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TRAVEL BUDGETS : EVIDENCE FROM A 1974 SURVEY

by

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ABSTRACT

GUNN, H.F. (1981) Travel Budgets : evidence from a 1974 survey.
Leeds : University of Leeds, Inst. Transp. Stud., WP.147 (unpublished).

This paper describes a sequence of exploratory models fitted to individuals' travel times and overall households' travel times, costs and generalised costs, as reported in the 1974 County Surveyors' Trip Rate Data Bank.

The analyses involve an approximate allocation of travel times to those in connection with 'mandatory' activities (assumed fixed in the short term, in frequency and location) and those in connection with 'discretionary' activities (the rest). The most important 'background' variables are identified and discussed.

Finally, after controlling for these background variables, a comparison is made between amounts of travel performed in connection with discretionary activities by individuals and households grouped according to reported amounts of 'mandatory' travel. Little or no variation is found, leading to the conclusion that the two sorts of travel are undertaken independently; for example, there is no indication that those reporting above-average amounts of 'mandatory' travel perform below-average amounts of 'discretionary' travel.

CONTENTS

CHAPTER 1

INTRODUCTION

Many researchers have commented on the relative invariance of the average amounts of time and money spent on travel by people living in different types of location, e.g. urban and rural dwellers. (See for example in Gunn (1979)). Interpretations of this phenomenon differ, however. Zahavi (1974, 1979) has taken this stability as evidence for the existence of 'optimal' amounts of travel, for given network conditions and population characteristics. Golob et al (1980) have developed this idea further, leading to a 'utility maximising' description of individual travel behaviour in which travel is treated as a directly demanded commodity. In this line of theory, the stability of travel budgets is identified as being primarily a feature of the demand for travel. Goodwin (1973) has suggested an alternative mechanism, namely the association between population densities, trip lengths and speeds (via congestion), which would account for the phenomenon as a result of characteristics of the 'supply' side of travel.

Potentially, then, the apparent 'stability' of travel budgets raises questions for the basic structure of forecasts of travel demand.

THE DATA

The data set on which the work reported here was based was the County Surveyors' Trip Rate Data Bank (C.S.T.R.D.B.) for the year 1974.

The CSTRBD contains details of a single weekday's trip making (excluding non-home based work trips) for more than ten thousand individuals over the age of five, with a different sample for every year since 1974. The survey is not representative of trip-making in England and Wales as a whole; not all counties co-operated in the project (in particular, London and the South-East of England are not represented), and those counties that did supply data chose the locations of the households to be interviewed for reasons other than national representativeness; one result is that the data set is biased towards suburban households. (A fuller description of the sampling frame is given in ITS TN 18).

The aspect of the data that is considered first is the relationship between characteristics of the individual, (including those of the household to which the individual belongs) and the total amount of time that he or she reported as being spent on travel. This measure of travel time, taken here to include time spent waiting and time spent walking, is clearly liable to reporting errors due to misperception of duration and failure to recollect specific trips. However, this aspect will not be considered in this paper.

In its original form, the CSTRDB stores separately the personal characteristics, household characteristics, stages in each trip made and overall trips. It was necessary to merge and condense this information for analysis.

This summarising procedure involved three distinct stages; at the first stage, the data was merged to form a single file, based on the reported trips. For each trip, details of the trip-maker, including household information, were added on to the trip record. At the second stage, this data was reduced to a person basis; the only travel information kept was total travel time (non-travellers were introduced into the data, with zero travel times.).

Lastly, an extract file, also person based but containing a total of only 26 variables, was produced for analysis.

The contents and formats of the output files are given in Appendix I.

3. MARGINAL TOTALS

The first and most obvious analysis of the relationship between travel time and the other variables by which it can be classified is by examination of the marginal totals. The categorising variables that were selected for examination are listed in Table 1; the historical evidence for the importance of these particular variables is discussed in WP 119.

Table 2, and the accompanying Figures 2 to 9, illustrates the marginal variation during the survey, averaged over key personal and household variables. Figures 10 to 13 then compare the surveyed population with the corresponding UK population, in the same year.

Table 2

Categorising variable	mean T.T.	S.D. of T.T.*
Overall	60.4	60.2
AGE GROUP		
5-16	48.4	38.6
17-24	77.8	57.8
25-44	69.5	65.7
45-59	63.3	59.8
60-65	55.0	56.8
65+	44.4	72.1
SEX		
Male	67.8	65.1
Female	53.4	54.2
HOUSEHOLD CAR OWNERSHIP		
0 cars	54.0	58.2
1 car	60.0	58.9
2 cars	68.6	65.5
3 cars	76.5	61.5
4 cars	60.2	43.7
6 cars	60.0	40.0

* being the standard deviation of individual travel times around the mean.

Table 2 (cont'd)

Categorising variable	Mean T.T.	S.D. of T.T.
ANNUAL INCOME PER PERSON		
less than £250	47.9	39.6
£250 - £500	54.0	56.8
£500 - £750	56.3	61.5
£750 - £1000	60.7	58.4
£1000 - £1250	64.3	56.9
£1250 - £1500	71.2	57.4
£1500 - £1750	75.2	65.2
£1750 - £2000	79.5	91.5
£2000 - £2500	80.0	74.2
£2500 - £3000	87.6	65.2
£3000 - £4000	97.3	67.7
over £4000	92.1	66.6
DAY OF WEEK		
MONDAY	57.1	53.8
TUESDAY	56.8	55.2
WEDNESDAY	61.0	61.2
THURSDAY	61.4	65.3
FRIDAY	71.0	68.6
HOUSING DENSITY		
1. High, 50 houses/hectare	57.4	48.7
2. Mediume, 25 houses/hectare	60.1	59.3
3. Low, 10 houses/hectare	61.8	64.6
SITUATION		
Urban central	59.4	50.4
Sub-urban	63.7	61.1
Rural small town (5,000 - 10,000 pop.)	52.1	54.9
Rural	56.2	62.9

Table 2 (cont'd)

Categorising variable	Mean T.T.	S.D. of T.T.
DISTANCE to town centre		
0 to 1.5 km	56.3	58.6
1.5 to 5.0 km.	65.3	61.3
5+ km.	57.7	61.4
DISTANCE to railway station		
0 to 1.5 km.	61.0	59.6
1.5 to 5.0 km.	66.5	61.3
5+ km.	56.6	59.8
BUS availability		
Good	63.3	57.7
Acceptable	59.5	63.3
Bad	51.2	49.6
None	-	-
TRAIN availability		
Good	68.2	63.5
Acceptable	61.0	59.4
Bad	57.3	48.7
None	56.8	61.3

From Table 2 it can be seen that the categorising variables which produce the most marked variations in the marginal sums are age (a range of 33 minutes between highest and lowest), occupation (55 minutes), and income (50 minutes on a household basis, 44 on a person basis.) Thereafter, categorisations by sex (14 minutes), car ownership (22 minutes), and day-of-week (14 minutes) seem important; however of the several locational variables available, only the 'de-facto' classification "Situation"

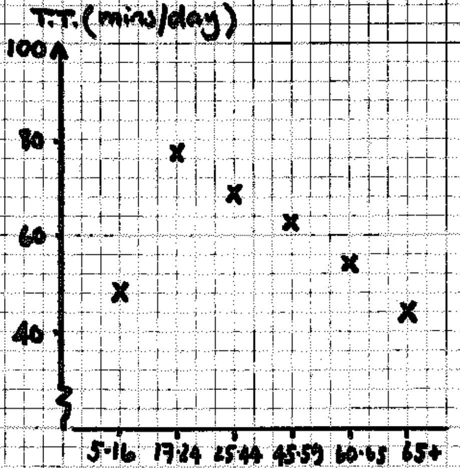


FIGURE 2 - AGE GP.

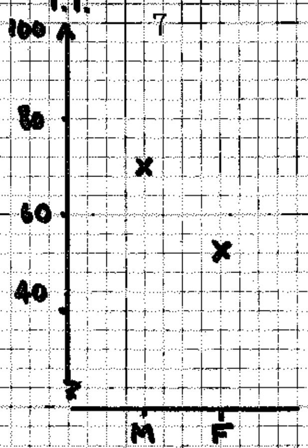


FIGURE 3 - SEX

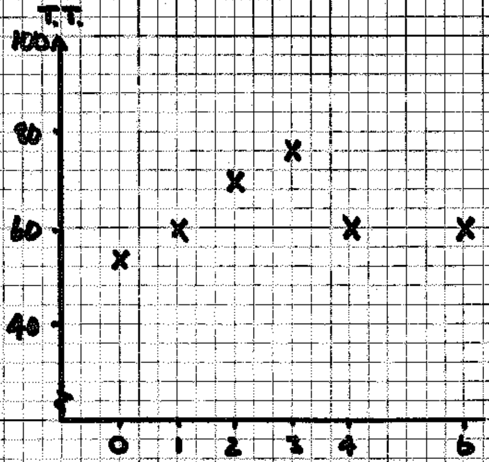


FIGURE 4 - H/HLD CARS

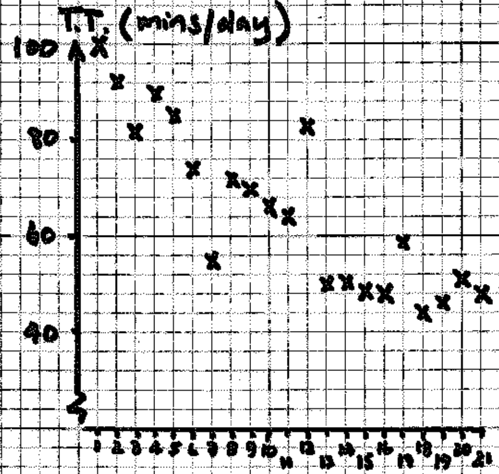


FIGURE 5 - OCCUPATION

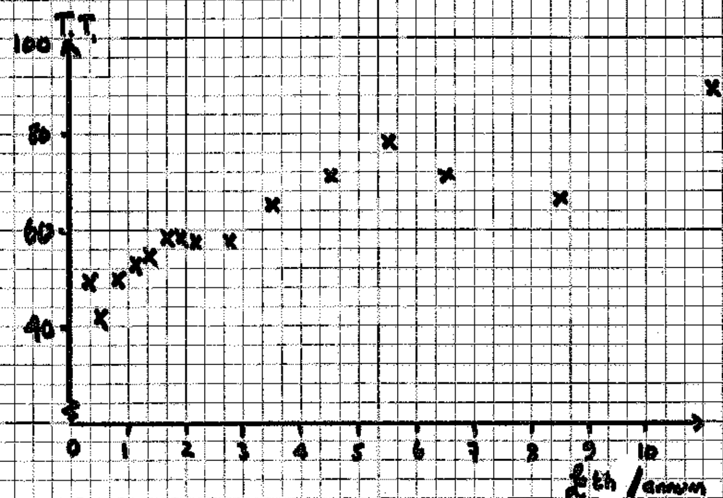


FIGURE 6 - H/HLD INCOME

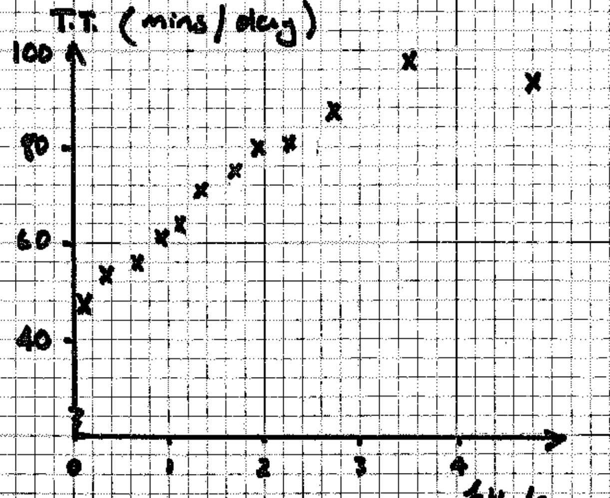


FIGURE 7 - INCOME/PERSON

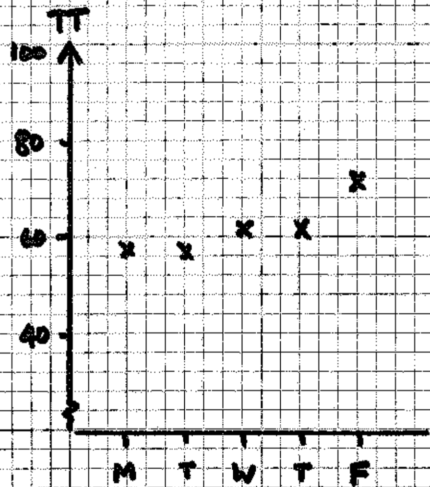


FIGURE 8 - DAY OF WEEK

(12 minutes) is substantial. Similar ranges are evident under the public service availability classifications. Comparisons of the overall distributions of the responding population in the various categories with national sources suggest that the C.S.T.R.D.B. is biassed towards lower income households, although, contradictorily, it shows higher car-ownership levels than the national average. This indication that the C.S.T.R.D.B. sample is atypical, merely in terms of mean income but more importantly in the apparent allocation of income to car purchase, and hence possibly to travel, would raise grave difficulties for the use of the data as a basis for models of average national travel behaviour. However, there are three aspects of the sampling frame and survey method that would lead us to expect such results without having to assume that the travel behaviour of the responding households is atypical.

Firstly, the exclusion of Greater London and the South East of England must tend to bias average incomes downwards (although the concurrent exclusion of Scotland and Northern Ireland will have the opposite effect). Secondly, it is well known that gross household income is poorly measured in transportation studies, and that relative to the detailed methods and definitions used for the F.E.S., the response given by heads of households tends to under-estimate gross income consistently (particularly for households with more than one working member). Thirdly, the C.S.T.R.D.B. sampling frame is almost certainly biassed towards suburban and rural households, and it has been established that such households tend to have higher than average levels of car ownership for a given income level.

For these reasons, we need not be unduly alarmed by the apparent discrepancies in the car-ownership and income characteristics of the sample. The age distribution does correspond closely to the U.K. average for the year 1974.

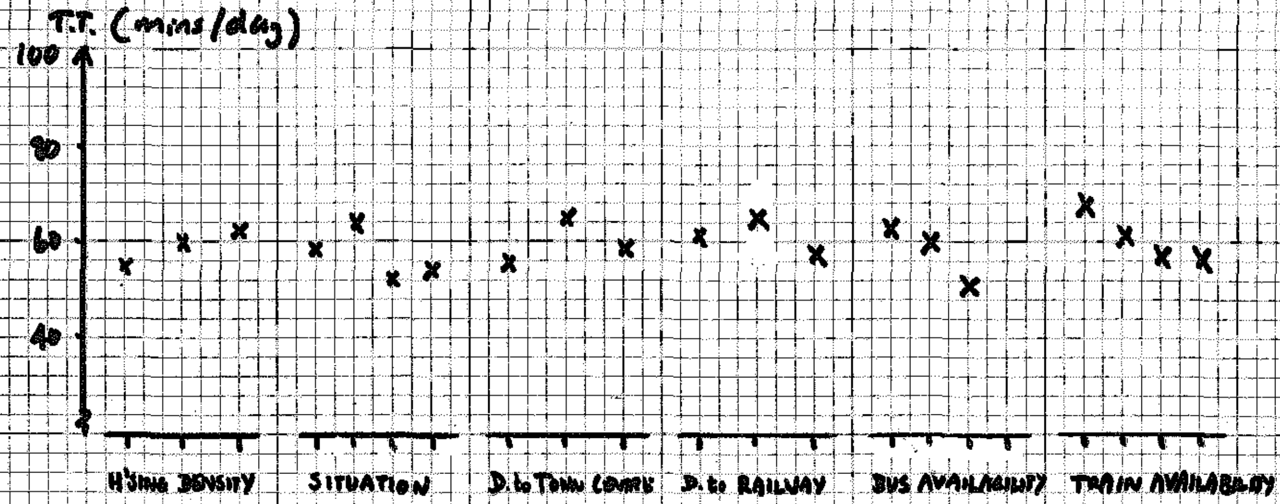


FIGURE 9 - LOCATIONAL VARIABLES

FIGURE 10 - H/HLD. INCOME

C.S.T.R.D.B. vs. F.E.S. (1974) (U.K.)

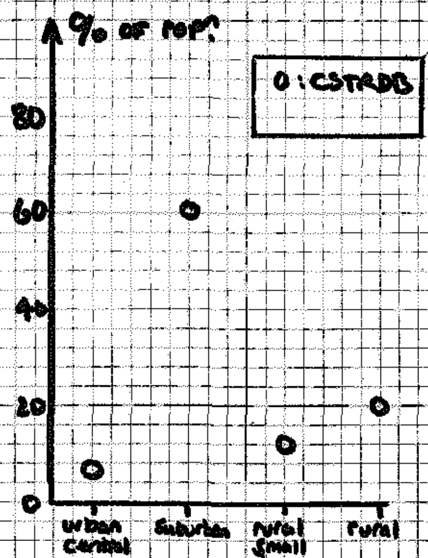


FIGURE 11. SITUATION

C.S.T.R.D.B.

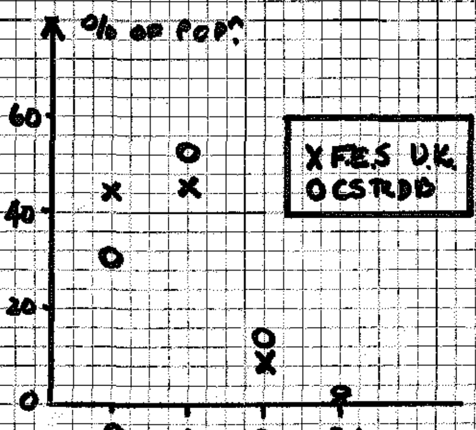


FIGURE 12 - CARS/HHLD

C.S.T.R.D.B. vs. FES (1974) (U.K.)

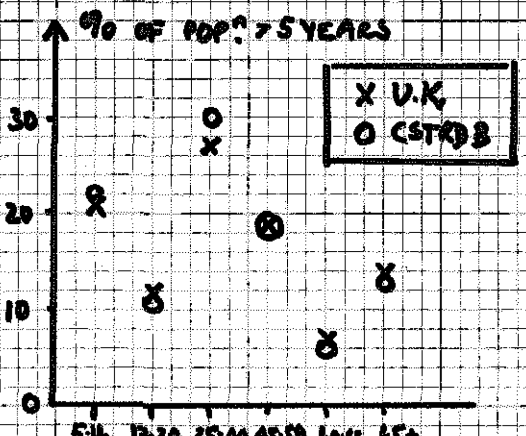


FIGURE 13 - AGE

C.S.T.R.D.B. vs. U.K. (1974)

from Monthly Digest of Statistics, no. 355

CHAPTER 2.

EXPLORATORY ANALYSES OF INDIVIDUAL TRAVEL TIMES

The examination of the marginal totals provides a useful first description of the data; however, there are circumstances in which this approach can mislead, in particular when there are strong intercorrelations between the categorising variables. For example, in Table 2, time spent on travel varies between income groups and between car ownership groups, between location types and between households with different access to public transport. Given that vehicle ownership increases with income, and public transport provision varies with location type, it could happen that, having corrected for income and location differences, vehicle ownership and access to public transport had no effect whatsoever on travel times, even though the categorisation appeared important from the marginal totals. (Equally, of course, seemingly unimportant or unrelated categorising variables may have shown little variation in the margins because they are negatively correlated in the data with a variable with an opposite influence).

It would be necessary to consider all the categorisations simultaneously to detect every possible inter-relationship; however with ten categorising variables we would face examining ten-way tables which is clearly out of the question.

There are various approaches available to tackle this problem; the A.I.D. program, makes sequential binary splits on the most effective categorising variable at each stage; various log-linear programmes (including GLIM) use procedures analagous to analysis of variance techniques to identify a 'best' set of categorising variables.

However, for our purposes, perhaps the simplest approach is to use a dummy variable stepwise regression analysis, based on a set of selected categorising variables and chosen interactions. For this approach, we postulate a simple linear model

$$TT_i = \alpha + \sum_{j=1}^{k} \beta_j \delta_{ji} + \varepsilon_i \quad .. \qquad (1)$$

where TT_i denotes the travel time of individual i,

α is a constant

β_j is a constant corresponding to category j

$$\delta_{ji} = \begin{cases} 1 \text{ if individual } i \text{ falls into category } j \\ 0 \text{ otherwise} \end{cases}$$

k is the total number of categories (ie. the sum of the categories for each categorising variable, including interactions,) and

ε_i is an error term peculiar to individual i, such that

$E(\varepsilon_i) = 0$, and $\text{var}(\varepsilon_i) = \sigma^2$, for all i.

If this model is put into a stepwise regression package, we can identify a maximum set of 'significant' categories, which is to say those categories in which the variation of TT from its average value is significantly greater than that which might be expected by chance, given the estimated distribution of the error terms, ε.

This procedure is a simple and fast device to fit a model to the travel time variable; however some caveats should be stated.

(1) The model cannot be interpreted as 'causal', it is a descriptive device.

To feel justified in using the 'description' as a forecasting model we would need to demonstrate that it held good under a wide variety of circumstances and in different time periods.

(2) The model itself is only an approximation - for example there is not even any constraint to ensure that it predicts non-negative times, although we would expect that this would not occur within the range represented in our data set.

(3) The co-efficients of the dummy categorising variables are being judged against their computed standard errors, on the basis of the model (1). These s.e's are only approximate, since they assume that the 'errors' associated with each category have the same variance, and this will not be true in practice.

(4) We choose to stop the regression at that point where all variables in the equation have significant co-efficients, and the introduction of any more variables produces a set in which not all coefficients are significant. This rule is sensible, but is certainly arbitrary.

(5) A similar point to the last, but probably even more crucial; we have to choose one particuar level to call significant. If we chose a different level, we would expect a different model - at least in that we would expect more or less variables to be involved, coresponding to lower and higher requirements for significance.

With these reservations, then, the dummy variable approach offers a robust and straight forward means by which to identify the variables most strongly connected with variations in travel times, and by which to assess their relative importances.

5. THE CHOICE OF VARIABLES - VARIABLE SET A

The first analyses that were performed on the 1974 CSTRDB records, used the set of variables shown in Table 3, with the indicated choice of categorisation;

Table 3 VARIABLE SET A

Sex	Age	Occupation	Annual Income/ Person	Situation	H/hld car ownership
Male	5-16	Professional[1]	£0 - £750	Urban central	no car
Female	17-24	Non-Profess.[2]	£150 - £1500	Suburban	1 car
	25-59	Other[3]	£1500 - £2500	Rural/small town	two or more cars
	60+		Over £2500	Rural	

1. being categories 1,2,3,4,12,13,14, in Table 2, "occupation".
2. being categories 5,6,7,8,9,10,11,15,16 in Table 2, "occupation".
3. being the remaining categories in Table 2, "occupation".

