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STATED PREFERENCE EXPERIMENTS CONCERNING LONG DISTANCE BUSINESS TRAVEL IN GREAT BRITAIN

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Abstract

Marks, P. and Fowkes, A.S. (1986). Stated Preference Experiments Concerning Long Distance Business Travel in Great Britain.

Stated preference techniques are now widely used in transport economics as an experimental tool for gathering data on consumer preferences to derive, amongst other things, estimates of demand elasticities and values of travel time, service frequency, service reliability and other determinants of travel behaviour. However, these techniques have not to our knowledge been used in research on long distance business travel behaviour. This forms the subject of this paper. In particular, results of a stated preference experiment answered by two samples of long distance business travellers are presented. Disaggregate mode choice models are calibrated with this data, and the results are used to derive estimates of the value placed by long distance business travellers on savings in business travel time. The design of the stated preference experiment means that these values can be interpreted as leisure values of time.

The results show that long distance business travellers place a high value on travel time savings. It is demonstrated that this can largely be explained by their high incomes and long work days, and the unsociable hours at which time savings occur. It is our view that the value of time estimates reported in this paper are not appropriate for use in forecasting exercises, rather they can be used to construct a value of business travel time for evaluation purposes.

STATED PREFERENCE EXPERIMENTS CONCERNING LONG DISTANCE BUSINESS TRAVEL IN GREAT BRITAIN

Introduction

Stated preference techniques are now widely used in transport economics as an experimental tool for gathering data on consumer preferences to derive, amongst other things, estimates of demand elasticities and values of travel times, service frequency, service reliability and other determinants of travel behaviour. However, these techniques have not to our knowledge been used in research on long distance business travel behaviour. This subject area is the focus of this paper. In particular, we present the results of a stated preference experiment answered by 2 samples of long distance business travellers. A disaggregate mode choice model is calibrated with this data and the results are used to derive estimates of the value placed by long distance business travellers on savings in travel time. The first 4 sections of this paper describe and check the quality of the data used in model estimations. In the fifth section results of these estimations are presented and discussed. In Section 6 our results are compared with value of time estimates obtained elsewhere and some concluding comments are given in Section 7.

1. The Data

The methods used to construct our 2 samples of business travellers are described fully in Fowkes, Johnson and Marks (1985). These 2 samples comprise:

i) 411 business travellers who had answered BR's 1983 East Coast Main Line survey and indicated there they would be willing to take part in a further survey. We call this the ECML sample.

ii) 442 employees of those organisations which had participated in our survey of organisation travel policies (see Fowkes and Marks (1985)). We call this the ORGN sample.

In both cases respondents were asked (using almost identical self completion questionnaires) to report details of a recent long distance business trip and to answer 12 questions about a hypothetical long distance business trip. The latter was the stated preference experiment, the results of which comprise the subject of this paper.

In this experiment, respondents were asked to consider a hypothetical situation in which they would make a day return trip of 300 miles each way (e.g. a journey between Newcastle and London) for the purpose of undertaking an unspecified business activity. For this trip the traveller could choose to travel by either air, first class rail, second class rail or car. Although it was expected most respondents would not regard travel by car as a viable option, this mode was included for completeness. A fixed lump sum of £100 was 'given' for travel expenses, whilst 'other' expenses were said to be fully reimbused. If travel costs were more (less) than £100 the traveller was told he/she would have to pay the extra (could keep the difference). We assume the traveller would not expect to pay tax on any 'windfall income'.

Each of the four permitted travel modes was described by the round trip travel cost, and the journey start and finish times (see Figure 1). Differences in start and finish times between modes accounted for differences in both main mode travel times and access/egress times. Given this information, the traveller was then asked to rank the 4 modes in order of preference, with a rank of 1 being associated with the most preferred mode and a rank of 4 associated with the least preferred mode. Each respondent was asked to do 12 of these ranking exercises (see Appendix 1 for the full set of ranking exercises).

Figure 1 An Example of the Ranking Exercise

	Cost £	Leave home	Arrive home	Rank
Air	80	07.00	18.30	____
Rail 1st	75	06.30	20.00	____
Rail 2nd	50	06.30	20.00	____
Car	40	05.30	20.30	____

2. Design of the Ranking Experiment

It was hoped that respondents would answer the ranking exercise by trading differences in cost against differences in time away from home, the inconvenience of start times and any other perceived differences between the services offered by the 4 modes. The experiment was designed by setting the start times and total journey times, which together determined the finish times. Levels of the time and cost variables were chosen so that the data would identify a reasonably wide range of time valuations. An orthogonal design (Winer(1971)) was not considered possible because of the constraints imposed by the following 2 'real life' considerations:

i) Travel times by first and second class rail should be equal, unless we were to complicate the analysis by having frequent first class only trains.

ii) The cost of first class rail should be about 50% greater than the cost of second class rail, as is usually the case during the business peak. As in (i) we wished to keep our hypothetical options as close as possible to travellers' actual experiences.

In order to ensure the experiment could identify a wide range of values of time, 'iso-utility' or boundary values of time were calculated for each modal comparison. An iso-utility or boundary value of time is the value of time at which an individual would be indifferent between a given pair of modes. (see Appendix 2 for a fuller explanation of this approach to experimental design). Table 1 contains the 'iso-utility' values of time for the experiment calculated assuming the utility derived from modal attributes other than cost and time is zero. The table shows that there is a wide range of boundary values. The intention was to allow for a wide range of in-vehicle values of time, together with a wide range of variability in valuations of factors other than cost and time. The effect of these others factors is captured by Alternative Specific Constants (ASCs) included in model calibrations, where they represent the utility gain (or loss) of, say, flying as opposed to travelling by first class rail, assuming the costs and times are identical for both modes.

Attribute values were primarily chosen so that choices between air, and first and second class rail covered a wide range of boundary values of time. Travel by car was not expected to be a serious option for most respondents because of the length of the hypothetical journey. Any aversion to the use of car means the boundary values given in columns 1, 4 and 5 of Table 1 are biased upwards.

3. Interpretation of Business Travellers' Values of Time

In this section we discuss the interpretation of the results obtained from the ranking experiment. As was said above, the experiment was designed in the expectation that respondents would rank modes by trading off cost against other modal attributes and thus reveal a value of travel time savings.

In practice business travellers are not generally given a fixed lump sum to pay for their travel costs. Rather an employer usually either issues the traveller with a ticket or reimburses the traveller for all travel costs after the trip has been made (see Fowkes, Johnson and Marks(1985)). Thus, whenever the traveller does have some discretion over the travel mode used for a long distance business trip, cost is unlikely to be a major factor influencing his/her decision. Non-cost attributes, such as journey time, convenience of start time and ability to work whilst travelling , have been found to be more important determinants of mode choice (Marks(1986a)). Cost is , however, likely to be relevant to the employer when deciding which modes the traveller can use for a particular trip (or for trips in

Table 1 Iso-utility Values of Time (£/hr)*

Question no.	Air vs car	Air vs R1	Air vs R2	R1 vs car	R2 vs car
1	11.4	2.5	15.0	23.3	6.7
2	14.3	15.0	17.5	20.0	40.0
3	15.0	80.0	110.0	2.0	4.0
4	17.1	40.0	60.0	8.0	0.0
5	10.0	-15.0	2.5	43.3	20.0
6	11.3	-8.8	1.3		
7	13.3	20.0	40.0	10.0	0.0
8	15.0	-17.5	5.0	47.5	25.0
9	13.8	1.3	8.8		
10	11.1	15.0	17.5	-20.0	-40.0
11	13.3	5.0	30.0	17.5	5.0
12	13.8	10.0	22.5	17.5	5.0

* Negative values of time occur whenever the choice is dominated by one mode i.e the cheaper option is the faster. Positive infinite values of time occur whenever there is no difference in travel times and so, all else being equal, one would chose the cheaper mode.

general). Neo-classical economic theory suggests the employer's willingness to reimburse for travel on a given mode will depend on the value of the extra output generated by saving travel time. Hence, one would expect higher paid employees to be permitted to use faster, more comfortable (i.e. more expensive) travel modes. Support for this hypothesis comes from our survey of organisations' travel policies, reported in Fowkes and Marks (1985).

