Working Paper 566

December 2001

INTER-TEMPORAL VARIATIONS IN THE VALUE OF TIME

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June 2001

1. INTRODUCTION

The objective of the research reported here is to examine how the value of time varies over time. A key factor in inter-temporal variations in the value of time is expected to be the impact of income growth, although changes in other socio-economic, demographic, attitudinal, employment and travel characteristics could also lead to variations in the value of time over time.

The most widely held convention relating to the adjustment of recommended values of time over time is that they should be linked proportionately to growth in some measure of income. No consideration is given to possible changes in the value of time for other reasons. Even disregarding the latter issue, there is no reason from a theoretical standpoint why the income elasticity for private travel should be unity since it is a matter of personal preference how an individual or household allocates additional income to time savings. In contrast, the case for a close link between the value of time and income is much stronger for business travel.

Official recommendations in Britain, as elsewhere, increase the value of non-work travel time over time in line with growth in income. DETR's Transport Economics Note specifies that both work and non-work time values should be increased in line with real GDP per head.

Beesley (1971) pointed out various sources of variation in the value of time over time and, on the basis of the uncertainty as to even the direction in which the values might vary, he argued for in favour of a zero trend value. The first British national value of time study (MVA et al., 1987) claimed that a constant real value of time was on theoretical grounds "equally logical and defensible" as the convention of linking the value of time to income growth. However, it was recognised that there did seem to have been an increase in the value of time over time. It was concluded that, "We do not feel able, therefore, in the absence of any specific work on this topic within our programme, and given the existence of plausible arguments in contrary directions, to come to any firm conclusions. The matter must remain on the agenda for further investigation".

A large amount of recent evidence, which we shall cover, is being taken to indicate that the income elasticity for the value of time spent in private travel is far less than unity. It is important that such a challenge to the widely used convention is tested against the widest body of evidence possible before any conclusions are drawn, particularly given the implications of amended recommendations for practical project evaluations.

The aim of this paper is to review the existing evidence relevant to inter-temporal variations in the value of time and to present some fresh empirical evidence. The approach adopted here is threefold. Firstly, we examine the cross-sectional variations in the value of time with income apparent from a number of empirical studies, both British and from other countries, and we develop a model to explain cross-sectional income elasticities across British studies. Secondly, the opportunity exists of analysing two data sets obtained from the same SP design conducted in the same area but at different points in time. Finally, variations in values of time over time are analysed by means of 'meta-analysis' of a large data set of British empirical evidence.

The structure of this report is as follows. Section 2 contains a discussion of various background issues relating to theoretical maters, methodology and previous findings. Section 3 reports analysis of cross-sectional variations in values of time with income whilst section 4

reports on joint analysis of two data sets collected in the first and second national value of time studies commissioned by the Department of Transport. Section 5 reports the findings of our meta-analysis of a large body of British evidence on the value of time. A discussion of the various findings is provided in section 6 and concluding remarks are provided in section 7. The final stage of the study will draw together this evidence to form recommendations concerning the value of time over time.

2. BACKGROUND

Three background issues are covered in this section. These are the guidance that theory gives on variations in the value of time over time, the various approaches that could be used to shed light on this issue and a review of evidence provided by several recent national value of time studies.

2.1 Theoretical Considerations

The money value of time for non-work travel is the ratio of the marginal utility of time and the marginal utility of money. The former is made up of components attributable to the disutility of time spent travelling and to the opportunity cost of travel time.

At the outset, we recognise that theory can give no precise guidance on how the value of time varies over time. We can, however, look to theory for guidance on the likely direction of change in the value of time over time and for assistance in model specification and interpretation. We here concentrate on how an individual's value of time might vary over time, as opposed to how the value of time in the travelling population as a whole might vary. The latter is additionally influenced by variations in its socio-economic composition.

We expect that income will grow over time and that travellers will become less sensitive to variations in money costs as their income increases. This reduction in the marginal utility of money will mean that the value of time increases with income. However, there is no reason to expect that the value of time varies in direct proportion with income. It is a matter of personal preference how an individual allocates additional income to purchasing time savings. All that we can reasonably conclude is that since time savings are not an inferior good the income elasticity is expected to be positive.

The inter-temporal value of time will also be influenced by trends in the disutility of travel and the opportunity cost of travel, issues which tend to be ignored in official recommendations.

The disutility of travel will fall over time as quality, comfort and facilities improve. Cars have become more comfortable over time and there have been improvements to in-car entertainment and environment. Public transport modes have also become more comfortable, with improvements in attributes such as interior decor, seating, ride quality and, in some instances, better on-board facilities and services.

There might however be offsetting effects in certain circumstances. For example, urban car driving conditions are worsening whilst problems of crowding have heightened on some rail services into major conurbations. These would act to increase the disutility of time spent

travelling. The incidence of 'road rage' as symptomatic of generally reduced levels of patience may reflect an exogenous increase in the value of time over time.

On balance, given the continual improvement in vehicle quality and available facilities, we feel that changes in the disutility of travel will operate to reduce the value of time over time.

As the quantity and quality of leisure time activities increase, and there becomes more effective competition between these activities, the opportunity cost of time spent travelling can be expected to increase. However, offsetting this will be the trend towards fewer working hours so that time constraints are reduced. In addition, the opportunity to use travel time productively can be expected to impact on the value of time, and in this respect the advent and widespread ownership and use of mobile phones and the possibility to use laptop computers on some modes may have had a significant downward influence on the value of time.

As far as the marginal utility of money is concerned, we expected income growth over time to lead to increases in the value of time, although theory gives no guidance on what the elasticity might be. However, the effect on the marginal utility of time of changes in the disutility of travel and the opportunity cost of travel time over time is indeterminate.

2.2 Methodologies for Estimating Inter-Temporal Variations in the Value of Time

If we wish to conduct research to determine how the value of time varies over time, there are a number of different approaches that can be adopted.

An approach that achieves a close degree of control over the conditions of comparison, and which can provide evidence on both the effect of income on the value of time and variations due to changes in the marginal utility of time, is to repeat a study using the same SP design, survey method, means of presentation and choice context, with respondents selected to ensure that differences in the socio-economic, demographic, cultural and trip characteristics of the two samples are minimised.

Controlled comparisons of this form are quite clearly practical, but few have been conducted. Instead, reliance is more commonly placed on purely cross-sectional evidence derived from a study conducted at a particular point in time. The income elasticity derived across decision makers would then be taken as the best estimate of how the value of time varies over time with income growth. The study might also provide evidence on how the marginal utility of time will vary over time, according to such factors as the amount of free time and some types of travel condition, but it is unlikely to be able to provide a complete picture of such possible variations. A further drawback of this approach is that it assumes that relationships that apply across the population will also apply over time.

These approaches ignore the large amount of empirical evidence relating to the value of time which can provide estimates of how the value of time varies over time. Meta-analysis aims to draw together the findings from separate studies and to develop a quantitative relationship to explain variations in the values. Some of the variation across studies will be due to inter-temporal variation in the value of time. An attraction of this approach is that not only is it based on a large number of values of time obtained from many studies but it is also based on many different time periods rather than just two. With regard to the analysis of inter-temporal variations in the value of time, there are three basic forms that the meta-analysis could take.