For each categorisation, dummy variables were created to indicate whether or not an individual fell into each category. This required dummy variables to the number of one less than the number of categories, for each categorising variable.

For example, the categorisation by sex required a single dummy variable, DI, which was defined to be '0' if the individual was male, '1' if female. Two variables, D13 and D14, were created to identify the individual's household car-ownership level: D13 was '1' if the household owned two or more cars, '0' otherwise; D14 was '1' if the household did not own a car, '0' otherwise.

The fourteen dummy variables that were required, and their definitions, are indicated on table 4:

Table 4: Dummy variables for VSA

Category		Dummy	Effect
Sex	Male	-	-
	Female	D1	U
Age	5 - 16	D2	
	17 - 24	D3	F
	25 - 59	-	-
	60+	D4	-
Occupation	Professional	D5	F
	Non-professional	-	-
	Other	D6	U
Inc./Person	£0 - £750	D7	U
	£750 - £1500	-	-
	£1500 - £2500	D8	
	over £2500	D9	
Situation	Urban central	-	-
	Suburban	D10	-
	Rural small town	D11	-
	Rural	D12	U
Car ownership	No car	D14	-
	1 car	-	-
	2+ cars	D13	F

Also indicated in Table 4 is a column headed "effect"; this column contains the symbol "U" where membership of a category was expected to coincide with lower than average travel times ("unfavourable conditions) and, correspondingly, "F" for expectations if higher than average travel times ("favourable conditions").

Two extra dummy variables were created from the first 14;

$$D16 = (D8 + D9)$$

$$D15 = (D2 + D4)$$

Thus D15 took the value 1 for individuals between the ages 5-16 OR over 60, and D16 was 1 for individuals with income per head above £1500. D16 was coded "F", and D15 was "U".

With fourteen basic variables, we have approximately 20,000 possible interactive terms to consider. To reduce the scale of this problem, only certain of these were admitted to the variable set; these were the interactions between pairs and triplets of "favourable" variables, and pairs and triplets of "unfavourable" variables. The reasoning behind this choice of subset of interaction teams was that we are particularly interested in the extremes of travel time, in those groups of people with greatest and least average expenditure of time and travel - and that it is likely that these groups are characterised by many "favourable" or many "unfavourable" attributes.

With the choice of definition of the 'favourable' and 'unfavourable' variables described above we thus have 30 extra dummy variables to consider, defined as indicated on Table 5.

Table 5: DUMMY INTERACTION VARIABLES

F1	D3.D5	U1	D1.D15	U11	D1.D15.D6
2	D3.D14	2	D1.D6	12	D1.D15.D7
3	D3.D13	3	D1.D7	13	D1.D15.D12
4	D5.D14	4	D1.D12	14	D1.D6.D7
5	D5.D13	5	D15.D6	15	D1.D6.D12
6	D14.D13	6	D15.D7	16	D1.D7.D12
7	D3.D5.D14	7	D15.D12	17	D15.D6.D7
8	D3.D5.D13	8	D6.D7	18	D15.D6.D12
9	D3.D14.D13	9	D6.D12	19	D6.D7.D12
10	D5.D14.D13	10	D7.D12	20	D15.D7.D12

Lastly, four dummy variables were defined to pick up day-of-the-week variations, taken relative to Monday. These were as indicated on Table 6

Table 6 : DAY-OF-THE-WEEK DUMMY VARIABLES

Monday	-
Tuesday	D17
Wednesday	D18
Thursday	D19
Friday	D20

REGRESSIONS FOR VARIABLE SET A

The first analysis was a stepwise regression of total travel time, for those present during the interview day, on the 48 variables described in the previous section. In theory, the regression halted when all coefficients in the model given by equation (1) had estimated standard errors no greater than ½ absolute value of the coefficient (ie. where all coefficients were significantly different from zero at a rough 95% confidence level) and where inclusion of any other variable resulted in at least one coefficient having a standard error larger than ½ of its absolute value. However, in practice it did occur that a variable which entered early on in the regression, with a significant coefficient, could become insignificant a number of steps later, when significant variables were still entering. Such variables are indicated by an asterisk; their effects should be ignored. The results are set out as Table 7.

Perhaps the first observation to be made about this analysis must be that the R^2 value, at 0.083, demonstrates how little of the person to person variability in travel times that we can "account for" in terms of overall effects of the categorization that we have defined. However, the coefficients given in Table 7 indicate a regular and intuitively sensible variation in mean travel times.

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

Table 7: REGRESSION 1

VARIABLE SET A - ALL PERSONS PRESENT: 1974.

Basic variables		Coefficient
D1	: Sex : Female	- 8.0
D2	: Age 5-16	- 7.6
D3	17-24	+14.9
D4	60+	-11.0
D5	: Occupation "prof"	+13.2
D6	"other"	-13.3
D8	: Income med/high	+ 8.2
	high	+20.0
D10	: Location suburban	+ 2.6
	rural/small town	- 6.6
Interactions		
F1	17-24 Ⓧ "professional"	-16.5
F5	2+ cars Ⓧ "professional"	+10.7
F6*	2+ cars Ⓧ high income	+ 3.3
F8	17-24 Ⓧ "professional Ⓧ 2+ cars	-35.1
U1	Female Ⓧ (5-16 or 60+)	+ 5.6
U4	Female Ⓧ rural	- 4.5
Day-of-week effects		
D18	Wednesday	+ 4.5
D19	Thursday	+ 5.9
D20	Friday	+13.9
CONSTANT TERM		65.7
R^2 = 0.083		S.E. of estimate =57.7
Number of cases		10034

* denotes coefficient with estimated standard error greater than ½ the absolute coefficient value.

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.

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.

An extra insight into the data over and above that provided by the inspection of the marginal totals is that, after allowing for the effects of the variables in Table 7, (and income is probably the most important of these in this connection) household car ownership does not appear as a 'significant' category.

It has been suggested elsewhere (see the discussion in Gunn 1979) that travel budgets should only be defined for travellers, not per person; the same variable set as was used for regression 1 was used to model travel times amongst those respondants who actually made at least one trip; the results are given in Table 8, together with the differences between the coefficients in this model and that for all persons present.

Some 87% of the people actually present in the household on the interview day reported at least one trip. Once again, the first conclusion from this analysis is that the model explains very little of the traveller-to-traveller variability in travel times - the R^2 value, at 0.067, is even lower than that for regression 1, albeit with two less variables in the model.

Overall, the fitted coefficients in regression 2 are very similar to those in regression 1. There are five major differences - in D2, D4, D6, F1 and F8. The interaction terms, F1 and F8, although absolutely large in their coefficients, are relatively less important in that they apply to only a small group of people. (In fact, the variable F8 would be the next variable to enter regression 2, with a coefficient of -24.)

Table 8: REGRESSION 2

VARIABLE SET A - TRAVELLERS : 1974

Basic variables			Coefficient	Change from "All present"
D1	Sex :	female	- 6.8	+ 1
D2	Age :	5-16	-16.5	- 9
D3		17-24	14.1	- 1
D4		60+	-	+11
D5	Occup'	"prof"	+16.1	+ 3
D6		"other"	- 4.7	+ 8
D8	Income :	med/high	+ 9.1	+ 1
D9		high	+18.1	- 2
D10	Location :	suburban	-	+ 3
D11		rural/small town	- 7.4	0
Interactions				
F1	17-24 ⊗ "professional"		-27.6	-11
F5	2+ cars ⊗ "professional"		+ 8.3	- 3
F6*	2+ cars ⊗ high income		+ 3.7	+ 1
F8	17-24 ⊗ "professional" ⊗ 2+ cars		-	+35
U1	Female ⊗ (5-16 or 60+)		+ 7.0	+ 1
U4	Female ⊗ Rural		- 5.8	- 1
Day-of-Week Effects				
D17*	Tuesday		- 0.9	- 1
D18	Wednesday		+ 4.7	0
D19	Thursday		+ 5.5	0
D20	Friday		+13.6	0
CONSTANT TERM			69.1	+ 3
R^2 = 0.067			S.E. of estimate	= 57.7
Number of cases				8911

* denotes coefficient with estimated standard error greater than ½ the absolute coefficient value.

We can relate the changes in the coefficients of the main effects to typical trip rates and trip durations; for example, the mean difference in travel time for travellers in the 5-16 year age group from those in the 25-59 year group was -17 minutes, as opposed to -8 minutes for the same comparison for all persons present. That the addition of 'zero-time' travellers to both groups brings the mean times for the 5-16 year group closer to the 25-59 year base level must mean that there are relatively fewer non-travellers in the 5-16 year old group - ie. on average they travel more frequently but for shorter times than the base group.

This is confirmed by the proportions of each group travelling - 96% of all 5-16 year olds present, 92% of all 25-59 year olds. Correspondingly, we find that the proportion of travellers amongst the 60+ group is only 69%; all other things being equal, travellers in this age group spend on average, the same amount of time on travel as travellers in the base 25-59 year age group, but the proportion of travellers in the 60+ group is much lower, thus producing the lower overall average indicated by regression 1. The same is true of members of the "other" occupation category.

VARIABLE SET B

The allocation of occupational groups to the final three categories was the product of a rough rule-of-thumb, based on casual inspection of the marginal variations, that higher-paid workers and professionals tended to have the highest average travel times, and that the non-workers, being housewives, pensioners and so on tended to have the lowest. Two aspects of work status could be responsible; firstly, that those in employment have an extra journey purpose, the journey to work, which would tend to increase their travel time over that of similar persons not in employment (offset, of course, by the transfer of responsibility for shopping trips for example, within households from 'employed' to 'unemployed'.)

Secondly, it may be more difficult to find specialised (or highly-paid) employment close to a given residence (or, conversely, to find a 'suitable' residence close to such employment,) resulting in longer work journeys, on average, for such workers.

Attributing these causes to the observed variations in travel times is, of course, merely speculative at this stage. However, these were the broad principles guiding the choice of occupational categorisation. Some occupational groups were still difficult to categorise under this rule-of-thumb. In particular, farmers (employers, managers or own-account) were deemed specialist workers, and were classified as "professionals" in VSA. However, they are also in the unusual position of actually living at their work-place in many cases - so that the speculative reason for an increased amount of travel, namely not only a journey to work, but one to a relatively remote location, is absent. On these lines, a case could be made to categorise farmers with the non-workers. Another anomaly was for the group 'students', who were classified as "non-workers" for VSA, but for whom the education journey will effectively replace the work journey. Yet another anomaly was for part-time workers allocated to the 'non-worker' group is VSA, many of whom will have a regular journey to work.

For purposes of comparison with national statistics, it is useful to have farmers and students classified as in VSA, but to have two models corresponding to the two different treatments of part-time workers. (Some national sources give work-force statistics inclusive of part-time workers.)

Accordingly, VSB was defined. VSB was identical to VSA, except that part-time workers were classified with the base group, not as "others".

REGRESSIONS FOR VARIABLE SET B

Table 9 presents the results of regression 3 on this variable set.

The overall fit of the model is virtually unaffected by the re-allocation of the part-time workers (as might be expected since they form only 4% of the population.) The base group is now slightly different, as reflected by a small change in the constant term. Some slight changes take place in the location coefficients, reflecting a differing proportion of part-time workers in the base (urban central) as compared to other locations. The changes are generally as would be expected if there were a higher concentration of part-time workers in the urban central areas as compared to other areas.

Table 9: REGRESSION 3

VARIABLE SET B - ALL PRESENT 1974.

Basic variables			Coefficient	Change from V.S.A.
D1	Sex :	female	- 9.0	- 1
D2	Age :	5-16	-	+ 8
D3		17-24	+16.4	+ 2
D4		60+	- 5.4	+ 6
D5	Occup':	"prof"	+13.8	0
D6		"others"	-19.3	- 6
D8	Income :	med/high	+ 8.3	0
D9		high	+20.0	0
D10	Location :	suburban	+ 4.6	+ 2
D11		rural/small town	- 4.6	+ 2
Interactions				
F1	17-24 ⊗ "professional"		-17.6	- 1
F5	2+ cars ⊗ "professional"		+10.6	0
F6*	2+ cars ⊗ "professional"		+ 3.3	0
F8	17-24 ⊗ "professional" ⊗ 2+ cars		-35.2	0
U1	Female ⊗ (5-16 or 60+)		-	- 6
U2	Female ⊗ "other" occup.		5.1	+ 5
U4	Female ⊗ rural		-	+ 5
Day-of-Week Effects				
D18	Wednesday		+ 4.7	0
D19	Thursday		+ 6.1	0
D20	Friday		+13.9	0
CONSTANT TERM			63.2	- 3
R^2 = 0.083			S.E. of Estimate	57.7
Number of cases				10034

* denotes coefficient with estimated standard error greater than ½ the absolute coefficient value.

The most interesting changes are to coefficients representing the age groups and the "other" occupational category; as before, the interaction terms are of secondary interest. With the transfer of the part-time workers to the base group, members of the non-working "other" category are typified by comparatively lower travel times than before; the part-time workers were bringing the average up. In the regressions with VSA, a compensating effect was brought in for subsets of the non-part-time workers in the"other" category, namely for the young (5-16 year olds) and old (over sixties); membership of these groups was then associated with a compensating penalty or reduction on average travel times. With the re-allocation of part-time workers, age group became less important, work status more so.

Although this re-adjustment is not accompanied by any improvement in model 'fit', the same results are being achieved with two less variables.

VARIABLE SET C

Before proceeding with further adjustments to the occupation categorisation, one other possible amendment to the variable set was explored; this was the creation of a surrogate variable for 'car-availability' for each person, rather than using car-ownership at a household level for each household member regardless of their opportunity to use any vehicle owned by the household.

A variable taking only the values 1 or 0, intended as a surrogate for car-availability, was generated using the household 'status' variable, the household car-ownership and the driving licence variable. The 'status' variable denotes the head of household by the value 1, and increasing values then correspond (roughly) to decreasing age; thus, commonly, the first record will be husband, the second wife, and so on (with less obvious order thereafter). The procedure that was adopted was as follows : if the household did not own a car, then all household members were deemed to have no car available; if the household owned one car, it was allocated to the member of the household who had (a) a motor vehicle driving licence, and (b) the highest 'status', as indicated by the lowest value of the 'status' variable. For households with more than one car, the same rules were used to allocate successive cars to other licenced drivers, in decreasing order of household 'status'.

For a number of reasons, this procedure can only give an approximate indication of actual car-availability; however, it was deemed an acceptable proxy for the purposes of this exercise.

REGRESSIONS FOR VSC.

Table 10 sets out the coefficients of the regression model for VSC, which differs from VSB only in that the two dummies indicating membership of non-car-owning households or multiple-car-owning households, D14 and D13, are replaced by a single variable, D13, now denoting 'car-availability'.

The fitted model is very, very slightly better than previous regressions, judged by the slight increase in R^2 using two less variables than were used for regression 3 on VSB, and four less than for regression 1 on VSA.

The introduction of the 'car-availability' proxy has, however, resulted in some fairly major changes to the fitted coefficients. Firstly, it does itself appear as a significant variable; on average, persons classified as having car available travelled for some 8 minutes more than a similar person without a car available. Major corresponding adjustments have occurred to two classifying variables: sex and occupation. Age, income, day-of-week and location are substantially unaffected. (We shall ignore interactions, once again, on the grounds that they are only important for subsets of the data.) The largest change is to the coefficients of the occupational variables: here, a range of 33 minutes has now reduced to 14 as between most active and least active categories. The "professional" group have similar average travel times to the base "working" group, instead of 14 minutes longer.

Table 10: REGRESSION 4

VARIABLE SET C - ALL PRESENT 1974

Basic variables			Coefficient	Change from VSB
D1	Sex :	female	- 3.1	+ 6
D2	Age :	5-16	-	0
D3		17-24	+17.2	+ 1
D4		60+	- 5.6	0
D5	Occup':	"professional"	-	-14
D6		"other"	-14.3	+ 5
D8	Income :	med/high	+ 8.8	0
D9		high	+20.6	+ 1
D10	Location :	suburban	+ 2.9	- 2
D11		rural/small town	- 6.2	- 2
D13	Car Availability		+ 8.3	n.a.
Interactions				
F1			-	+-8
F5			+17.0	+ 8
F6*			-	- 3
F8			-43.5	- 8
U1			-	0
U2			-	- 5
U4			- 5.0	- 5
Day-of-Week Effects				
D18			+ 4.5	0
D19			+ 6.0	0
D20			+13.8	0
CONSTANT TERM			59.0	- 4
R^2 = 0.085			S.E. of Estimate	57.6
Number of cases				10034

* denotes coefficient with estimated standard error greater than ½ the absolute coefficient value.

The "other" group have 14 minutes less travel time, on average, instead of 19 minutes less. Another marked change is to the average difference between males and females, which has now reduced from 9 minutes to 3 minutes. Predictably, our allocation system has made cars available mainly to males - and hence there has been an adjustment in which a reduction in the 'penalty' for the female average is offset by a 'bonus' for the male average via the car availability variable. The changes to the occupational coefficients are perhaps rather less predictable; if anything, adjustments to the income coefficients, on the grounds that the car-availability variable will identify not only males predominantly, but high-income males in particular. However, the income variable has been defined as <u>income per person</u>, not income per household; the former quantity is clearly less directly associated with car-ownership than the latter. It is males from high-income households (regardless of household size) that the car-availability variable picks up, in the main, and these for the most part fall into the "professional" occupational category. Thus, the introduction of a 'bonus' for car-availability is offset by a compensating reduction in the 'bonus' for membership of the "professional" occupation category.

Reasoning along these lines does help to underline the purely descriptive nature of these models. We have produced a number of different possible descriptions for the observed variations in the data; from a single data set, only appeal to intuition serves to judge between them, and only if a particular description proved adequate for different data sets from different time periods and sub-areas, would we consider advancing it as an "explanation" and attributing causes to the effects we have measured.

VARIABLE SET D

In the last variant of the choice of variable set, the occupational categories were reallocated as described in section 7; farmers, other than farm labourers, were reclassified with "non-workers" (on the grounds of not making journeys to work) and students were reallocated with the base group (having an educational trip instead of a work trip). The income categorisation was replaced by a continuous relationship between travel time and income per person; thus equation (1) becomes

$$TT_i = \alpha + \gamma I + \sum_{j=1}^{k} \beta_j \delta_{ji} + \varepsilon_i \qquad (2)$$

with notation as before, but with I denoting income per person (£/annum) and γ being a fitted constant.

Other than these changes, the variable set was as for VSC.

REGRESSION FOR VSD

The results are set out in Table 11. Overall we have once again made very slight improvements to the model at the same time as reducing the number of independent variables in the model.

The major alterations have taken place between the co-efficients in the sex, age and occupation categories, principally as a consequence of the re-allocation of students with the base occupation category. This has left 'housewives' making up some 64% of the "other" category, instead of 35% when students were also classified there. As a result, this category has adjusted to be more directly representative of housewives, and the extra adjustment of the 'female' co-efficient is no longer needed; the "other" category is now typified by an extra "penalty" of 2 minutes, and the separate penalty of 3 minutes for the female average is not needed. Likewise, the separate penalty for old age is no longer necessary. However, an extra penalty for membership of the 5 - 16 age group is now needed to correct for the lower than average travel times of schoolchildren.

The four bands for income per head that were defined in Section 5 have mean points somewhere around £500, £1200, £2000 and £3500 respectively; the continuous income co-efficient, 6 minutes extra travel time per £1000 of income, would correspond to differences of 4 minutes, 5 minutes and 9 minutes between these means: thus, relative to band 2, we would expect co-efficients for D7, D8 and D9 of -4, +5 and +14 respectively: these were estimated as 0, +9 and +21 in regression 4, which may indicate some non-linearity in the response to income.

This possibility was explored by including a quadratic term in income in the variable set, but this did not enter the equation and had no effect on the model.

Table 11: REGRESSION 5

VSD - All present, 1974

Basic variables			Coefficient	Change from VSC
D1	Sex:	Female	-	+ 3
D2	Age:	5 - 16	-12.8	-13
D3		17 - 24	+15.0	- 2
D4		60+	-	+ 6
*D5	Occup.:	"professional"	+ 7.8	+ 8
D6		"other"	-16.5	- 2
D8	Income:	med/high	-	n.a.
D9		high	-	n.a.
V	£/annum		+ 0.006	n.a.
D10	Location:	suburban	+ 4.0	+ 1
D11		rural/small town	- 4.5	- 2
D13	Car availability:		+ 9.4	+ 1
Interactions				
F5			+11.4	- 6
F8			-39.2	+ 4
U4			-	+ 5
U11			- 6.4	- 6
Day-of-the-week effects				
D18	Wednesday		+ 4.7	0
D19	Thursday		+ 6.2	0
D20	Friday		+13.8	0
CONSTANT TERM			51.5	- 7
$R^2 = 0.088$			S.E. of estimate	57.5
Number of cases			56.1	10034

SUMMARY

In this Chapter, we have presented a number of models giving alternative descriptions of the relationship between total travel time and person and household characteristics. These result in differing emphases being placed on categorisations by major related variables, sex, age, income, car-ownership, and occupation. On the basis of a single cross-sectional data set, it is not possible to advance any of these as stable relationships which might be used to forecast. In any event, none of the hypothesised models explain much of the observed variation in individual reported total travel times - all have values of R^2 between 8% and 9%.

However, together the models do testify to regular, intuitively sensible and statistically significant variations in mean travel times for groups of similar individuals.

CHAPTER 3

A BREAKDOWN OF INDIVIDUAL TRAVEL TIMES INTO 'MANDATORY' AND 'DISCRETIONARY' TRAVEL.

The conclusions from the last chapter were that individual travel times were not strongly related to personal or household characteristics.

This chapter reports the results of an analysis which was designed to provide more insight into the pattern of expenditure of time on travel, and in particular to permit some tentative inference as to the importance of the overall travel time budgets in determining response, (i.e. change in individual total travel times) to network characteristics. Ideally, such inference would be based on data which described each individual's movements before and after particular network changes; unfortunately, this sort of data set is not available to us. Instead, we have information covering only one day's travel patterns for each of a large number of individuals from different areas. Clearly no direct inference is possible.

However, consider the hypothesis that individuals have target 'budgets' of travel time which have been determined prior to actual trip-making, and which the individual seeks to preserve by an appropriate choice of a set of activities/locations, together with a sequence by which to link these and a selection of modes for each link in the sequence. In some form, this hypothesis would be central to the idea that travel budgets 'govern' travel, and thus that forecasts of travel budgets can be used to generate (or judge) more detailed forecasts of travel. If travel budgets are only incidental to the choice of activities/locations, then in general network changes should simply result in altered travel patterns and changed travel budgets. On the other hand, evidence pointing to a tendency to adjust travel patterns to preserve an original budget could be taken to support the hypothesis that this budget would also tend to remain unchanged after any network alterations in the future; i.e. that there is a stable behavioural phenomenon, (albeit still in need of rational explanation) which could be used to predict some aspects of travel behaviour.