What all this means is that, in general, observed mode choices are the result of an interaction between decisions made by both employers and business travellers. The answers to our ranking experiment are unlikely to reflect this interaction. Rather the values of time derived from the ranking experiment measure the values travellers place on spending an additional unit of time either working or in some leisure activity, relative to spending the time travelling. This value is a measure of the gain to the traveller from reducing travel time as distinct from any gains in output which may accrue to the employer. However, it seems likely the traveller will make his/her travel choices taking account of the impact these will have on his/her ability to work at the business meeting. If this is the case the values of time reported below will include the value of a 'productivity effect', the benefits of which will accrue to the employer, through increased output, and possibly also to the employee, through better career prospects.

In the context of our stated preference experiment it was expected that respondents would be substituting travel time for leisure time, because time savings accrued either early in the morning (before 0730) or in the evening (after 1800), i.e. outside 'normal' work hours. Only 1% of our respondents normally started work before 0730, and 19% of the ECML and 13% of the ORGN samples normally finished work after 1800. Hence the value of time estimates we have estimated are interpreted as the value of substituting travel time for leisure time. The theoretical model from which this value is derived is a utility maximizing model of consumer choice, in which an individual chooses one travel mode in preference to another in order to maximise his/her utility (minimise disutility) of travel (De Serpa(1973)). That is, if the (indirect) utility of travel by mode m for individual k is given by:

$$RU_{mk} = f_k(A_m) + e_k$$

where, A_m are the attributes of mode m,

e_k is a random error caused by random variations in behaviour

then, mode i is preferred to mode j if

$$RU_i > RU_j$$

We assume 1) the errors e_k are independent and identically distributed with a multinomial logit distribution.

2) $f_k(.)$ is a linear function of the attributes A_m.

Maximum likelihood estimates of the parameters of $f_k(.)$ are obtained below (see Maddala (1983) for a comprehensive discussion of multinomial logit models).

4. Quality of the Ranking Data

Before analysing the ranking data we first checked whether the respondents answered the experiment 'sensibly' and whether they traded off cost and time, or ranked modes on the basis of only one of these attributes.

Although the presence of unquantified mode specific attributes means that seemingly 'inconsistent' responses may in fact be the result of perfectly rational behaviour, it is possible to identify two cases in which a respondent has made an irrational choice.

i) In questions 5, 6 and 8, any person who chose 1st class rail over travel by air, prefers it despite a penalty of £30-£35 and of 2-4 hours. This is totally inconsistent with choosing air to save 0.5-1 hour at a penalty of £40 in questions 3 and 4 (see Appendix 1 for the stated preference questions).

ii) In question 10 a preference for car over first or second class rail shows a strong aversion to travel by rail. This would not be consistent with choosing rail in preference to car in question 9, where rail is more expensive than car and both modes have the same journey time.

We checked the data for occurrences of the above 2 situations and found only 4 respondents in each sample gave 'irrational' choices. These people were excluded from the data used in model estimations reported in the next section.

The data from the ranking exercise will clearly be of little value if a large proportion of respondents did not trade off time and cost when deciding their rankings. We were, therefore, interested to find out how many people appeared to:

i) Always rank modes on the basis of time alone, i.e. had a very high value of time;

ii) Always rank modes on the basis of cost alone, i.e. had a very low value of time;

iii) Always gave the same ranking i.e. considered attributes other than time and cost to be overwhelmingly important.

As Table 2 shows none of the ECML and only 6 of the ORGN sample gave rankings on the basis of only cost or time. This suggests the experimental design was adequate, in the sense that almost all respondents' values of time could be identified by the data.

Table 2 Number of 'Non-trading' Respondents

	Order on cost alone*	Order on time alone*	Same rankings*
ECML	-	-	18
ORGN	1	5	30

* Only respondents with 2 or more sets of rankings were counted here.

18 of the ECML and 30 of the ORGN respondents gave the same ordering of modes for all of the ranking exercises they answered. Looking in more detail at this data we found that in each sample approximately half of these respondents gave the ranking 1234 (i.e. air = 1, 1st rail = 2, 2nd rail = 3, car = 4). One could either interpret this as meaning cost considerations are dominated by the value placed on short journey time and comfort, or that these peole did not take the ranking exercise seriously and always wrote down the most obvious answer, i.e. 1234. Some support for the former explanation comes from the observation that a relatively large proportion of respondents who always answered 1234 earned £20,000 or more per annum (43% compared with 25% in the complete ECML sample and 15% in the complete ORGN sample). Nevertheless, we decided to remove respondents who always gave the same answer from the sample because it was still not clear they had taken the ranking exercise seriously. Removing these respondents from the sample resulted in a slight reduction in the value of time estimates.

Further indication of the importance of factors other than time and cost in determining rankings comes from examination of those choice situations where, on cost and time grounds alone, one mode dominates another. (Note here we exclude comparisons of first and second class rail). Eight such situations occur in the data and in Table 3 we give the numbers of people who gave 'contradictory' answers, i.e. chose the dominated mode. These data suggest we should expect a modal bias in favour of travel by rail in preference to travel by car, which is hardly surprising given the length of the hypothetical journey (i.e. 600 miles).

Table 3 Number of Respondents Preferring a Dominated Mode

		ECML	ORGN
Question 6	Car dominates R1	154	168
	R2	270	295
Question 9	Car dominates R1	257	245
	R2	290	283
Question 5	Air dominates R1	27	28
Question 8	Air dominates R1	29	27
Question 7	R2 dominates car	17	29
Question 3	R2 dominates car	15	30

To summarise, almost all respondents from both samples appear to have answered the stated preference exercise as was intended, with time and cost attributes being traded and with very few irrational choices being made. Responses thought likely to have arisen other than in the expected way have been removed from the data used for model calibrations.

5. Results

The exploded logit technique was used to analyse the ranked data (Chapman and Staelin (1982)). The software used to perform the estimations was an augmented version of the Australian Research Board's Basic Logit (BLOGIT) package (Crittle and Johnson (1980)) provided by John Bates. Because this package uses a large amount of disk space when analysing ranked data, we were only able to perform estimations on subsets of each of the ORGN and ECML samples. From each sample we drew a random subset comprising the stated preference answers of every second respondent who gave 'rational' rankings, and who supplied income and occupation data. Separate models were estimated for the ECML and ORGN subsamples.

