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Published paper

Mark Wardman (1997) *A Review of Evidence on the Value of Travel Time in Great Britain.* Institute of Transport Studies, University of Leeds, Working Paper 495

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A REVIEW OF EVIDENCE ON THE VALUE OF TRAVEL TIME IN GREAT BRITAIN

Mark Wardman

Abstract

The purpose of this research was to review the large number of empirical studies which have been conducted in Britain since 1980 which provide value of time estimates. The wealth of evidence that exists is useful in interpreting the results of current studies and in evaluating current practice, both in estimation and application, whilst it can be expected to identify areas for further research.

We have reviewed 105 studies based on disaggregate methods and either Revealed or Stated Preference data. These studies have yielded 444 value of time estimates, disaggregated by at most purpose and mode, which represent a wide range of circumstances.

The main aspect of the research has been the development of a regression model to explain variations in the value of time across studies as a function of relevant variables. The latter include GDP, distance, journey purpose, type of data and choice context, method of SP presentation and mode used and valued. This model allows value of time estimates to be obtained for situations which can be covered by the variables it contains. The study has also conducted a detailed review based on within-study variation in the value of time.

A number of interesting findings have emerged, including the consistency between current Department of Transport recommendations and previous evidence and similarity between the reviewed studies and the results of the Department of Transport's recently completed value of time study. The value of time is found to vary according to mode, purpose and distance whilst there is encouraging evidence with regard to the correspondence of values of time derived from Revealed and Stated Preference models.

A number of recommendations are made on the basis of this review. These include the extension of this type of review to cover types of travel time other than in-vehicle time, and further research relating to the impact of group travel, the numeraire and the size and sign of travel time variations on the estimated value of time.

Acknowledgement

I would like to express my thanks for the assistance and co-operation provided by the following organisations:

- Accent Marketing and Research
- Babtie Traffic and Transportation
- CENTRO
- Department of Transport
- Halcrow Fox
- MVA Consultancy
- Oscar Faber
- Peter Davidson Consultancy
- Rail Operational Research
- Steer Davies Gleave
- TecnEcon
- Travers Morgan
- Tyne and Wear PTE
- WS Atkins

I am also grateful for the assitance and advice provided by Professor Peter Mackie of the Institute for Transport Studies and John Knowles of the Department of Transport.

This research was sponsored by the HETA Division of the Department of Transport. All opinions expressed are those of the author alone.

CONTENTS

1.INTRODUCTION AND OBJECTIVES

The value of travel time is an important aspect of applied transport research and a very large number of studies have been conducted in Great Britain which provide estimates of the value of travel time. This significant body of evidence can shed light on a number of issues relating to the value of travel time and its estimation and can be used to assess recent evidence and current recommendations and to direct future research.

The objective of this study is to conduct a comprehensive review of the available British evidence on the value of time that has been amassed since 1980. It is solely concerned with the value of in-vehicle time, although the reviewed studies provide a wealth of evidence on estimated valuations of other forms of time such as walking time, waiting time, idle time, search time, delay time and travel time variability. It also restricts itself to value of time estimates obtained from disaggregate behavioural models. However, we have not restricted the analysis to those studies whose primary purpose was value of time estimation.

Value of time estimates are included which have been obtained from Revealed Preference (RP) and Stated Preference (SP) data. We have not included findings based on Transfer Price (TP) data in part because this method is not as widely accepted and also because at the outset of the study we felt that there would not be sufficient values obtained using the TP method to support detailed analysis of them. With the benefit of hindsight, however, these views might not be correct.

Some of the studies we have reviewed are published works, such as academic journal articles, conference papers, books or contributions to books, and documents that have been made available by the Department of Transport, local authorities, transport consultancies, and British Rail and its successor organisations. Other documents have been provided on a confidential basis which allows their results to be reviewed as part of a larger number of studies but requires that specific results cannot be attributed to that study.

2.BACKGROUND

When the Department of Transport's first value of time study was being undertaken in the early 1980's, there was relatively little evidence regarding the value of time in Great Britain. The evidence cited by that study (MVA et al., 1987) included Atkins (1984), Daly and Zachary (1977), Davies and Rogers (1973), Lee and Dalvi (1971), Ortuzar (1980) and Quarmby (1967).

The Department of Transport commissioned a second major value of time study in 1993 which has recently been completed (HCG and Accent, 1996). The focus of that study was mainly empirical, with little elaboration of theoretical issues and, more significantly, no detailed literature review. As far as passenger travel was concerned, the study related solely to car travel. Given the amount of evidence amassed since the first value of time study, the absence of a comprehensive literature review from the remit of the second value of time study acted as the stimulus for the Department of Transport to commission this review.

3.OUTLINE OF RESEARCH

There are two aspects to the research, namely a general review of value of time estimates and a more detailed analysis of specific issues.

3.1General Review

The general review of value of time research will tend to be based on a comparison of results across studies. It will have two main components:

i)General overview of value of time research, highlighting the main trends and advances in value of time estimation;

ii)A quantitative exercise examining the relationship between reported value of time estimates and relevant explanatory variables.

3.2Detailed Review

A problem with comparing values of time across different studies is of isolating extraneous influences. With regard to variation in the value of time due to the size and sign of time variation, HCG and Accent (1996; p11) state that, "our findings indicate that comparing averages between different VOT experiments can be misleading". The problem of confounding effects is reduced, although not necessarily overcome, by comparing values of time from within the same study or even from within the same model; the detailed review concentrates on such comparisons. We have selected a number of important issues to be examined, some of which have been neglected areas of value of time research. The specific issues which we examine are:

i)Numeraire Used

The implied money value of time may depend on whether it is expressed in toll, parking, fare or petrol units.

ii)Functional Form

The estimated value of time may vary with the amount of time, the amount of variation in time and whether time is saved or lost.

iii)RP v SP

Some studies provide value of time estimates obtained from both RP and SP methods and the extent to which these correspond is an important issue.

iv)Value of Time, Mode and Journey Purpose

The value of time can be expected to vary between modes and across journey purposes but, as most transport researchers will be aware from even limited experience of empirical results, the evidence can often be conflicting. Thus a large sample of studies which provide value of time estimates split by mode or by purpose is particularly useful in this respect.

v)Individual versus Group Travel

Analysts have tended to be quite cavalier in the treatment of group travel effects. We will examine the evidence in this area and consider the implications of practices which have not adequately dealt with this issue.

4.DATA COLLECTION EXERCISE

4.1The Data Collected

We have reviewed 105 studies, where the data was collected between 1980 and mid 1996, which have yielded 444 value of time estimates across a wide range of circumstances. The list of studies we have reviewed is presented in Appendix 1.

We have included in our data set values of time which at most are disaggregated according to the key variables of journey purpose or mode. Distinguishing between every socio-economic factor and trip characteristic which has been successfully used to segment the value of time in the studies reviewed here was beyond the scope of this study, particularly given that segmentation, for example due to income, is not done on a consistent basis across studies. We collected information on all of the following variables for each of the value of time estimates included in the study:

i)Year and quarter of data collection and associated GDP and RPI;
ii)Sample size;
iii)Urban, suburban or inter-urban context;
iv)Distance;
v)Type of data;
vi)Journey purpose;
vii)Choice context;
viii)Mode used and mode valued;
ix)Unit of cost presented;
x)Location;
xi)Omission of non traders and use of logic checks;
xii)Purpose of the study;
xiii)Means of presenting the SP exercise;

Ideally, we would have also collected information on the standard error of the value of time estimate. However, we knew from the outset that few studies would provide this statistic and hence we use sample size as a proxy for the efficiency with which the value of time is estimated.

4.2Descriptive Statistics

We here present some descriptive statistics to outline the principal characteristics of our value of time data set. Of the 105 studies reviewed, 8% were specifically concerned with value of time estimation, and these provide 9% of the 444 value of time estimates. 59% of the studies, which contain 51% of the values, were primarily concerned with forecasting travel behaviour whilst the purpose of the remaining 33% of studies, from which 40% of the value of time estimates are obtained, was the valuation of a range of travel attributes but not specifically travel time.

75% of the studies were conducted by transport consultants, 23% were undertaken by academic establishments and 3% were conducted by local authority organisations. The vast majority of the studies are of comparatively recent origin, with 70% being undertaken in the 1990's and only 12% conducted prior to 1987.

Distance Distribution

The proportions of values of time classified as relating to urban, suburban and inter-urban travel are 17%, 40% and 35%, with the remaining 8% covering a range of contexts. The distance characteristics of trips in each of these categories is given in Table 1. It can be seen that the values of time cover a very wide range of distances and this provides a firm basis for the analysis of the effect of distance on the value of time.

Table 1: Trip Context and Distance (Miles)

	Mean	Min	25%	Median	75%	Max	Obs
Urban	4.3	1	3	5	6	8	76
Suburban	8.7	4	5	10	12	20	177
Inter Urban	102.8	20	40	95	150	400	154
All	43.1	1	5	10	50	400	444

Data Source and Choice Context

Of our 444 value of time estimates, only a small minority (6%) were obtained from RP models. The remaining values are obtained from three forms of SP data. The most common form of SP exercise is the choice exercise and values based on this data form 67% of the total. Values of time based on standard ranking exercises, involving between eight and twelve alternatives, form a further 16% of the sample whilst the remaining 11% of values are derived from a special case of ranking exercise which we have termed Rank4. The latter involves the ranking of a limited number of alternatives, typically four, with a series of these smaller ranking exercises being presented to individuals.

Table 2 shows how the different types of data were combined with different choice contexts. We distinguish between the three contexts of mode choice, route choice and abstract choice. In general, the latter involves choices between alternatives which are identical except for the differences in travel attributes. An example would be offering motorists different time and fuel trade-offs on an existing motorway. The principal attraction of abstract choice contexts for value of time estimation is that they isolate extraneous influences which could otherwise have a distorting effect. We are aware of destination choice models which have been developed in the United States and the Netherlands which could provide evidence on the value of time. However, we did not uncover such models in the course of this review of British evidence.

