; quantities which, it is argued, can be more reliably forecast than trip ends.

4.5 Both the Tanner model and the Halder model were produced by direct analogy with gravity model formulations, the first deducing a model from a chosen general model form and suitable constraints, the second using the constraints in conjunction with the 'maximum entropy' criterion to select a suitable model. A third approach can be suggested immediately, following the work of Kirby (1974), using maximum likelihood methods to estimate parameters within a general model form from the available data. This approach would clearly be much more flexible than the other two, and could make use of numbers of different data sets quite simply (assuming that these were independent). For example, the general 'gravity model' form for interaction data could be fitted given independent estimates of any or all of trip ends, travel budgets and specific trip interchanges (whether the last formed a complete interaction matrix or not).

4.6 In the model forms described above, travel budgets are preserved at a zonal level by suitable choice of the numbers of trips making specific trips between zone pairs. The theory has been developed without reference to differences in trip purposes (and hence zonal 'attractiveness' and 'productiveness' for trips) or to mode choices. Further, subsequent travel from the destination zone is not tackled. Whether or not the general framework of any of these models could be adapted to deal with more complex and realistic situations, no practical applications have been discovered in the literature.

4.6 In contrast to these approaches, which simply re-define travel demand in terms of 'amounts' of travel rather than numbers of trips and then alter fitted trip distribution patterns to conform with the estimated demand Zahavi (1977) has proposed a theory of travel behaviour which is radically different to that underlying conventional models, based on the concept of predictable (though not generally constant) travel budgets. Put at its very simplest, Zahavi's model assumes that the speeds and costs of travel by the different possible modes, together with the income distribution in the population, determine car-ownership levels and travel budgets - in terms of money and time to be allocated to travel. Within these budgets, people will allocate their time and money resources to travel by different modes in such a way as to attempt to maximise their 'spatial opportunities' as measured by distance travelled. By so doing, they may impose demands on the network which alter network speeds; if this occurs, adjustments will take place in the levels of motorisation and travel budgets, and thus in speeds also, until an equilibrium is reached at which travel 'demand' (as given by the budgets) is compatible with system 'supply' (as characterised by network speeds). Forecasts for any given circumstance are thus made on the basis of forecast populations, income distributions, mode costs and networks, and general relationships between these and car ownership, travel budgets and network speeds; at the equilibrium point the model produces distances travelled by each mode, and speeds, together with car-ownership, all compatible with the forecast circumstances.

4.8 Zahavi's model has been devised to describe urban travel behaviour, at a highly aggregate level. It does not differentiate between trips for different purposes, nor in different locations; as such, it cannot be used to supply the sort of information that the conventional transportation models provide, and is not in direct competition with these models; in fact, in an early paper Zahavi sees it as having an almost complementary role. "In no way does the new proposed procedure replace the current comprehensive and sophisticated traffic models. It is a macro-tool only, for rapid estimation and evaluation purposes. After assessing many alternative planning policies and options, and establishing control totals, part of the present traffic models will have to be applied for a micro-evaluation of the components of the planning alternatives". (Zahavi (1973)). More recent developments of the model have been directed towards producing more specific information such as trip rates and loadings on different parts of the network (Zahavi (1977)).

4.9 In contrast to the general approach which uses travel budgets as a control on trip distribution, preserving the budget constraints at a zonal level without reference to individual trip making, Zahavi's model applies the budget constraints at an individual or household level. The mechanism by which the budgets are preserved is the individual (or household collective) choice of distance to travel by each mode.

In order to maximise 'distances' all travel decisions would have to be taken simultaneously - i.e. planned in advance. In reality, of course, the traveller will have no option but to make certain trips - for example, to work - and may well have little choice of mode in many cases. Also, the relative locations of the various possible alternative destinations will affect the distances he will travel. At any time, then, it is to be expected that actual travel will be more or less at variance with the model predictions of 'distance maximising' travel. Zahavi hypothesises that the resulting "disequilibrium is one of the major forces that can change urban structure". (Zahavi (1977)).