Searching for an appropriate model specification, we started with a simple time and cost model and added variables which gave a statistically significant improvement in the fit of the model, at the 5% level. To perform this test we used the Chi-squared test statistic for nested models i.e. $2\,(LL(M_k) - LL(M_{k+1}))$

where M_k = model with k explanatory variables

M_{k+1} = model with k+1 explanatory variables

$LL(M)$ = log-likelihood of model M

The variables we first considered adding to the model were as follows:

Morning start dummies E1, E2, E3 and E4 where:

E1 = 1 if start before 0600
0 if otherwise

E2 = 1 if start before 0630
0 if otherwise

E3 = 1 if start before 0700
0 if otherwise

E4 = 1 if start before 0730
0 if otherwise

We did not experiment with dummies for arriving home late because the time at which the traveller arrives at home is a function of the start time and journey time. Although values of the early start time dummies will be related to the length of time spent away from home, we thought there was probably enough variability in the relationship between these 2 variables across the different ranking exercises to avoid serious problems due to multi-collinearity.

Use of E1,E2,E3,E4 is equivalent to attaching different coefficients to time savings at different times in the morning (see Appendix 3). To calculate the disutility of an additional minute of travel time when this time occurs, say between 0600 and 0629, the estimated coefficient of E2 should be multiplied by 2, added to the estimated time coefficient, and the sum divided by 60 (in regressions time was measured in hours).

Tables 4 and 5 contain the estimation results for our initial model specification search. Taking first the ECML data, we have that the addition of E1 to the simple time,cost model is associated with a sizeable reduction in the absolute value of the time coefficient, while other coefficient values are relatively stable (Model B, Table 4). The coefficient of E1 is statistically significant (at the 5% level) and, as the Chi-squared statistics in Table 6 show, the inclusion of E1 in the model leads to a significant improvement in the model fit. Additional travel time before 0600 clearly yields a large amount of disutility : it is approximately four times as large as the disutility of the same amount of additional travel time occuring later in the day (see Appendix 3).

Addition of E2 to model B gives model C and a further significant (at the 5% level) improvement in model fit. There is no gain in model fit from adding E3 to model C (Model D). Model E is model C less E1 and comparison of the log-likelihoods for these two models shows that model E performs better i.e. the dummy variable E2 (starting before 0630) captures the negative effects of an early start time. Reductions in travel time occuring before 0630 are valued at approximately four times the rate of an equivalent time saving occuring later in the day.

Estimations using the ORGN data gave similar results to those obtained with the ECML data. The major difference being that, in the case of the ORGN data the dummy variable E1, and not E2, was the only start time dummy to give a significant improvement in model fit. Again time savings early in the morning are valued much more (approximately 350%) than the equivalent time savings occuring later in the day.

Looking at the results for our preferred models (Model E for the ECML data and Model B for the ORGN data) in more detail, all mode specific constants are positive, indicating a bias away from travel by car. Also this bias is largest in the case of first class rail. These results are as expected given the relative levels of comfort of the 4 modes.

Estimated values of time are relatively high for all models and this is caused in part by the early departure times for travel by some modes, in particular, for travel by car. While it could be argued we are capturing an aversion to travel by car with the start time dummies, in regressions which excluded the ranked data for car (not shown) the coefficients of the start time dummies were even larger than those obtained from the complete data sets. Remembering that our sample comprises people with above average incomes, who will probably want to arrive at their business meeting feeling alert, the value of time estimates in Tables 4 and 5 do not seem unreasonably large. Bradley, Marks and Wardman(1986) found long distance rail travellers making leisure trips with incomes greater than £10,000 per annum had estimated values of time of at least 6 p/min.

In the ranking exercise expenditure over £100 came out of the traveller's pocket, while expenditure below £100 came from the hypothetical travel allowance. It was hoped respondents would treat these two sources of money identically. To test this we introduced a cost excess variable, CL, into the estimations, where CL was defined as;

CL = travel cost- £100, if cost > £100
= zero , otherwise

If CL has a non-zero coefficient then our experiment will have failed to get respondents to answer questions as if they were using their own money. In the event CL did have a non-zero coefficient for estimations on both data sets (see Appendix 4). However, the introduction of cost excess variables with (arbitrarily chosen) thresholds at £50 and £75 resulted in the coefficient of CL becoming insignificantly different from zero, thus confirming that respondents did treat the hypothetical travel allowance as if it was their own money.

The thresholds at £50 and £75 were significant for the ECML data, while only the threshold at £75 was significant for the ORGN data (Models F and G, Table 7). These results suggested a non-linear cost effect was at work in the data. This was perhaps to have been expected given the cost differences between modes in the stated preference experiment were generally not small (often in excess of £30). Large cost changes will have a non-marginal effect on respondents' incomes and hence their marginal utility of income could be expected to be an increasing function of travel costs. (Hensher and Louviere(1983) obtained a quadratic effect for international air travel, where again cost differences between options are large.) We therefore added a quadratic cost term to models E and B for the ECML and ORGN data, respectively (see model H, Table 7).

Table 4
Results of Estimations with ECML Data Using Start Time Dummies
(Standard errors in brackets)

MODEL	A	B	C	D	E
ASC - air	2.168 (0.123)	2.109 (0.124)	2.089 (0.124)	2.061 (0.150)	2.101 (0.124
ASC - rail 1	2.467 (0.078)	2.282 (0.091)	2.226 (0.093)	2.216 (0.097)	2.300 (0.087)
ASC - rail 2	1.783 (0.063)	1.569 (0.084)	1.555 (0.084)	1.554 (0.084)	1.660 (0.069)
Cost	-0.038 (0.001)	-0.039 (0.001)	-0.037 (0.001)	-0.037 (0.002)	-0.036 (0.001)
Time	-0.377 (0.028)	-0.296 (0.035)	-0.238 (0.041)	-0.236 (0.042)	-0.261 (0.039)
E1		-0.414 (0.111)	-0.265 (0.124)	-0.251 (0.131	
E2			-0.303 (0.109)	-0.298 (0.110)	-0.403 (0.098)
E3				-0.035 (0.104)	
Rho-bar squared	.4180	.4187	.4190	.4190	.4188
Log-likelihood	-5396.55	-5389.43	-5385.75	-5385.42	-5387.87
Value of Time (p/min)					
Before 0600		48.42 (9.43)	62.00 (10.18)	63.99 (11.91)	
0600 to 0629	16.75 (1.28)		38.08 (10.70)	41.12 (13.53)	(49.92 ((9.97)
0630 to 0659		12.71 (1.62)	10.73 (1.85)	13.93 (10.00)	12.20 (1.77)
After 0659				10.77 (1.88)	

Table 5
Results of Estimations with ORGN Data Using Start Time Dummies
(Standard errors in brackets)

MODEL	A	B	C
ASC - Air	1.867 (0.116)	1.803 (0.117)	1.793 (0.117)
ASC - Rail 1	2.039 (0.072)	1.849 (0.086)	1.826 (0.089)
ASC - Rail 2	1.524 (0.059)	1.308 (0.081)	1.304 (0.081)
Cost	-0.033 (0.001)	-0.034 (0.001)	-0.034 (0.001)
Time	-0.399 (0.026)	-0.321 (0.033)	-0.297 (0.039)
E1		-0.409 (0.106)	-0.340 (0.121)
E2			-0.131 (0.105)
Rho-bar Squared	.4034	.4041	.4042
Log-likelihood	-5774.6	-5767.43	-5766.44
Values of Time (p/min)			
Before 0600		55.11 (11.22)	61.38 (10.57)
0600 to 0629	20.00 (1.30)		27.70 (10.17)
After 0629		15.52 (1.65)	14.68 (1.90)