Table 2: Type of Data and Choice Context

	Mode Choice	Route Choice	Abstract
RP	4.5%	1.2%	0.0%
SP Choice	48.3%	4.6%	13.8%
SP Ranking	2.9%	0.5%	12.7%
SP Rank4	0.0%	0.5%	10.5%

In Britain, RP models have been most often developed in mode choice contexts, which is hardly surprising given the limited opportunities for observing time and cost trade-offs between routes. The attractions of SP choice exercises for the analysis of mode choice, along with the importance of mode choice analysis, is evident in the figures in Table 2. As would be expected, ranking exercises tend to be based on abstract choice contexts. However, to some extent the choice context used is determined by the purpose of the study. For example, if the objective of the study is to forecast route choice behaviour then a route choice context is the most appropriate. Table 3 examines how the combinations of data type and choice context interact with the purpose of the study across the 444 value of time observations.

Table 3: Type of Data, Choice Context and Purpose of Study

	Value of Time	Forecasting	General Valuation
RP	2.3%	3.4%	0.0%
SP Choice Mode Choice	1.1%	38.1%	9.0%
SP Choice Route Choice	2.5%	1.4%	0.7%
SP Choice Abstract Choice	2.5%	2.9%	8.3%
SP Ranking Mode Choice	0.0%	2.9%	0.0%
SP Ranking Abstract Choice	0.4%	0.9%	11.5%
SP Rank4 Abstract Choice	0.0%	0.0%	10.6%
Other	0.4%	0.9%	0.2%

As would be expected, abstract choice contexts are rarely used in studies whose main purpose is forecasting. On the other hand, abstract choice contexts in general and ranking exercises in particular form the majority of applications for general valuation studies. Abstract choices are less common in value of time studies, although a contributory factor here has been the desire to develop SP models which are comparable to RP models for validation purposes and this has resulted in the relatively large number of mode and route choice models in value of time studies. Forecasting studies have been dominated by SP choice models, notwithstanding the potential problems involved in using SP models for forecasting (Bates, 1988; Wardman, 1991).

Modal Characteristics

An important influence on the value of time is mode and we make a distinction between the mode used and the mode valued since the value of time may vary according to each. Mode can be a proxy for personal wealth and circumstances, for example, car users have on average higher incomes than bus users and as such their value of time can be expected to be higher. Offsetting this, however, is that the disutility of travel time spent in a car is generally regarded to be less than time spent on a bus, due to comfort and privacy characteristics amongst others, and hence the value of savings in bus time will be higher than savings in car time other things equal.

Table 4 presents the distribution of modes used and modes valued. Complicating factors here are that in 28% of cases the same value of time is estimated to more than one mode as a result of specifying generic coefficients whilst 18% of the values are estimated across users of different modes.

The large proportion of values of car time for car users is not solely a reflection of the significance of car as a mode of travel but also stems from its dominance in Britain of practical cost benefit studies where the value of time is a fundamental input. To a lesser extent, it also reflects a growing interest in tolled roads.

Another noticeably large proportion of value of time estimates relates to rail travel by rail users. This reflects the large amount of empirical research that has been undertaken in the railway industry in Britain, where there has been widespread use of SP methods to examine service quality factors.

The very small proportions of values for rail users of time on other modes illustrates that railway operators are primarily interested in rail travel. In contrast, concerns about the consequences of high and increasing levels of car traffic has prompted a large number of studies examining choices between car and other modes and hence the relatively large proportions of values relating to public transport modes for car users.

Table 4: Modes Used and Valued

Mode Used	Mode Valued	%	Mode Used	Mode Valued	%
Car	Car	20.9%	Rail	All	0.5%
Car	Bus	1.6%	UG	UG	5.2%
Car	Rail	2.3%	PT	Bus	0.6%
Car	LRT	2.0%	PT	Rail	0.6%
Car	All	14.2%	PT	PT	1.6%
Bus	Bus	2.5%	All	Car	4.3%
Bus	Rail	0.7%	All	Bus	1.0%
Bus	LRT	0.9%	All	Rail	2.3%
Bus	PT	5.2%	All	PT	2.3%
Rail	Car	0.2%	All	All	3.0%
Rail	Bus	0.2%	Rail	Rail&Air	1.1%
Rail	Rail	26.1%	Rail&Air	Rail	0.7%

Note: PT denotes bus, rail and LRT. All denotes PT and car.

Bus operators are much less inclined to conduct quantitative market research than rail operators, which results in the small proportion of bus users' valuations of bus travel. Indeed, many of such values stem from studies which have examined the potential for attracting bus users to new rail or LRT services. There is also a significant amount of evidence relating to users of London's underground (UG) but only a small proportion relating to air travellers.

Journey Purpose Characteristics

One of our key segmenting variables will be journey purpose. Matters are complicated a little here because studies do not categorise on a consistent basis; a notable difference being that some studies distinguish between peak and off-peak travel whilst others distinguish between commuting and leisure. Table 5 presents the split of journey purposes for urban/suburban journeys and inter-urban journeys separately.

Table 5: Journey Purpose

	Urban and Suburban	Inter Urban
Employer's Business	3.6%	16.7%
Commuting	17.0%	17.8%
Leisure	7.5%	23.5%
Peak	13.4%	1.0%
Off Peak	13.0%	2.1%
No Distinction	30.0%	17.3%
Shopping	5.5%	1.6%
Visiting Friend/Relatives	2.4%	2.1%
Personal Business	2.0%	1.6%
Social/Recreation	2.8%	1.6%
Non Commuting	1.6%	1.1%
Non Business	1.2%	1.6%
1st Business	0.0%	6.8%
Std Business	0.0%	5.2%

Employer's business forms only a small proportion of the values of time for urban/suburban journeys. A contributory factor here is that studies of LRT schemes and new local rail stations and services form a large number of urban/suburban studies and these tend to focus on commuting and leisure trips. On the other hand, business travel forms 29% of the inter-urban values of time. This is largely because of the dominance of values of time relating to rail, where business forms a large proportion of total traffic and particularly revenue, and where a useful distinction is often made between first class and standard class business travellers.

It is more common to distinguish between peak and off-peak travel for urban and suburban travel, presumably because the concept of the peak is less useful for long distance travel and because urban transport models typically have peak and off-peak networks and demand matrices. Given that peak travel is dominated by commuting trips and that the no distinction category is largely made up of commuters and leisure travellers, the other main difference between the urban/suburban and inter-urban studies is that, as would be expected, the former contains a larger proportion of commuting trips. Some studies disaggregate values of time for leisure trips into more specific purposes but these are small proportions.

Other Characteristics

The value of time estimates cover a wide range of areas of Britain and urban characteristics. 30% of the values of time cover London and the South East with a further 22% accounted for by metropolitan areas. Other conurbations provided 11% of the values of time, with other freestanding towns and rural locations accounting for 3% and 5% respectively. This categorisation is inappropriate for the remaining 29% of values, many of which relate to long distance travel.

We have seen that the vast majority of the value of time estimates were obtained from SP studies and to conclude this section we report some statistics relating specifically to the SP exercises.

There have always been concerns about whether SP responses supplied by individuals are an accurate reflection of their true preferences, and these concerns have generated a desire to try and identify and remove at least the worst excesses of error in SP responses. One method that is used is to remove those who always prefer the same alternative, or who rank alternatives according to the levels of one variable only, although of course such non-trading behaviour may well be a true reflection of an individual's preferences. It is not always apparent in studies that non-traders have been removed, and hence our figures will be underestimates. Some studies use logic tests, such as those based on transitivity requirements. Again, we believe that our figures will understate the extent to which logic tests have been conducted. Table 6 presents the proportions of value of time estimates obtained from the choice and ranking procedures where non-traders have been removed and logic tests used to omit respondents.

Table 6: Non Trader and Logic Tests

	Choice	Ranking
Non Trader	29%	3%
Logic	15%	22%
Both	7%	2%

There are different ways in which an SP exercise can be presented. Overall, the proportion of studies which collected the SP data by presenting the scenarios within a questionnaire is 42%, with the next largest proportion being 31% for the computer assisted method. Setting the SP scenarios out on cards which are then presented to respondents was used in 22% of studies and only 5% used an adaptive computerised SP design. However, the method of presentation can be expected to vary across different forms of SP exercise. For example, it is not always practical to set out the alternatives to be ranked within a questionnaire whilst using cards simplifies the task of ranking numerous alternatives. These arguments are less relevant to the SPRank4 and choice approaches which have therefore more often exploited the cost advantages of the questionnaire approach. Table 7 shows how the means of presentation varies across the type of SP exercise.

Table 7: Means of Presentation by Type of SP Exercise

Year	Questionnaire	Cards	Computer	Adaptive	SP Studies
Choice	49%	13%	31%	7%	70
Rank	14%	57%	29%	0%	21
Rank4	67%	0%	33%	0%	6

Note: The figures within a row sum to 100%.

5.REVIEW OF EVIDENCE

This section consists of four parts. Firstly, we examine some trends in research which has provided value of time estimates. Secondly, we present some overall value of time estimates from the sample collected. Thirdly, we report the results of regression analysis of the value of time as a function of key explanatory variables. Finally, we discuss variations in the value of time over time.

5.1Overview of Value of Time Research

In this section, we aim to provide an overview of research into the value of time over the period in question. This is supported, wherever possible, by evidence from our data set.

All the values of time which are contained in the data set were obtained from disaggregate behavioural models. However, although an overview of trends in disaggregate modelling will give a useful insight into trends in value of time research, it is not synonymous with it. Not all disaggregate SP models provide value of time estimates and, more significantly, value of time estimation was not necessarily the primary purpose for which the model was developed.

Trends in Number of Studies and in Data Sources

Table 8 illustrates some interesting trends which have emerged in disaggregate modelling studies in Great Britain over the period covered by this review. The trends are similar if we restrict the analysis to just those studies which are concerned with valuation.

Table 8: Type of Data by Year of Data Collection

Year	RP	SP Choice	SP Rank	SP Rank4	VoT's	Studies
80-85	21%	21%	58%	0%	38	10
86-88	8%	71%	21%	0%	24	9
89-91	4%	51%	18%	27%	166	37
92-94	5%	87%	8%	0%	182	38
95-Mid96	0%	86%	12%	2%	34	11

A noticeable trend is the very large increase in the number of studies per year. In the first six years, we have 1.6 studies per year, with 3.0, 12.3, 12.6, and 7.3 studies per year in each of the subsequent specified periods. The number of value of time estimates per year in each of the periods is 6.3, 8.0, 55.3, 60.6 and 22.6. No doubt the proportion of relevant studies that are not contained in this review will be greater for the earlier periods, although we do not believe that this would materially alter the trends apparent in Table 8, whilst the number of studies in the most recent period is bound to be understated given that the date used here relates to when the survey data was collected rather than to when the report was produced.