From the data we have analysed, there is evidence of sizeable variations in overall average travel times for different groups of the population, and even larger variations in individual travel times within these groups. Clearly, if the notion were to be one of a single travel time budget for all individuals, or a single travel time budget for each of a number of particular groups of individuals, the data suggests that people are remarkably unsuccessful in achieving these targets. Is there any indication that they are trying to do so?

In an attempt to answer this question, total travel time has been split into travel for 'mandatory' purposes (work, employer's business or education) and travel for 'discretionary' purposes (the rest). In as much as 'mandatory' travel, thus defined, is virtually inescapable, in the short term the individual can only adjust his overall travel time by varying his allocation of time to discretionary travel. If a particular group of individuals were endeavouring to achieve a common allocation of time to travel, we would expect that those with the highest 'mandatory' travel outlays would try to compensate by reducing their 'discretionary' travel. If no such compensation occurred, we might argue that no attempt was being made to achieve a common time budget.

More generally, within groups of 'similar' individuals, (and here we must allow for the various background variables such as age, sex, etc.) we would expect those with higher than average allocation of time to mandatory travel to have lower than average allocations to discretionary travel, even if each individual had his own unique 'target' of total travel time.

THE LOGIC OF THE PROGRAM TO PERFORM THIS BREAKDOWN

The program takes the combined trip, person and household information, deletes non-travellers, and merges this information with data describing the location of the primary destinations (coded as the first eight letters or numbers of the address, converted to numerical values) and information on trip purpose, converted to one of three values (1,2,3) corresponding to three categories of trips. These comprise; trips made to work, education, on employer's business, or as an escort; trips made for personal business, shopping, social/recreational, tour or learner; and trips made going home. Provision is made to delete dummy origins from the file; these arise because the first trip recorded in any survey period may be to the home, from an unknown destination which is thus coded zero. Deletion is performed by skipping over records which are coded with purpose as zero.

Time spent on each trip for each person is sorted into two categories; the categories correspond to the purpose categories 1 and 2 for their definitions of 'mandatory' and 'discretionary' travel. The output file contains one record for each traveller, in which his travel time is allocated between M or D travel according to simple rules described below. (Note; not all complex trip patterns can be unambiguously dissected in this way, and travellers whose travel is too complex for this analysis are indicated by the use of the marker variable ICOMP. An alternative would be to allocate all tours which could be analysed by the chosen rules. For this analysis,each person record would have three categories of time spent; one for mandatory (M) travel, one for discretionary (D) travel, and one for un-analysable travel.)

It will be seen from the rules set out below that an arbitrary decision has been made to consider only tours with four or less trips, where a tour is defined as a home-to-home circuit. The relaxation of this rule, to five or more trips, would result in some travel patterns which are presently considered to be 'un-analysable' becoming amenable to dissection.

Another reason for a tour being 'un-analysable' is described below; briefly, the method adopted involves imputing a diversion time to discretionary activities which are undertaken during a primarily mandatory tour; for some sequences of M and D trips, it is not possible to deduce the basic and diversion components of the tour. This event is noted on the person record by a marker variable called ICHECK, which takes the value 1 if all tours are analysable, 2 if the first trip is to the home (an occurence which should be excluded if the trip started before the survey period, since the origin would then be a dummy zero along with the trip purpose, but which might arise if the trip started within the survey period;) and finally 3 if the tour cannot be resolved into M and D components despite being less than five trips long.

Also retained and output on the person record is a variable IND which records the number and sequence of the M and D trips within analysable tours. In this variable, mandatory tours are represented by odd numbers 1, 3 and 5, which would be taken to represent three different mandatory destinations (or more exactly, those mandatory destinations within which set the first destination is not revisited; we know that destination 3 is not at the same address as destination 1 or 5, but 3 and 5 might be identical.) Similarly, discretionary tours are represented by even numbers; thus a value of IND of 123 would represent a four trip tour which commenced with a journey to a mandatory destination, a discretionary journey, a third trip to a different mandatory destination followed by a return to the home (unless the value of the marker ICCMP indicated that the fourth trip did not return home; if the tour was more complicated than four trips it would not be analysed by this version of the program). In fact this pattern would not be analysable by the rules adopted, which insist that a tour combining mandatory and discretionary trips be treated as if the discretionary trips were all diversions from the mandatory pattern. Thus a tour 12, a mandatory trip followed by a discretionary trip followed by a return home (we assume that ICOMP confirms this) would be anlaysed so that the M time was either twice the outward time or the total tour time, whichever was least, and the discretionary time was either the difference between the total tour time and twice the outward M time, or zero, whichever was greater. In this way, we never get 'negative' times; however, if outward and return legs of a journey (i.e. a.m. and p.m. speeds in many cases) were markedly different, this simple rule would lead to unrealistic results in individual cases. (Presumably, corresponding 21 tours would then be biassed in the opposite direction, which would compensate.)

Table 12 sets out the possible values of IND, their associated values of ICHECK and the allocation of the trip time to either M or D purposes, or its division between them. The last item should be interpreted sequentially, in the sense that a tour 131 would be encountered four times; one as 1 in a current tour, once as 13 and once as 131 also in current tours, and once as 131 on encountering a return trip home.

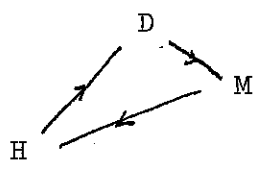
If the fourth 'leg' of the tour does not consist of a trip home, then the indicator ICOMP is set to 1; subsequent trip times are then added to the TA running tour total. In the table below, the program sequence is to identify the nature of the current trip - i.e. M or D or home - and then check the value of IND. For example, suppose a work trip had been encountered, and the value of IND in the tour was 2; the program would recognise that the current tour was now '21', and would perform the operation from table 12, namely setting the current total of time spent on M travel at the time spent on this trip, T. The current total of time spent on D travel in this tour remains at TB, the time spent on the first trip in this case. In this version of the program, the only 'analysable' tour which starts with the sequence 21 is the completed tour 21 - i.e. if the next trip is back to the home. If a home trip is encountered next, the program will set TB, the tour D time, at max(0, TB-T) and TA at min(2T, TB+T). The logic of this can be seen by considering figure 14 below, in which the movement between

Table 12.

IND	Current tours	Home trip	ICHECK
1	TA = TA + T	TA = TA + T	1
13	TA = TA + T	TA = TA + T	1
132	TB = TB + T	TA = TA + T	3
131	TA = TA + T	TA = TA + T	1
135	TA = TA + T	TA = TA + T	1
12	TB = T	TA = min(2TA, TA+T)	1
		TB = max(0, T-TA)	1
124	TB = TB + T	TA = min(2TA, TA+TB+T)	1
		TB = max(0, TB+T+TA)	1
123	TA = TA + T	TTA = TTA + TA + T	3
121	TB = TB + T	TA = TA + T	1
2	TB = TB + T	TB = TB + T	1
24	TB = TB + T	TB = TB + T	1
241	TA = T	TB = max(0, TB-T)	1
		TA = min(2T, TB+T)	
242	TB = TB + T	TB = TB + T	1
246	TB = TB + T	TB = TB + T	1
21	TA = T	TB = max(0, TB-T)	1
		TA = min(2T, TB+T)	
213	TA = TA + T	TTA = TTA + TA + T	3
214	TB = TB + T	TTA = TTA + TA + T	3
212	TB = TB + T	TTA = TTA + TA + T	3

the M and D and home locations are represented by the triangle MDH. The basis of the program is that the trip between H and D is 'inescapable' in both directions, and that the time spent on discretionary travel is thus only the diversion time, HD + DM - MH. In most cases this will probably be reasonable; however it is likely that there will arise instances when the direct trip between the mandatory location M and the home H takes longer than the sum of the two movements HD and DM, and in these cases the mandatory trip time is simply taken as the total travel time on the tour, and the discretionary diversion time estimated at zero.

Figure 14: a three leg tour



	HD	DM	MH	TA	TB
Tour (a)	15	15	20	40	10
Tour (b)	15	15	35	65	0

The resulting breakdown of travel time into discretionary and mandatory components forms a basis for investigating the nature of individual travel behaviour. Dummy variable regression models can then be fitted to the data to isolate and measure the direct and interaction effects of those variables which have been found to affect travel times in the previous stage of the study . A full set of categorising variables will be investigated, since it is possible that groups with overall average travel behaviour in terms of total time outlay have distinctly unusual divisions of that total outlay into discretionary and mandatory travel.

BREAKDOWN RESULTS

Application of the program based on 'Four leg maximum' trips led to 8541 of the 8911 individual day's travel reports being capable of being subdivided into mandatory and discretionary times. Thus, even without refining the program to deal with five or more 'leg' trips, we have 95% of the records dissected; this will be taken to be a sufficient proportion of the data for our purposes. Figure 15 displays the proportions of the 'analysable' population in various categories, against the corresponding proportions in the population of travellers. It can be seen that the only difference is in the proportions in the occupational categories; there is a very slightly higher proportion of workers in the DISCAN

PROPORTIONS WITH 'ANALYSABLE' TRAVEL vs. ALL PRESENT

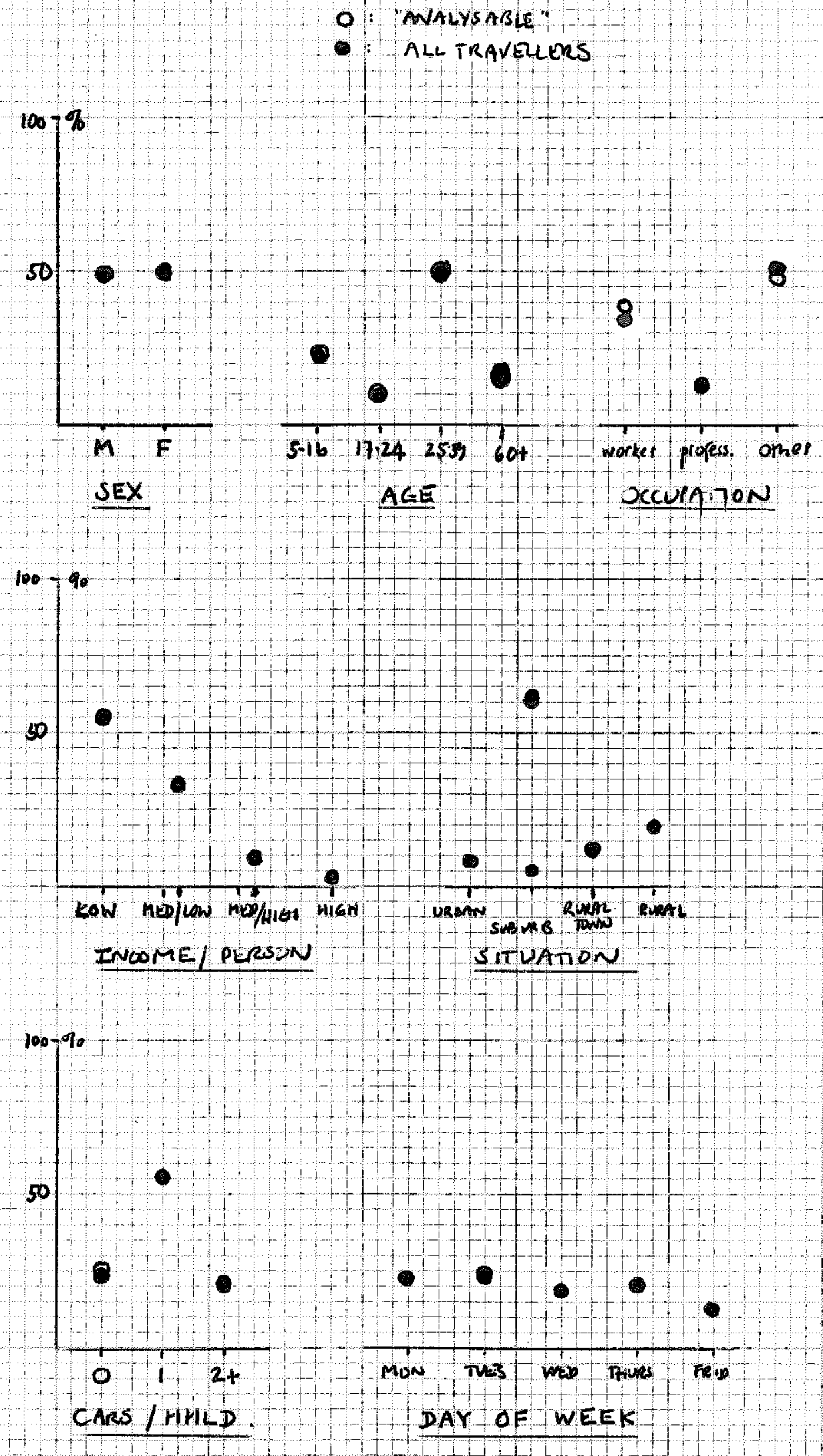


FIGURE 15

set, together with a lower proportion of 'unemployed-other'. Apart from this, the percentage of 'analysable' records appears to be constant over all categories.

In Table 13 is set out the model that was fitted to the total travel time of the 'analysable' travellers using the procedure and category definitions of variable set B (column 5). On the same table, the corresponding model fitted to all travellers is listed (column 4). It may be seen that, ignoring the adjustments that have taken place in the interaction terms, the variations in travel times in the 'analysable' sub-population are very similar to those displayed by the total travelling population, as might be expected, since only 5% of travellers are 'unanalysable'. Columns 1 and 2 on Table 13 set out the results of the dummy variable regression, using VSB definitions, for 'analysable' travellers, distinguishing between time spent on mandatory activities (col.1) and time spent on discretionary activities (col.2). Column 3 is merely the sum of the entries in columns 1 and 2. Comparing column 3 with column 4 or column 5 confirms that the overall picture given by considering variations in mandatory and discretionary times separately conforms broadly to that given by direct inspection of total travel time.

The interesting results of this analysis are seen by inspection of the way in which the overall variations in travel time are seen to vary as between discretionary and mandatory activities.

Firstly, the constant terms indicate that, for the base group and day-of-week, the ratio of mandatory to discretionary travel time was roughly 5:2 in 1974. However, it is clear that there are wider ranges of inter-person-type variations in Mandatory (M) and Discretionary (D) travel than is overall total travel. The patterns that appear are unsurprising, although a welcome corroboration of the procedures that have been used to assess M and D travel time.

The lower average travel time in the female population is seen to fall in the category of reduced M travel, as might be expected. Taking "age" and "occupation" together, children of school age (who will also appear as "other occupation" in this variable definition) are seen to have greater M travel, but very much less D travel than average. The extra travel reported by 17-24 year-olds is seen to be connected with

M activities. Finally, the 60+ group report considerably less M-travel, but slightly more D-travel than average. The "occupation" categories also show striking differences in the way that M and D travel combines to produce overall travel time patterns. The increased travel associated with "professional" workers all attaches to M-travel. The "other", or non-work category, have a slightly lower than average overall time, but this results from the cancelling out of a considerable less

commitment to M-travel by an only slightly lower extra amount of D-travel.

Income effects are seen to be mostly associated with M-travel, as are the less important variation according to location. Level of car-ownership affected neither M nor D travel. Once again, as might be expected, day-of-the-week variation was entirely due to variations in D-activity. The R^2 values associated with these models are 0.20 for M-travel, 0.11 for D-travel. Although still fairly low, these levels are encouragingly higher than the values around 0.08 found in similar models based on overall total travel time. It seems that by dissecting travel time in the way we have, we have isolated aspects of individual's daily travel which lend themselves more readily to interpretation in the context of the background variables that we have chosen.

Table 13

1974 CSTRDB - Models of Mandatory, Discretionary and Total Travel Time.
(c.f. Table 7 of WN.26)
For Travellers: V.S.B.

Basic Variables	Co-efficients				
	(1) Mandatory M	(2) Discretionary D	(3) Total M+D	(4) VSA Total Travellers	(5) Total 'analysable'
D1 Sex Female	-14.4	-	-14.4	-6.8	-9.8
D2 Age 5-16	+15.8	-39.2	-23.4	-16.5	-15.0
D3 17-24	+12.6	-	+12.6	+14.1	+13.8
D4 60+	-13.8	+4.3	-9.5	-	-
D5 Occupn "prof"	+10.3	-	+10.3	+16.1	+15.7
D6 "other"	-30.9	+26.3	-4.6	-4.7	-4.1
D7 Income low	-	-3.9	-3.9	-	-2.1
D8 med/high	+5.7	-	+5.7	+9.1	+8.5
D9 high	+10.3	-	+10.3	+18.1	+16.7
D10 Location suburban	+2.2	-	+2.2	-	-
D11 rural/small town	-4.9	-	-4.9	-7.4	-7.9
D13 Car-ownership 2+ cars	-	-	-	-	+3.3
D14 0 cars	-	-	-	-	-
Interactions					
F1 17-24 & "prof"	-14.1	-	-14.1	-27.6	-28.4
*F4 "prof" & high inc.	+4.3	-	+4.3	-	-
F5 2+ cars & "prof"	+7.7	-	+7.7	+8.3	-
*F6 2+ cars & high inc.	+2.8	-	+2.8	+3.7	+3.1
F8 17-24 & "prof" & 2+ cars	-27.7	-	-27.7	-	-
U1 female & (5-16 or 60+)	+10.5	-	+10.5	7.0	U7 -15.1
*U2 female & other	+3.5	-	+3.5	-	
U3 female & low inc.	-	-	-	-	
U4 female & rural	-	-	-	-5.8	U12 +10.4
U6 low inc & (5-16 or 60+)	-	+7.6	+7.6	-	U18 +12.1
U13 female & rural & (5-16 or 60+)	-	-5.0	-5.6	-	
Day-of-Week Effects					
D17 Tuesday	-	-	-	-0.9	-1.4
D18 Wednesday	-	+7.1	+7.1	+4.7	+5.2
D19 Thursday	-	+5.7	+5.7	+5.5	+5.2
D20 Friday	-	+11.3	+11.3	+13.6	+12.0
CONSTANT TERM	48.3	21.9	70.2	69.1	68.3
R^2/S.E. of Estimate	0.20/39.0	0.11/43.2		0.07/57.7	0.07/54.2
No. of cases	8541	8541		8911	8541

U7: rural & (5-16 or 60+) U18: "other" OCC & (5-16 or 60+) & rural
U12: female & low inc & (5-16 or 60+)

Table 14

'Typical' Individuals (all urban, 1 car owners, Monday travel.)

Individual	Age	Sex	Occupn.	Income	Travel Time (mins./day)			All Travellers Actual Average	'Analysable' Travellers Actual Average
					Model 1A (col.5 of T.1)	Model 1 (col.4 of T.1)	M+D (col.3 of T.1)		
A	5-16	M	"other"	med/low	49	48	42	43	42
B	5-16	F	"other"	med/ high	47	57	48	50	47
C	17-24	M	"prof"	med/ high	79	80	89	85	76
D	17-24	F	worker	low	66	76	65	74	69
E	25-59	M	worker	med/low	68	69	70	69	68
F	25-59	F	"other"	low	52	57	51	53	50
G	60+	M	worker	high	85	88	71	81	83
H	60+	F	"other"	low	62	64	52	64	64

A = Constant + D2 + D6 + U5.

B = Constant + D1 + D2 + D6 + D8 + U2 + U1 + U5 + U11.

C = Constant + D3 + D5 + D8 + F1 + F2 + F4 + F7.

D = Constant + D1 + D3 + D7 + U3.

E = Constant

F = Constant + D1 + D6 + D7 + U2 + U3 + U8 + U14.

G = Constant + D4 + D9.

H = Constant + D1 + D4 + D6 + D7 + U2 + U3 + U1 + U8 + U5 + U11 + U12 + U14.

The main reason for analysing travel time in this way was to examine the hypothesis that individuals had 'target' travel times which they would continue to try to achieve after, for example, network changes. If such 'targets' exist, then it will clearly be highly informative to try to place numerical values on them, and to use this information in forecasts. In the main, we have identified what may loosely be described as patterns of social organisation which run through the data set. For example, by our definition of mandatory, on average non-working housewives have lower than average time outlays on M travel. On the other hand, typically they perform most of the activities associated with household maintenance, and thus have on average an extra component of D travel. This sort of organisational compensating mechanism is of no interest to us as far as casting light on the credibility of the 'targetting' hypothesis is concerned. Similarly, the fact that retired people have little or no M travel but do travel more than average during the day on D activites is beside the point. What we are looking for are broadly homogenous groups of individuals who seem to have broadly similar schedules. Within each of these groups, were each group member 'targetting' for the group average total travel time, we would expect to find, on average, that individuals with unusually (by group standards) high M travel commitments compensated by reducing their D travel. Correspondingly, we would expect to find those with lower than average M travel to use the time released to travel longer on D activities. (Note that, if each group member were 'targetting' to a unique desired travel time, then provided that the average of the personal targets for those with high mandatory commitments was the same as the average for those with low mandatory commitments, we would expect a similar pattern to emerge in the date - i.e. low M tending to be associated with high D, and vice-versa.).

We can also test a strong counter hypothesis, that the time allocated to travel connected with discretionary activities is independent of that allocated to travel for mandatory activities, using the CSTRDB.

Tables 15 and 16 set out the number of travellers, male and female respectively, in the age range 17 to 59 years, classified as 'working', but excluding the group of individuals classified as having 'professional' occupations and also being in the 17-24 year age group. Only such individuals as reported <u>both</u> mandatory and discretionary travel on the survey day are recorded in these tables. In the (i.j) cell of each table, n_{ij}, the number of individuals with reported M time in range i and D time in range j is set out beside a modelled value, $n_{ij}*$. This model is the conventional model of independence in two-way tables, calculated as

$$n_{ij} = \frac{\sum_k n_{ik} \sum_h n_{hj}}{\sum_{kh} n_{kh}} .$$

The correspondence is marked, and is confirmed by the values of the statistic $X^2 = \sum_{ij} \frac{(n_{ij}-n_{ij}*)^2}{n_{ij}*}$, which, on the null hypothesis of independence of choice of mandatory and discretionary travel times, is X^2 distributed with (r-1) (c-1) degrees of freedom, (r and c being respectively the number of rows and columns in the table).

The calculated values (using unrounded values of $n_{ij}*$) were $X^2 = 66.0$ with 49 degrees of freedom for table 4 and $X^2 = 40.1$ with 42 degrees of freedom for table 5. Using the approximate transformation $z = (\sqrt{2X^2} - \sqrt{2n'-1})$, where n' = degrees of freedom, we can convert these values to N(0,1) variables : we obtain

z = 1.63 for table 4, and

z = 0.16 for table 5.