4.10 All of the approaches described in this section have been based on the assumption that details of an individual's travel behaviour are affected by the total amounts of travel he performs, implying that the travel budgets in some sense are determined prior to actual travel. This hypothesis was suggested on the basis of empirical evidence which pointed towards a relative constancy of average travel budgets for similar groups of individuals in different locations. Later evidence points towards fairly regular and stable relationships of the budgets with such variables as network speeds and income levels, rather than any universal constancy, and to considerable variation between individuals within any group; however, the suggestion is still made that budgets can be predicted in isolation, and used to condition predictions of detailed travel patterns. Two of the major researchers in this area, Tanner and Goodwin, have questioned the logic of this deduction, and constructed simplified models of travel to demonstrate that reasonably stable budgets could arise even when travel behaviour is not explicitly constrained to reproduce them.

4.11 Tanner (1979) rejects the idea of constant time budgets or constant money budgets out of hand, as being in conflict with rational economic behaviour (Zahavi's later formulations of the budgets as relationships rather than constants supports this view). By considering a suitable general expression for demand for travel as a function of mode costs (in money and time per unit distance) and income, Tanner demonstrates that a hypothesis that "total generalised expenditure by all modes, in hours per year, is independent of income" would also be consistent with fairly stable time budgets.

4.12 The hypothesis that 'generalised time' spent on travel might be taken as a constant, independent of income, was first made by Goodwin (1973), on the basis of empirical evidence taken from the 1965 National Travel Survey. Goodwin estimated the values of time that would be required to explain the observed travel time and travel money budgets of the different income groups under the 'constant generalised time' hypothesis, and found the results to be reasonable when compared with values of time estimated in other ways from different sources.

4.13 Goodwin (1973) has also constructed a detailed, if idealised, representation of urban travel by combining a 'utility-maximising' approach with a simplified description of an urban area in terms of continuous functions. He concludes that "the total time spent on travel is probably not a constant (though it is considerably more stable than some other indicators)".

5. SUMMARY, CONCLUSIONS AND COMMENTS

5.1 The review of empirical evidence led to the following conclusions:

(a) at an individual level, the amount of time spent on travel is highly variable; typically, standard errors are only slightly less than the mean values.

(b) at an aggregate level, both time and money expenditures on travel are strongly related to income levels. Time spent per head increases roughly proportional to disposed income, and money expenditure rather faster (see Goodwin (1973)).

(c) At an aggregate level, in addition to income, the variables age, sex, employment status and probably location affect mean travel times; some data sources indicate differences in travel times in different car-ownership groups also, but these are almost certainly less important. There is evidence of a 'saturation' effect; travel times only increase up to some limit. (Goodwin has suggested approximately 90 minutes).

(d) At a national level, there has been a steady increase in the overall proportion of income or disposable income allocated to travel, at least over the last 25 years, in the UK, unlike Canada and the USA where the proportions have remained virtually constant. However, Mogridge has illustrated that the UK trends conceal an interesting stability, in that the proportions of income allocated to travel by the different income groups has not changed significantly over the same period; further, there is evidence that car-owning households as a group have maintained a stable % allocation to travel even during the period of rapidly changing prices during and after the oil crisis.

(e) For the UK, estimates of average travel times over a 25 year period suggest that these too have risen steadily; however, it is possible (although it remains to be demonstrated) that this trend could also result principally from changes in incomes, consistent with 'stable' travel time budgets for different groups of individuals.

(f) At the aggregate level, there is evidence of considerable seasonal and day-of-the-week variations in both money and time expenditures on travel.

(g) At the small area level, evidence from the UK (Reading) and from other countries suggests that the cross-sectional characteristics of travel time budgets displayed by national data also persist in small-area data; and

(h) as evidence for variations in travel budgets over time at the small area level (Godard (1978) the travel time budgets of groups of individuals did not remain stable in either of two French cities over periods of about ten years.

5.2 But for the last point, then, the evidence suggests that it may be possible to produce reasonable forecasts of travel budgets, at least at an aggregate level. However, Godard's analysis of data for Marseilles and Rouen underlines the need to confirm that broad stability at a highly aggregate level does not mask considerable and mutually offsetting variations at a smaller scale, if it is at the smaller scale that forecasts will be used.

5.3 Early work on travel budgets established interesting similarities in the average travel budgets of residents in different locations; the three most important results were probably (a) Tanner's demonstration of stable generalised expenditure as between rural and urban dwellers, (b) Zahavi's evidence for 'stable' average travel times (by motorised modes) for different cities at different times, and (c) Goodwin's analysis of NTS data, which showed that average total travel times were not affected by residential density. Justification for the use of stable travel time budgets in forecasts appears to have been based on interpreting these results as demonstrating that average travel times were fixed independently of travel 'costs' (where 'costs' might include such characteristics as speeds and comfort as well as money cost), and hence would persist in any forecast year irrespective of network changes. Later evidence (in particular the time series analyses of Tanner and Godard, and Zahavi's analysis of different cities) suggests that this is altogether too much of a simplification, and that some measure of travel costs may well be an important variable in determining average travel budgets.