Table 6 Chi-Square Statistics for Model Specification Search

1. ECML Data

MODELS	$-2\ (LL(M_k) - LL(M_{k+1}))$
A vs B	14.24
B vs C	7.36
E vs C	3.12

2. ORGN Data

A vs B	14.34
B vs C	1.98

Note: In each case one degree of freedom is gained or lost and the critical value of the Chi-squared statistic with one degree of freedom at the 5% level is 3.84

In both cases the quadratic cost term is highly significant and the linear cost term loses significance, though only just in the case of the ORGN data. The quadratic cost model fits the ECML data almost as well as the model with thresholds at £50 and £75. All further modelling on this data set was, therefore, performed assuming a quadratic cost effect. Note that dropping the linear cost term does not significantly reduce the explanatory power of the model (columns 2 and 3, Table 7). In the case of the ORGN data the model with the £75 threshold performs slightly better than the model with the quadratic cost term (compare the log-likelihoods for models G and H, Table 7). However, because there are good a priori reasons (see above) for expecting a continuous rather than a discrete non-linear effect, the quadratic formulation seemed more appropriate. Dropping the linear cost term from Model H gives a significant loss in the explanatory power of the model and hence, both the linear and quadratic cost terms were retained for further analysis of the ORGN data set.

Thus model I for the ECML data and Model H for the ORGN data are our preferred models. The average values of time (for time savings after 0629) from these two models are almost the same: 11.6p/min for the ECML data and 11.8p/min for the ORGN data.

Next we examined the stability of the estimated cost and time parameters across different sample segments. In particular, we were interested in finding out whether these parameters varied according to respondents' incomes and work hours. The utility theory of consumer choice, which underlies our estimated models, suggests the cost coefficient, and hence the marginal utility of income (for a given cost), will decrease as income increases. To test this hypothesis we allowed the cost coefficient to vary across the four income groups: 0-£10,000 p.a.; £10,001-£15,000 p.a.; £15,001-£20,000 p.a.; £20,001+ p.a.

For the ECML data this was done by constructing a different cost variable for each of the four income groups, that is cost variable is partitioned by income (see Value of Time (1986), Judge, Hill, Griffiths, Lutkepohl and Lee(1982)). Allowing this variation in the cost coefficient gives a substantial, statistically significant improvement in model fit. The cost coefficients differ significantly (when comparing adjacent income groups) and decrease (in absolute value) as income increases. Value of time estimates increase by a factor of 2.4 when moving from the bottom to the top income group i.e. range from approximately 8p/min to 19p/min.

For the ORGN data constraints imposed by computing resources meant it was not possible to partition each of the two cost coefficients by the 4 income groups. To get around this problem each of the two cost terms was divided by the median income for the four income groups: £0-10K, £10-15K, £15-20K, >£20K. This is equivalent to imposing the constraint that values of time are linearly related to income. Although this constraint was rejected by the ECML data, we found imposing a linear income constraint on the cost coefficients for the ORGN data gave better results than the alternative solution of imposing the constraint that the relative size of the cost coefficients (i.e. of cost and cost squared) be the same for each of the four income groups. Dividing the cost coefficients by income does give a significant improvement in model fit, once again supporting the hypothesis that values of time are positively related to income. Values of time increase from 8.8p/min, for respondents in the bottom income group, to 25p/min for the top income group.

In addition to the income effect on the cost coefficient, it could also be hypothesised that people with high incomes have less spare time than others, because they spend more time working, in which case the marginal utility of time should be observed to increase with income. A more direct test of this hypothesis could be carried out by allowing the time coefficient to vary by hours worked, rather than by the proxy variable income. Our approach here was to use the sum of time normally spent at work plus time spent commuting each day as an indicator of the severity of an individual's time constraints. This sum we refer to as the length of the work day. Commuting time was added to hours worked as this seemed to give a better indication, than just hours worked, of the amount of 'free' time each individual had available for leisure activites. For some people this will underestimate the amount of work done, because lack of relevant data means our measure does not take account of work done at weekends or differences in holidays. In both samples income and length of work day are, as expected, correlated, with higher incomes being associated with longer work days (Table 8).

We also had data on whether respondents worked fixed hours, flexitime or variable hours (i.e. until the job was done). Segmenting the time coefficient by these 3 types of work hours gave a poorer explanation of the data than that obtained with the segmentation by length of work day.

Firstly, the results obtained from segmenting the time coefficient by the length of the work day (Tables 9 and 10) show, for both data sets, the addition of this segmentation gives a significant improvement in model fit. For the ECML sample only people with a work day of more than 10.5 hours have a significantly larger marginal utility of time than the rest of the sample, while for the ORGN sample people with work days of less than 9.5 hours ; 9.5 to 10.5 hours and over 10.5 hours all have significantly different marginal utilities of time. The results are consistent with the hypothesis that people with longer work days are more time constrained/have less leisure time than others, and hence have higher marginal utilities of time.

Secondly, segmenting the time coefficient by income gives evidence of a strong positive relationship between income and the marginal utility of time, and hence the value of time. Although in both samples the model fit is good, the insignificance of the value of time estimate for incomes less than £10,000 p.a. throws some doubt on the appropriateness of the income segmentation. We therefore tested whether the income segmentation is best applied to cost or both cost and time, bearing in mind that economic theory suggests only the marginal utility of money, and not the marginal utility of time, should vary with income. In estimations on the ORGN data, adding the income segmentation on time to that on cost gave no significant improvement in model fit and, consistent with this, time coefficients for the different income groups were not significantly different (see Table 11). By contrast, for the ECML data there was a noticeable improvement in model fit when the income segmentation on time was added to that on cost, and the time coefficients for the different income groups were significantly different. Whether income here is proxying for another variable, such as the amount of leisure time or the severity of time constraints, is explored later in this section.

Table 7 : Estimation Results for Models with Non-Linear Cost Terms
(Standard errors in brackets)

	EOML			ORGN		
	Model F	Model H	Model I	Model G	Model H	Model I
ASC - AIR	1.739 (0.138)	1.683 (0.126)	1.645 (0.123)	1.717 (0.119)	1.835 (0.118)	1.800 (0.124)
ASC - R1	1.899 (0.092)	1.884 (0.088)	1.841 (0.084)	1.854 (0.087)	1.935 (0.087)	1.912 (0.085)
ASC - R2	1.566 (0.073)	1.533 (0.07)	1.535 (0.068)	1.233 (0.080)	1.287 (0.080)	1.286 (0.080)
COST	-0.018 (0.004)	-0.007* (0.004)		-0.026 (0.002)	-0.0074* (0.0039)	
COST x COST		-0.00020 (0.00003)	-0.00025 (0.00001)		-0.00026 (0.00003)	-0.00025 (0.00001)
COST > £50	-0.015 (0.006)					
COST > £75	-0.015 (0.004)			-0.024 (0.003)		
TIME	-0.253 (0.043)	-0.238 (0.042)	-0.218 (0.040)	-0.260 (0.034)	-0.223 (0.034)	-0.225 (0.034)
E1				-0.504 (0.107)	-0.574 (0.107)	-0.507 (0.107)
E2	-0.420 (0.103)	-0.487 (0.104)	-0.528 (0.100)			
L (0)	-8630.96	-8630.96	-8630.96	-9134.51	-9314.51	-9314.51
Log Likelihood	-4950.19	-4952.79	-4953.92	-5505.95	-5510.79	-5512.75
Rho-bar Squared	.4262	.4259	.4258	.4087	.4082	.4080
Value of Time p/min (at average cost of £63.25)	12.7 (2.5)	12.1 (2.0)	11.6 (2.1)	16.8 (2.5)	11.8 (2.5)	12.0 (1.9)

* Insignificantly different from zero at the 5% level.