Thus we would not reject the null hypothesis at the 95% confidence level for either table; and conclude that there is no evidence that discretionary travel time varies with committed mandatory travel time.

According to our earlier analysis, the only major systematic influences left after grouping in this way are day-of-week (Friday in particular), income (high income in particular) and occupation (professional, "other" having already been excluded.)

To demonstrate that these factors are not masking a 'targetting' relationship in tables 15 and 16, tables 17 and 18 set out the same information but for all individuals, male and female separately, excluding

(a) non-travellers;

(b) those less than 17 or over 60;

(c) non-workers;

(d) high income;

(e) 'professional' workers; and

(f) Friday travel.

The calculated Z values were -0.08 and 0.47 respectively; on the null hypothesis, H_o say, these Z values would be distributed as $N(0,1)$, and we would thus not reject H_o at the 95% confidence level unless we observed a Z value in excess of 1.96. Accordingly, we would conclude that there is no evidence of dependence between travel time connected with discretionary activities and travel time connected with mandatory activities for these tables either.

Finally, there is the question of whether or not a relationship exists between time allocated to M travel and the <u>frequency</u> with which out-of-home discretionary activities are reported. Figure 16 displays the appropriate percentages of males and females reporting no D travel at all, plotted against the level of M travel reported. It may be seen that there is indeed some indication of an upward trend in each case; the effect is very slight, but, for these two groups at least, increasing mandatory travel times correspond to marginally decreasing frequency of reporting out-of-home discretionary activities.

Figure 17 displays the average D travel times corresponding to the several bands of M travel time, both for all analysable travellers and for all such travellers as reported <u>both</u> M and D travel. There are no obvious trends in this data.

We can conclude that, for this data set, (a) there is no systematic relationship between travel times for M and for D activities for those travellers who reported both sorts of activity; (b) there is some indication of a slight decrease in the frequency of reporting out-of-home discretionary activities for those with higher M travel, but (c) this latter effect is <u>so</u> slight that there is no resulting downward trend in average D travel times for increasing M travel.

<u>CONCLUSIONS</u>

Figure 18 sets out a scattergram of the reported mandatory and discretionary travel times for 5000 individuals from the 1974 CSTRDB. The features of the data that are obvious from this display are that

Table 15

Observed and Modelled Numbers of Travellers:

Male, 17-59, Working, excluding (17-24 x 'prof')

obs^n. ; model

M-times (minutes) \ D-times (minutes)	<10	10-20	20-30	30-40	40-50	50-60	60-70	70+
<10	11 ; 11	14 ; 14	7 ; 11	8 ; 6	1 ; 5	5 ; 5	6 ; 3	8 ; 6
10-20	23 ; 26	39 ; 32	27 ; 27	15 ; 15	9 ; 11	12 ; 11	5 ; 7	12 ; 14
20-30	34 ; 32	33 ; 39	42 ; 33	16 ; 18	13 ; 13	11 ; 14	9 ; 8	17 ; 17
30-40	28 ; 27	36 ; 34	34 ; 29	18 ; 16	8 ; 12	7 ; 12	8 ; 7	13 ; 15
40-50	20 ; 18	15 ; 22	12 ; 18	17 ; 10	10 ; 7	9 ; 8	3 ; 5	11 ; 9
50-60	28 ; 24	37 ; 30	29 ; 25	7 ; 14	9 ; 10	7 ; 10	3 ; 6	11 ; 13
60-70	8 ; 9	13 ; 11	8 ; 9	9 ; 5	1 ; 4	5 ; 4	2 ; 2	4 ; 5
70+	27 ; 33	46 ; 31	27 ; 34	14 ; 19	25 ; 14	23 ; 15	12 ; 9	19 ; 18

Total Number = 990

Table 16

Observed and Modelled Numbers of Travellers:

Female, 17-59, Working, excluding (17-24 x 'prof')

obs^n. ; model

M-times (minutes \ D-times (minutes)	<10	10-20	20-30	30-40	40-50	50-60	60-70	70+
<10	20 ; 16	11 ; 15	12 ; 14	11 ; 9	7 ; 8	6 ; 5	8 ; 4	4 ; 9
10-20	31 ; 28	31 ; 28	22 ; 25	12 ; 16	16 ; 14	4 ; 10	5 ; 7	21 ; 15
20-30	25 ; 26	23 ; 25	26 ; 23	16 ; 14	7 ; 13	15 ; 9	5 ; 6	13 ; 14
30-40	18 ; 19	21 ; 19	22 ; 17	9 ; 10	8 ; 10	3 ; 6	5 ; 5	9 ; 10
40-50	20 ; 17	18 ; 17	11 ; 16	10 ; 10	11 ; 3	9 ; 6	3 ; 4	7 ; 10
50-60	10 ; 15	14 ; 15	16 ; 13	8 ; 8	13 ; 8	6 ; 5	3 ; 4	7 ; 8
60+	17 ; 21	22 ; 21	16 ; 18	12 ; 12	11 ; 11	5 ; 7	3 ; 5	17 ; 12

Total Number = 718

Table 17

Observed and Modelled Numbers of Travellers

(See text.)

obs^n. ; model

M-times (minutes) \ D-times (minutes)	<10	10-20	20-30	30-40	>40
<10	8 ; 7	11 ; 8	6 ; 7	3 ; 5	11 ; 11
10-20	17 ; 18	28 ; 20	17 ; 18	10 ; 11	22 ; 28
20-30	20 ; 20	21 ; 22	25 ; 20	11 ; 13	28 ; 31
30-40	24 ; 19	22 ; 22	20 ; 19	13 ; 12	23 ; 30
40-50	10 ; 10	9 ; 11	6 ; 10	10 ; 6	18 ; 16
-60	14 ; 14	17 ; 16	16 ; 14	4 ; 8	22 ; 22
60 +	17 ; 23	19 ; 26	22 ; 23	15 ; 15	49 ; 36

Total Number = 588

Table 18

Observed and Modelled Numbers of Travellers

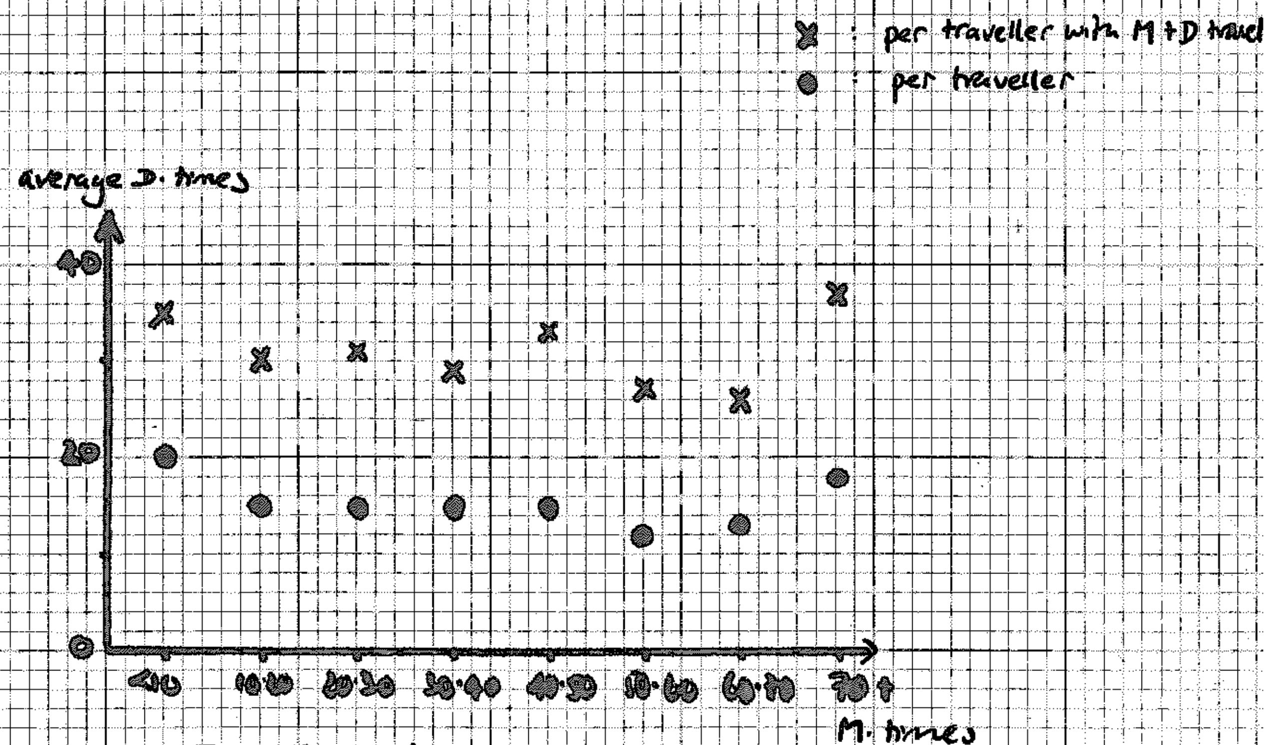
(See text.)

obs^n ; model

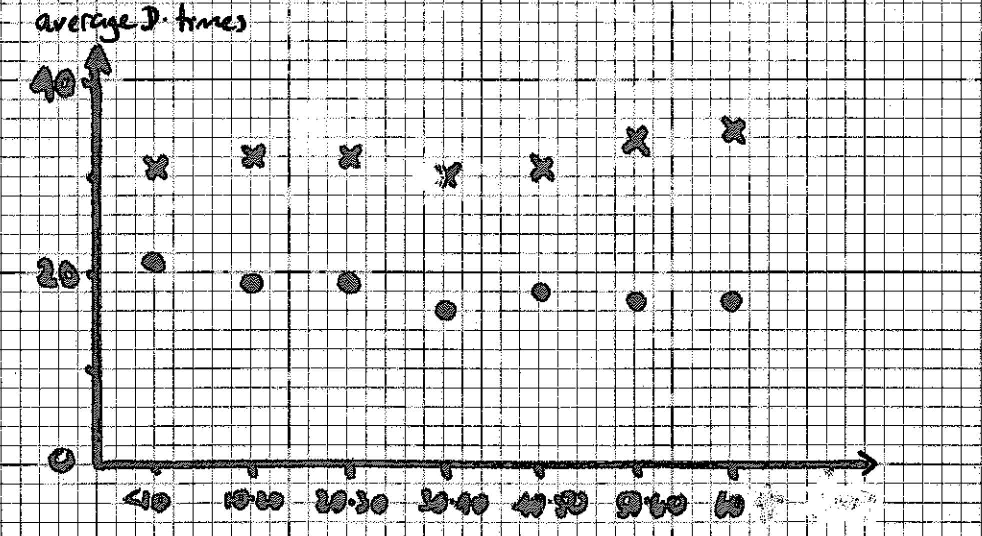
M-times (minutes) \ D-times (minutes)	<10	10-20	20-30	30-40	40-50	>50
<10	17 ; 13	8 ; 13	10 ; 10	9 : 7	7 ; 7	12 ; 13
10-20	28 ; 22	24 ; 22	16 ; 18	18 ; 12	11 ; 12	22 ; 23
20-30	20 ; 21	17 ; 22	21 ; 17	15 ; 12	7 ; 11	25 ; 23
30-40	13 ; 16	19 ; 16	17 ; 13	7 ; 9	8 ; 8	14 ; 17
40-50	14 ; 14	16 ; 14	9 ; 11	9 ; 8	7 ; 7	12 ; 14
50-60	9 ; 12	11 ; 12	8 ; 10	8 ; 7	11 ; 6	13 ; 13
60	13 ; -6	20 ; 16	9 ; 13	7 ; 9	8 ; 8	22 ; 17

Total Number = 561

FIGURE 17: AVERAGE D. TIMES BY M. BAND.

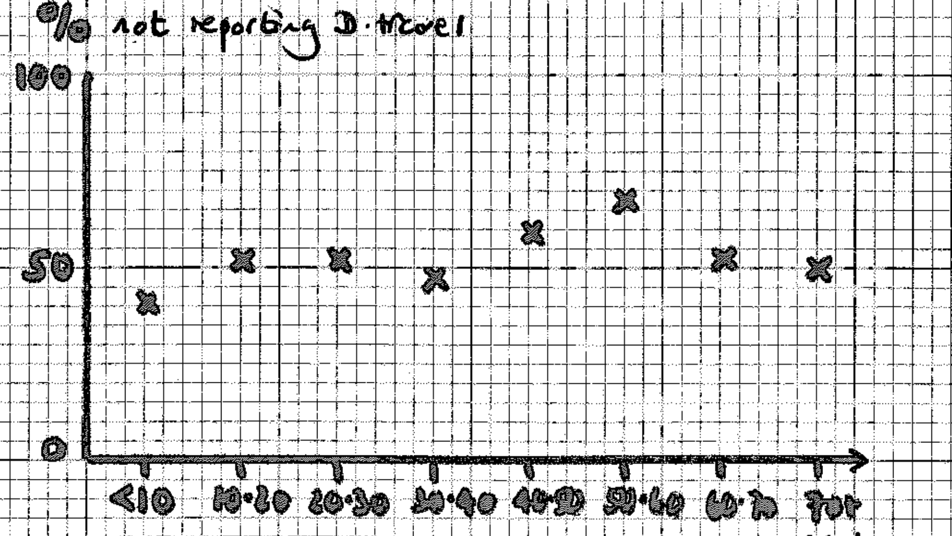


as Table 15: males.

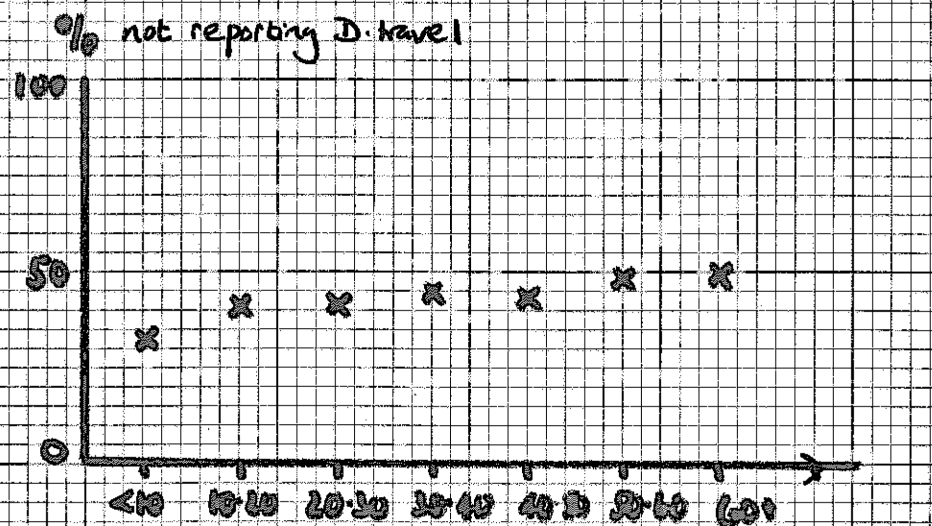


as Table 15: females.

FIGURE 16: PROPORTIONS REPORTING NO D·TRAVEL

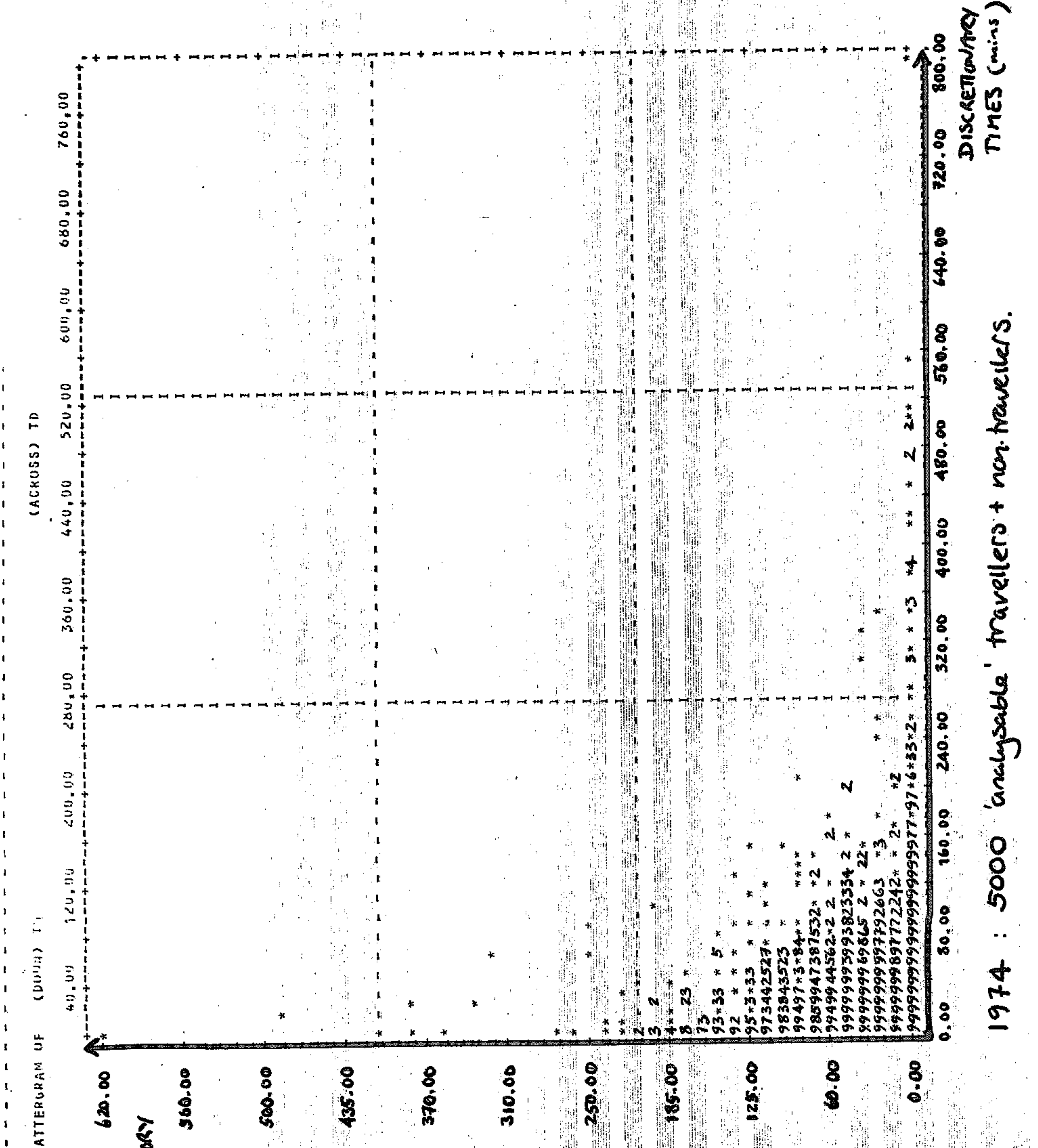


as Table 15 : males



as Table 15 : females

Figure 18: Mandatory vs. Discretionary Times.



1974 : 5000 'analysable' travellers + non-travellers.

(a) The bulk of the data is concentrated in the region bounded by 70 minutes M travel and 70 minutes D travel.

(b) There are extremely long 'tails' outside this region, and when several hours are being spent on one or other sort of travel, little or no time is allocated to the other.

The second feature does testify to an inevitable form of 'targetting', in the sense that there are only 24 hours in the day and a realistic upper limit rather less than this normally available for travel. If one 'sort' of travel occupies a large part of the day, there simply may not be time left to spend on travelling to, and participating in, other activities.

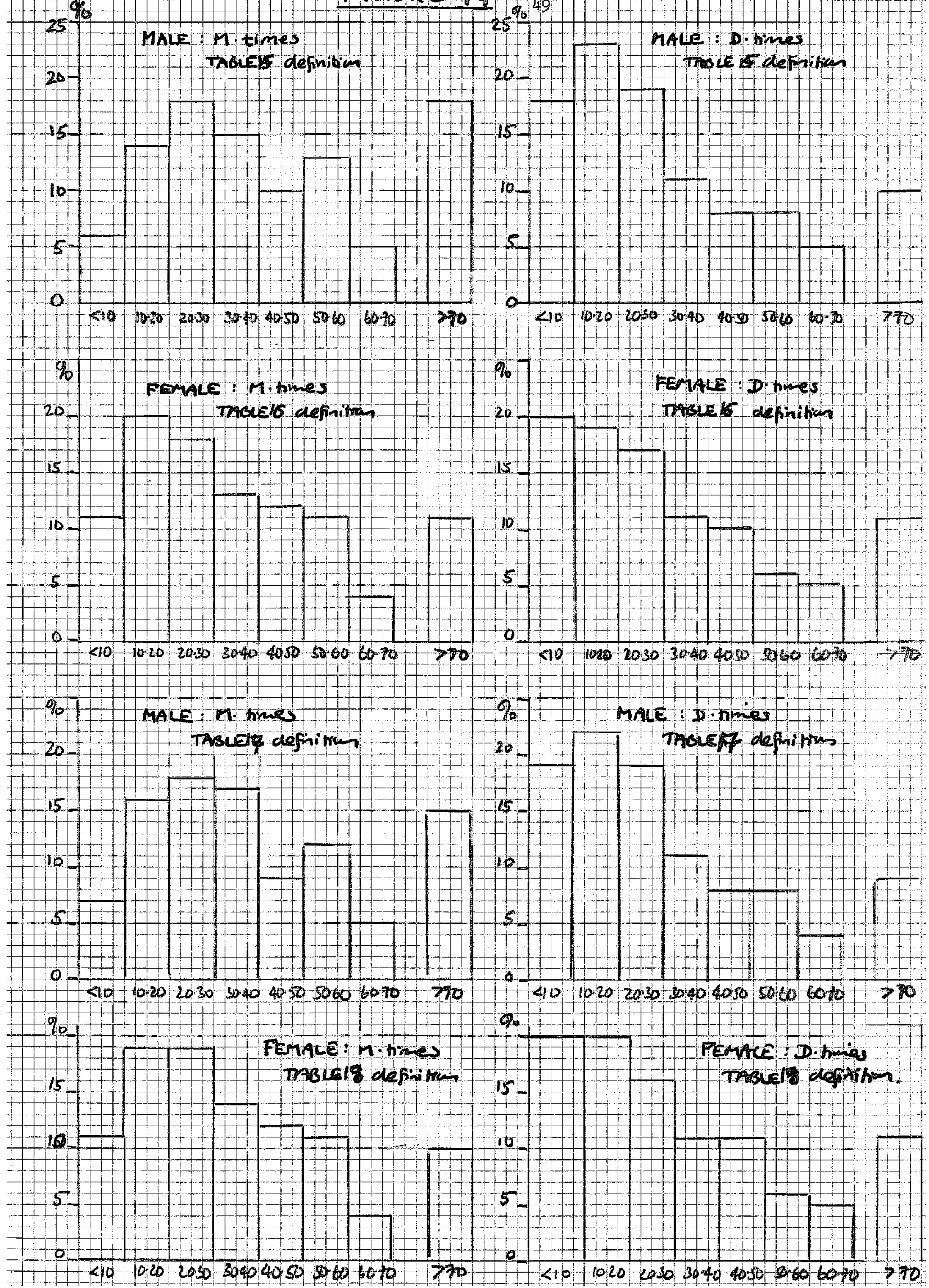
Figure 19 sets out the marginal distributions of the total amounts of M and D travel for the travellers recorded in tables 15 to 18, i.e. members of groups chosen such that there is little variation in personal travel times which can be correlated with any common background variables. In this respect, the distributions derived from the table 17 and table 18 figures are from an even more 'homogeneous' group; not only have we excluded those over sixty, or under 17 and those not categorised as employed, (as in tables 15 and 16), but also all interviews conducted on Fridays, all 'high' income individuals and those in our classification of 'professional' employment. Males and females are treated separately. The broad patterns are similar for both group definitions.