The most general approach is that the study could collect values of time from different studies which included disaggregations by income group as well as other variables such as purpose and mode. This would allow analysis of both cross-sectional and time series variations in the value of time. A special case of the above approach, and one that will yield far more data given that many studies do not perform income segmentations, is to collect information on values of time without any income segmentations and to rely solely on inter-temporal variations. The resulting elasticity would contain the combined effects of changes in the marginal utilities of time and money. Finally, the most straightforward approach would be to collate evidence on the cross-sectional variations in the value of time with income that are apparent within studies. If comparisons were only made across values obtained within studies, the need to explain the influence of other factors such as mode and purpose is avoided since they will not vary within any comparison.

In this study, we have used the second and third of the meta-analysis approaches outlined above along with an opportunity to analysis two comparable SP data sets undertaken at different points in time.

2.3 Previous Evidence

Almost all evidence relating to the impact of income on the value of time is cross-sectional, obtained from the estimation of separate values of time by income group within disaggregate choice models. The vast majority of such evidence is derived from SP within-mode choice models.

There have been a number of national value of time studies conducted since the pioneering first British study and a key segmenting variable in these studies has been income. We focus our attention here on the income effects apparent in these national value of time studies.

Great Britain 1

One of the major aspects of the first British national value of time study (MVA et al., 1987) was to conduct a thorough investigation of the relationship between the value of time and income because the then existing evidence was so weak.

A number of separate studies were conducted which examined how the value of time varied with income. Models were reported which involved relatively straightforward segmentations of choice models according to income alone. More complete models were also developed, using the segmentation procedure now common in value of time studies, whereby the effect of income was examined within the broader context of other socio-economic and trip characteristics. This reduces the chances that could occur in the former procedure of other effects being confounded with that of income.

Table 2.1a lists the modifiers to the value of time due to the income segmentation of the cost variable obtained in several studies (Bradley et al., 1986). The variations are not as strong as when household income was the only segmenting variable but nonetheless an income effect is apparent and clearly the income elasticity is less than unity.

Table 2.1a: Value of Time Modifiers by Income from First British Study

Household Income	Urban Bus	Urban Car Commute	Urban Car Leisure	Inter Urban Car	Inter Urban Rail	Inter Urban Coach
<5000	1.00	1.00	1.00	1.00	1.00	1.00
5-10000	1.00	1.16	1.11	1.00	1.49	1.10
10-15000	1.10	1.23	1.11	1.05	1.45	1.10
15-20000	1.18	1.23	1.31	1.34	1.94	1.30
20000+	1.18	1.23	1.31	1.34	1.94	1.30

Source: Bradley et al. (1986) Tables 1-4. Additional 'income' related incremental effects were often obtained, such as for single person households, the retired and households containing children.

Of greater interest, however, is the income effect estimated to the RP model developed in the North Kent commuter mode choice study undertaken in an earlier phase of the study. The difference between this and the other studies undertaken within the first British study was that individual rather than household income provide the basis of the segmentation. The results for four income segmentations are reported in Table 2.1b for the value of IVT relating to rail and coach separately.

Table 2.1b: North Kent Mode Choice RP Values (p/min)

Personal Income	Rail	Coach
5259	0.76	2.30
9037	1.54	2.47
12683	5.20	4.77
19844	7.54	5.29

Source: Fowkes (1985)

The effect is particularly strong. Indeed, a yet more impressive relationship was apparent when a more detailed segmentation using overlapping income groups was conducted. This involved the estimation of separate models and the specification of a generic IVT coefficient (Fowkes, 1986). The results are presented in Table 2.1c2b. A monotonic relationship is apparent for IVT and, although it is not as strong for walk and wait time the results are still impressive.

Table 2.1c: Further North Kent Income Segmentations

Band	Mean Income	Value of IVT	Value of Walk	Value of Wait
1,2	5259	2.15	1.99	4.82
2,3	6946	2.24	1.85	5.99
3,4	9037	2.54	1.87	6.22
4,5	10759	2.79	1.47	7.51
5,6	12683	4.78	2.66	12.04
6,7	16011	7.38	9.79	11.35
7,8	19844	8.66	11.11	13.91

Source: Fowkes (1986). Individual income measure.

For IVT, the implied income elasticity between the lowest and highest values of IVT is 1.05. The corresponding values for walk and wait time are 1.30 and 0.80.

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The strong income relationship could be due to the use of individual rather than household income or it could be due to the use of a robust RP model. Although the income effect apparent in the SP model was very weak, it was argued that this might have been due to deficiencies in the experimental design (MVA et al., 1987).

The first British national value of time study (MVA et al., 1987; p122) concluded that, "..... we have clearly demonstrated the existence of an income relationship, which has never been done before with any conviction" and that "the value of time as a proportion of income is a decreasing function of income, rather than a constant as has hitherto been assumed".

Great Britain 2

The second British study (Hague Consulting Group and Accent, 1999) examined the influence of income within the broader context of the impacts of a wide range of socio-economic and trip characteristics on the value of time. Table 2.2 lists the average values obtained by household income group and journey purpose.

An impressive monotonic income effect has been obtained across a wide range of income categories for all three journey purposes. Additional effects were attributable to who would pay for the time saving, the amount of free time and size and composition of the household. Hague Consulting Group and Accent (1999, p31) concluded that, "The findings of this study, supporting those reported in The Netherlands, are that VOT is indeed related to income, but the relationship is not one of proportionality. Rather, income elasticities of around 0.5 have been found".

Table 2.2: Values of IVT from Second British Study (pence/min)

Household Income	Business	Commute	Other
0-10000	7.0	2.6	2.3
10-20000	8.7	3.1	2.9
20-30000	10.3	4.1	4.0
30-40000	12.9	5.5	4.3
40-50000	14.5	7.7	6.0
50-60000	16.6	11.4	6.9
60000+	19.9	14.0	14.3

Netherlands 1

The values of time estimated for different household income groups of car, train and bus/tram users in the first Dutch (1988) national value of time study are reported in Table 2.3. These are income effects within a model containing a wide range of socio-economic segmentations, and hence they are independent of household composition, occupation and 'personal free time' effects which otherwise might influence the pattern of value of time variation across income groups.

Table 2.3: Values of IVT from First Dutch Study (1988 f/hour)

Household Income	Commute	Business	Leisure
0-1500 f/month	7.0	9.1	6.3
1501-2500 f/month	7.0	9.1	7.4
2501-4000 f/month	7.7	12.2	7.9
4001-6000 f/month	10.3	12.7	8.9
6001-8000 f/month	10.4	14.5	10.4
8000+ f/month	12.2	31.4	12.3

Source: Gunn and Rohr (1996) Table 1

Gunn and Rohr (1996) conclude that, "Income does affect VOT, with progressively higher VOT's at higher income levels, for all purposes. However, the effect is not one of proportionality". Additional quite substantial effects were estimated for the amount of personal free time and household composition.