The period 1989-91 shows a dramatic increase in the number of studies. This is so even though there was a decline in British GDP during most of 1990 and in 1991. In the immediately following years, the number of studies was yet higher. A contributory factor here is the changed 'supply side' conditions brought about by the increasing acceptance of SP methods.

It can be seen that RP methods have formed a diminishing proportion of studies over time, although the absolute number of RP studies per year shows a slight positive trend. The success of pioneering SP studies undertaken for British Rail (Steer Davies Gleave, 1981) and for the Department of Transport (MVA et al., 1987), along with evidence showing a reasonable degree of correspondence between the value of time estimates obtained from RP and SP models (Bates, 1984; Wardman, 1986, 1988), was a stimulus to the widespread use of SP methods. The attraction of SP methods lay in their ability to analyse situations where other techniques were inappropriate and in their relatively low data collection costs, and these meant that more empirical studies covering a wider range of issues were now feasible. For example, the late 1980's saw novel applications to issues such as reliability, innovative transport schemes and overcrowding as well as an increasing number of routine mode choice applications.

Another strong trend is the movement toward choice exercises. Ranking exercises dominated early applications, largely because of their pre-eminence in marketing research from where they were imported. However, concerns arose that the difficulty of the task required of the respondent could impact on the reliability of the data, although there was little empirical evidence at the time that ranking exercises performed worse than choice exercises and indeed evidence from marketing research suggested that the concerns were unfounded (Benjamin and Sen, 1982; Bovy and Bradley, 1986; Leigh et al., 1984; Malhotra, 1982). Despite this evidence the concerns persisted, whilst a further stimulus to using SP choice exercises instead was because the latter could be closely linked to an actual choice situation and to mimic the real decisions travellers make which is appealing both for realism and for those who wanted to use SP directly for forecasting. The popularity of choice models in the area of demand forecasting has been maintained despite awareness that the error structure in SP models may not be appropriate for forecasting (Bates, 1988) although the so-called scale factor problem[1] does not apply to the use of SP models for valuation purposes.

The final trend apparent in Table 8 is the brief experimentation with what we have termed the Rank4 approach. This offered simpler ranking exercises in an attempt to overcome concerns surrounding the reliability of data obtained in response to complex ranking exercises. A series of rankings were offered to compensate for the lesser information obtained. This method formed a significant proportion of studies in the period 1989-91 (MVA, 1989, 1990, 1991; TPA, 1990) but has since been dropped in favour of the choice approach.

Trend Towards Simpler Choice Exercises

Another trend which has coincided with the movement away from ranking exercises as a difficult task, is a movement towards making choice exercises simpler. Early applications of SP choice exercises often involved 16 or even 18 comparisons (Bates, 1984; Wardman, 1986). More recently, 9 or 12 comparisons are more typical and the reduction was caused by concerns that offering a large number of comparisons increases respondent resistence to the SP exercise and reduces the quality of the data obtained. In our data set, we have 295 value of time estimates which were obtained from SP choice exercises and 72 which were obtained from ranking exercises. Table 9 shows how the average number of scenarios presented in choice exercises and the average number of alternatives in ranking exercises has varied over time.

Table 9: Average Number of Choices/Alternatives Presented

Year	Number of Choices	Obs	Alternatives Ranked	Obs
80-88	12.48	25	9.4	27
89-92	11.75	133	8.9	30
93-Mid96	10.13	137	9.0	15

[1]The coefficients of discrete choice models are estimated in units of residual deviation. If there is too much error in the model, as may be the case where it is based on SP choices, the coefficients will not have the appropriate scale and this will affect forecasts obtained from the model. However, since the scale applies to all coefficients, it does not affect the value of time estimate which is obtained as the ratio of coefficients whereupon the scale factor cancels out.

There is a clear reduction in the average number of scenarios in choice exercises over time. However, the number of rankings offered on average does not vary greatly over time. In part this is because those who advocated the ranking approach remained with it and saw no need to reduce the number of alternatives offered whilst those who were concerned about the reliability of ranking response data had switched to other methods. In addition, orthogonal designs are commonly preferred and these tend to be of plans involving nine alternatives and, unlike choice exercises which had tended to use 16 scenarios, there was little scope to reduce the numer of alternatives whilst maintaining an orthogonal design framework.

Trends in Method of Presentation

Table 10 reveals some interesting trends in the methods of presentation. Given that, as Table 7 shows, the means of presentation varies across the type of SP exercise, the figures presented in Table 10 relate solely to choice exercises which are the dominant form of SP.

Table 10: Method of Presentation used in SP Choice Studies

Year	Questionnaire	Cards	Computer	Adaptive	Choice Studies
80-88	38%	38%	12%	12%	8
89-92	41%	12%	35%	12%	34
93-Mid96	61%	7%	32%	0%	28

Note: Rows sum to 100%.

The preference in the earlier years for using cards to present the SP scenarios has given way to an increasing proportion of studies which have used the questionnaire approach so that in recent years it has become by far the most common method. To some extent this may have stemmed from a belief that SP exercises can be presented well and reliable answers obtained by using the questionnaire approach, particularly given advances in printing, although we suspect commercial pressure to have had a bearing here. As would be expected, there has also been a large increase in the proportion of studies using computer presentation, although we are aware of practitioners who are doubting the presentational advantages of computer assisted SP exercises. Further controlled experimentation using different means of presentation may well be warranted. It seems that the transport profession has heeded the warning contained in Bradley and Daly (1993) about the dangers of using adaptive SP designs because of the correlation it induces between the independent variables and the error term. None of the studies in our data set which collected data in 1993 or after have used the adaptive approach.

Trends in Purpose of Studies

Finally, we examine trends in the purposes for which the studies were undertaken. Section 4.2 reported that overall 8% of the studies were conducted for the purposes of value of time estimation, 59% were undertaken for forecasting purposes and 33% were conducted for valuation in general. Table 11 shows how these proportions vary over time.

Table 11: Purpose of Studies

Year	Time Valuation	Forecasting	General Valuation	Studies
80-88	32%	32%	36%	19
89-92	0%	71%	29%	51
93-Mid96	6%	57%	37%	35

Note: Rows sum to 100%.

Studies which are primarily concerned with the value of time have become rare in recent years. This is not primarily because there has been a large increase in the number of general valuation studies, as might be expected as SP is applied to examine a wider range of transport attributes, but because forecasting studies have tended to dominate.

The form of models developed explicitly for forecasting purposes are dictated by the choice context for which forecasts are required. On the other hand, studies whose purpose is valuation can be based on a wider range of choice contexts. For example, the value of motorists' travel time can be obtained from any exercise which offers trade-offs between time and cost, such as a route choice exercise, a destination choice exercise, a mode choice exercise or, made possible by the SP approach, an exercise involving two abstract alternatives. Our impression was that there had been a trend towards abstract choice contexts when the purpose of the study was valuation since these avoid possible extraneous influences arising from the real choice context. However, this has not been the case. The proportion of valuation studies which used an abstract choice context in the period 1980-88 was 62%. This increased to 87% in the period 1989-92 but fell back to 67% after 1992.

Other Trends

We have here concentrated solely on trends apparent in our value of time data set but we recognise that there are other significant trends which our data cannot cast any light upon. These include:

- Advances in the statistical design of SP experiments and its impact on the efficiency of the value of time estimates obtained (Fowkes, 1991; Fowkes, Wardman and Holden, 1993; Wardman and Toner, 1996);

- Advances in estimation, including the direct estimation of the value of time (Bradley and Daly, 1993), the allowance for variation in the value of time across individuals (Bradley et al., 1993; Ben-Akiva, 1996) and the use of statistical techniques to overcome the repeat observations problem in SP data (HCG and Accent, 1996; MVA, 1996).

5.2Overall Value of Time Results

Descriptive statistics for the value of time for the overall sample are presented in Table 12. These values will be influenced by the composition of the sample; the task of the modelling exercise reported in the next section is to disentangle the key influences on the values of time. All values are expressed in 1994 quarter 4 prices. The Department of Transport inflates the value of time in line with average earnings. However, we subsequently found the GDP effect to be very low. We have therefore provided descriptive statistics for unadjusted values of time and also values of time adjusted in line with GDP to the level prevailing in 1994 quarter 4. It can be seen that the GDP adjustment does not make a great deal of difference to the results.

The presence of some large values of time relating to business travel impacts on the overall mean value and on the skewness of the distribution and hence equivalent statistics for business and non business are also reported. As would be expected, the average value for business travel is somewhat higher. However, we shall see that this mean value for business travel masks some quite large differences between urban/suburban and inter-urban travel. It should also be noted that the business travel values of time in our sample can be taken to represent briefcase travellers, such as those attending a business meeting, course or seminar or visiting a client.

There is some uncertainty as to what the value of business travel in these studies actually represents. If a study is based on RP data, then the resulting valuations ought to be a reflection of the employer's valuation of time saved rather than the employees. However, we have only one RP business value of time.

Table 12: Value of Time for Overall Sample, Business Travel and Non Business Travel

	Mean	SD	Std Err	Min	10%	25%	50%	75%	90%	Max
All 1	7.26	8.64	0.40	0.71	1.84	2.92	4.91	7.76	13.26	64.44
All 2	7.71	9.12	0.43	0.74	1.93	3.01	5.13	8.32	14.53	68.26
EB 1	20.16	16.24	2.03	2.58	5.09	7.59	14.23	29.06	52.03	64.44
EB 2	21.43	16.92	2.11	2.70	5.12	7.90	14.84	31.92	55.67	68.26
Non EB 1	5.64	3.05	0.25	0.92	2.04	3.44	4.99	7.59	9.61	18.32
Non EB 2	5.98	3.26	0.27	0.97	2.16	3.58	5.41	7.99	10.13	18.50

Note: The first set of figures do not adjust for GDP and the second set of figures apply a GDP elasticity of unity and adjust to the 1994 quarter 4 GDP level. The Non EB values exclude cases where it is not clear that the purpose is non business.

In some studies, business travellers are asked to bear in mind company travel policy when completing the SP exercise. If they have correctly done this, then such studies ought to reflect the employer's values. However, some SP studies do not give any particular instructions as to what the business traveller should assume. Whilst we feel that there will be a tendency for respondents to bear in mind company policy, given that the SP exercise relates to their business trip, it is not inconceivable that the individual provides answers which essentially represent their own valuation rather than that of the company. In addition to all this is of course the issue as to whether respondents know and accurately take into account their company's travel policy when instructed to do so.