For both male and female travellers, there was a far higher percentage of reported D travel times in the range 0-20 minutes than of M travel times in the same range. This was compensated by a slight reduction in proportions of travellers in all the higher travel-time bands.

The distribution of male travel times showed some differences from female; for M travel, a higher overall average results from a general shifting of the distribution towards the higher time bands. The D travel distribution, although not noticeably tending towards higher time bands, does point towards male travellers having less frequent 'very-short-duration' trips.

Given these broad overall patterns, the tests we have conducted indicate that there is <u>no evidence</u> that individual total daily travel

FIGURE 19


%
25
20
15
10
5
0
MALE : M. times
TABLE 15 definition
<10
10-20
20-30
30-40
40-50
50-60
60-70
>70
MALE : D. times
TABLE 15 definition
FEMALE : M. times
TABLE 15 definition
FEMALE : D. times
TABLE 15 definition
MALE : M. times
TABLE 17 definition
MALE : D. times
TABLE 17 definition
FEMALE : M. times
TABLE 18 definition
FEMALE : D. times
TABLE 18 definition.

is arranged such that the 'committed' time outlay on travel associated with mandatory activities affects the time spent on travel for discretionary activities. The reported pattern of M times and D times amongst those reporting both sorts of activity is consistent with a hypothesis that D times are chosen <u>at random</u> from the marginal distributions independently of the committed M time. Nor is there evidence of a sufficient trend in reducing frequency of reporting out-of-home discretionary activities to result in any systematic reduction in mean D travel with increasing M travel <u>per traveller</u>. (i.e. When we also include those reporting no D travel.)

CONCLUSIONS.

In this chapter, we have looked for a link between time spent travelling connected with mandatory activities and time spent travelling connected with discretionary activities, considering only groups of individuals with 'similar' characteristics (as far as average travel schedules are concerned), and we have found no evidence of any interdependence.

The hypothesis was advanced that network changes which affect speeds will result in more or less travel as a result of the 'pre-change'travel time budgets being preserved subsequent to the network change. To test this hypothesis directly would require data spanning a period of which such network changes had taken place; these are not currently available. Instead, we have tried to test the theory indirectly, by breaking down individual travel times into time allocated to travel connected with 'mandatory' activities (defined to be those activities whose frequency and location are fixed in the short term,) and 'discretionary' activities, being all the rest. We have tried to stratify the sample from the 1974 C.S.T.R.D.B. into groups of individuals with broadly similar average amounts of travel time, both for M and D purposes. Within such groups, we have looked for a relationship between 'M travel' time and 'D travel' time, and found them to be apparently independent.

We have then reasoned that, if time be allocated to travel on discretionary activities independently to time committed to M activites, then <u>individuals</u> cannot be considered to be 'targetting' towards any preselected travel time 'budget'. Were we to speed-up journeys to work, for example, there would be no corresponding increase in time spent travelling for discretionary activities, at least on the evidence of the data we have examined so far.

Our conclusions must be qualified as being indirect. We have also examined only one data set, albeit a large one. The fact that the survey recorded only a single day's travel is another reason to look for further confirmation. However, our results, and the analyses that led up to them, seem plausible and in reasonable accord with intuition.

Evidence from many countries testifies to a striking regularity in the average amounts of time being spent on overall travel. In this paper we have tried to decide whether or not the travel patterns reported in a large U.K. survey are consistent with the hypothesis that individual travellers try (within the constraints of broad schedules of activities, possibly corresponding to household roles, income and occupational status) to achieve 'targets' of travel time expenditure. We have formally tested a counter hypothesis, that travel connected with activities which are, in the short term, variable in location and frequency, is undertaken independently of the travel reported by the individual as being associated with activities which are, once again in the short term, fixed in both location and frequency. We could not reject this hypothesis.

The implication of this conclusion is that the observations of stability in overall average travel times are probably not due to the existence of personal travel budgets, in the sense of targets.

CHAPTER 4.

PATTERNS OF HOUSEHOLD MANDATORY AND DISCRETIONARY TRAVEL

This Chapter describes an analysis of travel expenditures similar to that reported for individuals, but aggregated to the level of the household. In addition to the examination of overall total household travel times, an attempt is also been made to analyse household cash outlay on travel (ignoring vehicle standing costs) and also household 'generalised expenditure' on travel, by factoring travel times by a single crude average 'value of time' and combining this with cash outlay.

For each trip reported, an estimate of the cash outlay has been made on the basis of approximate costs per unit time by mechanised modes and the in-vehicle times reported. Table 20 sets out the costs per minute that were used for each mode; these were based on estimates given by Tanner (1979).

Table 20. COSTS PER MINUTE BY MODE : 1974 IN 1970 PRICES

Mode	Costs per minute	Note
Car/van driver	0.404 p	1
Car/van passenger	0 p	
Bus/train	0.438 p	2
Other	0	

Note 1 : Tanner (1979) Table 11 gives 6.2 pence per person per day, in 1970 prices, as the average outlay on private vehicle travel. Table 10 gives an approximate time outlay of 23 minutes per person per day. Taking an average vehicle occupancy of 1.5 gives an average cost per minute per vehicle of approximately $(6.2 \times 1.5)/23 = 0.404$ pence. This has been allocated to the driver in the absence of any other information.

Note 2 : Table 11 gives 3.5 pence per person per day as the average outlay on public transport, once again in 1970 prices; this corresponds to a time outlay of approximately 8 minutes per person per day, giving an approximate cost per minute of $3.5/8 = 0.438$ pence.

Clearly, these figures are only crude estimates. Within the 'other' category are the modes 'taxi' and 'motor cycle driver', both of which will have an associated cost outlay. However, the majority of the modes included under this heading (and almost certainly the main part of the time spent) will be cost-free, by our definitions. The remaining modes (see TN 18) are Other Passenger, Works Bus, Pedal Cycle, Walk, School Bus, Others. Further, the convention of allocating all costs to the driver will not be too unreasonable, given that we then amalgamate travel to a household level, at least for passengers from the driver's household. Thus the cost estimates that we produce, whilst undeniably crude, should be adequate for a broad-brush analysis such as is reported here.

Difficulties with the convention adopted to discriminate between costs incurred for M-travel and costs incurred for D-travel are also worth mentioning at this stage. For example, in the three leg tour illustrated by figure 1, if the HD and DM legs were performed by bus, but the MH leg as a car passenger, all costs would be allocated to D-travel. By implication, we would then have assumed that a lift by private car would have been available for a direct HM leg, which is clearly not sensible. Thus, even when the overall travel costs are reasonably approximated, it may be more difficult to impute sensible 'diversion costs' than 'diversion times'; in the same set of circumstances our estimate of 'diversion time' would also be wrong, but only by the difference in journey time as between the unavailable mode and that mode which would have been used. However, this sort of problem only arises for mixed-mode, complex (ie. multi-leg, multi-purpose) tours; consequently the practical implications for our analysis will almost certainly be negligible.

Given the output of the program, being total travel times, M-travel times and costs, D-travel times and costs for each traveller in the data bank, together with personal and household characteristics and indicator variables to denote those individuals whose travel patterns could not be analysed by the set of rules adopted a program was written to simply amalgamate records of individuals within households. The output file contents and format are given in Table 21.

This file contains records for those households with at least one household member reporting travel on the survey day.

Table 21. CONTENTS OF HOUSEHOLD FILE

FOR EACH HOUSEHOLD -

Variable	Code
No. of individuals of 'Type M' (see footnotes)	IN
Zero, unless one tour has more than 4 legs	ICO
One, unless one tour is 'unanalysable' (but see footnotes)	ICH
Travel time - mandatory	CC(1)
Travel time - discretionary	CC(2)
Travel cost - mandatory	CC(3)
Travel cost - mandatory, alternative definition	CC(4)
Travel cost - discretionary	CC(5)
Travel cost - discretionary, alternative definition	CC(6)
Age of head of household	IAGE
No. of driving licences in h/hld	I1
Job of head of household	J1
Industry/profession of h. of h/hld.	P1
(ICC(I), I=9,27) household variables	

Footnotes:

1. For a definition of ICC(.) see Appendix 1. 'Type M' denotes an individual with a commitment to an out-of-home activity; these were taken as everyone except those in the 'other' occn. category of VSB, but includes students.

2. In its original version, the file also contains some dummy entries corresponding to non-travellers; these records all have zero values of the variable ICH, and hence can be skipped for the analysis.

3. The 'alternative definitions' of travel cost originally contained estimates including provision for vehicle standing costs. These were eventually dropped from the analysis.

The course of the analyses carried out on this data set followed that described in Chapter 2 for overall travel time, and Chapter 3 for M-travel and D-travel; however, to avoid distortion of the overall models, households reporting more than 100 minutes travel per member over 5 years were ignored. (Analyses of the total data set are reported later.) A number of background variables were selected for investigation, and a set of zero-one dummy variables defined in such a way as to permit investigation of the degree to which average travel expenditure varied as between individuals characterised by different values of the background variables. (Travel expenditure being defined variously as time, cost and generalised cost outlays on M-travel and D-travel respectively.) As with the earlier analyses, a number of interaction effects were also defined, corresponding to first and second order interactions between subgroups of 'favourable' and 'unfavourable' background variables. The range of dummy variables that were so defined is given in Table 22.

Also as in the previous analyses, the SPSS package was used to perform a stepwise regression of the travel expenditure variables on the set of dummy variables, plus the variable IN entered as a 'continuous' variable.

Table 22. DUMMY VARIABLES FOR REGRESSION ANALYSIS

Dummy	Coding	Nature of variable
D5	F	Professional) occupation of head of household
D6	U	Non-worker)
D7	U	Low)
D8		Med/high) household income
D9	F	High)
D10		Suburban)
D11		Rural small town) household location
D12		Rural)
D13	U	Zero) household car ownership
D14	F	Two plus)
D17		Tuesday)
D18		Wednesday) day of week of interview
D19		Thursday)
D20		Friday)
D21	F	Good) public transport access
D22	U	Bad)
D23		Infant(s) less than 5 years old in household
F1		D5 x D9
F2		D5 x D14
F3		D5 x D21
F4		D9 x D14
F5		D9 x D21
F6		D14 x D21
U1		D6 x D7
U2		D6 x D13
U3		D6 x D22
U4		D7 x D13
U5		D7 x D22
U6		D13 x D22

Footnotes:

Exact definitions of the categories, following Tn 26, are:

D5 = 1 IFF J1 = 1,2,3,4 or 12
D6 = 1 IFF J1 = 13,14,18,19 or 21
D7 = 1 IFF ICC(16) = 1,2,3,4 or 91
D8 = 1 IFF ICC(16) = 8,9,10 or 92
D9 = 1 IFF ICC(16) = 11,12,13,14,15 or 93
D10 = 1 IFF ICC(20) = 2
D11 = 1 IFF ICC(20) = 3
D12 = 1 IFF ICC(20) = 4
D13 = 1 IFF ICC(14) = 0
D14 = 1 IFF ICC(14) = 2 or more
D21 = 1 IFF ICC(24) = 1 and ICC(25) = 1
D22 = 1 IFF ICC(24) = 3 or 4 and ICC(25) = 3 or 4
D23 = 1 IFF ICC(13) = 1 or more

The interaction variables are defined in a way analagous to that described in Chapter 2, using the chosen 'coding'

PATTERNS IN HOUSEHOLD TRAVEL TIME EXPENDITURE

Since the dependent variable in our analysis is household travel expenditures, it is clear that there may be a direct dependence on the number of household members. To overcome this difficulty, in the initial analysis of all the aspects of travel expenditure we shall treat as separate populations households with different numbers of members potentially reporting trips - being those over five years of age. Separate analyses are thus performed on households with one, two, three, four, five and six members over five years of age.

Tables 23 and 24 summarise the results of performing the stepwise regression analysis on the set of independent variables described above, for overall times spent as M-travel and D-travel. The regression was designed to add in explanatory variables up to the point when the next most powerful explanatory variable had a coefficient which could not be statistically distinguished from zero, given the approximate standard errors (calculated on the basis of a simple linear model with expectation of independent error structure with constant variances). The limitations of this approach were discussed in Chapter 2.In brief, we have argued for the use of the approach as a tool to identify the most important effects (and to exclude those for which there is little evidence of any systematic influence) in the spirit of an exploratory analysis, accepting that the accuracy of some coefficients may be overstated or understated to some extent.

Perhaps the first observation to be made about the fitted models is that, as was the case with individual travel times, a higher proportion of the variation of the mandatory times can be explained (in terms of variation in background effects) than of discretionary times; the R^2 values are all considerably higher for the models of M-travel. Table 25 sets out the mean and standard error of the M-times and D-times together with the standard error of estimate subsequent to model fitting.

Table 23 TIME SPENT TRAVELLING PER HOUSEHOLD (by persons over 5 years in household)

MANDATORY TRAVEL

Variables	1 person	2 persons	3 persons	4 persons	5 persons	6 persons
No. 'occupied' (IN)	+24	+34	+36	+36	+35	+31
Med/high income		+ 5				
High income		+11	+14	+19	+32	
Non-working head	- 7					
Suburban		- 6				
Rural small town		- 8	-27			
Thursday						-74
Prof. ⊠ 2+ cars		+ 9		+16		
Prof. ⊠ High inc.		+15				
Prof. ⊠ Good P.T.		+15				
High Inc. ⊠ Good P.T.						
Non worker ⊠ Bad P.T.						
Constant	8	7	13	7	6	66
R^2	.54	.41	.33	.31	.25	.32
Mean	13	45	85	123	162	209
No. of cases	382	1086	503	451	188	58

Table 24: TIME SPENT TRAVELLING PER HOUSEHOLD (by persons over 5 years old)

DISCRETIONARY TRAVEL

Variables	1 person	2 persons	3 persons	4 persons	5 persons	6 persons
No. 'occupied' (ΣN)	-24	-16	- 7			
Med/high income	+12					
2+ cars					+33	
Infant in h/hold					+68	
Thursday				+23		
Friday				+18		+107
Bad P.T.				-40		
Suburban		- 5				
Rural			-17			
Low income $\boxtimes$ no cars						- 96
No cars $\boxtimes$ bad p.t.		-33				
Constant	41	67	75	68	75	106
R^2	.22	.08	.03	.04	.07	.28
Mean	31	47	56	74	89	110
No. of cases	382	1086	503	451	188	58

Table 25: TRAVEL TIMES

Household size (persons over 5 yrs)	Mean	S.D.(1)	S.E.E.(2)	R^2
	Mandatory			
1	13	20	14	.54
2	45	42	32	.41
3	85	60	49	.33
4	123	68	57	.31
5	162	80	69	.25
6	209	81	68	.32
	Discretionary			
1	31	27	24	.21
2	47	43	42	.08
3	56	53	52	.03
4	74	60	59	.04
5	89	83	81	.07
6	110	89	77	.28

(1) S.D. refers to the standard deviation of the population of times

(2) S.E.E. refers to the residual error after fitting the model.

Comparing the models fitted to the different household categories across tables 23 and 24, there are very few effects which show up systematically in all categories. For M-travel, there is a clear and persistent influence of the number of individuals in the household who are categorised as belonging to occupational categories which have been associated with a commitment to mandatory travel (IN, the 'no. occupied' variable). Further there is an interesting 'high income' effect : high income households report more M-travel than average, but the extent of the increased travel increases with household size even after allowing for 'no. occupied'. (It is possible that this testifies to an accessibility factor in the sense that 'high income' households may tend to make location choices which produce, on average, longer M-travel outlays for all committed journeys (work or education)). There is little in the way of consistent effects to be found in the models of D-travel: 'no. occupied' has the intuitively sensible effect of reducing D-travel per household as more household members are committed to M-activities, but this is only apparent in the one, two and three person households.

The two tables can be compared with Table 14, in which variations in M-travel and D-travel by <u>individual</u> travellers were modelled. Grouping individuals into households should have the effect of reinforcing the influence of those characteristics of the individual which are shared by members of the same household - location and car-ownership are the most obvious household based measures, although all household members will also have interview 'day-of-week' in common. Further, although income was defined as 'income per person' for the individual models and as 'total household income' for the household models, since we are treating different household sizes separately we should find that the income effect in the household models are consistent with those in the individual models.

Broadly speaking, we see from Tables 23 and 24 that

(a) the income effects are as expected, with increased income coinciding with extra M-travel;

(b) the (lack of) car ownership effect is as expected;

(c) such day-of-the-week effects as there are point to increased D-travel on Thursdays and Fridays, as expected. However, these effects are only observed in the models for four and six person households.

(d) there is some indication that 'rural small town' location coincides with reduced M-travel as compared with the base group, 'urban' and 'rural' in this case. This is in accord with expectation from the individual models. However, 'suburban' M-travel appears to be lower than base group M-travel if only in the two person households; this is contrary to the expectation of slightly higher than average M-travel from the individual models. There were no detectable location effects in the individual models of D-travel. In the corresponding household models of D-travel, both 'suburban' and 'rural' locations show-up as coinciding with reduced time spent in D-travel, albeit each only in a single household group.

In summary, the process of combining individuals to household and rejecting households in which at least one member's travel was unanalysable, or total travel was above a threshold, and then subdividing the sampled households by number of household member over five years of age, appears to have masked some of the effects that we would have expected from the individual models. In particular, the day-of-the-week effect is less marked than might have been expected, and there are some (slightly) contradictory trends in the influence of location. However, the effect of income is consistent and well-defined, and car-ownership also continues to prove unrelated to travel expenditure in terms of time spent. Note that Table 14 refers to travellers, whereas the grouping in Tables 23 and 24 of this chapter have been by household size regardless of the presence of non-travellers. Some discrepancies can therefore be expected. As with the models for individual travel time expenditures, household time expenditures on both M-travel and D-travel are marked by considerable variability. Once again in accord with expectation on the basis of the individual models, little of the variability in D-travel can be accounted for in terms of variation in the selected background variables; on the other hand, a number of systematic influence on household M-travel can be detected, in particular household composition and income.

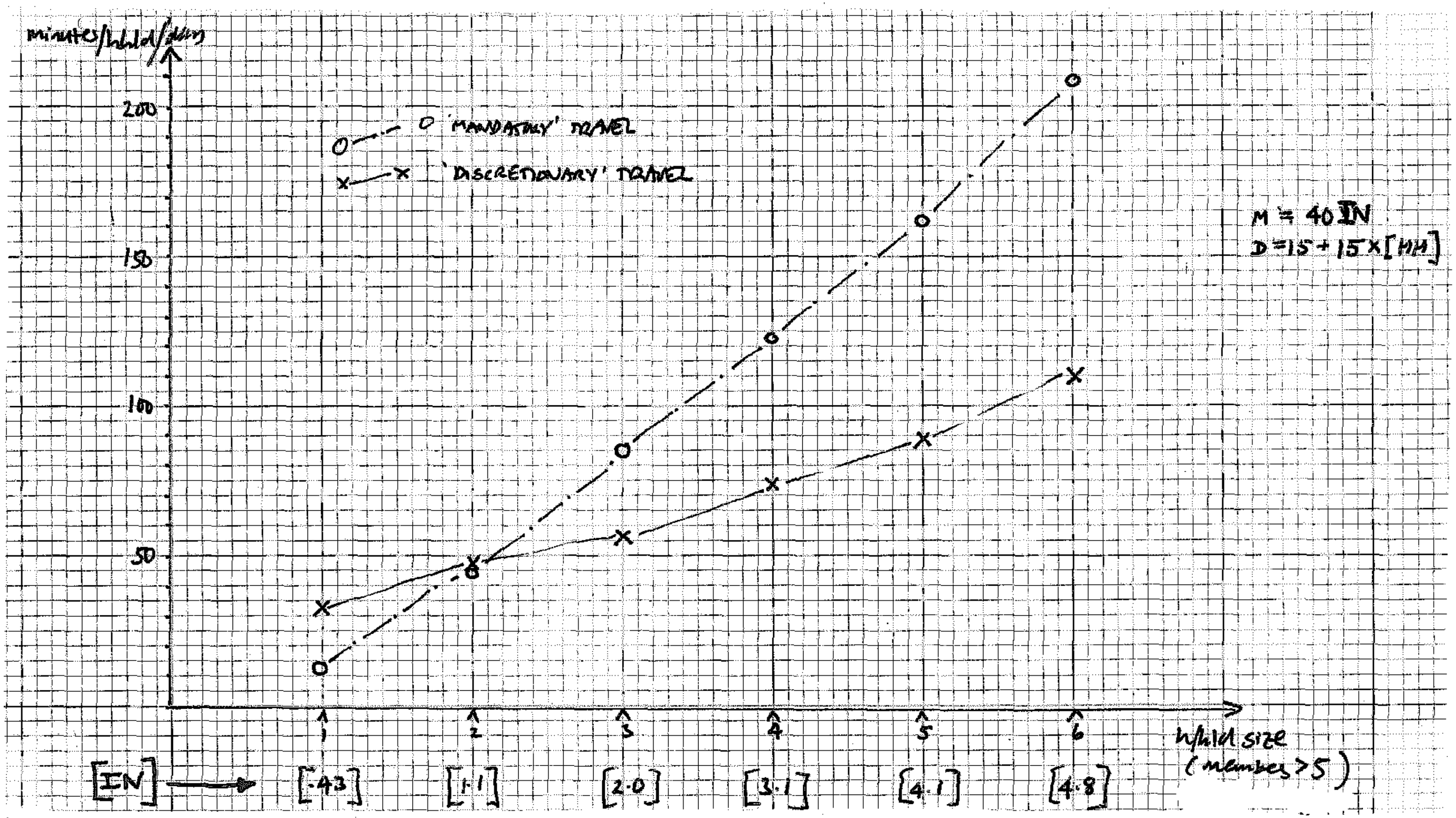
A number of variables were introduced into the household analyses as possible 'explanatory variables' which had no direct counterpart in the individual models. These were

(a) occupational status of the head of household,
(b) presence of at least one infant (less than five years old)
(c) quality of public transport provision (both bus and rail).