Netherlands 2

The second Dutch (1997) national value of time study provides not only an household income segmentation along similar lines to the first study but is novel in its comparison of two very similar SP exercises conducted at two different points in time. As far as we are aware, this is the first such attempt to compare values of time over time in such a controlled manner.

Table 2.4 reproduces the values of in-vehicle time obtained by household income group and purpose obtained from models which contained variables to detect the effects of household composition and the amount of free time. A positive monotonic effect from income on the value of time is apparent, but again the relationship is far less than proportional.

Table 2.4: Values of IVT from Second Dutch Study (1997 f/hour)

Household Income	Commute	Business	Other
<2500	9.03	7.53	6.26
2500-4000	9.37	11.80	6.86
4000-6000	10.00	14.36	7.31
>6000	16.56	28.40	9.55

Source: Gunn et al., (1998) Table 4.4.

The study also found that between 1988 and 1997, after allowing for income and other socio-economic and trip characteristics, there had been a trend decline in the value of time for all three journey purposes. This trend decline was sufficient to offset the positive effect on the value of time due to income growth such that the real value of time remained broadly constant between the two periods.

Gunn et al. (1998) concluded that, "It could be assumed that the changes (compared to 1988) would be due to the use of mobile telephones and laptops during transport, overcrowding in trains during peak hours causing a shift for the VOT travellers towards car, and the 36 hour working week, but further research is needed to confirm these assumptions".

Norwegian

Table 2.5 reproduces the income segmentation results obtained by Ramjerdi et al. (1997) in the Norwegian national value of time study. An interesting feature of the study is that both personal and household income were examined, in contrast with most studies which examine only household income.

Table 2.5: Norwegian Values of Time for Private Travel by Income Group (NOK/hr)

	Personal/Household Income		Personal Income		Household Income	
	Single	Single	2 Adults	2 Adults	2 Adults	2 Adults
	Employed No Children	Employed With Children	Employed No Children	Employed With Children	Employed No Children	Employed With Children
<100	100	100	100	100	100	100
101-200	118	115	119	121	253	292
201-300	151	224	123	121	88	107
301-400	121	161	173	171	-	-
401+	300	250	233	203	525	372

Source: Ramjerdi et al. (1997) Table 10

At least as far as one person households and two person households but using personal income are concerned, there seems to be a relationship of the expected form between the value of time and income. However, the implied income elasticity is again somewhat less than one. However, the use of household income appears to work less well. Ramjerdi et al. (1997) state that, "The relationship of VoT and income is more explicit when individual income is used".

Table 2.6 contains the values of time split by income group for business travel in the Norwegian study. The authors again conclude that the relationship between the value of time and income is more clearcut when individual income is used, although the evidence is not as convincing as for personal travel.

Table 2.6: Norwegian Values of Time for Business Travel by Income Group (NOK/hr)

	Personal/Household Income		Personal Income		Household Income	
	Single	Single	2 Adults	2 Adults	2 Adults	2 Adults
	Employed No Children	Employed With Children	Employed No Children	Employed With Children	Employed No Children	Employed With Children
<100	-	-	100	100	100	100
101-200	100	100	131	102	267	103
201-300	274	278	202	249	424	403
301-400	149	143	175	260	-	-
401+	63	345	331	259	199	153

Source: Ramjerdi et al. (1997) Table 17

Sweden

Algers et al. (1996) in the Swedish national value of time study followed a similar procedure to that adopted in the Norwegian study. Experimentation was conducted with the use of both individual and household income to explain the value of time. Table 2.7 reports the values of time for private travel for various income groups.

Table 2.7: Swedish Values of Time for Personal Travel by Income Group (Crowns/hr)

		Personal Income		Household Income	
	Singles	2 Employed No Children	2 Employed With Children	2 Employed No Children	2 Employed With Children
<100	100	100	100	100	100
101-150	128	113	135	40	83
151-200	127	107	92	63	50
201-250	127	141	102	65	77
251-300	206	140	160	72	85
301-350				60	68
351-400				74	80
401-450				75	85
451+				89	83

Source: Algers et al. (1996). Income group is 251+ for singles.

The authors conclude that, “The relationship between income and VoT is, as in many other studies, positive but fairly weak” and “It also seems as if the relationship with income is more pronounced if individual income is used”. They go on to show that if the lowest income group is disregarded and the remaining categories are grouped into two halves, the value of time income elasticity is 0.46 for single person households. For two person households with and without children, it ranges from 0.07 to 0.24 when household income is used but from 0.23 to 0.42 when individual income is used.

The Swedish study also estimated values of time for business travel. These are reproduced in Table 2.8. Clearly the same cost segmentation applies across each mode but differs between the self employed business travellers (S) and the other business travellers (O). A clear relationship exists between the value of time and income for other business travellers as it does, with the exception of the lowest income group, for self employed travellers. Again, however, the relationship is far from proportional.

Table 2.8: Swedish Values of Time for Business Travel by Income Group (Crowns/hr)

	Car		Train		Air		X2000	
	S	O	S	O	S	O	S	O
<100	80	81	74	83	89	91	126	90
100-200	73	94	67	97	81	106	115	104
200-300	112	101	103	104	124	113	176	112
300-400	138	139	128	143	154	156	218	154
400+	-	144	-	148	-	161	-	159

Source: Algers et al. (1996). S denotes self employed and O denotes other business travellers.

Finland

The Finnish national study (Pursula and Kurri, 1996) reported the value of time to be a function of income for the bus users' SP route choice model but no income segmentations were reported in the car users' SP route choice models. For the two bus users' SP models reported, we have calculated the value of time in each of four income bands and these are reported in Table 2.9. There seems to be a strong relationship between the value of time and income and the income elasticity is again far short of unity.

Table 2.9: Finnish Values of Time for Bus Users (FIM/hr)

FIM/month	Model 1	Model 2
<8000	10.9	10.8
8000-18000	16.3	14.6
18000-30000	21.0	16.2
30000+	16.7	18.9

Source: Pursula and Kurri (1996) Table 4.

Overview of Cross-Sectional Evidence

Most studies have examined income within the context of the impact of a broader range of variables. Hence we can have some confidence that the income differences are not picking up other factors correlated with income. That said, income tends to have a much bigger impact than attributes correlated with income whilst most of the findings rely on segmentations of the cost coefficient when the marginal utility of time might also vary across income groups.

The cross-sectional evidence clearly points to a positive income elasticity. However, there is some evidence to suggest that the magnitude of this elasticity is a function of the form of income used to explain the value of time.

3. INTRA-STUDY EVIDENCE ON THE VALUE OF TIME AND INCOME

We have seen that the cross-sectional evidence from the national value of time studies overwhelmingly points to a positive income elasticity which is generally somewhat less than one. We here make an attempt to quantify the cross-sectional income elasticity for the value of IVT based solely on British empirical evidence.

Data was collected from studies which reported segmentations of the value of IVT by income group. The 20 studies covered are listed in Appendix 1 and yielded 157 values of time by income group. The data collected about each study related to:

- Study, year and quarter, and retail price index
- Money value of IVT by income category
- An estimate of mean income for each income category
- Journey purpose
- Mode used
- Distance
- Whether the model had segmented just the cost coefficient by income or whether both the cost and time coefficient were segmented

In all but one study[1], the income category was gross household income, and in almost all cases the values were taken from models where the sole segmentation was according to income group.