Unfortunately, we have not collected data on the precise instructions issued in each SP exercise. However, studies whose primary purpose was forecasting almost invariably specify that the company's travel policy is to be taken into account whilst studies concerned with the valuation of travel attributes tend to be less specific. Fortunately, we can isolate these two types of study.

Table 13 presents the mean values of time for inter-urban travel, which contains the largest proportion of business travel, for first class rail business travellers and other business travellers for studies whose purpose was valuation and forecasting. It can be seen that the values are somewhat higher when the purpose of the study is forecasting which leads us to suspect that being instructed to bear in mind company travel policy is having a bearing on the value of time estimate obtained.

Table 13: Inter-Urban Business Values of Time by Purpose of Study

	Valuation	Forecasting
First Business	33.86 (5.21) n=10	42.92 (9.37) n=3
Other Business	13.75 (1.72) n=26	24.81 (4.87) n=15

Note: Values are not adjusted for GDP growth.

In the absence of more precise information on the instructions issued to respondents, we will take the values obtained in forecasting studies to be representative of the employer's valuation of travel time savings. Any benefit attributable to the employee would be an additional amount.

The value of time to the employer calculated by the recent value of time study (HCG and Accent, 1996) using the Hensher formula was 28.5 pence per minute if the employer received the benefits of the time saving and 14.5 if the employer received half the time saving. The values for first business in Table 13 represents a special case of traveller who are not comparable with those upon which the recent HCG and Accent (1996) value of time study based its calculations. Our best estimate of the employer's value of time is therefore 24.8 pence per minute for the inter-urban travellers in Table 13 falling to 21.47 when the urban business travellers are included. The consistency of this value with the value obtained in the value of time study confirms our view that the forecasting values are closely related to employer's values[2].

We now turn to the value of time for non busines trips. The recently revised HEN2 value of non-working time, after converting to a behavioural value, is 6.35 pence per minute. This is based on the 1980's research and is adjusted for growth in average earnings as well as for inflation. It is only 6% higher than the mean value for non business travel after adjustment for GDP changes reported in Table 12. This degree of correspondence is encouraging.

Table 14 compares the average values of car travel time for commuting and leisure purposes for car users obtained in our study with the car users' average values reported in Table 88 of the recent HCG and Accent (1996) value of time study. The values of time derived by the two methods are similar and again this is an encouraging finding.

Table 14: Comparison with 1994 Value of Time Study

[2]The collection of additional data relating to the instructions given in each SP exercise would allow more detailed analysis of this issue and comparison with both the employer and employee values estimated in the recent value of time study.

Purpose	HCG/Accent	Mean 1	95% CI	Mean 2	95% CI	Obs
Commute	5.4	4.85	3.92 - 5.77	5.05	4.02 - 6.53	21
Leisure	4.3	5.11	4.36 - 5.85	5.35	4.52 - 6.18	30

Note: 1 denotes that the figures are unadjusted for GDP whilst 2 denotes adjustment to the 1994 quarter 4 GDP level.

5.3Quantitative Modelling Exercise

The data set we have amassed offers the opportunity to examine how the value of time varies across studies. This can be done by regressing the value of time on the range of variables about which we collected information and which are listed in section 4.1. However, it is clear that these variables do not cover all the sources of variation in the value of time across studies. For example, we cannot control for different income levels across studies, nor for different sample selection methods or indeed the competency of the design, conduct and analysis of the SP exercise. Moreover, the estimated value of time may be a function of the size or sign of the time variation. We assume that the net effect of such unexplained variation in the value of time is randomly distributed across studies and is incorporated within the regression model's error term such that it is not a cause for concern unless the goodness of fit is poor.

We have developed a multiple regression model relating the value of time to the relevant explanatory variables for which we have collected data. The results are presented in Table 15. The dependent variable is the logarithm of the value of time since, after adjusting R^2 for comparability, this model form performed slightly better than when the dependent variable was simply the value of time. Distance and GDP were entered in logarithmic form and hence their coefficients represent elasticities. All other variables are dummy variables and hence denote the proportionate effect of the level of a particular variable on the value of time; for example, if the aim of the study was general valuation (G-Val) the value of time was on average 13% lower than it would have otherwise been all other things equal. These proportionate effects are independent of the value of time to which they are applied.

A base value of time which can be used in interpreting the results is 1.99 pence per minute for a journey of 5 miles and a 1994 quarter 4 GDP index of 103.7 and with all the other variables at their base (omitted category) levels. This value of time is calculated as:

$$VoT = GDP^{0.075}\ Dist^{0.210}$$

Thus this base value of time relates to a situation where:

- the numeraire was not a toll charge
- the purpose of the journey was leisure

• cost was in the same units as journey time
• an RP approach or an SP route or abstract choice context was used
• the purpose of the study was forecasting or value of time estimation
• the SP presentation was a questionnaire
• bus was used and was valued

If we wanted an estimate of the value of time (in quarter 4 1994 prices) where the purpose was commuting in areas other than the South East (Comm-Oth), the mode used and being valued was car, the calculation for a given distance and GDP level would be:

$$VoT = GDP^{0.075}\, Dist^{0.210}\, e^{0.133\, Comm\text{-}Oth + 0.546\, Car}$$

We have been able to estimate a model with a satisfactory goodness of fit and which has a number of interesting features. Of the 24 coefficients in the reported model, 17 (71%) have t ratios in excess of two and all but one of the remaining coefficients have t ratios greater than 1.5. The correlations between estimated coefficients tend to be very low and the correlation matrix is given in Appendix 2.

The reported model excludes variables which had very low t statistics and which essentially had no discernible influence on the value of time. These variables were:

i)location;
ii)whether non traders were omitted;
iii)whether those failing a logic test were omitted;
iv)sample size.

It should not be concluded on the basis of these results that the removal of non-traders or those who fail a logic test does not influence the value of time obtained in a particular study. Rather, the application of these exclusion criteria does not have a systematic influence across the sample of values of time used in the model. Nonetheless, the variation in the value of time which occurs as a result of using these tests will have introduced noise which will impact adversely on the goodness of fit.

Table 15: Value of Time Regression Model

VARIABLE	CATEGORY	Coeff	t ratio	% Effect
GDP	GDP	0.075	2.67	
DISTANCE	DIST	0.210	7.76	
NUMERAIRE	TOLL CHARGE	-0.292	2.00	-25%
	EB-U	0.671	3.41	+96%

PURPOSE				
	EB-I	0.935	6.05	+154%
	EB-1st	1.552	7.01	+372%
	EB-Val	-0.288	1.72	-25%
	COMM-LSE	0.301	3.00	+35%
	COMM-OTH	0.133	1.87	+14%
	NODIST	0.139	2.09	+15%
UNIT	COST-RT	-0.151	2.09	-14%
TYPE OF DATA AND CHOICE CONTEXT	SP-MODE	-0.176	2.38	-16%
	SP-RANK	-0.167	1.86	-15%
	SP-RANK4	0.179	1.54	20%
STUDY AIM	G-VAL	-0.142	1.74	-13%
SP PRESENTATION	CARDS	0.214	2.72	+24%
	COMPUTER	0.063	1.22	+7%
MODE USED AND MODE VALUED	CAR	0.546	6.42	+73%
	RAIL-RAIL	0.813	6.48	+125%
	RAILAIR-RAIL	1.552	4.53	+372%
	RAIL-RAILAIR	1.024	3.56	+178%
	UG-UG	0.946	6.01	+158%
	PT-PT	0.242	1.64	+27%
	ALL	0.712	7.04	+104%
	Obs	444		
	Adj R^2 *	0.616		

Note: * This is the adjusted R^2 when the model contained the intercept. The dependent variable is ln(VoT).

Nor do we conclude that the value of time does not vary across locations, only that there is no variation in the value of time attributable to different locations after accounting for variations in the value of time due to the other variables in our model. In addition, the value of time may vary across locations due to differences in variables which it was not feasible to examine in the sort of aggregate model developed here.

Not only did sample size have no effect when specified as an independent variable but it had only a negligible influence when it was used, in the absence of comprehensive information on the variance of the estimated value of time, to weight the observations in the sample. We have also omitted the constant term because it was not statistically significant (t=1.40) and it was highly correlated with some of the independent variables and particularly GDP. We now discuss each of the variables contained in the model in turn.

GDP

The GDP elasticity is low but, even though it is statistically significant, we have some reservations about this value because of the very limited variation in GDP across many of the studies in the review. For example, the level of GDP at the 75th percentile is only 2.6% higher than the level of GDP at the 25th percentile whilst 80% of the observations have a GDP index between 92.0 and 103.7. This is the result of the recession in the early 1990's, around which time many of the value of time estimates were obtained, and low growth in some other periods.

We collected quarterly data on real personal disposable income on the grounds that this might provide a better guide to individuals' willingness to pay for time savings. However, the results obtained when we replaced GDP with real personal disposable income were just as disappointing. The estimated elasticity was 0.072 with a t ratio of 2.58 and the goodness of fit was slightly worse than when GDP was entered. When we replaced GDP with a time trend term, the average increase in the value of time was estimated to be 0.9% per annum although the t statistic was only 1.16, and again the fit was slightly worse than for GDP. We shall return to the issue of variation in the value of time over time in section 5.4.

Distance

The distance coefficient is precisely estimated and indicates that the value of time increases with distance, with a 10% increase in distance implying a plausible 2% increase in the value of time. This positive distance effect is consistent with the results of the recent value of time study (HCG and Accent, 1996) although the effect here is not as strong. This may be because there are instances where a representative distance has been used, particularly for longer distance journeys, and this could have operated to dampen the distance effect estimated here. On the other hand, the distance effect apparent in the recent value of time study does seem to be rather large.

We also estimated a model which replaced distance with the discrete categories of urban, suburban and inter-urban, but this did not achieve as good a fit and in any event the results would be less easy to apply in practice. In addition, we examined whether the distance elasticity differed between urban and inter-urban trips. Although the inter-urban distance elasticity was around 25% larger, the difference was far from statistically significant.