5.4 Even assuming that satisfactory forecast of travel budgets could be achieved, it is not clear what use should be made of them. There seem to be three main options. First, and simplest, they could be used to check the credibility of more detailed travel forecasts, for example those produced by conventional methods. However, different interpretations could be put on a departure from expectation on the basis of average travel budgets; for example, a forecast travel pattern which implied that the residents of a particular zone were paying more for travel, and travelling longer than might be expected for a group with their income, car-ownership, etc., characteristics might be interpreted as simply wrong, and in need of alteration by adjusting forecast trip rates or correct, but evidence of 'disequilibrium' which might at some later stage result in changes in residence and/or employment locations.

Secondly, the forecast budgets could be used to control travel demand within the conventional model framework, as in the Tanner or Halder models, for example. The difficulty with this approach is that travel budgets seem to lend themselves to forecast only at the aggregate level, and conventional models could only make use of budget forecasts if separate estimates could be made for different trip purposes. Some progress might be made towards this end if a division of travel as between discretionary and mandatory trips proved feasible. The residual budgets could then be used to control discretionary travel, after mandatory travel (such as work trips) had been modelled in the conventional manner; assuming, of course, that it could be established that this sequencing reflected observable behaviour.

Thirdly, Zahavi's model could be used (for urban areas, at least) to produce forecasts of key quantities, which might then be taken as inputs to parts of the conventional modelling process.

5.5 Of the three options that have been listed as ways in which to make use of forecasts of travel budgets, only Zahavi's model, leading to the "Unified Mechanism of Travel", has been developed to any extent. As may be seen even from the short outline of the model given in section 4.7 above, the assumption that travel budgets can be forecast is only one of many assumptions that underlie this model. Leaving aside the crucial relationships between travel times and network speeds, network length, vehicle numbers and network speeds, and vehicle numbers, incomes, mode costs and network speeds, the assumption basic to the operation of the model is that travellers seek to maximise their 'spatial opportunities', measured as a monotonically increasing function of distance - hence that travellers seek to maximise the distances they travel, within the constraints of their travel budgets. The evidence for this hypothesis needs careful sifting, but in passing it should be stated that there is considerable disagreement as to the realism of this aspect of the model. Foster (1977) argues that travellers seek accessibility, independently of distance travelled, and demonstrates that making that distinction can lead to very different conclusions for the evaluation of alternative planning proposals; emphasising accessibility keeps open "the option of moving the facility to the individual" where the 'distance maximising' approach "leads to more effective, faster ways of moving individuals to facilities".

5.6 Lastly, there are at least as important implications for economic evaluation as for travel forecasts in the concept of individual travel behaviour being controlled by time and money budgets, not only for the problem of valuing time saved from travel that is then used to allow more travel, but also in the doubts that are cast on what exactly is being measured by studies assessing 'a behavioural value of time'.

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APPENDIX I

Retail Price Index

Year	Jan 52 = 1.00 *	Jan 56 = 1.00 **	Jan 72 = 100 ***	Jan 74 = 100 ****	Chain linked final series
1952	1.360				.478
1953	1.400				.492)1953/54
1954	1.430				.503)= 0.498
1955	1.490				.524
1956	1.534	1.020			.539
1957		1.058			.559
1958		1.090			.576
1959		1.096			.579
1960		1.107			.585
1961		1.145	.608		.608
1962		1.175	.618		.618
1963			.630		.630
1964			.651		.651
1965			.682		.682
1966			.709		.709
1967			.727		.727
1968			.761		.761
1969			.802		.802
1970			.953		.953
1971			.934		.934
1972			1.000		1.000)1972/73
1973			1.092		1.092)= 1.046
1974			1.267		1.267
1975			1.573	1.348	1.573)1975/76
1976				1.571	1.834)= 1.704
1977				1.820	2.124

* \
** Monthly digest statistics

*** Annual abstract statistics 1977 Edition \
**** Annual abstract statistics 1979 Edition