Where both the upper and lower bound of the income category were known, the mean value was taken as representative of the group's income level. Where the upper or lower bound was not known, a reasonable assumption was made. However, we have tested whether the results are sensitive to the need to make such assumptions.

Ignoring other factors, we specify the relationship between the value of time (V) and income (Y) expressed in real terms to be of a multiplicative form:

$$V = \mu Y^{\lambda} \tag{1}$$

The parameter λ therefore denotes the income elasticity. Instead of attempting to explain variations in the value of time across studies, the analysis is here restricted to explaining intra-study variations in the value of time according to income. This can be done by specifying the model as a ratio of the values for two income groups:

$$\frac{V_2}{V_1} = \frac{\mu Y_2^{\lambda}}{\mu Y_1^{\lambda}} = \left(\frac{Y_2}{Y_1}\right)^{\lambda} \tag{2}$$

[1] The exception is the personal income categorisation used in the North Kent commuter study (Fowkes, 1986). As we have seen, the variations in the value of time with income in this study based on RP data are particularly impressive.

There is no need to include other explanatory variables as main effects since we are dealing with intra-study variations in the value of time with income and holding differences in key variables, such as purpose, mode and distance, to be constant. It seems reasonable to assume that any other influences on the value of time essentially have a random effect across income groups and are contained in the error term.

If a study provides n values of time by income group, we can specify n-1 independent ratios. There are various ways in which these ratios could be specified. One might be to select the values that enter the ratio so as to maximise the precision with which the coefficients are estimated. However, because of the need to make assumptions about the mean income level in the lowest and highest income categories, we selected the base to minimise the use of values related to income groups where the average income has to be assumed. We did this by using the second lowest income category as the base. Hence if a study reports four values of time segmented by income, we specify three ratios of values of time for the lowest, second highest and highest income group relative to the base of the second lowest income group.

Logarithmic transformation of equation 2 allows λ to be estimated by ordinary least squares regression. Other terms can be added to explore whether the income elasticity varies according to variables such as mode and journey purpose.

Table 3.1 reports models estimated to the 137 ratios of values of time in our data set. One model contains incremental effects upon the income elasticity for bus users (Income-Bus) and for income segmentations based on individual rather than household income (Income-Ind) and the other model contains only the income elasticity. In both cases, the intercept was not significant.

Table 3.1: Value of Time and Income Regression Models

Income	0.618 (17.2)	0.578 (16.7)
Income-Bus	-0.316 (3.8)	
Income-Ind	0.587 (3.0)	
R^2	0.64	0.59

Note: The reported R^2 is for the model containing an intercept term

The goodness of fit achieved is respectable and the income elasticities in both models are estimated very precisely, with 95% confidence intervals expressed as proportions of the central estimate of ±12% in each case. The incremental effect for bus users indicates that they have somewhat lower income elasticities whilst, as expected on the basis of results discussed in section 2, the income elasticity is much higher when the segmentation is based on individual income.

As expected, the household income elasticity is found to be somewhat less than one. A figure of 0.6 can be taken to be representative of British cross-sectional evidence. However, a figure around unity could be supported on the basis of individual income, although this is based on the evidence from a single British study.

A number of other incremental effects were examined but none were found to be statistically significant. These tested whether the income elasticity varied by journey purpose, between urban and inter-urban trips and according to whether the segmentation was based around the cost coefficient alone or both the time and cost coefficients.

We also examined the sensitivity of the results to the need to make assumptions about mean income in the lowest and the highest income categories. Observations containing a value of time either in the numerator or denominator of equation 2 where an assumption about mean income was necessary were removed. This left 59 observations. The income elasticity for these observations was estimated at 0.658, with a 95% confidence interval of ±14%. The estimated income effect therefore seems robust to the assumptions made in specifying representative income levels for some income categories.

4. THE 1985 AND 1994 TYNE CROSSING DATA SETS

As far as we are aware, only two studies have conducted comparisons of the values of time obtained from essentially the same SP design and the same type of travellers at two different points in time. One of these was undertaken as part of the Dutch national studies, and is reported in Gunn et al. (1998). The other was conducted in the British context. This involved the replication in 1994 as part of the second British value of time study of the Tyne Crossing study undertaken in 1985 in the first British study.

The Tyne Crossing study was based on motorists' choices between the Tyne Tunnel and Tyne Bridge. The two routes were characterised in terms of total time, split into free flow time and time spent in congested traffic (termed delay time), petrol cost and, in the case of the Tunnel, toll charge. The SP exercise was based around a trip that had actually been made.

Essentially the same SP design was used in 1994 as had been used in 1985, except that there was adjustment of the petrol and toll charges to account for inflation and increases in the levels of delay time to reflect the increases in congestion over the years.

Whilst Hague Consulting Group and Accent (1999) reports the models and values of time estimated to the two data sets separately, no joint estimation was conducted. Hence no allowance for possible differences in the socio-economic features of the two samples was possible. We here report combined analysis of the 1985 and 1994 data sets.

4.1 Overall Models

In order to examine the inter-temporal variation in the value of time, we have estimated models to the 1985 and 1994 pooled data sets. However, we first report models estimated separately to each data set, in order to replicate the previously reported results and to provide a first comparison of the values obtained from each data set.

All models are estimated in 1994 quarter 4 prices, the units of the second study. This means that the costs in the 1985 design have been inflated in line with changes in the retail price index between the two periods

Table 4.1 reports models estimated to commuting journeys. In addition to containing the time and cost variables, we also specify an alternative specific constant (ASC) with respect to the

bridge route and a variable denoting the route chosen for the actual journey made. The latter discerns habit and inertia effects but despite being highly statistically significant it has little impact on the values of time obtained.

Far more data was collected in the 1985 study, resulting in much more precise estimates. However, the original study obtains coefficients which are more precise per unit of data, indicating that there is less error in responses. This is also indicated by the much higher ρ^2 goodness of fit measure in the 1985 model. There is also clearly a difference in the scale of the two models and, since logit coefficients are inversely related to the standard deviation of the errors, this is consistent with a greater amount of error in the 1994 data.

Given that the two models appear to have different scales, it is essential that we allow for this in estimation to the combined data sets. This is done by specifying a hierarchical logit model where the artificial nesting of the 1994 choice data at a level below the 1985 choice data allows the estimation of a scale factor (θ) which 'corrects' for any difference in the scale of the two models.

Comparing the 1985 and 1994 values of time estimated separately to the two data sets, we can see that the values of delay and free time are slightly lower in 1994 despite the income growth between the two years. When we combine the two data sets and estimate a single model, but without allowing for scale effects or time trends, the results relate to the separate models in the expected manner.