It may be that the distance elasticity varies across modes. For example, it is conceivable that the more cramped conditions of car travel would lead to the value of time increasing with distance at a faster rate than does the value of train travel time. We examined whether the distance elasticity differed across modes but no effects were apparent. However, a distance effect is apparent across journey purposes and this is discussed below.

Numeraire

Value of time estimates are almost always derived as the ratio of estimated time and cost coefficients. If the sensitivity to different types of cost varies, then the value of time estimate will differ according to the numeraire used.

We collected information about the cost coefficient used in calculating the value of time, distinguishing between car petrol costs, toll charge, parking charge, bus fare, rail fare and various combinations of these where the reported model had estimated some form of generic cost coefficient. The only numeraire coefficient which did not have a very low t ratio related to toll charge. In such cases, the value of time is estimated to be 25% lower, and this result was unaffected by the specification of dummy variables denoting whether the SP exercise related to route choice where toll variables most often occur. This effect on the value of time presumably reflects an aversion or protest towards paying tolls but we cannot distinguish between this being an artefact of the SP exercise or a true reflection of actual preferences.

To some extent, the analysis here has been hampered by correlations between the numeraire and the variables relating to mode and because there are numerous differences in the specification of the numeraire across studies as a result of the different way in which costs are combined into generic variables and the different cost variables used. A more controlled analysis is required and it is to this point that we shall return in section 6.1.

Purpose

Table 5 set out the distribution of journey purposes in the sample and on the basis of this we have specified the following categories for the modelling exercise:

i)Employer's Businessvii)Visit friends/relatives and Personal Business
ii)First Class Businessviii)Off Peak
iii)Commutingix)Non Commuting
iv)Peakx)Non Business
v)Leisurexi)No Distinction
vi)Shopping and Recreation

The base category as far as the dummy variable specification is concerned was initially leisure travel. The coefficients relating to shopping/recreation and VFR/personal business both had very low t ratios, as did the off-peak category, and hence these variables were removed from the model. These results are not surprising given that the trips are similar in nature to the base category of leisure trips whilst some of the categories have only a small number of observations.
The precise nature of non commuting and non business trips is not clear and in order to isolate any possible differences between such trips and other types of trip we specified two dummy variable terms. However, the coefficients relating to both were negligible and hence they have been dropped from the reported model.

A distinction was made between three categories of business travel. Separate coefficients were estimated to urban business travel (EB-U), to inter-urban business travel (EB-I) and to first class business travel (EB-1st). The latter relates solely to inter-urban rail travel. As expected, business travellers have larger values of time than all other categories of traveller. Within this, first class business travellers have very much higher values and this is presumably because they generally hold senior management positions with consequent greater pressures on their time and also higher incomes. Inter-urban business travellers were found to have higher values than urban business travellers, over and above that which is implied by the distance effect. We feel that this may result from the different nature of inter-urban business trips; for example, the inter-urban business trips are almost entirely made up of 'briefcase' travellers whilst some of the urban trips will include less senior employees such as those in service related industries and making deliveries. In addition, there will be more instances in urban travel where expenses are not claimed because the costs involved are relatively minor and this will tend to deflate the value of time.

As discussed in section 5.2, the value of business travel time is higher where the purpose of the study was forecasting. We have argued that this is because in such studies there is a greater incentive to allow for company policy. We therefore included a variable (EB-Val) to denote whether the business travel value was obtained from a study whose main purpose was valuation. This variable is not far removed from having a significant effect and indicates that the value of business travel time is on average 25% lower in such instances.

Our results show that commuters have values of time which are higher than for leisure travellers other things equal. A distinction is here made between commuters in London and the South East (COMM-LSE) and commuters elsewhere and peak travellers (COMM-Oth). The latter two were combined because they had very similar coefficients. Separating the peak values of time into London and the South East and elsewhere did not prove worthwhile, nor did the use of other locations. London commuters are estimated to have values of time 35% higher than leisure travellers whilst commuters elsewhere and peak travellers had values 14% higher.

We do not believe that these results are simply reflecting a South East income effect since a dummy variable relating to London and the South East had a far from significant effect on the value of time whilst we also allowed the business and leisure values to vary between London and the South East and elsewhere but they did not exhibit significant variation. Nor does it seem that different modal usage between London and the South East and elsewhere accounts for the difference. We are therefore inclined to conclude that the higher value for London and South East commuters relates to the overall worse travel conditions.

The NODIST coefficient simply represents those values of time where no distinction was made according to purpose. Our impression is that business travel is not present to a great degree in these studies but that commuting is well represented. The NODIST coefficient therefore seems plausible.

Unit

We have some concerns that the presentation of attributes in SP experiments in different units may have an influence on the relative valuations obtained. We have therefore specified a dummy variable which denotes whether the cost variable was presented to respondents in round trip units (COST-RT). This most often occurs for public transport, particularly in the inter-urban context, because the round trip ticket is that most commonly purchased. In contrast, journey time is always presented in one-way units.

Our concern is that, even where round trip cost is the most natural unit, the presentation of round trip cost alongside single trip journey time in an SP exercise may lead some respondents to trade-off between the time and cost figures offered as if they were both in the same dimension. If this occurs, and given that the analyst will either halve the round trip cost variable at the modelling stage or make the appropriate adjustment in calculating the value of time, the value of time will be lower than it should be.

If there is some tendency for respondents to treat cost in the same dimension as time when it is not presented as such, the COST-RT coefficient would be negative. This is indeed the case here with the value of time estimated to be 14% lower and the t statistic is quite respectable. Our empirical findings therefore substantiate our theoretical concerns.

We are not aware of studies which have examined this precise issue, although we suspect that they may well have been undertaken, for example, at the pilot or pre-pilot stage of the study. Although the effect we have estimated is not particularly large, it is a relatively straightforward matter to test it in more detail and, in the absence of the findings of such research, we recommend that relevant future studies undertake such a test and report the findings.

Type of Data, Choice Context and Means of Presentation

We experimented with models which specified a full range of interactions between type of data and choice context and the means of presenting the SP exercise. This involved the specification of, for example, separate variables for an SP mode choice exercise according to whether it was presented within a questionnaire, using cards, on a computer or whether an adaptive design was used. However, the most notable effects apparent when this approach was used can be represented within the simpler specification which examines type of data and choice context separate from the means of presentation. Moreover, the more complex interaction form of model leads to categories with small sample sizes and some of these tend to be closely related to categories of other variables in the data set.

From Table 2, we can see that the main categories of type of data and choice context can be represented by the following categories:

i)RP
ii)SP Mode Choice (SP-Mode)
iii)SP Route Choice (SP-Route)
iv)SP Abstract Choice (SP-Abstract)
v)SP Ranking Mode and Route Choice (SP-RankMR)
vi)SP Ranking Abstract Choice (SP-RankA)
vii)SP Rank4 Abstract and Route Choice (SP-Rank4)

There are too few RP observations to split into mode and route choice and hence a single RP category was used and this was the initial base category. To this was added SP-Route and SP-Abstract since these both had very low t ratios and thus the distinction between them and the

RP values of time can be dropped. In addition, the coefficients for SP-RankMR and SPRankA were very similar and hence these have been combined into a single term (SP-Rank).

As far as the means of presentation is concerned, the base category was the use of the questionnaire approach. The coefficient relating to adaptive designs was insignificant and therefore dropped. However, only 2% of the values were obtained from adaptive designs.

The use of cards is associated with values of time which on average are 24% higher. The computer assisted presentation leads to a 7% increase in the value of time over the questionnaire approach, although the effect is not statistically significant at the usual 5% level.

Our feeling is that both the questionnaire and the computer presentation are inferior to a card presentation in terms of clarity. It may be that the former increases the chances that respondents concentrate on a subset of the variables and ignore the others. To the extent that cost is ignored to a lesser extent than time, the value of time will be lower using the questionnaire and computer approaches.

Table 16 uses the results obtained by the regression model to show how the value of time obtained from various types of SP approach is expected to relate to a value of time obtained from an RP model. The RP method is widely regarded to be an appropriate benchmark against which to assess the reliability of results obtained using SP techniques. Of course, it would be foolish to base an evaluation of the values of time derived from SP models on RP models which are deficient in key respects. However, the RP models contained in this study tend to be based on large sample sizes and to achieve at least adequate goodness of fit. Their values of time are generally plausible with the time and cost coefficients estimated with reasonable levels of precision.

Whilst we could speculate some reasons for the differences in performance across the various SP approaches there is no need to do this since, with the exception of the results for SPRank4, the values of time are sufficiently close to what would be obtained by an RP approach. This is encouraging with regard to the validity of using SP methods for valuation purposes. The appreciable differences apparent for the SPRank4 approach may have occurred because this method has generally been applied to estimate rail users' valuations of rail travel time which is expected to be relatively high. However, the SPRank4 method is not currently used.

A further encouraging feature of the results is that this reasonable degree of correspondence between RP and SP values of time is apparent across studies which have largely been conducted independently. The sceptic can claim that the modelling in studies which have directly compared RP and SP models proceeded with the aim of showing the two to produce similar results. It is difficult to make such accusations when the studies are effectively independent.

Table 16: SP Values of Time relative to RP

	Questionnaire	Cards	Computer
SP Mode Choice	-16%	+4%	-11%
SP Route Choice	0%	+24%	+7%
SP Abstract Choice	0%	+24%	+7%
SP Ranking	-15%	+5%	-10%
SP Rank4	+20%	+48%	+27%

Study Aim

We have already reported on the impact of a forecasting study on the value of time for business travellers. However, we also tested whether the aims of the study influenced the value of time for non business travel.

The omitted category here was whether the study was undertaken specifically for the purpose of value of time estimation. Given that forecasting studies provided the majority of value of time estimates, we were particularly concerned whether such studies have produced different values of time. However, the coefficient relating to whether forecasting was the main purpose for which the model was developed was far from significant. We have found that studies which were undertaken for general valuation purposes (G-VAL) obtained lower values of time, although the effect is not large.