Table 8 Length of Work Day by Income
(% of respondents in each income group)

EOML

Hours	≤ £10,000	£10,001-£15,000	£15,001-£20,000	> £20,000	Number Respondents
≤ 9	25	20	11	11	64
9 - 9.5	24	24	21	15	80
9.5 - 10	14	22	16	18	69
10 - 10.5	13	9	18	23	57
10.5 - 11	11	9	13	9	39
> 11	13	16	21	24	70
Number Respondents	71	133	82	93	379

ORGN

Hours	≤ £10,000	£10,001-£15,000	£15,001-£20,000	> £20,000	Number Respondents
≤ 9	24	19	6	3	61
9 - 9.5	34	28	11	6	90
9.5 - 10	19	23	24	17	91
10 - 10.5	10	12	23	22	67
10.5 - 11	6	8	13	23	67
> 11	7	10	23	28	65
Number Respondents	90	155	111	64	420

Bringing together the above results, first for the ECML data, we have that the cost coefficient varies significantly with income and the value of the time coefficient depends on the respondent's income and length of work day. Combining the income segmentation on the cost coefficient with the length of work day segmentation on time results in the value of time estimates listed in column 4 of Table 9. (Here working 0-9.5 hours and 9.5 - 10.5 hours were amalgamated into a single category, because their coefficient estimates were not significantly different in earlier runs.) This model gives a significantly better fit to the data than either of the models containing only one of the two segmentations, and futhermore, all coefficient estimates remain significantly different. Next, allowing the time coefficient to also vary by income gives a further improvement in model fit, as measured by the Rho-bar squared statistic, and the time coefficients now differ significantly by both income and length of the work day (column 5, Table 9). Thus, it would appear that people with high incomes have a greater marginal utility of time than others for some reason over and above the fact that on average they have less 'free' time. One possible explanation may be that richer people do more enjoyable things with their leisure time because they can afford to buy better quality leisure services.

We may also be picking up the effect of habit on mode choice. For if respondents answered the ranking questions with a bias towards the travel modes they normally used on business trips, then higher paid respondents would be expected to give a higher rank to travel by air than other respondents. (Travel by air had the lowest travel time in all 12 ranking exercises). Confirming this, income was significantly correlated (at the 1% level) with the (average) rank given to travel by air, with richer respondents giving on average a higher rank. In the ORGN data the (average) rank given to travel by air was only weakly correlated with income (not significant at the 10% level).

Taking individuals with incomes less than or equal to £10,000 p.a. and whose work day is 10.5 hours or less as a base, our value of time estimates for the ECML data suggest the following rating factors should be applied to the 'base group' values of time:

	Segment	Factor
Length of Work Day:		
	< 9.5 hours	1.0
	9.5-10.5 hours	1.0
	> 10.5 hours	2.0
Income:	£0-10K (median £7.6K)	1.0
	£10-15K (median £12.5K)	1.9
	£15-20K (median £17K)	4.2
	> £20K (median £24.5K)	

That is, if a person has an income of between £10,000 and £15,000 per annum and a work day of more than 10.5 hours, then their value of time is 380% (2.0 x 1.9) times that for someone in the base group (i.e. whose income is £10,000 or less and whose work day is 9.5 hours or less).

For the ORGN data, we have found that the cost coefficients differ significantly by income and the value of the time coefficient depends on the length of the work day. Combining these two sources of coefficient variation in a single model gives the value of time estimates listed in the last column of Table 10. Note this model fits the data much better than models containing only one of the two sources of coefficient variation.

As with the ECML data, we can derive rating factors for individuals with different income/length of work day characteristics. The base sample fraction now comprises individuals whose incomes are £10,000 or less and whose work day is less than 9.5 hours. The rating factors one should apply to value of time estimates for this base group are:

	Segment	Factor
Length of Work Day:		
	< 9.5 hours	1.0
	9.5-10.5 hours	1.5
	> 10.5 hours	1.5
Income:		
	£0-10K (median £8.3K)	1.0
	£10-15K (median £11.8K)	1.4
	£15-20K (median £17.1K)	2.1
	> £20K (median £24.3K)	2.9

Differences between the results for the two samples are to be expected as result of sampling errors and differences in the methods used to collect the samples. The ECML sample was drawn from a population of business trips, while the ORGN sample was drawn from a population of business travellers. ECML respondents made business trips more frequently than the ORGN respondents and so one would expect any 'habit' effects to be more pronounced in the former sample. This would appear to be the case, if (as discussed above) one interprets the effect of income on the time coefficients in models estimated with the ECML data as a habit effect.

Lastly, we estimated a model in which the time coefficient was allowed to vary by travel mode, but found no significant differences in the time coefficient estimates. Note that the design of our stated preference experiment only allows testing for the difference between the marginal utility of air travel time and the marginal utility of rail travel time: in the experiment travel times for car were constant, and travel times for first and second class rail were the same.

Table 9 Value of Time Estimates Allowing Cost and Time Coefficients to Vary by Income and Work Hours - ECM Data (p/min)*
(Standard errors in brackets)

	INCOME ON COST	INCOME ON TIME	LENGTH OF WORK DAY ON TIME	INCOME ON COST LENGTH OF WORK DAY ON TIME	INCOME ON COST, TIME LENGTH OF WORK DAY ON TIME
0-£10K	8.22	3.21		6.59	6.29
	(1.36)	(2.46)		(1.38)	(1.60)
£10-15K	10.15	11.42		8.42	12.02
	(1.69)	(2.19)		(1.74)	(1.46)
£15-20K	15.95	27.02		12.55	
	(2.66)	(2.33)		(2.64)	
£20K	19.34	30.07		15.39	26.25
	(3.30)	(2.42)		(3.27)	(2.07)
Work hours > 10.5				13.01	12.82
0-£10K				(1.58)	(1.74)
£10-15K				16.62	19.47
				(1.98)	(1.82)
£15-20K				24.59	
				(3.31)	
£20K				30.39	36.14
				(3.94)	(2.52)
Work up to 9.5 hours			8.17		
			(2.22)		
Work 9.5 10.5/2 hours			9.60		
			(2.15)		
Work > 10.5 hous			19.95		
			(2.34)		
L(0)	-8630.96	-8630.96	-8630.96	-8630.96	-8630.96
Log Likelihood	-4832.23	-4826.15	-4928.19	-4812.10	-4804.19
No. observations	2015	2015	2015	2015	2015
Rho-bar squared	.4399	.4406	.4288	.4422	.4431

* All values of time are for time savings after 0600 and are evaluated at the average cost of travel in the stated preference experiment, i.e.£63.25.