Table 4.1: Commuting Models

	85	94	Both	Both and Trend	Both, Trend and Scale
Observations	14637	3414	18051	18051	18051
% Bridge	57%	52%	56%	56%	56%
% Tunnel	43%	48%	44%	44%	44%
ρ^2	0.214	0.131	0.193	0.196	0.198
Coefficients					
ASC-Bridge85	-0.1670 (2.7)	n/a	-0.2039 (4.1)	-0.1226 (2.4)	-0.1507 (1.7)
ASC-Bridge94	n/a	-0.0600 (0.5)			-0.1611 (2.9)
Delay Time	-0.3070 (35.6)	-0.1877 (13.8)	-0.2809 (38.5)	-0.2865 (37.4)	-0.3055 (36.1)
Free Time	-0.2091 (39.4)	-0.1102 (12.6)	-0.1869 (41.5)	-0.1968 (41.7)	-0.2082 (39.8)
Petrol Cost	-0.0422 (30.8)	-0.0296 (15.0)	-0.0386 (34.4)	-0.0389 (34.6)	-0.0420 (32.6)
Toll Charge	-0.0472 (30.7)	-0.0328 (14.7)	-0.0451 (36.5)	-0.0434 (34.6)	-0.0469 (32.4)
Actual Route	0.8769 (43.3)	0.6773 (13.6)	0.8261 (45.9)	0.8439 (46.3)	0.8809 (44.4)
94*Delay	n/a	n/a	n/a	0.0362 (3.8)	0.0378 (3.2)
94*Free	n/a	n/a	n/a	0.0502 (8.2)	0.0511 (6.0)
Scale (θ)	n/a	n/a	n/a	n/a	0.7225 (19.5)
Values					
Delay Time	6.50	5.72	6.22	6.60:5.77	6.51:5.71
Free Time	4.43	3.36	4.14	4.53:3.38	4.43:3.35
Petrol Cost	0.89	0.90	0.86	0.90	0.90

Note: Values are expressed in units of toll cost.

Specifying time trends in the combined model for delay time (94*Delay) and free time (94*Free) indicates what we would expect. There has been a reduction in the value of time over time but the change is not large. The specification of the time trend effects allows the values of time in the separate models to be closely recovered by this joint model.

Finally, we allow for the different scale of the two data sets within a hierarchical logit structure. Given that the 1994 data is placed in the lower nest, we would expect the scale factor (θ) to be less than one, since the coefficients in the 1994 data set seem lower than in the 1985 data. This indeed turned out to be the case. Since this model estimates all the coefficients in units of the 1985 data set, and has rescaled the 1994 data to be consistent with it, the coefficients estimated in this model are very similar to those obtained to the separate 1985 commuting model.

We had expected that the difference in scale might have contributed to the time trends estimated to the joint model where no allowance was made for the different scale of coefficients in the two data sets. However, the introduction of the scale factor made little difference to the time trend coefficients. This joint model can almost exactly replicate the results of the separate models.

The same process was adopted for the leisure models. The corresponding leisure models are reported in Table 4.2. A similar pattern of results is evident here, and we shall not repeat the discussion. However, it should be noted that the reduction in the value of time between the two time periods, and hence the time trend effects estimated to the delay and free time coefficients, are much larger than in the commuting model.

Table 4.2: Leisure Models

	85	94	Both	Both and Trend	Both, Trend and Scale
Observations	7724	1778	9502	9502	9502
% Bridge	52%	59%	53%	53%	53%
% Tunnel	48%	41%	47%	47%	47%
ρ^2	0.222	0.112	0.188	0.198	0.202
Coefficients					
ASC-Bridge85	-0.1687 (2.0)	n/a	-0.3127 (4.5)	-0.1594 (2.2)	-0.1922 (2.5)
ASC-Bridge94	n/a	-0.1780 (1.2)			-0.1069 (0.8)
Delay Time	-0.3227 (27.4)	-0.1608 (9.0)	-0.2827 (28.9)	-0.3030 (28.8)	-0.3262 (28.2)
Free Time	-0.2110 (29.4)	-0.0788 (6.7)	-0.1808 (30.0)	-0.1984 (31.2)	-0.2130 (30.2)
Petrol Cost	-0.0327 (18.0)	-0.0226 (8.4)	-0.0290 (19.5)	-0.0301 (20.0)	-0.0330 (19.3)
Toll Charge	-0.0387 (19.5)	-0.0287 (9.3)	-0.0389 (24.7)	-0.0360 (21.8)	-0.0396 (21.1)
Actual Route	0.9740 (34.3)	0.5642 (10.6)	0.8706 (35.5)	0.8882 (35.7)	0.9671 (34.3)
94*Delay	n/a	n/a	n/a	0.0968 (7.4)	0.0996 (5.5)
94*Free	n/a	n/a	n/a	0.0926 (10.8)	0.1058 (7.9)
Scale (θ)	n/a	n/a	n/a	n/a	0.6346 (13.6)
Values					
Delay Time	8.34	5.60	7.27	8.42:5.72	8.23:5.72
Free Time	5.45	2.74	4.65	5.51:2.94	5.38:2.70
Petrol Cost	0.85	0.79	0.75	0.84	0.83

Note: Values are expressed in units of toll cost.

4.2 Segmented Models

If the 1985 and 1994 samples were identical in terms of socio-economic characteristics, including the absence of any real income growth, then the models reported in section 4.1 would be all that would be required to establish whether and to what extent there had been an exogenous change in the value of time between the two time periods.

However, the two samples are not identical and there was clearly significant income growth between 1985 and 1994. We have therefore enhanced the joint hierarchical model to include socio-economic effects.

We have adopted the standard procedure of segmenting the time coefficients according to socio-economic and trip factors that are expected to influence the marginal utility of time and of segmenting the cost coefficients by factors that are expected to impact upon the marginal utility of money. Note that we have constrained the incremental effects on the time and cost coefficients to be the same in the 1985 and the 1994 data sets and that we retain only those which, in at least one of the four models reported, achieved significance at the usual 5% level.

Income is a potentially key source of variation in the value of time over time. However, after allowing for inflation the income categories are not consistent between the two data sets. We have therefore taken the mid-point of each income category as the representative income level, with reasonable assumptions about income level for the lowest and highest categories. We can then adjust the representative income level for 1985 to account for inflation and hence allow comparability with the 1994 income levels.