However, none of these appeared in more than one model, so that no systematic effects could be claimed to have emerged. The 'infant' variable was included in the light of the TSU work on the importance of stage in family life cycle on household activities in general; no corroboration of the importance of the presence of an infant in the household on travel time was found, in this data set.

Finally, figure 20 displays the mean M-travel times and the mean D-travel times in each household size group.

Figure 20: DAILY TRAVEL TIME PER HOUSEHOLD



PATTERNS IN HOUSEHOLD TRAVEL CURRENT COSTS

The analysis of current costs followed that of travel time expenditure, using the costs per minute as defined in the Introduction. In the year of the survey, it happened that there was little difference between the average running costs per minute for private vehicles and the average fare per minute on public transport. Consequently the analysis of costs reported here can be interpreted as an analysis of in-vehicle times, with the caveat that

(a) car passenger times are not included
(b) motor cycle, taxi, works and school bus times are also excluded and
(c) public transport times are slightly higher weighted than private vehicle times.

The results of the analyses are presented in Tables 26 and 27. It may be seen that all of the general remarks made about the models for time expenditure also hold for our estimates of cash expenditure, both for M-travel and for D-travel. The major effects, of income and household composition in terms of the number of members with a committed out-of-home activity, are broadly as in the previous analysis; increased travel time coincides with increased cash outlay. Similarly for day-of-the-week variation; the pattern of increase through the week from Monday to Friday persists in cash outlay, albeit patchily evident in the models for the different household size groups; once again, it is discretionary travel that is affected. The location effects are also broadly consistent with the corresponding effects on travel times, although once again no consistent trends emerge across the different household size groups.

The most obvious difference between the cost models and the time models is that car-ownership emerges as an important categorising variable for cash costs, whereas no real effects could be identified on household travel time expenditure. There is a reasonable amount of agreement across the models that non-car-owning households spend less on current travel cash outlay than car-owning households for M-travel; the same effect appears, if only for one person households, for D-travel.

Table 26: RUNNING COSTS INCURRED PER HOUSEHOLD (by persons over 5 years old)
MANDATORY TRAVEL

Variables	1 person	2 persons	3 persons	4 persons	5 persons	6 persons
No. occupied	+ 3	+ 8	+ 7	+ 6	+ 4	
Med/high income		+ 3				
High income		+ 6	+ 7	+ 7	+15	+19
2+ cars			+ 6		+10	
No cars	− 7	− 5		− 7		
Non-working head	− 8					
Prof. head		+ 3				
Infant in h/hould					−14	
Rural small town			− 8	− 9		
Rural		− 3				
Bad P.T.						
Non worker ⊠ no cars	+ 7	+ 3				
Low inc ⊠ no cars			− 9			
Prof. ⊠ 2+ cars		+ 8		+13		
Prof. ⊠ Good p.t.		+ 8				
High inc ⊠ good p.t.					+15	
Constant	8	3	3	3	3	33
R^2	.35	.29	.20	.21	.19	.10
Mean	3	12	19	24	26	39
No. of cases	382	1086	503	451	188	58

Table 27: RUNNING COSTS INCURRED PER HOUSEHOLD (by persons over 5 years old)
DISCRETIONARY TRAVEL

Variables	1 person	2 persons	3 persons	4 persons	5 persons	6 persons
No. occupied	- 4	- 3				
High income		+ 3				
No cars	- 6					
2+ cars		+ 2	+ 5		+14	
Infant in h/hold					+11	
Tuesday	- 2					
Wednesday			+ 4			
Thursday			+ 4	+ 5		
Friday						+32
Bad P.T.				-11		
Rural		+ 3	- 3			
Suburban				- 3		
Prof. ⊠ 2+ cars						+16
High income ⊠ 2+ cars				+ 5		
High income ⊠ Good P.T.	- 8					
Low income ⊠ No cars		- 3				
Constant	12	10	7	12	7	11
R^2	.12	.05	.06	.05	.13	.27
Mean	5	8	9	12	12	17
No. of cases	382	1086	503	451	188	58

It is interesting that the calculated reduction in cost of M-travel is about 6p, regardless of household size. Ignoring the complications of lift-giving and multiple vehicle ownership, we would interpret this as showing that it is only the potential car-driver's mandatory travel that is affected, and hence that the effect of car ownership on household travel may be virtually independent of household size. Of course, this will not be absolutely true, but there is at least some verification that car ownership affects only car drivers' travel patterns to any consistent and marked effect in the fact that car ownership did not prove a significant categorising variable in the analyses of individual travel, whereas car availability did. Certainly, the extra expenditure of money by multiple car owning households does seem to increase with household size. However, this may be because the number of vehicles owned will also tend to increase with household size, and thus so will the average number of drivers per household.

In conclusion, for household money expenditure on travel, we have identified not only the systematic influence of income and household composition on M-travel (as for travel times), but also an influence of car-ownership status on both M-travel and D-travel. Location, public transport access and day-of-the-week effects are once again patchy but reasonably in accord with expectation on the basis of time outlays.

Table 28 sets out the means and standard errors of the household cash expenditures in the various household size groups, together with the standard errors of prediction to correspond to the fitted models.

The mean outlays on M-travel and D-travel are plotted against household size in figure 21.

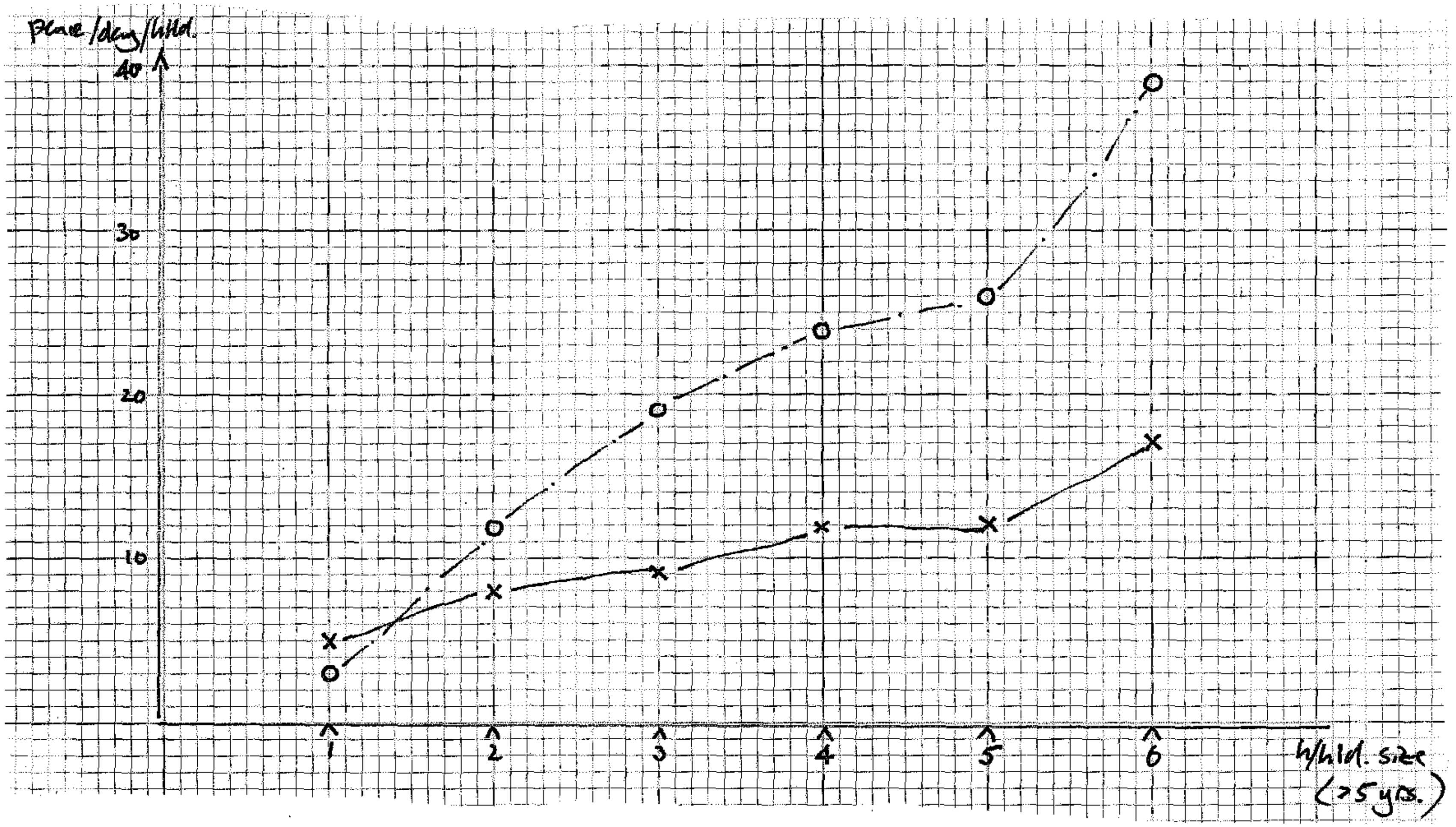
Table 28 TRAVEL COSTS

Household size	Mean	S.D.	S.E.E.	R^2
	Mandatory			
1	3	7	6	.35
2	12	15	13	.29
3	19	21	19	.20
4	24	23	21	.21
5	26	27	24	.19
6	39	28	27	.10
	Discretionary			
1	5	8	8	.12
2	8	12	11	.05
3	9	13	13	.06
4	12	15	14	.05
5	12	17	16	.13
6	17	23	20	.27

(1) S.D. refers to the standard deviation of the population of times

(2) S.E.E. refers to the residual error after fitting the model.

Figure 21: DAILY TRAVEL COST PER HOUSEHOLD



APPROXIMATE GENERALISED COST VARIATIONS

The analyses reported in this section are purely descriptive; a subsequent section will use the same data to examine the relationships between expenditures on M-travel and D-travel for evidence about the way in which travel decisions are made, rather than merely describing the average outcome of such decisions. As with the analysis of individual travel patterns reported on earlier, the central issue will be whether or not compensating variations take place between M-travel and D-travel in such a way as to suggest a potentially useable tendency to restrict overall travel, either to achieve some preselected target (on average) or to respect some upper bound of maximum feasible outlay on travel. It has been suggested (Tanner, 1979) that such behaviour, in the face of changing speeds and travel costs, would be highly irrational if directed to either of time and money outlays separately, but could at least conceivably, apply to 'generalised cost' expenditure, in which the two distinct components of travel expenditure, time and money, are weighted by relative values and summed. Accordingly, we performed the same (descriptive) analyses that were conducted on time and cash outlays, on a calculated approximate 'generalised cost' outlay; for this purpose, a single average approximate 'value of time' has been used to weight time outlays for each individual in the household, and the resulting 'cost of time' summed to household level and added to household cash outlay on travel. The use of a single value of time for all travel begs some important questions; for example, there is good reason to suspect that a unit of time saving will be differentially valued

(a) by individuals with different age, working status, economic status, and
(b) in different circumstances, such as when different uses may be made of the saved time, or when constraints dictate travel choices.

Ignoring all of these complications for the moment, a crude 'average' value of time per minute, for 1974 in 1970 prices, can be calculated as

$$\frac{(\text{average wage per week, } \pounds_{74}) \times (\text{price index, 70 relative to 74})}{(\text{average minutes worked per week})} \times \text{FACTOR}$$

using the conventional assertion that value-of-time is proportional to wage rate. Taking the average wage as £40 per week (corresponding to an average household income of around £50 from fig. 10, the hours worked per week at 40, the price index of 70 relative to 74 as

$\frac{0.953}{1.267}$ = 0.752(see Appendix 1 WP 119) and taking the value of FACTOR as 0.33* we produce a value of time per minute as

$$\frac{40 \times 0.752 \times 0.33}{40 \times 60} = £0.004$$ i.e. approx. ½p per minute, in 1970 prices.

This value has been used to give approximate generalised cost expenditures per household, regardless of socio-economic composition. Note that our dependent variable, travel outlay, omits travel in the course of work, by definition; (for a detailed description of the CSTRDB coverage, see I.T.S. TN.18.)

Tables 29 and 30 display the results of the stepwise regression on the calculated 'generalised cost' outlays per household. Unsurprisingly, since both time and cash outlays demonstrated broadly the same patterns, the weighted sum of the two also show the same trends. For M-travel, the most marked and regular effects are of household composition, in the sense of the IN variable, the number of household members with committed out-of-home activities, and the income variable. For D-travel, the IN variable has some effect for one, two and three person households (the more household members with committed M-activities, the less household D-travel reported) but none for larger households. There is indication that car ownership level affects both M-travel and D-travel; both increase with increasing car ownership level, although as before the evidence is patchy. Rural, rural small town and suburban locations each show reduced travel expenditures in relation to the grouping of the others with urban location. Day-of-the-week variables indicate increased D-travel at the end of the week. Where public transport provision enters as a 'significant' variable, 'bad' service coincides with reduced general expenditure, 'good' service with higher; however, once again the evidence is patchy.

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* in line with conventional expectation.

Table 29: GENERALISED COSTS PER HOUSEHOLD (by persons over 5 years old)
MANDATORY TRAVEL

Variables	1 person	2 persons	3 persons	4 persons	5 persons	6 persons
No occupied	+16	+24	+26	+24	+22	+21
Med/high income	- 7	+ 6				
High income		+11	+17	+17	+34	
No cars	-10					
Non working head	-12					
Prof. head		+ 4				
Infant in h/hold					-32	
Rural small town		-21	-16			
Rural		- 5				
Good P.T.		+ 8				+138
Bad P.T.		-13				
Thursday						-55
Non worker ⊠ no cars	+ 8					
Prof. ⊠ high income						+56
Prof. ⊠ 2+ cars		+13		+21		
Prof. ⊠ good P.T.						-192
Constant	14	4	9	7	9	40
R^2	.49	.38	.29	.29	.24	.45
Mean	10	34	61	85	107	143
No. of cases	382	1086	503	451	180	58

Table 30: GENERALISED COSTS PER HOUSEHOLD (by persons over 5 years old)
DISCRETIONARY TRAVEL

Variables	1 person	2 persons	3 persons	4 persons	5 persons	6 persons
No. occupied	-16	-10	- 4			
No cars	- 8					
2+ cars			+ 9		+30	
Infant in h/hold					+45	
Tuesday	- 4					
Wednesday			+11			
Thursday			+ 9	+15		
Friday						+84
Bad P.T.				-30		
Rural			-12			
Suburban		- 5				
No cars ⊠ bad P.T.		-25				
Low income ⊠ no cars						-62
Constant	35	44	42	46	45	67
R^2	.18	.07	.05	.04	.09	.29
Mean	20	31	37	48	56	72
No. of cases	382	1086	503	451	188	58

Overall the explanatory power of the models is poor, as for all the previous models. R^2 values are intermediate between those for cost and those for time - lying nearer to those for the time models, as one would expect given that the contribution of the time outlay to the generalised cost expression tends to be two or three times higher than that of the cash outlay.

In brief, no new insights into patterns of travel expenditure have been gained from the study of the 'generalised expenditure'. Table 31 sets out the means and standard errors associated with the various models; figure 22 plots means against household size. It can be seen that the overall patterns are virtually identical to those displayed by time and cost outlays separately.

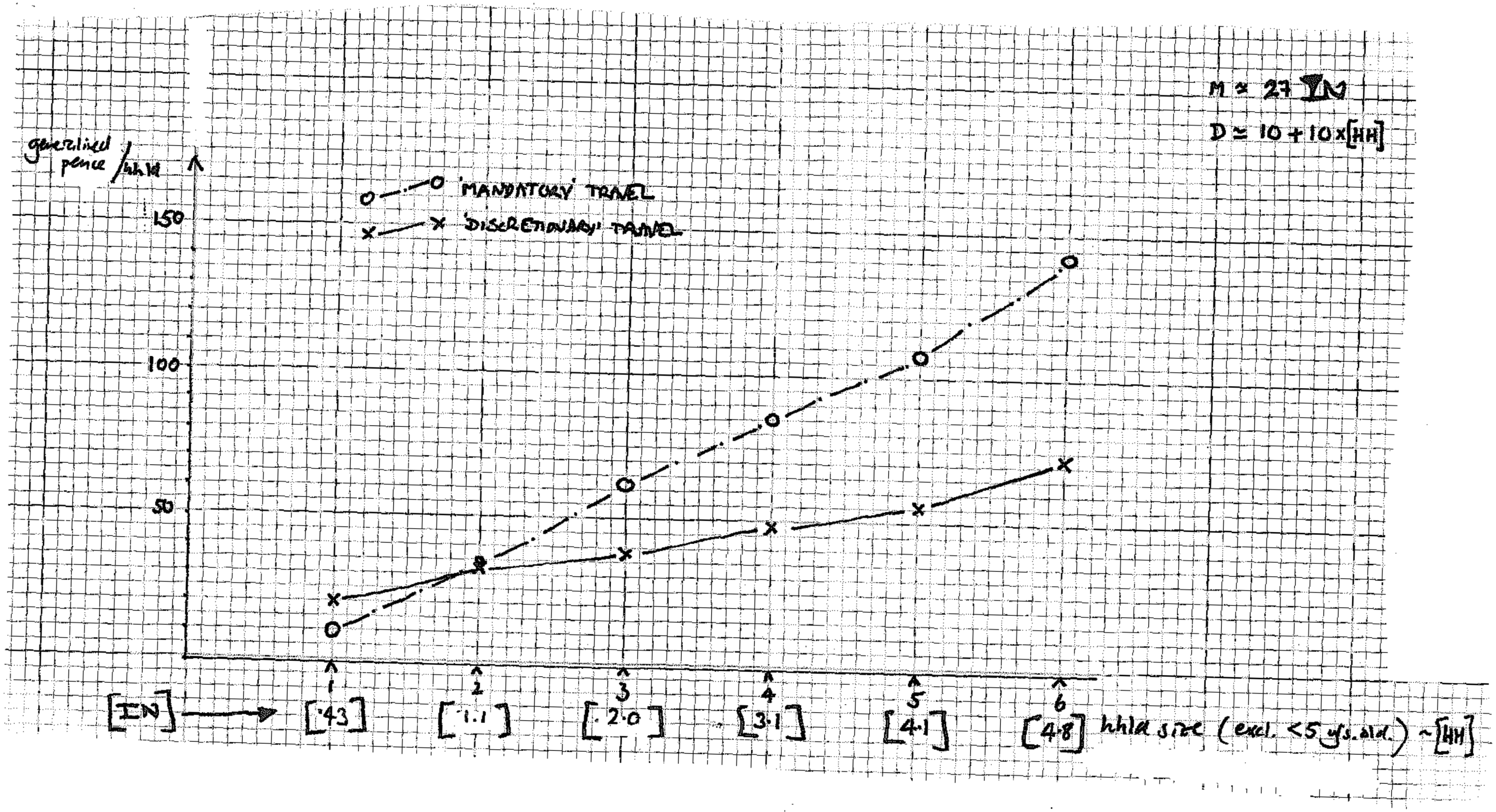
Table 31: GENERALISED TRAVEL COSTS

Household size (persons over 5 years)	Mean	S.D.	S.E.E.	R^2
	Mandatory			
1	10	16	11	.49
2	34	34	27	.38
3	61	48	40	.29
4	85	54	45	.28
5	107	61	53	.24
6	143	62	49	.45
	Discretionary			
1	20	19	18	.18
2	31	30	29	.07
3	37	36	36	.05
4	48	41	41	.04
5	56	54	52	.09
6	72	63	54	.29

(1) S.D. refers to the standard deviation of the popultion of times

(2) S.E.E. refers to the residual error after fitting the model.

Figure 22: DAILY GENERALISED COST PER HOUSEHOLD



CONCLUSIONS

The general patterns shown in all three measures of household travel expenditure that have been considered in this chapter have been broadly similar. There is a wide variability as between different households in the amounts of time, money outlay and 'generalised expenditure' (as we have defined above) allocated to travel, whether in connection with mandatory activities or discretionary activities. Little of this variability can be accounted for by corresponding variations in the background variables that have been examined. However, relatively more of the variability in mandatory travel can so be 'explained'. The number of household members with a committed out-of-home activity (IN) and household income both emerge as consistently important variables in the household regressions. For the money and generalised cost outlays, car-ownership levels may also affect mean travel reported. For discretionary travel, only car ownership level shows any systematic effect across different household size groups, and that for the money and generalised cost outlays.

Referring back to figure 20, the household size axis has also been labelled by mean value of the IN variable in each size group. Ignoring the mean household income and car ownership level for the moment, it can be seen that the within-size-group relationships, whereby M-travel is given by approximately 35 times the IN variable and D-travel is unaffected by background variables, is consistent with an explanation of <u>between</u>-size-group variations in which M-travel is related to IN and D-travel simply to household size. It can easily be verified that a reasonable fit to between group variation in household travel times would be given by the models

$$\text{mean M-travel time} = 40 \times \text{IN} \quad \ldots \text{(3)}$$
$$\text{mean D-travel time} = 15 \times 15 \times \text{H'hld Size} \quad \ldots \text{(4)}$$

and that such models would also be fairly consistent with within group variability. Similarly, for the generalised cost relationships shown in figure 22 the models

$$\text{mean M-travel gen.cost} = 27 \times \text{IN} \quad \ldots \text{(5)}$$
$$\text{mean D-travel gen.cost} = 10 \times 10 \times \text{H'hld Size} \quad \text{(6)}$$

would be broadly consistent with both within and between household size group variations.

Accordingly, we can combine all the household travel expenditure data and look for explanation of variation in amounts of travel reported in terms of

(a) IN, number of members with a committed out-of-home activity (for all M-travel)

(b) household size (for all D-travel); together with

(c) household income multiplied by IN (for all M-travel)

(d) car ownership level multiplied by IN (for cost and gen. cost M-travel)

(e) car ownership level multiplied by household size (for cost and gen. cost D-travel)

(f) day-of-the-week dummy multiplied by household size (for all D-travel).

The results of fitting such models are set out in Table 31. The R^2 values are fairly typical of each of the models within household size categories. The effects which were noted from the separate regressions have all entered the combined models; i.e. their coefficients are statistically significant (albeit in relation to approximate standard errors). In addition, the day-of-the-week effect which was evident only patchily in the individual size category models is now quite clear in the combined data set. In the way in which the day-of-the-week dummies have been defined, the coefficients given in Table 31 for 'Tues' to 'Fri' refer to expenditures per person interviewed. As in the individual models of Chapters 2 and 3, there is a clear increase in travel expenditure through the last part of the week; the reduction in travel on the Tuesday is also consistent with the individual models. (This, of course, is hardly surprising, since the effects must necessarily compound on aggregation to household level. However, it is welcome corroboration of the consistency of the procedures, given the lack of any clear picture in the separate size group models.)