Table 10 Value of Time Estimates Allowing Cost and Time Coefficients to Vary by Income and Work Hours - ORGN Data (p/min)*
(Standard errors in brackets)

	INCOME ON COST	INCOME ON TIME	LENGTH OF WORK DAY ON TIME	INCOME ON COST LENGTH OF WORK DAY ON TIME
0-£10K	8.80	3.18		6.79
	(1.22)	(2.13)		(1.33)
£10-15K	12.54	10.43		9.64
	(1.74)	(2.98)		(1.88)
£15-20K	18.11			13.92
	(2.52)	17.37		(2.72)
>£20K	25.84	(4.19)		19.86
	(3.60)			(3.88)
Work Hours >9.5				
£0-10K				10.26
				(1.31)
£10-15K				14.54
				(1.86)
£15-20K				21.01
				(2.68)
>£20K				29.97
				(3.83)
Work up to			5.11	
9.5 hours			(1.88)	
Work 9.5			14.17	
10.5 hours			(1.95)	
Work 10.5			17.53	
+ hours			(2.1)	
L(0)	-9314.51	-9314.51	-9314.51	-9314.51
Log Likelihood	-5447.18	-5462.80	-5469.00	-5438.57
No. observations	2212	2212	2212	2212
Rho-bar squared	.4150	.4133	.4126	.4159

* All values of time are for time savings after 0530 and are evaluated at the average cost of travel in the stated preference experiment, i.e.£63.25.

Table 11 Results of Segmenting Cost and Time Coefficients by Income
(Standard errors in brackets)

		EOML			ORGN	
SEGMENTATIONS		INCOME ON COST	INCOME ON COST + TIME		INCOME ON COST	INCOME ON COST + TIME
	ASC-Air	1.746	1.799		1.793	1.804
		(0.126)	(0.126)		(0.117)	(0.118)
	ASC-R1	1.917	1.989		2.262	1.921
		(0.086)	(0.092)		(0.076)	(0.087)
	ASC-R2	1.602	1.594		1.610	1.329
		(0.070)	(0.087)		(0.062)	(0.082)
2						
COST	0-£10K	-0.00039	-0.00035	COST/Y	-0.107	-0.116
		(0.00002)	(0.00002)	2	(0.048)	(0.048)
	£10-15K	-0.00031	-0.00031	COST/Y	-0.0023	-0.0023
		(0.00001)	(0.00001)		(0.0003)	(0.0003)
	£15-20K	-0.00020	-0.00023			
		(0.00001)	(0.00001)			
	>£20K	-0.00016				
		(0.00001)				
TIME	0-£10K		-0.135			-0.281
			(0.051)			(0.041)
	£10-15K	-0.243	-0.236		-0.256	-0.256
		(0.041)	(0.042)		(0.034)	(0.037)
	>£15K		-0.438			-0.246
			(0.041)			(0.037)
E2		-0.499		E1	-0.518	-0.523
		(0.103)			(0.108)	(0.108)
L(0)		-8630.96	-8630.96		-9314.51	-9314.51
Log-Likelihood		-4832.03	-4815.78		-5447.18	-5446.41
Rho-bar Squared		.4401	.4417		.4151	.4150

6. Comparison with Other Studies

Behavioural value of time estimates for UK long distance business travellers have been derived by 3 other studies: University of Leeds (1971); University of Southampton (1971); Steer, Davis and Gleave(SDG)(1981).* Wardman (1986) has estimated values of time for short distance (less than 25 miles one way) business travellers. We have converted the estimates from these studies to 1984 values by inflating or deflating by the relevant change in average full-time earnings, as measured by the New Earnings Survey (Department of Employment(1984))(see Table 12).

Comparison of these values shows our results are similar to those obtained by SDG and University of Southampton. Also most studies find business travellers value time savings at much higher rates than leisure travellers. The one exception to this is Wardman who found leisure and business travellers, making urban car journeys across the River Tyne, had approximately the same values of time. The low business values of time obtained in this study may be explained by the alternative use of the time savings. Urban travellers making a short business trip are likely to use travel time savings for work, whereas long distance business travellers are more likely to use travel time savings for leisure purposes, and hence these time savings are of greater value.

Table 12 Value of Time Estimates for Business Travellers (1984 prices)

Study	Value of Time for Business Travellers	Ratio of Business to Leisure Travellers' Value of Time (Approximate Values)
University of Leeds (1971)	30-50% of Hourly Household Income	3 - 5
University of Southampton (1971)	10.5 p/min	n.a.
Steer, Davies and Gleave (1981)	9.5 p/min	5
Wardman (1986)	4.2 p/min	1
This Study: ECML	11.6p/min	2 - 3*
ORGN	11.8p/min	

*This estimate was obtained by taking the ratio of the values of time estimated above to those found by Bradley, Marks and Wardman(1986) for long distance car, coach and rail travellers.

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* RTM Planning (1977) have constructed value of time estimates for business travellers for use in evaluation. These values were not, however, derived from data describing either actual or hypothetical choice behaviour.

Our work has shown that values of time depend on the traveller's income and work hours. Thus, when comparing the value of time estimates given in Table 12, one should allow for differences in the composition of the samples for each study. Unfortunately we do not possess sufficient data to do this properly. In the University of Leeds study the median income of business travellers was approximately 70% more than the median household income for the UK as a whole (Central Statistical Office(1970)). The median personal income of respondents to our surveys exceeded the average level of earnings by a similar amount. The median household income for respondents to Wardman's survey of business travellers was £11.4K. This is considerably below the median personal incomes for our two samples (£14.4K, £13.1K) and probably, in part, explains why value of time estimates derived in Wardman's study are less than half the estimates we have obtained. University of Southampton report only the occupational status of their sample: 52% were managerial and 28% were professional staff. These proportions are very similar to those for our ORGN sample, though not for the ECML sample which contained a much higher fraction of professional staff and a correspondingly smaller fraction of managerial staff. SDG do not report socio-economic data for their sample of business travellers. From the above evidence all that can be said is that, with the exception of Wardman (1986), our samples appear to be roughly similar, in terms of their socio-economic characteristics, to those collected by the other studies listed in Table 12.

University of Leeds and University of Southampton used actual mode choice data to derive their value of time estimates. The interpretation of such data is not straightforward; it depends on who made the mode choice decision and which alternatives were considered when making this decision. In general one cannot say whether the employer, the employee or the two together made a particular mode choice decision. Neither University of Leeds nor University of Southampton used data on who made mode choice decisions or which modes were considered when making these decisions to guide their analysis. University of Leeds did find, however, that over 40% of their sample of business travellers did not consider travelling by an alternative mode for their journey i.e. they were captive to the mode used. Swait and Ben-Akiva (1985) have demonstrated that when some respondents are captive to a particular mode (and so are not making mode choice decisions as modelled by the researcher) parameter estimates will be biased. Lastly, our results cannot be strictly compared with those derived by University of Leeds and University of Southampton because in these studies the employer would have normally paid for the costs of business travel, whereas our stated preference experiment was designed specifically to force the traveller to pay these costs.