Segmented commuting models are reported in Table 4.3, differing according to the elasticity applied to allow for income growth (η_I). The two 'extremes' are unity and zero elasticities. The other two elasticities used are 0.5, which we take to be a good representation of the large amount of cross-sectional empirical evidence and an income elasticity freely estimated to the data. The models enter cost and time in the form:

$$U = \alpha \frac{C}{Y^{\lambda}} + \beta T$$

whereupon the value of time income elasticity is:

$$\frac{\partial VoT}{\partial Y} \frac{Y}{VoT} = \lambda$$

Table 4.3: Segmented Commuting Models

	$\eta_I = 1$	$\eta_I = 0.5$	$\eta_I = 0.2$	$\eta_I = 0$
Coefficients				
ASC-Bridge85	0.6068 (10.0)	0.1787 (3.7)	-0.1000 (1.8)	-0.1430 (2.5)
ASC-Bridge94	0.4878 (13.3)	0.3060 (4.2)	-0.0506 (0.6)	-0.1497 (1.7)
Delay Time	-0.2793 (22.8)	-0.3290 (25.3)	-0.3508 (26.2)	-0.3469 (25.9)
Free Time	-0.1681 (27.8)	-0.1969 (30.7)	-0.2090 (31.6)	-0.2060 (31.2)
Petrol Cost	-0.7502 (33.8)	-0.2082 (34.2)	-0.0864 (33.2)	-0.0472 (32.6)
Toll Charge	-0.5416 (30.9)	-0.1853 (33.1)	-0.0909 (33.7)	-0.0511 (33.1)
Actual Route	0.8521(42.6)	0.8731 (43.1)	0.8797 (43.2)	0.8769 (43.2)
94*Delay	0.1011 (9.2)	0.0778 (6.9)	0.0532 (4.6)	0.0343 (2.8)
94*Free	0.0894 (11.4)	0.0733 (9.1)	0.0579 (7.0)	0.0467 (5.5)
Scale (θ)	0.7969 (18.4)	0.7732 (19.6)	0.7510 (20.0)	0.7218 (19.8)
Incremental Effects				
Delay-Male	0.0435 (4.2)	0.0451 (4.2)	0.0469 (4.3)	0.0482 (4.4)
Delay-Age35+	0.0485 (5.2)	0.0418 (4.4)	0.0319 (3.3)	0.0227 (2.3)
Free-Age35+	0.0269 (4.8)	0.0234 (4.1)	0.0173 (3.0)	0.0111 (2.0)
Delay-Kids	-0.0319 (3.4)	-0.0331 (3.4)	-0.0326 (3.3)	-0.0316 (3.2)
Free-Kids	-0.0235 (4.2)	-0.0243 (4.2)	-0.0239 (4.1)	-0.0231 (3.9)
D&F-Occs	-0.0176 (2.5)	-0.0175 (2.4)	-0.0165 (2.3)	-0.0152 (2.1)
Petrol-Comp	0.3067 (8.7)	0.0850 (9.2)	0.0364 (9.3)	0.0201 (9.3)
Toll-Comp	0.2787 (13.1)	0.0742 (13.6)	0.0314 (13.7)	0.0173 (13.7)
ρ^2	0.183	0.202	0.208	0.205
Observations	17533			

The models with the pre-defined income elasticities simply deflate the cost variable by the income level raised to the relevant income elasticity. Where the income elasticity is freely estimated, we estimate a series of models for different values of λ and select that with the best fit. In the case of the commuting model, and constraining the income elasticity to be the same in the two data sets, the best fit was achieved for an income elasticity of 0.2.

We experimented with the use of household income and household income per person. The best fit was obtained when we used the former and this is contained in the reported models. It may be that the low income elasticity is the result of the approximations that have had to be used in order to calculate representative income levels that are comparable across time periods.

Only a few significant incremental effects were discerned. Males were found to be more tolerant of travel time spent in congested conditions, as were those in older age groups. Those with children in the household had higher values of time, presumably the result of greater constraints on available time. The values of both delay and free time were found to be higher when there were other occupants in the vehicle (D&F-Occs), which may be the result of the respondent bearing in mind the time saving benefits to other travellers. As expected, the sensitivity to petrol and toll charge is lower when the company pays for them.

As would be expected, the lower the income elasticity in the model, the smaller is the negative time trend on the value of time. In addition, the time trend is now much lower when the socio-economic effects are included, indicating that differences in the composition of the samples was influencing the overall values of time derived for each year.

Segmented leisure models are reported in Table 4.4, with income elasticities of 1, 0.5 and 0 as for commuting, but here the best fitting income elasticity was found to be slightly higher at 0.3.

Table 4.4: Segmented Leisure Models

	$\eta_I = 1$	$\eta_I = 0.5$	$\eta_I = 0.3$	$\eta_I = 0$
Coefficients				
ASC-Bridge85	0.4243 (8.7)	0.1882 (2.9)	-0.0148 (0.2)	-0.2027 (2.5)
ASC-Bridge94	0.6223 (5.9)	0.3712 (3.2)	0.1240 (1.0)	-0.1350 (1.0)
Delay Time	-0.2715 (19.8)	-0.3265 (22.2)	-0.3517 (23.1)	-0.3707 (23.7)
Free Time	-0.1658 (15.6)	-0.1975 (17.8)	-0.2124 (18.7)	-0.2247 (19.3)
Petrol Cost	-0.4097 (19.7)	-0.1417 (21.1)	-0.0845 (20.7)	-0.0362 (19.9)
Toll Charge	-0.2820 (18.4)	-0.1230 (20.6)	-0.0859 (21.6)	-0.0423 (21.5)
Actual Route	0.9600 (33.0)	0.9889 (33.4)	0.9995 (33.6)	1.0070 (33.7)
94*Delay	0.1658 (8.8)	0.1605 (8.5)	0.1538 (8.1)	0.1381 (7.1)
94*Free	0.1635 (11.1)	0.1582 (10.8)	0.1532 (10.5)	0.1437 (9.6)
Scale (θ)	0.6600 (13.1)	0.6600 (13.8)	0.6595 (14.1)	0.6423 (14.1)
Incremental Effects				
D&F-Fix	-0.0309 (3.7)	-0.0333 (3.9)	-0.0348 (4.0)	-0.0373 (4.3)
Free-Male	-0.1680 (2.0)	-0.0172 (2.1)	-0.0170 (2.0)	-0.0162 (1.9)
Delay-Age55-59	0.0521 (2.1)	0.0502 (2.0)	0.0508 (2.0)	0.0547 (2.1)
Free-Age55-59	0.0392 (2.7)	0.0382 (2.5)	0.0379 (2.5)	0.0384 (2.5)
Delay-Age60+	0.1155 (5.1)	0.1247 (5.4)	0.1319 (5.7)	0.1466 (6.3)
Free-Age60+	0.0643 (4.0)	0.0672 (4.1)	0.0694 (4.2)	0.0745 (4.5)
Delay-Kids	0.0454 (3.0)	0.0428 (2.8)	0.0422 (2.8)	0.0427 (2.8)
Free-Kids	0.0384 (4.4)	0.0376 (4.2)	0.0376 (4.2)	0.0388 (4.3)
D&F-VFR	-0.0132 (1.6)	-0.0151 (1.8)	-0.0151 (1.8)	-0.0133 (1.7)
D&F-Retired	0.0117 (0.7)	0.0164 (1.0)	0.0231 (1.5)	0.0409 (2.4)
D&F-LTM	-0.0141 (1.5)	-0.0166 (1.7)	-0.0185 (1.9)	-0.0228 (2.4)
D&F-1st	-0.1306 (5.3)	-0.1376 (5.5)	-0.1395 (5.6)	-0.1422 (5.6)
Petrol-Comp	0.2696 (3.3)	0.1030 (4.7)	0.0655 (5.2)	0.0306 (5.9)
Toll-Comp	0.1656 (3.5)	0.0569 (4.5)	0.0358 (5.0)	0.0176 (6.0)
ρ^2	0.201	0.218	0.232	0.226
Observations	9187			

A larger number of incremental effects have been obtained, although not all are consistent with the findings for commuters. Those with fixed arrival times had higher values of delay and free time (D&F-Fix), as might be expected, but now males were more averse to free flow time than females.