One interesting feature of the fitted models is that car ownership level appears to have the same effect on M-travel as on D-travel.

Table 31 MODELS OF HOUSEHOLD TRAVEL EXPENDITURE: HOUSEHOLDS WITH LESS THAN 100 MINUTES TRAVEL PER MEMBER.

Expenditure	Variables									R^2
	IN	WINC	NCAR	NPRES	TUE	WED	THUR	FRID	CONST	
M-time	33	1.8	-	X	X	X	X	X	4	.63
D-time	X	X	-	13.1	-1	2	3	6	17	.13
M-cost	2	1.1	.8	X	X	X	X	X	4	.29
D-cost	X	X	.8	0.5	0	1	1	1	4	.06
M-Gencost	19	2.0	.8	X	X	X	X	X	6	.40
D-Gencost	X	X	1.1	6.4	-	2	3	4	13	.05
Mean levels	1.83	5.37	2.61	2.71	-	-	-	-	-	-

Notes: X denotes not fitted

- denotes fitted, but non-significant so not entered

IN - no. of household members with committed out-of-home activities

WINC - household income, £70'000 X IN

NCAR - cars available (including guests) X persons interviewed.

NPRES - persons interviewed : all over 5 years, household members plus guests

TUES-FRID - dummy entry of NPRES on each day - hence effects are person based, not household.

The general patterns of expenditure on M-travel are that the most important factor is the number of members with committed out-of-home activities. There is relatively much smaller additional component which increases with income level for each such member, and for costs and generalised costs, an even smaller component which increases with car ownership level for each household member. Each expenditure has a small (positive) additive constant; this may well arise from the definition of M-travel as including 'escort' trips - such as mothers accompanying children to school. Thus there is a component of average household M-travel which is performed by household member who are not categorised in the IN variable. However, it is a relatively small component of overall M- travel.

For D-travel, the patterns are of a major component for each person interviewed, plus a substantial constant term for each household, and marked by fluctuation over the week, increasing to a maximum on Fridays. High car ownership levels coincide with high expenditures of money and generalised cost on D-travel, but do not affect travel times. A simple (although not necessarily correct!) interpretation of the main effects are that an amount of D-travel is being undertaken regardless of household size, possibly on household maintenance activities such as shopping, and thereafter there is a component of travel expenditure for each household member, possibly corresponding to leisure and recreation activities. The variation over the days of the week should then correspond mainly to the leisure and recreation travel (being fitted for each household member), as should the car ownership variation (for the same reason).

Pursuing this simplistic interpretation of the models, it is interesting to note the relative magnitudes of the time and cost components of D-travel expenditure; on an 'average' weekday, the time outlay on leisure by each household member is fairly similar to the time outlay on household maintenance, each being around 17 minutes. The cost outlay per person, however, appears to be rather less than half that of the maintenance travel, for which an average cost per minute of 4/17 = 0.23 p indicates an approximate 50% use of mechanised modes. Table 32 sets out the mean levels of the various travel expenditures in the data, and it can be seen that the average cost per minute for M-travel is 16/75 = .21 p, and that of D-travel is 9/56 = .16 p. This suggests that both household maintenance and mandatory travel are both characterised by about 50% use of mechanised modes (by time), but that leisure travel has a corresponding level around 25%, increasing sharply with increasing car ownership. Given that the chosen population includes all children over 5 years of age, these approximate figures seem at least plausible.

Table 32 MEAN LEVELS OF HOUSEHOLD TRAVEL EXPENDITURE

	Mean	S.D.
M-time (mins)	75	74
D-time (mins)	56	56
M-cost (pence 1970)	16	20
D-cost (pence 1970)	9	14
M-gencost (pence 1970)	53	54
D-gencost (pence 1970)	37	38

Table 33 MODELS OF HOUSEHOLD TRAVEL EXPENDITURES : ALL ANALYSABLE HOUSEHOLDS

Expenditure	Variables									R^2
	IN	WINC	NCAR	NPRES	TUE	WED	THUR	FRID	CONST	
M-time	32	3.0	-	X	X	X	X	X	10	.49
D-time	X	X	2.0	10.4	-4	-	-	7	40	.05
M-cost	2	1.6	0.8	X	X	X	X	X	6	.23
D-cost	X	X	1.0	-	-	1	1	2	7	.04
M-gencost	18	3.1	1.0	X	X	X	X	X	6	.40
D-gencost	X	X	2.1	6.4	-	2	3	4	13	.12
Mean levels										

Notes : as for Table 31 .

However, these figures are descriptive of circumstances in 1974 in the UK, and are thus reflecting the particular levels of car ownership, decisions about car availability, patterns of land use, and tastes, of those circumstances. Further analyses of data sets for different years will be needed to gain deeper insights into the causes and effects behind the observed variations in travel expenditures.

It was stated at the outset that the data set was restricted to those households which satisfied two requirements, namely having all members or guests with 'analysable' travel patterns, and also reporting a total travel time less than 100 times the total number of persons present. This was done to remove the influence of individuals in the extreme tails of the observed travel expenditure distributions - Chapter 3 displays these tails for travel time expenditures, on Figure18. It is of interest to enquire what the effect of such a decision has been on the fitted models. Table 33 sets out the models corresponding to those of Table 31, but fitted to a data set in which the requirement for total time to be within the chosen limits was removed. It may be seen, in comparison with Table 13, that no major changes occur when the larger data set is used (3116 households are within the second definition, as compared to 2698 within the stricter first definition.) However, the models are generally poorer, as judged by the indications of the R^2 statistics.

We can now compare the factors affecting household travel as given by our models with the categorisation into 'stage in family life cycle' devised by the TSU at Oxford. The presence of an infant under 5 years of age in the household was considered for its effect on travel expenditure patterns; no significant influence was uncovered. On the other hand, the major factors that were established were household size and number of members with a committed out-of-home mandatory activity. Both of these factors would vary as between typical households in the different stages of a 'life cycle'. By way of example, Table 34 sets out the model predictions for mean travel time expenditures for five 'stages' in life cycle.

Table 34. TRAVEL TIME AND STAGE IN FAMILY LIFE CYCLE

	Family group	IN	WINC	NPRES	M-time	D-time	Total	Total IN
A	Single person, working	1	3	1	42	30	72	72
B	Married couple, both working	2	6	2	81	43	124	62
C	Married couple, one small child, 1 wkg.	1	3	2	42	43	85	43
D	Married couple, 2 school children, 1 working	3	9	4	119	69	188	47
E	Married couple, both retired	0	0	2	4	43	47	24

Notes: WINC is at a single average income
Weekday effects as on Monday.

The advent of the child, by reason of the resulting cessation of one household member's work activity, is forecast to have a dramatic effect on overall household travel time. (However, our models, crude as they are, would predict a similar effect should one member merely decide to give up work.) The point to be made is that 'stage in family life cycle' does indeed correspond to systematic variations in IN and NPRES, the two most important explanatory variables in our models, and we would correspondingly predict very different total travel expenditures (and breakdowns as between mandatory and discretionary travel) for just those reasons. We have looked for an effect of having a small child in the household over and above the effects of IN and NPRES, but found none, at least in this data set. (Of course, this is not to argue that the concept of 'stage in family life cycle' is redundant in any general sense, given household size and occupational status).

Finally, note that the more detailed models of D-time given in Table 24 would differentiate between the two-traveller households B, C and E, giving expected D-times of 35, 51 and 67 minutes respectively.

CHAPTER 5.

RELATIONSHIPS BETWEEN 'MANDATORY' TRAVEL AND 'DISCRETIONARY' TRAVEL AT THE HOUSEHOLD LEVEL

INTRODUCTION

The last chapter has set out the models that have been developed to summarise the patterns of variation in mandatory and discretionary household travel expenditures, in terms of time, money cost and generalised cost (using an approximate figure for the value-of-time). The factors that were found to correspond to significant variations in expenditures were:

a) the number of household members with a committed out-of-home activity ('active' members).

b) household income;

c) the number of cars available;

d) the number of persons interviewed(i.e. those present over 5 years old), and

e) day of the week.

In various interactions, factors a and b were linked with household M-time, factors a, b and c with M-cost and M-generalised cost, and factors c, d and e with all D-expenditures. The most important factors were a, b and d, in terms of size of corresponding variations in travel expenditures.

This Chapter develops the analyses further, along the lines of that performed on individual travel expenditures in Chapter 3 to investigate the nature of the relationship between M-travel and D-travel expenditures at the level of the household. Chapter 3 demonstrated that individual D-travel times appeared to be effectively independent of reported M-travel times, after controlling for the most important background variables.

There are two major reasons why grouping individuals into households might produce a different conclusion; both reasons concern the possibility of correlation between travel patterns of members of the same household. Firstly, tasks and responsibilities may be shared amongst household members in such a way that one member takes over the activity and the related travel of another member, thus introducing a negative correlation. Secondly, all household members have in common the geographical location of the household as initial origin and ultimate destination; this may produce a positive correlation in travel expenditures, in that access may be good or bad to all relevant destinations. Both of these effects will be present in the data to an extent; in this note we set out to determine whether or not there is evidence that the net product of such effects results in either 'compensating' or 'reinforcing' variations at the level of the household.

As discussed in Chapter 4, another reason for considering the household as the basic travel unit is that it is then possible to avoid the worst problems associated with allocating costs for car-passenger trips.

In view of the scarcity of households with five or more members over five years old, and the need to distinguish between very young and very old single-person households, analysis is restricted to two, three and four person households. The effect of number of persons with committed out-of-home activity is controlled by selecting those households with a single member without such an activity; this being the most common circumstance. Finally, the most extreme effects of income differences were avoided by omitting the highest income group (Table 22 definition).

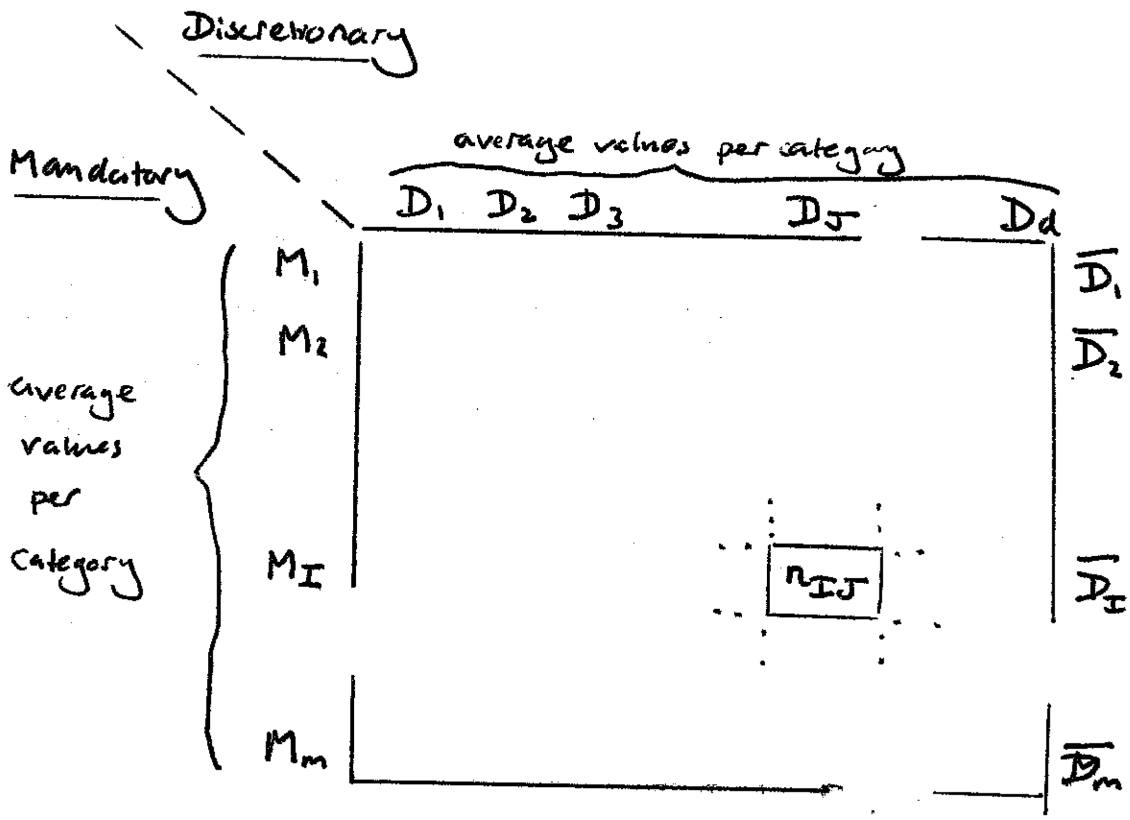
MANDATORY AND DISCRETIONARY EXPENDITURES FOR SELECTED HOUSEHOLDS

Tables 35 to 43 set out the number of households falling into different categories of M and D travel expenditure, for two, three and four person households of the type described above. The figures have been converted back to approximate average D-expenditures per M-category using approximate mid-category D-values, and the results are displayed in Figures 23 to 25.

As was the case for individual travel expenditures, there appears to be virtual independence of the two categories of travel. Discretionary travel expenditures, of time, cost and generalised cost, are almost constant regardless of mandatory travel time outlay.

As for the individual travel analyses, this trend is in apparent contradition to the simple hypothesis that households have 'target' expenditures of overall travel time, cost or generalised cost.

KEY TO TABLES 35 to 43



n_{IJ} : no. of households with M. travel in category I and D. travel in category J.

$$\bar{D}_I = \sum_{j=1}^{d} n_{Ij} D_j \Big/ \sum_{j=1}^{d} n_{Ij}$$

Table 35
SPTAB42
C1 by C2

Time

C1 \ C2	0	10	30	50	70	100	$\bar{C}2$
0	0	9	11	9	3	34	61
10	27	23	9	11	4	20	35
30	30	29	15	22	16	26	40
50	26	13	30	22	12	20	40
70	11	6	11	6	4	12	43
100	11	11	17	14	5	31	46

Table 36
SPTAB42
C3 by C4

Cost

C3 \ C4	0	2	6	10	14	20	$\bar{C}4$
0	146	8	13	10	9	43	5.1
5	5	1	4	2	2	5	7.9
	15	5	6	7	8	6	
10	23	7	6	6	5	10	6.7
18	29	4	3	2	2	5	5.6
	80	14	13	14	15	27	

Table 37
SPTAB42
C5 by C6

Generalised cost

C5 \ C6	0	6	18	30	42	60	$\bar{C}6$
0	0	7	8	9	4	38	44
6	24	10	7	5	1	16	21
18	19	14	18	17	13	21	33
30	35	15	18	14	15	26	25
42	11	8	15	15	4	8	23
60	16	14	30	21	15	49	33

Two Person Households - 1 'active'

Table 38

C1 by C2

Time

C1 \ C2	0	12	37	62	87	120	$\bar{C}2$
0	0	0	0	1	0	4	81
20	0	5	2	3	4	10	
60	6	9	15	6	9	11	56
100	6	9	8	5	4	8	51
140	3	1	6	2	3	3	54
200	2	3	9	1	1	6	56

Table 39

SPTAB43

C3 by C4

Cost

C3 \ C4	0	3	9	15	21	30	$\bar{C}4$
0	24	1	2	2	3	7	10.4
3	1	0	1	1	1	4	
9	8	2	4	3	4	5	12.3
15	5	6	2	2	3	1	8.4
21	11	4	4	1	1	3	7.5
30	23	7	3	2	4	10	9.4

Table 40

SPTAB43

C5 by C6

Generalised Cost

	C5 \ C6	0	$7\frac{1}{2}$	$22\frac{1}{2}$	$37\frac{1}{2}$	$52\frac{1}{2}$	70	$\bar{C}6$
8	0	0	0	0	0	1	4	51
	12	0	3	2	4	1	9	
	36	5	8	9	8	2	11	33
	60	4	6	8	4	7	13	39
	84	5	4	6	1	2	3	25
	120	3	9	8	2	3	10	34

Three Person Households - 2 'active'

Table 41
SPTAB44
C1 by C2

C1 \ C2	0	25	75	125	175	250	$\bar{C}2$
30	0	7	2	6	2	3	109
90	2	21	18	12	3	4	82
150	4	15	14	8	3	5	86
250	0	6	7	3	1	0	101
	0	0	0	2	2	2	

Time

Table 42
SPTAB44
C3 by C4

C3 \ C4	0	3	9	15	21	30	$\bar{C}4$
0	19	1	4	3	0	12	9.2
4	3	5	5	1	1	1	7.9
12	8	3	3	2	2	2	8.4
20	6	5	1	2	1	5	11.2
28	2	1	8	2	0	3	12.2
38	16	3	10	3	2	7	9.7

Cost

Table 43
SPTAB44
C5 by C6

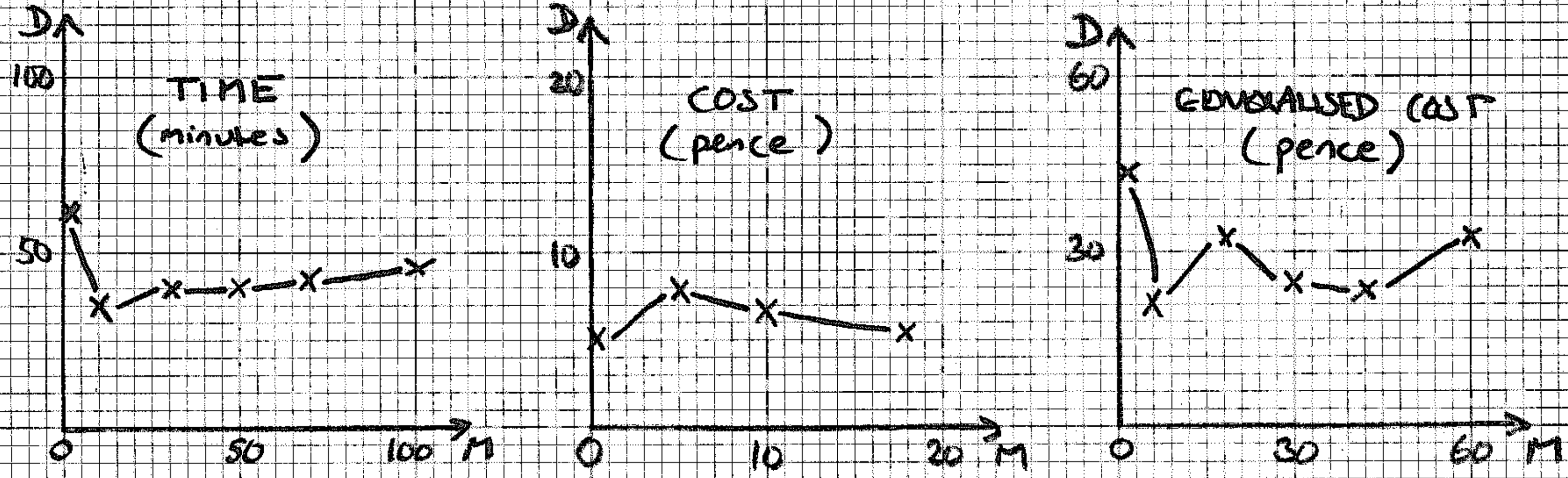
C5 \ C6	0	9	27	45	63	90	$\bar{C}6$
18	0	4	4	2	2	7	52
54	2	12	12	6	7	18	48
90	3	3	9	6	5	11	50
126	1	6	1	6	2	5	44
170	0	4	2	2	3	7	56

Generalised cost

Four Person Households - 3 'active'

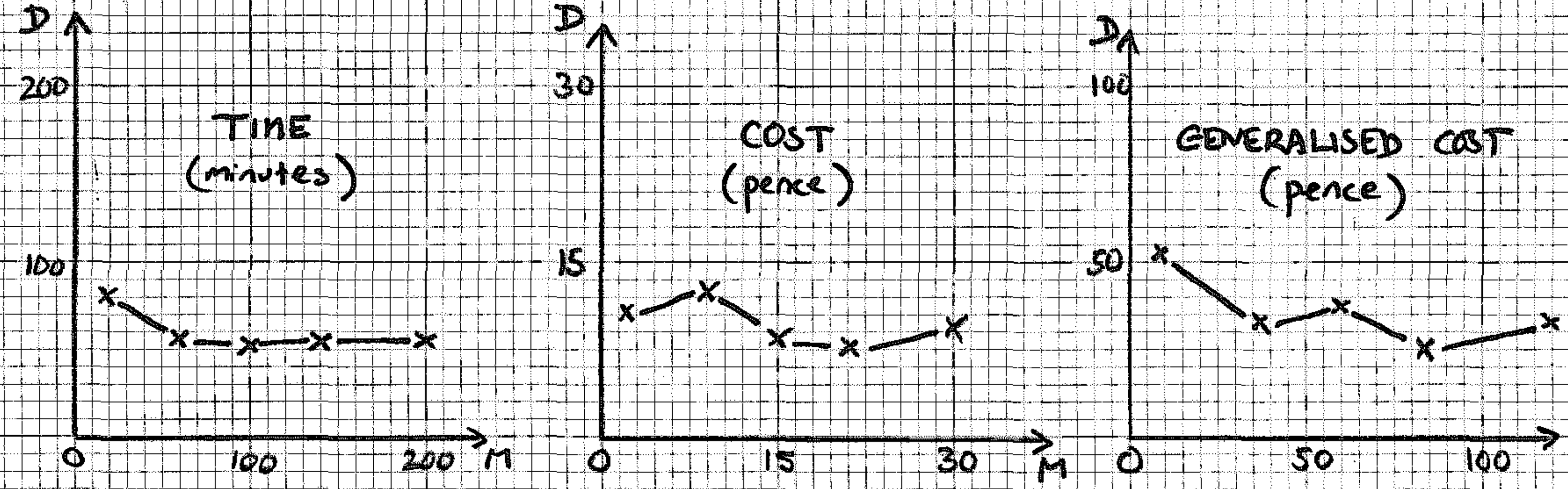
Figure 13: Two person households, 1 active, income ≤ £4000.