SDG avoided the specification problems discussed above by using the results of a hypothetical journey planning game to derive their value of time estimates. In this game business travellers (on trains) were asked to rank 9 different train services each of which was described by cost, travel time, frequency and, in some cases, the number of interchanges. Although it is now clear the business traveller is making the travel decision, it is not clear in SDG's report who is paying for (receiving the benefit of) any (hypothetical) fare increases (decreases). This is important because one might expect the traveller to be more generous with the firm's rather than his/her own money (i.e. values of time would be higher in the former as compared with the latter case Marks(1986b)).

7. Conclusion

The results of our work have shown that long distance business travellers place a high value on travel time savings. This is in part explained by their high incomes and long work days, and the unsociable hours at which time savings occur. Time savings after 0629 for respondents in the lowest income group, that is with a median income of approximately £8.K, and whose work day was less than or equal to 9.5 hours were valued between 6 and 7 p/min. Values of time for long distance car, coach and rail leisure travellers, with household incomes in the range of £5-10K, estimated by Bradley, Marks and Wardman (1986) were found to equal 3.0 p/min, 4.1 p/min and 6.5 p/min, respectively. Any differences between these values of time for leisure travellers and our own estimates for business travellers could be explained by the tiring nature of the destination activity (i.e. the business meeting) and the fact the hypothetical journey in the stated preference experiment was a day return, and not an overnight, trip.(Of the sample of rail and coach travellers analysed by Bradley, Marks and Wardman (1986) only 15% were making a day return trip.) In addition, the time of day at which time savings occur may still have an effect here. Leisure travellers in Bradley, Marks and Wardman could choose to travel at times which were convenient to them, whereas our business travellers did not have this freedom. Hence, it seems likely that travel time savings will be more useful to business, as compared with leisure travellers, in say, lessening the impact of time constraints imposed by the needs of other household members.

The work presented in this paper has demonstrated that stated preference techniques can be successfully used both to derive values of time for business travellers and to examine sources of variation in these values. Further work is required, however, to rigorously validate the use of stated preference data in the context of business travel and to examine the relationships between values of time, and travel mode and duration of the business trip.

Lastly, we reiterate our earlier comments concerning the interpretation and use of our results. We caution against using these results for <u>forecasting</u> the demand for long distance business travel. Our stated preference experiment was specifically designed so that the business traveller would pay for travel expenses and so that he/ she had total control over mode choice decisions. It is well known that these conditions do not generally hold in practice; the employer pays for travel expenses and often influences mode choice decisions. It is this situation which should form the basis of any forecasting model. The main aim of our work was, however, to derive business travellers' values of time to use in constructing a value of business travel time for evaluation purposes. The values presented in this paper are used in this way, together with data on the employer's valuation of travel time savings, in work reported elsewhere (Fowkes, Marks and Nash (1986)).

References

Bradley M., Marks P. and Wardman M. (1986) 'A Summary of Four Studies into the Value of Travel Time Savings', Paper to be presented at PTRC, 14th Summer Meeting, Seminar M.

Central Statistical Office (1970) Social Trends 1970, No. 1, HMSO: London.

Chapman R.G. and Staelin R. (1982) ' Exploiting Rank Order Choice Set Data Within the Stochastic Utility Model', Journal of Marketing Research, Vol. XIX.

Crittle, F.J. and Johnson L.W. (1980) 'Basic Logit (BLOGIT) Technical Manual', Australian Road Reserach Board Technical Manual No. 9.

Department of Employment (1984) New Earnings Survey 1984, Government Statistical Office.

De Serpa A.J. (1973) 'Microeconomic Theory and the Valuation of Travel Time : Some Clarification', Regional and Urban Economics, Vol 2.

Fowkes, A.S. Johnson I. and Marks P. (1985) 'Long distance business travel and mode choice: the results of two surveys of business travellers', Institute for Transport Studies, University of Leeds, Working Paper No. 211.

Fowkes, A.S. and Marks P. (1985) 'The results of a survey of business travel policies in Greater London and North East England', Institute for Transport Studies, University of Leeds, Working Paper 202.

Fowkes, A.S., Marks P. and Nash C.A. (1986) 'The Value of Business Travel Time Savings', Institute for Transport Studies, University of Leeds, Working Paper 214.

Hensher D.A. and Louviere J.J. (1983) 'Identifying Individual Preferences for International Air Fares' Journal of Transport Economics and Policy, Vol XVII, No 3.

Judge G.G., Hill R.C., Griffiths W.E., Lutkepohl H. and Lee T.C. (1982) Introduction to the Theory and Practice of Econometrics, John Wiley & Sons, 1982.

Maddala, G.S. (1983) Limited Dependent and Qualitative Variables in Econometrics, Cambridge University Press, 1983.

Marks, P. (1986a) 'Long Distance Business Travel - A Literature Review', Institute for Transport Studies, University of Leeds, Technical Note 180.

Marks, P. (1986b) 'Results from the Analysis of the Mode Choice

Decisions of Long Distance Business Travellers', Institute for Transport Studies, University of Leeds, Working Paper 225.

RTM Planning Partnership (1977) 'A Study of Business Values of Time', Final Report Prepared for the Department of Transport, April 1977.

Steer, J., Davies and Gleave Ltd (1981) 'Elasticity of Demand in Respect of Service Frequency and Through Trains', Report prepared for British Railways Board, 1981.

Swait, J.D. and Ben-Akiva M. (1985) 'Analysis of the Effects of Captivity on Travel Time and Cost Elasticities', 1985 International Conference on Travel Behaviour, Noordwijk, Netherlands.

University of Leeds (1971) 'Intercity Modal Split in Great Britain Air v Rail', Centre for Transport Studies, University of Leeds.

University of Southampton (1971) VTOL: A European Study (Potential Sites and Business Travel), Volume Three: Business Travel, September 1971.

Value of Time (1986) 'Research into the Value of Time', Final Report prepared for the Department of Transport by the MVA Consultancy, Institute for Transport Studies, University of Leeds and Transport Studies Unit, Oxford University.

Wardman, M.W. (1986) 'Route Choice and the Value of Motorists' Time : Empirical Findings', Institute for Transport Studies, University of Leeds, Working Paper 224.

Winer, B.J. (1971) Statistical Principles in Experimental Design, John Wiley and Sons, New York.

APPENDIX 1. THE STATED PREFERENCE QUESTIONS.

Q19. We would now like you to consider a hypothetical situation in which you have to make a round trip of approximately 600 miles.

eg. a journey between Newcastle and London.

You would travel out and back on the same day, but would have a free choice of means of travel from these options :-

Air
Rail 1st class
Rail 2nd class
Car Driver

You will receive a fixed lump sum of £100 towards travel expenses and will be free to keep any unspent money. Subsistence expenses will be reclaimed seperately later.

On the following page there are several sets of travel options describing the cost of travel, the time you would have to leave home and the time you would return home from that journey.

Please study each block of options seperately and decide which means of travel you would use. Rank your chosen means of travel 1 and then rank the remaining means of travel 2,3,4 in decending order of preference.

Repeat this process with each block of options.

Write your rank in the box provided.

This example may help.

	Cost £	Leave home	Arrive home	Rank
AIR	100	07.00	20.30	3
RAIL 1st	100	07.00	19.00	2
RAIL 2nd	40	07.00	19.00	1
CAR	40	05.30	20.30	4

FOR OFFICE USE

3				

1 – 5

11 – 34

35 – 58

1.