Older travellers have lower values of time, as did those with children in the household. Presumably the latter is now operating more in terms of income constraint than time constraint. Not surprisingly, the retired have lower values, in line with their greater amount of available time, and those who travelled less than monthly (D&F-LTM) or who were making the journey for the first time (D&F-1st) also had higher values. The frequency effect may in part be discerning an income effect, but the magnitude of the difference for those who were travelling for the first time seems to suggest there is a different effect to do with unfamiliarity at work here. Where the costs are paid by the company, the sensitivity to cost is less than it would otherwise be and hence the values of time are higher.

As could well be expected from comparison of the overall leisure models for 1985 and 1994, the time trends are very large, forming unreasonably large proportions of the base coefficients for delay and free time. The evidence relating to the time trend for leisure travel is not credible, and we can offer no reasons as to the cause of such a large discrepancy between the values obtained by the two studies. Differences in trips length between the two samples and non-linear utility functions were tested as possible explanations but no significant effects were detected.

Although the intention of such repeat studies is to closely control the conditions of comparisons so that extraneous influences are minimised, and the 1994 study clearly attempted to replicate the 1985 study as closely as possible, there are a number of differences between the two surveys

- The 1985 study used an initial self completion questionnaire distributed at road-side in order to identify those who would be in scope. This allowed close control between the individual's current journey and the SP exercise offered, since those making journeys to which the SP exercises would not closely relate were not screened in. The procedure adopted in the 1994 study was to specify that the SP exercise related to a portion of the journey beyond a screenline.

- It was not possible in the 1994 study to recruit car drivers as they approached the Tyne Bridge as was done in the 1985 study. The layout of the road junction at the Bridge approach helped to ensure that drivers were travelling from destinations where there would be a realistic choice between the two routes. It also avoids other problems arising in the screening-in of an appropriate target sample.

- The most significant difference is that the 1985 study set out each of the 16 pairwise comparisons on a separate card. The 1994 study set the 16 comparisons out within a questionnaire. The former approach requires more resources, which were available to the first study, but we regard it to be a preferable means of presenting SP exercises to respondents. This may have contributed to the greater amount of noise in the 1994 data. The meta-analysis reported in an accompanying paper denoted that the value of IVT is 15% lower when obtained using the pen and paper method.

Allowing for the impact on the value of time of the difference in the means of presentation would reduce the estimated time trends, although some of the effect might operate to increase the income elasticity. For commuting, the resulting trend would be plausible, although we do have reservations about the estimated income elasticity and this is intimately bound up in the

value of the time trend obtained. However, the difference between the leisure values of time would still remain far too large even after correction for the means of presentation.

Our feeling is that there is evidence of an exogenous fall in the value of time, and the results for commuting are at least believable. The results for leisure travel cannot be believed. A major factor in the latter is that the values of time obtained in the 1985 leisure model seem to high, a symptom of which is that they were actually higher than for commuters. Our meta-analysis has shown that commuters have a value of time which is 10% larger than for leisure travellers.

5. INTER-STUDY EVIDENCE ON THE VALUE OF TIME AND INCOME

We have reported in section 3 analysis of intra-study variations in the value of time with income for a large number of British studies. We now turn our attention to the analysis of variations in the value of time apparent across many empirical studies, where inter-temporal variations are but one influence among many. The contribution that analysis of this form could make has long been recognised but, as far as we are aware, has not previously been conducted on the scale of the analysis reported here.

> *Surveys and analyses of the values of travel times have typically been based on individual cross-sectional analysis and not repeated over time. Nonetheless, the conclusions derived from such analyses are generally assumed to apply to the future as well as the past. The attention that has been given to the problem of improving cross-sectional estimates has not been accompanied by concommitant attention to analyses of changes in the value of travel time savings over time. As repeated cross-sections of behaviour become available from transport studies, some attention could perhaps be given to investigating and explaining shifts in the implied values of time and their relationship to changes in income.* McKnight (1982, p21)

The accompanying paper set out the methodology that we have used to explain values of time across studies. Our previous meta-analysis (Wardman, 2001) reported an elasticity to GDP of 0.51 but the 95% confidence interval of ±118% does not allow us to place a great deal of confidence in it. This was attributed to the clustering of the values around the years 1988 and 1994 during which time a recession limited the amount of variation in income levels.

We have extended the data set previously used to cover studies prior to 1980 and studies since 1997. The aim of this is not only to obtain more precise estimates as a result of a larger data set but also to obtain more precise coefficient estimates to the income variable as a result of greater variation.

Not only have we increased the IVT data set from 539 to 719 values and the data set of IVT, walk, wait and headway values from 889 to 1167 observations, but the variance in GDP has increased more than fourfold.

We have used two measures of income. One is the widely used gross domestic product per capita (GDP) and the other is household disposable income (HDI). The latter is defined as total household income before tax less payments of income tax and other taxes, social contributions and other current transfers. We can also specify a simply time trend to detect how the value of time varies over time. However, the very high correlations between the time

trend and income measures means that it is not possible to use this method to reliably distinguish between the effects of income on the marginal utility of money and other inter-temporal effects on the marginal utility of time[2].

An accompanying paper dealing with public transport valuations provides more details of the modelling of the value of time data set. We here restrict the discussion to the aspects of the model relevant to inter-temporal variations in the value of time.

We have estimated models to both the data set relating to walk time, wait time, headway and in-vehicle time (ALL) and also to that relating solely to IVT. Models were estimated to the former data set because it is larger, and hence should provide more precise coefficient estimates, and because another aspect of the study was interested in public transport valuations other than in-vehicle time. However, models were also developed solely on IVT values since these values tend to be more precisely estimated and their variation over time has usually been the main focus of attention.

Table 5.1 reports the key parameters estimates for various models estimated to the ALL and IVT data sets. The GDP elasticity is slightly higher for the model based solely on IVT and it is also more precisely estimated despite the fewer observations. The latter presumably stems from the greater precision with which values of IVT tend to be estimated. However, the GDP elasticity in the ALL model was allowed to vary between the different attributes but no significant effects were obtained.