Figure 13



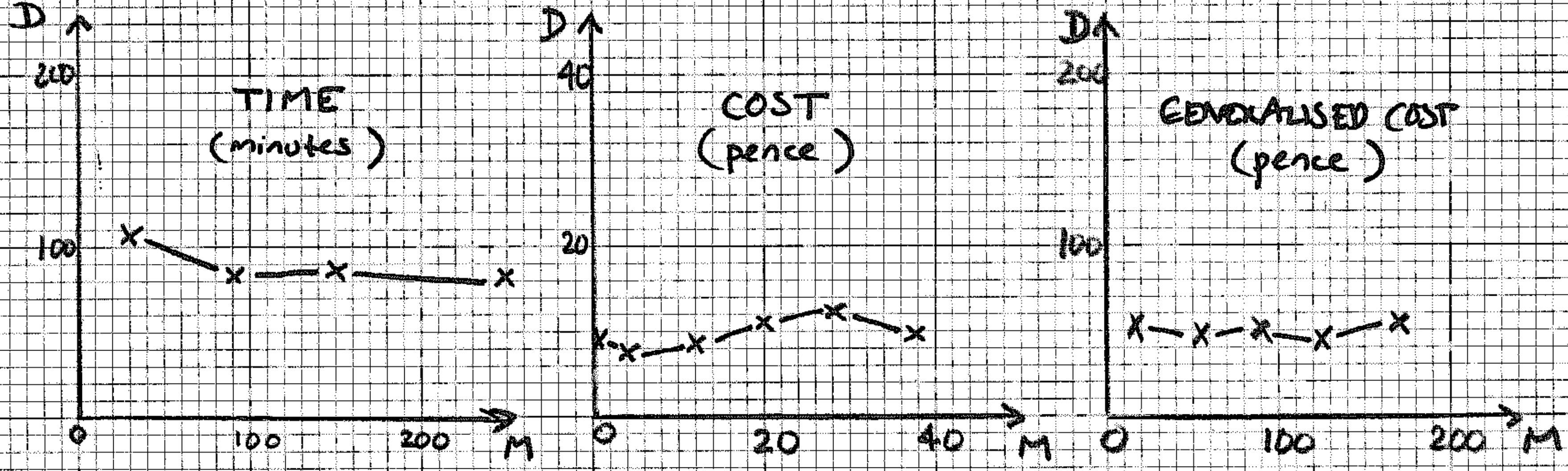
560 households

Figure 24 : Three Person Households – two 'active', no incomes ≥ £4000 p.a.



165 households

Figure 25: Four Person Households – three 'active', income ≤ £4000



152 households

Figure 25

ALTERNATIVE GROUPINGS

Chapter 4 advanced some simple models to describe variations in travel expenditures at the household level. In particular, for travel time, the two equations

M-time = 10.0 + 32.0 IN + 3.0 WINC (7)

D-time = 40.0 + 2.0 NCAR + 10.4 NPRES - 4.0 TUES + 7.0 FRID (8)

were given for 'all analysable' households. (Where IN denotes the number of 'active' members, WINC denotes IN x household income (£000), NPRES denotes no. of persons interviewed, NCAR denotes 'cars available' x NPRES, and TUES and FRID are dummies such that NPRES is entered again only if the interview was conducted on a Tuesday or a Friday respectively.) A variety of different groupings of the data were explored in order to examine the consistency of these simple models; in particular, the households were grouped into

a) those with more than 84 minutes M-travel, and those with less (84 minutes being the overall average),
b) those with above-expectation M-travel times, on the basis of the simple models, and those with less, and
c) zero, one and two-or-more car-owning households.

Table 44 sets out the resulting mean travel times and the expected travel times, given the models and the mean levels of the explanatory variables in the populations defined by the groupings.

TABLE 44: Alternative Groupings

Grouping		Observed		Expected	
		M-time	D-time	M-time	D-time
A:	All households	84	72	[84]	[72]
B:	>84 mins M-time	170	77	[135]	84
	<84 mins M-time	29	69	[53]	65
C:	>Expected M-time	159	67	[100]	76
	<Expected M-time	44	75	[76]	70
D:	0 cars	55	61	51	64
	1 car	91	74	90	73
	2+ cars	122	93	131	88

Two points may be made immediately from inspection of table 45 firstly, average discretionary times remain fairly constant over wide ranges of different mandatory times, and secondly, the simple models work fairly well for all the D-times, and also for the M-times of grouping D. (Groupings B and C were made conditional on unusual M-times, so that the model could not be expected to hold for M-travel there.)

CHAPTER 6

CONCLUSIONS FROM THE ANALYSES

We have analysed travel patterns into two 'sorts' of travel with the aim of assessing the evidence for the existence of 'target' budgets of travel expenditures, and we have chosen our groups of 'mandatory' and 'discretionary' activities with the intention of identifying variations in the former with 'cause' and variations in the latter with 'effect' (at least in terms of short term decisions). No such 'effect' was found in the 1974 County Surveyors' Trip Rate Data Bank.

We have then tentatively advanced a hypothesis that at least two different 'sorts' of travel expenditure should be considered, since the factors that affect the two seem to be distinct. 'Mandatory' travel, defined as travel in connection with 'final' activities that we have deemed fixed, in the short term, in both location and frequency of participation, appears dependent of income levels and household structure (the number of 'active' members), from our cross-sectional analyses. 'Discretionary' travel, the residual, we have found to vary with car-ownership, household size and day-of-the-week. From the cross-section, however, it appears that random fluctuations far outweigh any such systematic differences. Our future course of work must involve analyses of both time series and repeated cross-sectional studies, to establish the validity of these insights.

Finally, a crucial feature of most 'budget' based models is the confrontation of a forecast 'budget' with an estimate of network speeds; it is from the assumption of 'travel maximising' behaviour given these two that forecasts of travel derive. Our tentative suggestions are that a) it may not be appropriate to consider travel as a unified activity at all (thus tending back to the purpose-specific approach of conventional models), and b) that forecasts of travel budgets contain implicit assumptions about network speeds. Using such budgets as constraints in conjunction with independent, presumably different, estimates of network speeds may lead to difficulties. An equilibrating device, such as in the UMOT model, is needed; however the mechanism may have to address aspects of non-travel expenditure, at least for long term forecasts. (See Zahavi, 1979).

Having made these points, criticising models for being less than "perfect" does not take us very far. We have concluded that there is evidence that it may be necessary to make separate estimates of travel budgets for different individuals, different households and for different sorts of trip, and demonstrated this using our definitions of 'mandatory' and 'discretionary' travel. In Table 33 we have outlined crude models relating cross-sectional variations in household expenditure of time, money and generalised cost to household characteristics. We can now consider whether or not the historic trends in national average travel times and costs per person, as estimated by Tanner (1979), are broadly consistent with the cross-sectional models, taken together with historic trends in activity rates, household sizes and age structures, incomes and car-ownership levels.

Table 45 sets out the relevant variables for a number of years between 1951 and 1978. Figure 26 plots the corresponding model "predictions" for travel costs and times per person over the 25-year period; note that the absolute levels of the two series are not to be compared, for one reason because the model refers only to weekday travel.

TABLE 45

	1951	1961	1967	1971	1977	1974
Hhld. Income £/week	12.3++	19.8	28.2	38.5	81.4	52.3
$\overline{P}72$ ¤	.450	.608	.727	.934	2.124	1.267
$\overline{P}70$ ¤¤	.472	.638	.763	.950	2.229	1.329
$£_{70}000\ \overline{I}$	1.4	1.6	1.9	2.0	1.9	2.0
Index (74=100) $\overline{I}$	70	80	95	100	95	100
$\hat{IN}$ ***	1.99	2.16	2.01	1.88	1.82	1.84
$\hat{IN}$ Index (74=100)	108	117	109	102	99	100
$\hat{NPRES}$ ***	2.92	2.84	2.78	2.67	2.54	2.63
$\hat{NPRES}$ Index (74=100)	111	108	106	102	97	100
CARS/head	.050+	.116	1.93	.222	.258	.250
CARS/hhld.	.160	.358	.579	.644	.699	.698
CARS Index (74=100)	23	51	83	92	100	100
H/hld size	3.21	3.09	3.00	2.90	2.71	2.79
NCAR Index (= $\hat{NPRES}$ x $\hat{CARS}$)	26	55	88	94	97	100
WINC Index (= IN * $\overline{I}$)	73	94	104	102	94	100
$\hat{\hat{IN}}$ X	1.94	2.11	1.96	1.84	1.78	1.8 *
$\hat{\hat{NPRES}}$ X	2.89	2.81	2.76	2.65	2.52	2.6 *
$\hat{\hat{WINC}}$ X	3.94	5.08	5.62	5.51	5.08	5.4 *
$\hat{\hat{NCAR}}$ X	0.68	1.43	2.29	2.44	2.52	2.6 *
M-travel times **	83.9	92.8	89.6	85.4	82.2	
D-travel times **	71.4	72.1	73.3	72.4	71.2	
(M + D) /H'hld. size	48.4	53.4	54.3	54.4	56.6	
M/person	26.1	30.0	29.9	29.4	30.3	
D/person	22.2	23.3	24.4	25.0	26.3	

Footnotes

Sources :

Mean household income	:	National Income + Expenditure survey, 64-74, 65-75, 67-77, 1980. distribution of household incomes before and after tax.
Mean household size	:	Social trends, 1973, 1980, C.S.O. General household survey 1976.
Cars per household	:	Transport statistics G.B, 1967-77.

\+ From tables in LR 650

* From analysis of CSTRDB 1974

X Implied by factoring CSTRDB results for 1974 by appropriate index.

** From the models

M-time = 10.0 + 32.0 IN + 3.0 WINC
D-time = 40.0 + 10.4 NPRES + 2.0 NCAR

++ estimated from Wages & Prices Index, Table 151, Monthly Digest (C.S.O.)

	June 1947 = 100	June 1956 = 100	Calculated : av. 1961 = 100
av. 1951	100		62
Jan. 1956	156	100	80
av. 1961		125	100

(using obvious linking).

Thereafter : av. income 1951 = 0.62 x av. income 1961.

⊠ see Appendix in WP119, I.T.S. Leeds.

⊠⊠ calculated from the above by linking.

*** Approximately, using % popn. < 5 years ($\doteq$ 8 thus NPRES $\doteq$ 0.92 x H'hld size)
% popn. 5 - 18 ($\doteq$ 20 thus IN $\doteq \frac{(\%W+20)}{100}$ x H'hld size)

and %W = percentage of popn. in employment is approximately :

1951	42
1961	50
1967	47
1971	45
1977	47

Sources : Social Trends & Annual Abstract of Statistics - see below.

% of Population less than 5 years of age, and between 5 and 18.

	1951	1961	1963	1965	1967	1969	1971	1973	1974	1975	1977
total population	48.9	51.4	52.1	52.9	53.5	54.0	54.1	54.4	54.4	54.4	54.3
0-4 years	4.19	4.07	4.38	4.5	4.65	4.57	4.35	4.3	3.98		3.41
% of pop.	8.6%	7.9%	8.4%	8.5%	8.7%	8.5%	8.0%	7.9%	7.3%		6.3%
0-19 yrs.	14.01	15.50					16.67				16.31
5-19 yrs.	9.82	11.49	11.6	11.6	11.84	12.00	12.32	12.4	11.96		12.9
% of pop.	20.1%	22.4%	22.3%	21.9%	22.1%	22.2%	22.8%	22.8%	22.0%		23.8%

Sources

for 1951, 1961, 1971, 1977, 0-4 yrs. and 0-19 yrs : Social Trends 10, 1980 Edition, C.S.O. Table 3.1 'Childrens and young people by age group' GB, p.93.

for 1963, 1965, 1967, 1969, 0-4 yrs and 5-19 yrs, summed from table in : Annual Abstract of Statistics, 108, 1971, table 9 'Age distribution of the defacto or home population, mid year estimates, p.10.

for 1974, 0-4 yrs. and 5-19 yrs, summed from table in : Annual Abstract of Statistics, 1975, 'Age Distribution of Home Population' table 11, p.15.

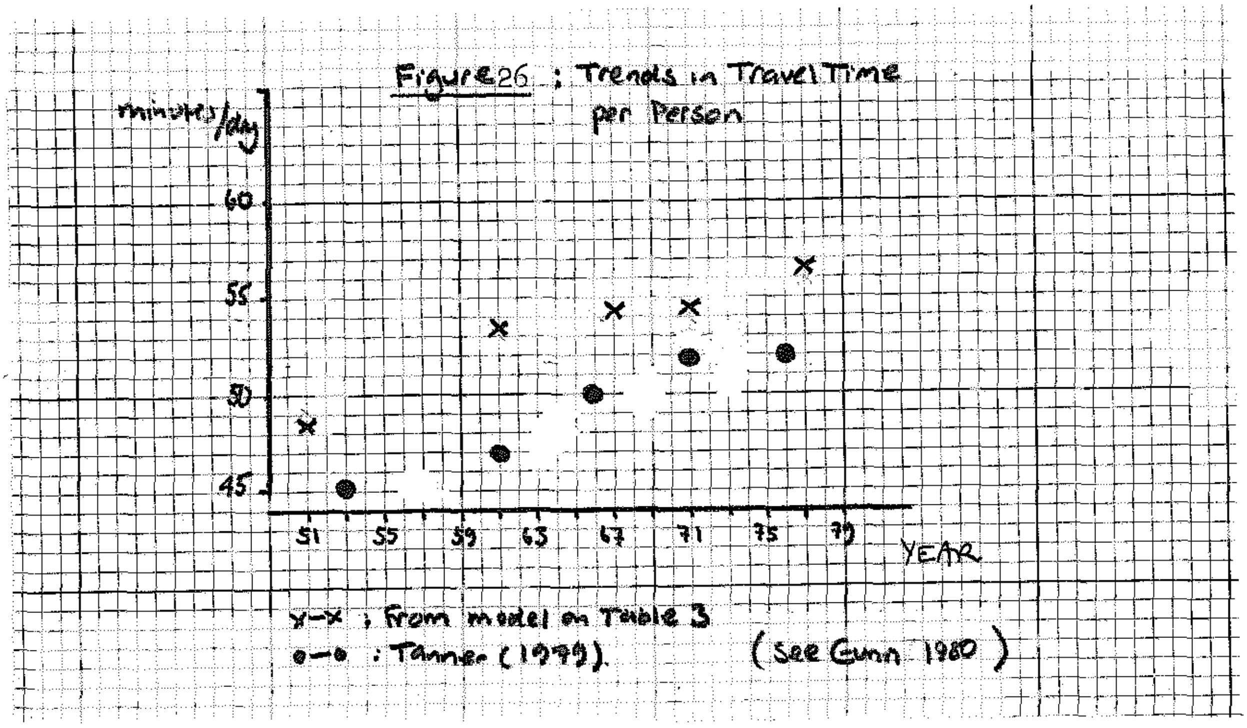
for total populations : Annual Abstract of Statistics, 'De facto or home populations, mid year estimates', 1971, 1981.

Persons in employment

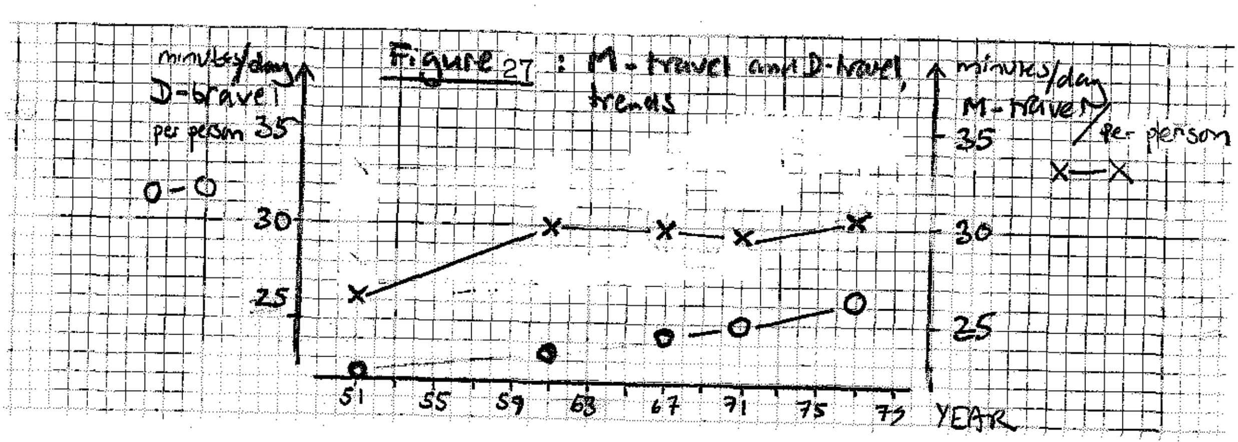
	1951	1961	1963	1965	1967	1969	1971	1973	1974	1975	1977
Total working population	20.7	25.77	25.16	25.46	25.39	24.79	24.55	24.97	25.07	25.20	25.71
% population	42.3	50.1	48.3	48.1	47.5	45.9	45.4	45.9	46.1	46.3	47.3

Sources

Annual Abstract of Statistics, 1965, 1967, 1971, 1975, 1977, 1980 'Distribution of total working populations', GB.



Over the period activity rates have risen and then declined, mainly as a result of increasing proportions of the retired offsetting greater female participation in the workforce; these trends have been counterbalanced to some extent by the effects of increased wealth and car-ownership. In the context of steadily reducing household sizes, this implies an increasing trend of travel per person. Whilst the models are obviously crude (for example the effects associated with incomes and car-ownership must also reflect complicated changes in land-use), the general similarity in the overall trends is encouraging. Figure 27 illustrates the model estimates of the component 'mandatory' travel times per household member, and 'discretionary' travel times per household member, over the same period, roughly 1/2 of the overall growth is attributed to increased travel in connection with discretionary activities.



At a highly aggregate level, then, average travel expenditures have remained fairly stable over a twenty five year period; there is also little evidence of variation between residents of different types of area. Such information could be useful in the estimation and prediction of general spatial interaction models, such as a conventional combined mode split/distribution models.

APPENDIX 1.

DATA FILES

Table 1A: CONTENTS AND FORMATS OF EXTRACT FILES

(variables defined below)
(XT(i), i = 1,34
(XP(i), i = 1,11
(XH(i), i = 1,14
(XHH(i), i = 1,12

FORMAT (1X, 3I2, 2I4, I3, 25I2, 3I4/1X, I2, 5I1, 2I2, 2I1, 2I4, I6, 2I1, 9I2, I4, 10I1, I2, I4)

Local variable name	Card type 4 (trip)	Format
XT(1)	Person number	I2
XT(2)	Trip number	I2
XT(3)	No. of stages	I2
XT(4)	Start time	I4
XT(5)	Duration of trip	I4
XT(6)	Wait time between stages	I3
XT(7)	Land use at destination	I2
XT(8-31)	Group purpose/mode	24I2
XT(32)	Unique mode/purpose combination	I4
	Card type	I1
XT(33)	Survey number	I4
XT(34)	Houshold code	I4
	Card type 2 (person)	
XP(1)	Person number	I2
XP(2)	Present/absent	I1
XP(3)	Sex	I1
XP(4)	Status	I1
XP(5)	Age group	I1
XP(6)	Driving licence	I1
XP(7)	Job	I2
XP(8)	Industry/profession	I2
XP(9)	Trips	I1
		63X
XP(10)	Card type	I1
XP(11)	Household code	I4

Table 1A (cont'd)

Local variable name	Card type 1 (household)	Format
XH(1)	Survey number	I4
	Grid reference	A8
XH(2)	Date	I6
XH(3)	Day of week	I1
XH(4)	Completion code	I1
XH(5)	People in household over 5 - Present	I2
XH(6)	- Absent	I2
	Other people in household over 5	
XH(7)	- present	I2
	Number of persons under 5	
XH(8)	- normally present	I2
XH(9)	Cars/vans available - to household	I2
XH(10)	- to others	I2
XH(11)	M/c available - to household	I2
XH(12)	- to others	I2
XH(13)	Income	I2
	1977 only: *number of persons in household*	33X
		I2 37X
	1977 only: number of trip stages	I2
	Card type	I1
XH(14)	Household code	I4
	Card type 8 (area)	
		4X
	County name	A26
	Survey name	A29
XHH(1)	Residential type	I1
XHH(2)	Housing density	I1
XHH(3)	Housing age	I1
XHH(4)	Situation	I1
XHH(5)	Distance to nearest town centre	I1
XHH(6)	Distance to neighbourhood shopping	I1
XHH(7)	Distance to railway station	I1
XHH(8)	Public transport - bus	I1
XHH(9)	- train	I1
XHH(10)	Communication pattern	I1
XHH(11)	Year of survey	I2
	Card type 8	I1
	Survey number	I4
XHH(12)	Household code	I4

Table 1A (cont'd)

Contents of HGCOL74P (MULT): (IR(i), i = 1,74
(XXT(i), i = 35,71

where IR(1) = XT(1)
IR(2) = XT(3)
IR(i) = XT(i+5), i = 3,26
IR(i) = XT(5)xXT(i-19), i = 27,50
IR(i) = XT(6)xXT(i-43), i = 51,74
XXT(i+34) = XP(i), i = 1,11
XXT(i+45) = XH(i), i = 1,14
XXT(i+59) = XHH(i), i = 1,12

FORMAT (IX, 2I6, 3(/2X, 24I4)/,2X, I2, 5I1, 2I2, 2I1, 2I4, I6, 2I1, 9I2, I4, 10I1, I2, I4)

Contents of HGRED74P2(MULT): (TT
(IV(i) i = 1,25

where TT = total trip time + wait time for all trips

$$= \sum_{j=27}^{74} IR(j)$$

and IV( ) are as shown below:

Local variable name	Card type 2 (person)	Format
IV(1)	Person number	I2
-	Present/absent	I1
IV(2)	Sex	I1
IV(21)	Status	I1
IV(3)	Age group	I1
IV(22)	Driving licence	I1
IV(4)	Job	I2
-	Industry/profession	I2
IV(5)	Trips	I1
		63X
-	Card type	I1
-	Household code	I4

Table 1A (cont'd)

Local variable name	Card type 1 (household)	Format
IV(23)	Survey number	I4
-	Grid reference	A8
-	Date	I6
IV(6)	Day of week	I1
IV(7)	Completion code	I1
IV(8)	People in household over 5 - Present	I2
IV(9)	- Absent	I2
IV(10)	Other people in household over 5 - Present	I2
	Number of persons under 5	
IV(11)	- normally present	I2
IV(12)	Cars/vans available - to household	I2
IV(25)	- to others	I2
-	M/c available - to household	I2
-	- to others	I2
IV(13)	Income	I2
	1977 only (number of persons in household	33X
	(number of trip stages	12 | 37X
		12
-	Card type	I1
-	Household code	I4
	Card type 8 (area)	
		4X
-	County name	A26
-	Survey name	A29
-	Residential type	I1
IV(14)	Housing density	I1
-	Housing age	I1
IV(15)	Situation	I1
IV(16)	Distance to nearest town centre	I1
-	Distance to neighbourhood shopping	I1
IV(17)	Distance to railway station	I1
IV(18)	Public transport - bus	I1
IV(19)	- train	I1
-	Communication pattern	I1
-	Year of survey	I2
-	Card type 8	I1
-	Survey number	I4
IV(20)	Household code	I4