	Cost £	Leave home	Arrive home	Rank
AIR	80	07.00	18.30	
RAIL 1st	75	06.30	20.00	
RAIL 2nd	50	06.30	20.00	
CAR	40	05.30	20.30	

2.

	Cost £	Leave home	Arrive home	Rank
AIR	90	07.30	19.00	
RAIL 1st	30	05.30	21.00	
RAIL 2nd	20	05.30	21.00	
CAR	40	05.30	20.30	

3.

	Cost £	Leave home	Arrive home	Rank
AIR	85	07.00	19.00	
RAIL 1st	45	07.00	19.30	
RAIL 2nd	30	07.00	19.30	
CAR	40	05.30	20.30	

4.

	Cost £	Leave home	Arrive home	Rank
AIR	100	07.30	19.00	
RAIL 1st	60	07.00	19.30	
RAIL 2nd	40	07.00	19.30	
CAR	40	05.30	20.30	

5.

	Cost £	Leave home	Arrive home	Rank
AIR	75	07.00	18.30	
RAIL 1st	105	06.00	19.30	
RAIL 2nd	70	06.00	19.30	
CAR	40	05.30	20.30	

6.

	Cost £	Leave home	Arrive home	Rank
AIR	85	07.30	18.30	
RAIL 1st	120	06.00	21.00	
RAIL 2nd	80	06.00	21.00	
CAR	40	05.30	20.30	

7.

	Cost £	Leave home	Arrive home	Rank
AIR	80	07.00	19.00	
RAIL 1st	60	07.00	20.00	
RAIL 2nd	40	07.00	20.00	
CAR	40	05.30	20.30	

8.

	Cost £	Leave home	Arrive home	Rank
AIR	100	07.30	18.30	
RAIL 1st	135	06.30	19.30	
RAIL 2nd	90	06.30	19.30	
CAR	40	05.30	20.30	

9.

	Cost £	Leave home	Arrive home	Rank
AIR	95	07.30	18.30	
RAIL 1st	90	05.30	20.30	
RAIL 2nd	60	05.30	20.30	
CAR	40	05.30	20.30	

10.

	Cost £	Leave home	Arrive home	Rank
AIR	90	07.30	18.00	
RAIL 1st	30	07.30	22.00	
RAIL 2nd	20	07.30	22.00	
CAR	40	05.30	20.30	

11.

	Cost £	Leave home	Arrive home	Rank
AIR	80	07.00	19.00	
RAIL 1st	75	06.30	19.30	
RAIL 2nd	50	06.30	19.30	
CAR	40	05.30	20.30	

12.

	Cost £	Leave home	Arrive home	Rank
AIR	95	07.30	18.30	
RAIL 1st	75	07.00	20.00	
RAIL 2nd	50	07.00	20.00	
CAR	40	05.30	20.30	

Appendix 2 Derivation of Iso-Utility Values of Time

Suppose the utility an individual derives from travel by mode m, Um, is given as:

$$Um = am + b\ Cm + c\ Tm + e$$

where, Cm = cost of travel by mode m
Tm = travel time by mode m
am, b, c are parameters
e = random error

Then the value of a small saving in travel time equals c/b. An individual will be indifferent between modes m and n if E[Um] = E[Un] or equivalently

$$0 = am - an + b\ (Cm - Cn) + c\ (Tm - Tn)$$

The 'iso-utility value of time' for modes m and n is defined to be the value of time at which E[Um] = E[Un] i.e. it is the value

$$VT = \frac{an - am + Cn - Cm}{Tm - Tn}$$

Cn, Cm, Tn, Tm are all chosen by the researcher in the design of a stated preference (SP) experiment. The value of an - am will have to be either 'guessed at' or taken from other studies if values of VT are to be calculated from a given SP design. The iso-utility values of time reported in Table 1 (p. 5) were calculated assuming an = am for all n, m.

Appendix 3 Interpretation of the Coefficients of the Start Time Dummy Variables

Here we demonstrate that, for our particular data set, use of the start time dummy variables E1-E4 is equivalent to estimating different time coefficients for 4 different times of the day namely: travel time before 6.00; travel time from 6.00-6.30; travel time from 6.30-7.00; travel time from 7.00-7.30. The coefficients of the dummy variables E1-E4 equal 30 times the difference between the marginal utility of time after 7.30 and the marginal utility of time in the relevant 1/2 hour interval. This is a direct result of our experimental design, because journey start times for the different modes were set at half hourly intervals from 05.30 to 07.30.

To show this suppose mode m departs at 0600 then the utility from using mode m is given as:

1. Using the dummy variable formulation

$$Um = \beta 1 \times 0 + \beta 2 \times 1 + \beta 3 \times 1 + \beta 4 \times 1 + a1T + \sum_{i=2}^{n} ai\ X\ i \qquad (1)$$

2. Using the segmentation by time of day formulation

$$Um = \sum_{i=1}^{4} \alpha_i\ Ti + a1\ (T - \sum_{i=1}^{4} Ti) + \sum_{i=2}^{n} aiXi$$

where T1 = travel time between 0531 and 0600
T2 = travel time between 0601 and 0630
T3 = travel time between 0631 and 0700
T4 = travel time between 0701 and 0730

Because in this example the individual departs at 0600 90 minutes of travel time occurs before 0730 i.e. $\sum_{i=1} Ti = 90$ and $T1=0$, $Ti=30, i=2,3,4$. Thus substituting in equation (2) and rearranging gives;

$$Um^{*} = (\alpha 1 - a1) \times 0 + (\alpha 2 - a1)\ 30 + (\alpha 3 - a1)\ 30 + (\alpha 4 - a1)\ 30 + a1\ T + \sum_{i=2}^{n} aiXi \qquad (3)$$

Setting $\beta\ i = (\alpha i - a1)\ 30$ (or equivalently $\alpha\ i = \frac{\beta i}{30} + a1$)

$$i = 1, 4 \qquad (4)$$

and substituting (4) in (3) one derives (1), and hence $Um^{*} = Um$ and the two formulations are equivalent. This proof can be repeated for each of the other possible start times: 0530, 0630, 0700 and 0730.

Note that from our estimates of β_i we can obtain estimates of the value of saving time early in the morning compared with the value of time savings later in the day, by substitution in equation 4.

APPENDIX 4: ADDITIONAL ESTIMATION RESULTS.

In the table given below we list the results obtained from regressions on models which include the cost levels variable CL, where CL is defined:

$$CL = \text{cost} - £100, \quad \text{if cost is greater than } £100$$
$$= 0, \quad \text{otherwise}$$

The results show that the estimated coefficient of CL is significantly different from zero for both data sets. This suggests that respondents treated expenditures from their own money differently from expenditures from the hypothetical travel allowance, given in the stated preference experiment.

Estimations Using the Cost Levels Variable
(standard errors in brackets)

		ECML Data	ORGN Data
ASC	Air	1.574 (0.123)	1.673 (0.115)
	Rail 1	1.946 (0.085)	1.784 (0.082)
	Rail 2	1.489 (0.067)	1.195 (0.076)
Cost		-0.0289 (.0015)	-0.0301 (.0013)
Time		-0.2342 (.041)	-0.2221 (.0328)
E1			-0.5949 (.1014)
E2		-0.5278 (.1)	
CL		-0.0202 (.0042)	-0.0228 (.0039)
LL*		-5753.1	-6407.78
Rho-bar Squared		0.4084	0.3932