Table 5.1: Meta-Analysis Models

	ALL	IVT	ALL	IVT	ALL	IVT	ALL	IVT
GDP	0.723 (4.6)	0.823 (5.0)	n/a	n/a	n/a	n/a	0.715 (4.6)	0.811 (4.9)
HDI	n/a	n/a	0.475 (4.1)	0.524 (4.3)	n/a	n/a	n/a	n/a
TREND	n/a	n/a	n/a	n/a	0.0036 (4.5)	0.0041 (5.0)	n/a	n/a
EB	0.498 (5.6)	0.559 (6.8)	0.494 (5.6)	0.552 (6.6)	0.496 (5.6)	0.557 (6.7)	n/a	n/a
EBFore	0.470 (4.3)	0.411 (3.9)	0.476 (4.4)	0.420 (3.9)	0.471 (4.3)	0.412 (3.9)	n/a	n/a
GDP-EB	n/a	n/a	n/a	n/a	n/a	n/a	0.063 (5.6)	0.070 (6.7)
GDP-EBFore	n/a	n/a	n/a	n/a	n/a	n/a	0.058 (4.3)	0.052 (3.8)
R^2	0.620	0.669	0.618	0.666	0.619	0.669	0.620	0.669

Comparing the specifications based on GDP and HDI, we find the former to provide a better fit, although the difference is only slight. What is more noticeable is that the HDI elasticities are much lower than the GDP elasticities. In part this may be because household income is

[2] Enhancement of the data set to include values of time for separate income groups from as many studies as possible might support analysis which tried to disentangle the two effects.

not the most appropriate measure of individuals' willingness to pay for time savings. Moreover, HDI is survey based and can be expected to be a less reliable indicator than the GDP measure. However, it does take into account variations in tax rates.

Very similar fits to the data are achieved when the GDP elasticity is replaced with a time trend. The latter indicates that the value of time is growing at 0.36% and 0.41% per year in the ALL and IVT data sets respectively. These figures are low in the context of GDP growth of 2% per annum but they will have been influenced by the recession years.

We examined whether the GDP elasticity varied by mode or by journey purpose by the specification of incremental effects. No mode effects were apparent and the effect for commuters was also insignificant.

When we allowed the GDP elasticity to be different for business trips (GDP-EB) and business trips where the purpose of the study was forecasting (GDP-EBFore), there is some evidence that the elasticity is higher. However, the variables relating to the main effects of business trips (EB) and business trips where the purpose was forecasting (EBFore) become insignificant and are removed. The resulting model provides the same fit as that where the incremental business effects on the GDP are not included. Thus whilst the results indicate more support for an elasticity of unity for business trips, which is consistent with theory, the evidence is not particularly strong.

6. DISCUSSION

A number of disparate findings have emerged from the analysis reported here, and there is a need to attempt to reconcile them.

Whilst the income elasticity would seem to be less than unity, this is not the key issue since this was in any event a matter for empirical investigation. The main issues that need to be addressed are the extent to which there is evidence for a time trend on the value of time and the consistency between the evidence obtained from the meta-analysis with the cross-sectional income elasticities.

Due to correlation between GDP and the time trend, the GDP elasticity obtained from the meta-analysis of around 0.75 covers both an income and time trend effect. The nature of the model is that the time trend can be a pure exogenous effect or else it can stem from any other influences over time on the marginal utility of time. The cross-sectional evidence can, and sometimes does, isolate some influences on the marginal utility of time, such as changes in the amount of working time, but cannot isolate changes that occur over time in the opportunity cost of travel time, comfort and exogenous changes in preferences

Taken at face value, the cross-sectional household income elasticity evidence of around 0.6 is only consistent with the meta-analysis GDP elasticity if there has been a positive trend in the value of time. The evidence from the Netherlands, and limited British evidence, suggests that the time trend is negative. Thus the income elasticity obtained from the cross-sectional elasticity should exceed the GDP elasticity obtained from the meta-analysis. Clearly, this still applies if the marginal utility of time has not changed over time.

The results can be reconciled if the cross-sectional household income elasticities understate the elasticity of the value of time with respect to income growth over time. There a number of reasons why this might be so.

MVA et al. (1987, p122) state that, " …. Inasfar as there does exist a relationship between values of time and income, there is a possibility that the evidence from within-mode SP experiments will underestimate the slope of the relationship". Almost all the cross-sectional evidence has come from within-mode SP experiments, although noticeably the mode choice based evidence implies a larger elasticity (Fowkes, 1986).

The argument is based around inter-personal taste variation, self-selectivity and choice based sampling. Let us suppose that over the population as a whole, the value of time does increase with income. Amongst bus users, we would expect to find relatively low incomes. Those with higher incomes ought to have a value of time that is sufficient to make them choose car, and thus those high income travellers remaining with bus are those who have below average values of time for their income. The relationship between the value of time and income will then be dampened. Similarly, a car sample may well include some low income users who have high values of time and have as a result of this chosen to buy and use a car. There may be some high income travellers who have not selected rail because they have relatively low values of time. These will again dampen the estimated impact of income on the value of time.

Another possible explanation why cross-sectional income elasticities are too low lies in the widespread practice of using household income as the segmenting variable. Where individual income was tested against household income, a more pronounced relationship was apparent with the individual income data, higher elasticities were obtained and the authors expressed a preference for this (Algers et al., 1996; Ramjerdi et al., 1997). In addition, Fowkes' (1986) cross-sectional evidence based on individual income is not only impressive but implies income elasticities much higher than is typical. This was discerned in regression analysis of a large number of cross-sectional income segmented values of time.

With regard to the specification of income, there tends to be little allowance for economies of scale in two and more people living together and no allowance for the different levels of deductions to the widely used gross household income to arrive at disposable income. Where allowance is made for household size, it is usually in the form of an incremental effect where there are two or more members or where there are children rather than the identification of a disposable income level per person. In addition, some individuals may be uncertain as to household income and there may be other household dynamics that we are unaware of.

It may also be that some of those with higher incomes may have an inherently different attitude towards money, which is precisely why they have become richer. They might even be more sensitive to changes in money than those with less income. This would have a serious dampening effect on the relationship between the value of time and income at the cross-sectional level, but such a cross-sectional relationship would not apply to the same individual over time.

In conclusion, upon inspection of the quite large body of empirical evidence, it would be observed that variations in the cost coefficients with income group tend not to be the most spectacularly impressive of results. Bates (1994) states that, "In the author's experience, market segmentation has seldom led to significant differences in valuations. When fine distinctions are made, for example, along the income scale, inconsistencies normally appear

which result in a coarsening of the scale until an acceptable pattern is found. The process whereby this is achieved is not usually reported to the client!"

7. CONCLUSIONS

We have here provided a number of results from different sources relevant to how the value of time varies over time. This has been a theme of recurring interest to transport economists and planners over many years but where until recently relatively little evidence existed.

A number of issues need to be reconciled before we are in a position to make recommendations regarding inter-temporal variations in the value of time. These recommendations will be made in the final stage of this project. Feedback to and comment upon the results and views presented in this paper are welcomed as a contribution to the recommendation making process.

At this stage, it does not seem that there is sufficiently convincing evidence regarding time trends to specify these as a separate term over and above any income elasticity. The most reliable evidence relates to the Netherlands and is not necessarily transferable to the British context.

There are also doubts about the cross-sectional income elasticities obtained, and whether the income elastictity over time is as low as the cross-sectional evidence implies. In part this relates to whether the use of household income has distorted the results.

A relatively simple way forward involves adoption of the meta-analysis results, which are plausible and include the effect of changes over time in both the marginal utility of money and of time. However, different elasticities are implied according to whether income is defined as GDP or HDI.

Much will also depend on other recommendations to be made as part of this project. For instance, Working Paper 5 contains segmented models and, to the extent to which these are taken forward in recommendations, we need to ensure that we avoid double counting.

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