Mode Used and Valued

In the data collected, we distinguished according to the modes respondents were using and the modes which were being valued. Thus a car-rail SP choice model with alternative specific time coefficients and based on cars users will provide a car value of time for car users and a train value of time for train users. The categories that we examined were selected on the basis of the groupings of mode used and mode valued reported in Table 4. These were:

i)Car-Car (21%)viii)PT-PT (3%)
ii)Car-PT (6%)ix)All-PT (6%)
iii)Car-All (14%)x)All-Car (4%)
iv)Bus-All (9%)xi)All-All (3%)
v)Rail-Rail (26%)xii)RailAir-Rail (1%)

vi)Rail-Oth (1%)xiii)Rail-RailAir (1%)
vii)UG-UG (5%)

PT represents any or all of the public transport modes of bus, rail and LRT and All denotes car and PT. Oth denotes modes other than rail and UG represents the London underground.
The omitted category was that of bus users, with no distinction made according to the mode being valued given the relatively small number of bus users in the sample and that most observations related to the valuation of bus, rail or public transport in general.

The three coefficients relating to car users were very similar and hence we have specified a single term for car users (CAR). RAIL-OTH was insignificant, although it contained very few observations, and was therefore dropped, whilst the ALL-PT, ALL-CAR and ALL-ALL variables were combined into a single term (ALL) because their coefficients were similar.

There are some large variations in the value of time according to mode. As would be expected, all the specified categories have higher values than the base bus user category.

We would expect car users to have relatively high values of time because of their relatively large incomes. However, the effect estimated to CAR will be tempered by the fact that car is itself being valued in the majority of instances and the disutility of time spent in a car is relatively low.

Rail users' valuations of rail are higher than car users' values and there is presumably an income effect at work here whilst rail may be regarded as providing a less attractive travelling environment. We allowed the rail value of time to vary between urban/suburban and inter-urban travel, on the grounds that inter-urban trains might be regarded as superior, but no significant difference was obtained.

Rail and air users' values of rail travel time and rail users' values of rail and air travel time are both very high. These represent particular segments of the business travel market who can be expected to have very high values of time. Given that air travellers can be expected to have higher values of time than rail users, but that air travel time can be expected to have a greater disutility than rail travel time, it would seem that the mode user effect is outweighing the mode valued effect.

Underground users' values of underground travel time are relatively high, presumably reflecting a combination of relatively large average incomes and the often poor travel conditions on the underground.

The PT-PT sample contains a large proportion of bus users who are expected to have low values of time and hence the low coefficient estimate is not surprising. On the other hand, the ALL coefficient relates to categories which contain a large proportion of car users and rail users who have high values of time whilst the modes with relatively high travel time disutilities are also well represented. As a result, the ALL coefficient has a large impact on the value of time.

What seems to be emerging from this particular segmentation is that variation in the value of time due to mode used, which proxies for other factors such as income, is somewhat stronger than variation in the value of time due to the different travel conditions across modes. In section 6.4, we examine the relationship between the value of time and mode in more detail.

5.4Value of Time over Time

A particularly useful purpose of this exercise is to examine how the value of time varies over time. An important objective of the second value of time study was "..... to determine how much change can be identified in the valuations since 1985" (HCG and Accent, 1996; p4) but we here have much more evidence at our disposal.

The regression model contains a very low GDP elasticity but we have argued that this has been influenced by the limited amount of variation in GDP across a large proportion of the values of time. We have therefore conducted additional analysis in an attempt to overcome this problem.

The concept underlying our additional modelling is to compare value of time estimates which are as similar as possible in terms of all relevant background variables other than GDP but whose associated GDP's differ by as much as possible.

Each value of time is compared with each subsequent value of time in the data set and those which are not the same in terms of the background variables are excluded. The latter variables were the type of data, journey purpose, mode used, mode valued, choice context, type of study, means of presenting the SP exercise and whether the value of time related to an urban, suburban or inter-urban context. The one variable we did not use as a control was distance given that it is continuous. This variable is therefore entered into the subsequently estimated model. Where a value of time can be compared with more than one other value of time, we selected that comparison which involves the largest difference in GDP. Each value of time is compared with at most only one other value of time in the estimated model, otherwise the observations would not be independent.

Given that we have isolated the effects of the other variables in our data set on the values of time being compared, the form of model to compare two values of time (1 and 2) is specified as:

$$\ln \frac{VoT_2}{VoT_1} = \alpha_0 + \alpha_1 \ln \frac{GDP_2}{GDP_1} + \alpha_2 \ln \frac{D_2}{D_1}$$

where D denotes distance. The logarithmic form is specified so that the distance and GDP coefficients are interpreted as elasticities. The estimated model was based on 102 observations and is reported in Table 17.

Table 17: GDP Regression Model

Intercept	0.015 (0.21)
GDP	0.739 (0.82)
Distance	0.414 (3.71)
Adj R^2	0.105
Obs	102

Whilst the estimated GDP elasticity is plausible, it is unfortunately far from statistically significant and the goodness of fit is very poor. Rather extreme results were obtained when we estimated separate GDP elasticities to business, commuting and leisure trips.

The poor fit and low t ratio are rather disappointing given the manner in which we controlled for the effects of the other variables in our data set. A contributory factor here seems to be a failure of the value of time estimates to follow GDP in the downturn of the early 1990's. Thus we conclude that the value of time data set does not shed any light on the appropriate adjustment to be made to allow for variation in the value of time over time.

6.DETAILED REVIEW ISSUES

There are many factors which, in theory, could influence the value of travel time and indeed the recent value of time study (HCG and Accent, 1996) successfully discerned a large number of effects. However, it is not the purpose of our study to conduct a review of all the many possible factors that could influence the value of time and determine the consistency of the estimated effects across studies. The purpose here is to select some important issues concerning the value of time and to consider in detail the empirical evidence relating to them. The emphasis here is on evidence which can be obtained from within study comparisons of results rather than comparing values of time across studies which was the focus of the previous section.

6.1Numeraire Used

The regression model found that the use of a toll coefficient as a numeraire led to a lower value of time of the order of 25%. We feel that this is due to an aversion to paying tolls but it may well be, given that the evidence is derived solely from SP models, that this is a bias against tolls which is specific to SP responses. However, we argued that examining numeraire effects in this way is not ideal and that a more detailed comparison involving evidence from studies which have estimated different numeraire coefficients would be illuminating.

The different numeraires encountered in this study relate to the following cost variables and various combinations of them.

i)Public Transport fares
ii)Fuel Costs
iii)Parking Charge
iv)Toll Charge

The toll charge includes existing charges to use road facilities, such as tolled bridges and tunnels, as well as various forms of pricing for the use of road space which is currently free of charge.

The recent value of time study (HCG and Accent, 1996) conducted some qualitative research which included attitudes to tolls. There was widespread resistance to the basic principle of road tolling. However, objections seemed to be less if there was some benefit involved, such as reduced congestion, or if it meant the construction of a new motorway.

We could hypothesise that the sensitivity to toll charges will be greatest for their introduction to currently untolled roads, will be lower for tolled new roads and will be least for facilities which are currently tolled. The sensitivity to tolls might also be expected to be reduced if the tolling brings advantages such as lower congestion.

In all cases we would expect tolls to have a higher estimated coefficient than petrol cost for the following reasons:

i)Protests against toll charges will inflate the toll coefficient relative to the petrol coefficient;

ii) Some respondents do not account even for petrol costs in decision making and hence the petrol coefficient will be deflated;

iii)Introducing realistic petrol cost variations is not always straightforward, such as where two routes have similar distances, and hence petrol cost variations might be ignored.

Points ii) and iii) would also lead us to expect that a parking charge coefficient would be higher than a petrol coefficient. The response to public transport fares is not regarded to be susceptible to the same sort of bias that toll charges attract, nor to be affected by points ii) and iii), and hence public transport coefficients might be expected to be of the same order as parking coefficients.

A number of studies provide evidence on travellers' responses to variations in different monetary variables. In principle, evidence in this area could be extensive, since the many mode choice studies which have been undertaken include at least two and sometimes three types of cost. However, parking cost and petrol cost for car are often combined into a single car cost variable whilst public transport fares and car costs are typically constrained to have the same generic coefficient.

HCG and Accent (1996) report the values of time given in Table 18 based on separate SP experiments within the same survey. Whilst the results do not show a systematic effect from the numeraire of the expected form, it was apparent in the toll experiment that there was a strong preference for the untolled route, other things equal, and this was attributed to bias against tolls. When the 25% of the business sample and 35% of the commuting and other sample who always chose the untolled option in the SP exercise were omitted, there was little effect on the values of time but the route specific constant was affected.

This SP exercise implied tolling existing untolled routes and hence bias against tolls might be expected to be relatively high. However, the bias in responses was here discerned by a route specific constant.

Table 18: Values of Time and Numeraire from HCG and Accent (1996)

Experiment	EB	Comm	Other
1 - Toll	8.0	5.4	5.8
2 - Parking and Petrol	12.1	5.4	4.3

In two closely related studies (Oscar Faber TPA 1993a, 1993b), the values of time obtained were very similar and are reported in Table 19. No constant was specified to discern any bias against tolls in the route choice exercise. However, the incentive to bias responses might not be as great as for the introduction of tolls on existing roads since here the payment of a toll would finance the construction of a new road.

Table 19: Car Values of Time from Operating Costs and Toll Costs

Experiment	EB	Other
Mode Choice SP - Operating Costs	12.5	6.7
Route Choice SP - Toll	12.8	6.5

Accent and Hague (1994) report a study which involved a within route SP and a between route SP, involving the attributes of toll, travel time and a package of motorway improvements. The within route SP involved tolling of currently untolled routes and led to a large protest response, with 40% always choosing the cheapest route, and much lower values of time than expected.

In the Oscar Faber (1993a) study, a dummy variable was included for increases in the toll level, in addition to the toll variable itself, and this was found to be significant which is consistent with the presence of bias in responses. Some interesting findings are reported in Wardman (1985) with regard to the use of piecewise estimation to obtain coefficients for the different levels of toll. The figures are reported in Table 20 and clearly show a protest against the introduction of tolls with an essentially constant effect thereafter.

Table 20: Piecewise Estimation of Toll Charge Effects

Inter Urban Route Choice	
Change in Toll	Unit Change in Utility
0-100p	-0.0206
100p-200p	-0.0058
200p-400p	-0.0052
400p-600p	-0.0051

When we now compare the coefficients for different monetary variables estimated not only within the same study but within the same model, some interesting and quite clear results emerge. The coefficients relating to parking, petrol, toll and public transport fare reported in a number of studies are given in Table 21.

There are four instances where parking and fuel coefficients are compared (studies 10 and 11) and in all four cases the parking coefficient is larger and in three of the cases it has a much better t ratio. The public transport fare coefficient is lower than the toll coefficient in all four comparisons (study 8) and is higher than the combined parking and fuel coefficient in all three cases (studies 7 and 9). In both cases where fare and fuel cost are estimated separate coefficients, the former is larger but the relationship between the fare and the parking coefficients is not clear.

The remainder of the studies all deal with the toll coefficient relative to a combined parking and fuel coefficient or more generally a fuel coefficient. In all 14 cases, the toll coefficient is the higher of the reported car cost coefficients. Where there is an existing tolled facility and the study is based on route choice (studies 1 and 6), the toll coefficient is on average only 15% greater. If we include the study which involves tolls and mode choice (study 2), the toll coefficient becomes 40% higher. Where the toll is levied on a new route (study 5), the toll coefficient is 23% higher than the fuel coefficient whilst the toll coefficient is on average 240% higher when it is introduced on an existing, untolled route (studies 3 and 4).

Table 21: Within Model Variations in Cost Coefficients

Study		Parking	Fuel	Toll	PT Fare
1 HCG/Accent (1996)	EB		1.0	1.12	
	Comm		1.0	1.09	
	Other		1.0	1.21	
2 Oscar Faber TPA (1993a)	EB	-0.0042 (7.1)		-0.0103 (5.1)	
	Other	-0.0086 (24.2)		-0.0137 (20.1)	
3 Accent/HCG (1994)	Comm		-0.0062 (6.0)	-0.0130 (9.4)	
	EB		-0.0012 (2.6)	-0.0070 (9.6)	
	Other		-0.0026 (2.6)	-0.0146 (9.6)	
4 Wardman (1985)	Urban		-0.0181 (1.85)	-0.0378 (11.57)	
	I-Urban		-0.0038 (7.24)	-0.0052 (16.45)	
5 TPA (1990)	Comm		1.00	1.30	
	Other		1.00	1.15	
6 Wardman (1988)	Comm		-0.0440 (36.64)	-0.0490 (34.74)	
	Leis		-0.0360 (19.80)	-0.0430 (22.13)	
7 Wardman et al. (1997)	Alone	-0.0013 (4.8)			-0.0015 (6.0)
	Group	-0.0014 (1.9)			-0.0029 (4.7)
8 HFA et al. (1993)	Work			-0.0019 (5.2)	-0.0007 (3.3)
	EB			-0.0025 (5.7)	-0.0014 (4.8)
	Shop			-0.0025 (4.4)	-0.0022 (4.3)
	Social			-0.0077 (6.4)	-0.0059 (4.5)
9 Halcrow Fox (1996)		-0.0089 (23.4)			-0.0356 (11.7)
10 MVA (1992)		-0.0364 (14.3)	-0.0212 (23.2)		-0.0212 (23.2)

11 Preston & Wardman (1991)		-0.0280 (12.9)	-0.0080 (2.5)		-0.0120 (3.3)
		-0.0090 (6.4)	+0.0080 (0.7)		-0.0100 (4.0)
		-0.0040 (2.3)	-0.0020 (0.9)		

Not only does the evidence strongly support the view that a value of time derived using toll charge coefficients will be lower than a value based on fuel costs, the results lend support to the view that the toll coefficient is too large since it was always found to be greater than a public transport fare coefficient. In turn, there is some evidence that the fuel coefficient is too low. There is also some evidence to support our hypothesis that the toll coefficient will be highest when tolls are introduced on existing, untolled routes followed by tolls on new routes with the least sensitivity where tolls are already in place on a route. However, we recognise that further research in this area is warranted, given that the numeraire has a crucial role to play in the calculation of the monetary value of time, the specific purpose of which would be to conduct a detailed comparison of whether and to what extent the sensitivity to cost varies with the nature of the cost variable.

6.2Revealed and Stated Preference

The issue of the equivalence of RP and SP methods is a perenniel subject of interest. We are aware that there is some disquiet about the performance of SP methods amongst those who commission research into travel behaviour.

Theoretical considerations would lead us to expect that the performance of SP techniques will vary across different circumstances; for example, according to the means of presentation used, the type of SP exercise used and the choice context. However, our regression results indicate that there is not a great deal of variation in the performance of SP according to these factors and also that there is an encouraging level of correspondence between RP and SP methods.

We here present the British evidence of which we are aware and which is available to us where disaggregate behavioural RP and SP models have been developed in the same study. This provides the firmest basis for comparing the value of time derived by the two means since it holds other factors constant. Both of the Department of Transport's major value of time studies have included comparisons of RP and SP methods.

The results of five studies are presented in Table 22. The RP values average 6.34 with a 95% confidence interval of ±1.54, and the SP values average 5.27 with a 95% confidence interval of ±1.02. The RP values are on average 20% higher, but the difference in the means is not significant (t=1.16). However, the mode choice values of time are much closer, with the average RP value of 6.14 being only 9% higher than the mean SP value of 5.63. Possible reasons for the greater disparity in the values obtained from route choice are that in one case the RP models were based on relatively few observations and in both cases the trade-offs between time and money may well be less satisfactory than would typically be the case in mode choice contexts. Nonetheless, we find that the overall degree of similarity between the RP and SP values of time is very reasonable.

A further issue is worth raising here, but one about which there is relatively little evidence. It is noticeable in the first study in Table 22 that although the RP and SP values are on average very similar there is much more variation in the RP values. A study by Wardman (1988) compared RP and SP values segmented by a number of socio-economic factors. Whilst there was a high degree of similarity between the RP and SP models in terms of the impact of these factors on the value of time, it was noticeable that the effects were stronger in the RP model. Whilst it is the case that SP studies have estimated an impressive array of effects from socio-economic variables on the value of time (Bradley et al., 1986; HCG and Accent, 1996), this is not always the case. Indeed, Bates (1994) expresses a general level of disappointment with the market segmentation within SP models. This is an issue which warrants further attention.

Table 22: RP and SP Values of Time - British Evidence

Context and Study	Mode or Purpose	RP VoT	Mode or Purpose	SP VoT
Inter Urban Mode Choice Oscar Faber TPA (1993a)	Car	8.06	Car	7.43
	Bus	10.84	Bus	8.22
	Rail	5.06	Rail	7.46
Inter Urban Mode Choice TPA (1992)	Rail & Car	6.92	Rail Car	6.38 5.60
	Rail & Coach	2.04	Rail Coach	3.41 3.18
Inter Urban	Rail Commuting	4.65	Rail Commuting	3.97

Mode Choice Wardman (1988)				
	Coach Commuting	5.44	Coach Commuting	4.99
Motorists' Route Choice Wardman (1986)	Car Commuting	7.70	Car Commuting	4.97
	Car Leisure	5.51	Car Leisure	6.45
Motorists' Route Choice HCG & Accent (1996)	Car Commuting	3.98	Car Commuting	2.98
	Car Other	9.54	Car Other	3.48

Note: All values are in 1994 quarter 4 prices. The business travel values for the final study have been removed because the RP and SP values may well reflect employer's values to somewhat different extents.

6.3Functional Form

The preceding discussion of RP and SP values of time was based on constant values of time. These are derived from utility functions which are linear-additive and which are by far the most commonly used.

A number of studies have examined the issue of the functional form of the utility expression of choice models and how the value of time might vary with respect to time and money. Analysis has been conducted of how the value of time is influenced by:

i)the sign of time or money variations;
ii)the size of time or money variations
iii)the absolute level of time and money.

Gains and Losses

One of the earliest findings regarding functional form to be derived from SP models was that losses had greater value than corresponding gains (Steer Davies Gleave, 1981). The recent value of time study has examined this issues in some detail. It was found that time increases are valued more highly than time reductions. The rather convincing argument advanced to explain this finding was that the values obtained relate to the short run where "a time loss on a given journey can be especially inconvenient; at the same time, in the short run it may be difficult to find good use for a corresponding time gain".

However, a finding of considerable significance to the interpretation of these results relates to the estimated cost coefficients being far higher for cost increases than cost reductions, with the difference being far greater than was apparent for the time coefficients, yet the arguments surrounding short run scheduling constraints do not apply to cost variations. This raises the possibility that there is some other explanation of the findings relating to gains and losses and the suspicion inevitably arises that the SP responses have been influenced by strategic bias

A possible solution to this is to conduct two separate SP exercises, one of which stresses the short run nature of the exercise whilst the other emphasises a longer term evaluation after allowing for any necessary rescheduling of activities. If both exhibit similar relationships between losses and gains then the short run explanation is not a valid one. We did not find any attempts to carry out such a test in the studies examined.

Magnitude of Time Variation

The recent value of time study also found that large changes in time often had a larger unit value than small changes, with small time savings having zero value in some instances. These results seem plausible, because better use can be made of larger time savings and larger time losses have more serious impacts. However, there is an element here of scheduling constraints which would imply that the finding relate more to the short run. There is also the issue of whether SP exercises are a satisfactory means of examining small time changes.

With regard to theory, the value of time will vary with the size of time variation if the utility function is non-linear with respect to time. In addition to constraints on the transferability of time and rescheduling activities, there are two components to variation in the value of time:

i)the opportunity cost of time spent travelling;
ii)the disutility of time spent travelling

The disutility of travel time might be quite low for, say, the first hour of a journey, particularly if there is some novelty involved, yet the second hour becomes more tedious whilst discomfort sets in during the third hour. With regard to the opportunity cost of time spent travelling, increases in the amount of travel time will lead the rational individual to cut back on those activities which have least utility with subsequent journey time increases impacting on activities with ever higher utility. This will be particularly the case with 'day trips', where increases in travel time by a constant amount will cause ever larger proportionate reductions in the time available at the destination.

What we are here saying is that we expect diminishing marginal utility to time savings and increasing marginal utility to time losses. This means that the unit value of time will fall as the time saving increases but that it will increase as the time loss increases. Only the latter of these results is consistent with the recent value of time study results.

Value of Time and Levels of Time and Money

For any given time or cost variation, the value of time may differ according to the level of time or cost. Given that time and cost are highly correlated, the issue is similar to that of how the value of time varies with distance.

Our regression analysis obtained a positive effect on the value of time from distance, with a 10% increase in distance implying a 2% increase in the value of time. This effect is of the same sign but less strong than that apparent in the recent value of time study. That study found that the sensitivity to cost changes is greater where the cost change forms a larger proportion of the cost. The same was also true of time increases but not of time reductions. The authors speculated that the latter might be a function of the survey method, with respondents regarding time savings to be unrealistic when they form a large proportion of the actual journey time. The net effect was for the value of time to increase strongly with journey time. Table 23 provides the commuting and leisure value of time estimates from the recent value of time study split by time band and for comparison the value of time estimates that would be predicted by our regression model for broadly corresponding distances.

Table 23: Reported and Predicted Car Values of Time by Time/Distance

Accent/Hague VoT Study			Regression Model			
Time	Comm	Other	Miles	Comm	Miles	Other
10-30m	3.8	2.9	10	4.52	10	3.97
31-60m	5.6	3.0	25	5.48	35	5.17
61-120m	8.5	5.2	50	6.34	80	6.15
121-180m	15.6	5.8	100	7.34	150	7.01
> 180m		8.4			210	7.53

Note: The values predicted by the regression model assume an RP approach and that the commuting is Non-London.

It was common in early applications of SP to use the piecewise estimation procedure which involves the estimation of different coefficients for different levels of the independent variables. Such models indicate the functional relationship between the sensitivity to a variable and the level of that variable. The piecewise evidence presented in Tables 24 and 25 suggests that there is tendency for the unit disutility of travel time to fall as time increases and a tendency for the unit cost disutility to increase as cost increases, although both effects are relatively small. Thus the evidence here is that the value of time will tend to fall with journey time.

Table 24: Piecewise Estimates - MVA (1986)

		London	Provincial I	Provincial II
Time	3-4 Hours	-0.029	-0.029	-0.020
	3-5 Hours	-0.020	-0.021	-0.016
Cost	£20-£25	-0.0015	-0.0026	-0.0018
	£20-£30	-0.0016	-0.0024	-0.0027

Note: For Provincial II, the cost variations were £18-£20 and £18-£22. All coefficients represent per unit effects.

Table 25: Piecewise Estimates - MVA (1985)

Time	15-23m	-0.020
	15-33m	-0.016
Cost	110p-230p	-0.008
	110p-320p	-0.009

Wardman (1985) reports a model with a quadratic time term for inter-urban car travel and the time coefficient falls as time increases. The value of time at 1, 2 and 3 hours was estimated to be 4.21, 3.53 and 2.86 pence per minute. However, this model does not make any allowance for the cost coefficient varying with the level of cost which could impact on the value of time.

A recent piece of evidence based on an RP mode choice model for inter-urban leisure travellers (Wardman et al., 1997) found that the sensitivity to time variations falls as journey time increases and the sensitivity to cost also falls as cost increases. This is the same as the recent value of time study. However, the elasticity of the value of time with respect to time was larger than the elasticity of the value of time with respect to cost and hence the net effect was for the value of time to fall as time increases which conflicts with the value of time study evidence. Table 26 shows how the marginal value of time varies across various quartiles of round trip journey times in the actual data set for car and train. However, it should be noted that the aim of this study was to identify the functional form which provided the best explanation of demand behaviour, with particular emphasis on the model's elasticity properties, and these may not necessarily provide the best account of variation in the value of time.

Table 26: Value of Time and Levels of Time - Wardman et al. (1987)

Car Time	Car VoT	Train Time	Train VoT
-92	14.01	-121	6.91
93-120	12.52	122-170	5.21
121-151	11.87	171-220	4.27
152+	10.82	221+	3.63

The within study evidence tends to suggest that the unit disutility of time falls with time and the unit disutility of cost falls with cost. This is a significant finding since it is not consistent with conventional economic theory. However, there is conflicting evidence across studies of the net outcome of these two effects and how the value of time varies with distance. The evidence from across studies used in the regression analysis reported in Table 15 is therefore particularly important in drawing together results from studies with somewhat disparate results.

6.4Value of Time and Mode

The regression model reported in section 5 was successful in estimating a number of strong influences from mode on the value of time. Since that exercise involved the comparison of values of time across studies, it was necessary to examine variation in the value of time according to both the mode used and the mode being valued. It was found that mode used was having a stronger effect on the value of time than the mode itself.

The previous analysis was hampered by the large number of combinations of mode used and mode valued, which meant some combinations had very small sample sizes. We here report in Table 27 the results of comparing variations in the value of time across modes which, because the variation is observed within a study, controls for the mode used. The results are obtained from models which have allowed the time coefficient to vary by mode, and we have also ensured that the numeraire is held constant, so that any differences in the value of time are attributable to different travel conditions by mode. The limited number of observations in Table 27 reflects the fact that the specification of mode specific parameters in mode choice models is not common practice.

The two modes being compared are denoted 1 and 2, with respective mean values of time of X_1 and X_2. The mean of the ratio of the value of time for mode 1 and mode 2 ($_R$) is also given whilst X_1>X_2 denotes the proportion of cases where the value of time for mode 1 exceeds the value of time for mode 2.

Table 27: Value of Time by Mode

$Mode_1$	$Mode_2$	X_1	X_2	tX_{1-X2}	$_R$	X_1>X_2	Obs
Urban Car	Urban Bus & Rail	3.84 (0.35)	4.25 (0.41)	0.77	0.99 (0.08)	30%	20
Urban Car	Urban LRT	2.86 (0.60)	2.85 (0.76)	0.01	1.18 (0.28)	33%	6
Inter Urban Car	Inter Urban Rail	8.61 (1.44)	8.60 (1.60)	0.00	1.05 (0.10)	43%	7
Inter Urban Coach	Inter Urban Rail	7.81 (1.85)	6.22 (1.57)	0.65	1.28 (0.16)	83%	6

Note: X_R is the mean of the ratio of X_1 and X_2. The standard deviations of the means (standard errors) are given in brackets.

The evidence suggests that there is little difference in the value of time by mode in the urban context. The results of comparing car and bus and car and train in the urban context were so similar that they have been combined. Although the public transport modes have a higher mean value of time, the difference is not significant. LRT performs better, presumably because it is perceived as offering an improved travelling environment compared to rail and bus, and its mean value of time is the same as for car. However, it should be noted that the results are based on the consideration within SP exercises of LRT services which were not in existence at the time.

In the inter-urban context, car and rail have the same mean values of time across the seven studies where they can be compared. The main difference apparent in Table 27 is that coach travel has a higher value than rail, which can be expected, although again the difference is far from significant.

The evidence from these controlled comparisons of the value of time across mode, whilst admittedly based on small sample sizes, tends to support the conclusions of the regression analysis that it is the characteristics of the modal user rather than of the modes themselves which is the main determinant of variations in the value of time.

6.5Value of Time and Purpose

The analysis of purpose reported here follows along the same lines as that for mode reported in the previous section. Unlike for the analysis of mode however, different individuals are contained in the different purpose categories. Whilst this means that there is more scope for extraneous factors to influence the results, we do not feel that this will pose a serious problem since the most important factors will be controlled for. Table 28 presents the results of studies which have reported value of time estimates split by purpose.

Table 28: Value of Time by Purpose

$Purp_1$	$Purp_2$	X_1	X_2	tX_{1-X2}	$_R$	$X_1>X_2$	Obs
Comm	Leis	5.84 (0.25)	5.06 (0.23)	2.32	1.24 (0.05)	61%	97
Comm London & SE	Leis London & SE	6.00 (0.22)	5.02 (0.22)	3.14	1.39 (0.06)	64%	66
Comm & Peak Non London	Leis & Off Peak Non London	4.84 (0.41)	4.25 (0.36)	1.10	1.28 (0.10)	59%	58
Std EB Urban	Leis Urban	6.86 (1.31)	4.52 (0.44)	1.70	1.57 (0.20)	63%	28
Std EB Inter Urban	Leis Inter Urban	15.09 (1.35)	7.02 (0.61)	5.45	2.26 (0.14)	100%	35
1st EB	Std EB	37.48 (4.61)	25.26 (3.08)	12.22	1.67 (0.16)	92%	12

Note:X_R is the mean of the ratio of X_1 and X_2. The standard deviations of the means (standard errors) are given in brackets.

Commuting is found to have a significantly greater value of time than leisure travel and the results are broadly consistent with the results presented in Table 15 where commuting had between a 14% and 35% higher value than for leisure travel. When we analyse this relationship just for London and South East travellers, we find that the value of time for commuting is on average 39% greater which is consistent with the regression results. For the Non London travellers, we have combined peak and commuting trips and off-peak trips and leisure trips. The difference between the two mean values of time is not significant, although the ratio of values of time is greater than for commuting and leisure as a whole. However, the regression model's results are not directly comparable since the latter combined commuters outside London and all peak travellers.

The values of time split by business and leisure are broadly consistent with the regression results, although the effect is not as large. On average, the business trips have values which are 57% and 126% higher than for leisure trips for urban and inter-urban travel. The corresponding figures in the regression model are 96% and 154%. Finally, first class inter-urban business travellers have a value of time which is on average 67% higher compared to the estimate of 84% in the regression model.

6.6Individual and Group Travel

The issue of individual and group travel is one which has not been handled well in disaggregate choice models and could well have introduced a considerable amount of noise into the regression model. It was not possible to include variables relating to this issue in the regression model because there is not sufficient evidence to permit worthwhile analysis. Perhaps analysis of the numeraire could proxy for some of the issues we shall consider here, but the regression model only discerned a significant effect for toll charge.

The issue of solus travel is relatively straightforward and we shall concentrate on group travel. Let us consider a group travelling together where the costs are borne entirely within that group and the decision process is internal to the group. We can specify six scenarios as far as the incidence of the cost and the nature of the decision making are concerned. These apply both to the choices apparent in real behavioural situations and to the responses derived from SP exercises.

a)One individual bears the group cost and makes the travel decisions but only on the basis of personal preferences;

b)One individual bears the group cost and makes the travel decisions on behalf of the group having some regard for the preferences of other group members;

c)One individual bears the group costs but there is some kind of group decision making;

d)Costs are shared amongst group members but one person makes the travel decisions;

e)Costs are shared and one person decides with some regard for the preferences of other group members;

f)Costs are shared and there is some kind of group decision making process.

Scenario a represents a personal value of time for the person bearing the costs and it is the group cost which reflects that person's willingness to pay. Scenario d also relates to the personal value of the decision maker but there here needs to be an adjustment to the cost variable to represent the proportion that the decision maker actually pays.

Scenario b will involve a higher value of time than scenario a because others are being considered. If there is no other source of willingness to pay within the group, it will represent the group's behavioural value of time. Scenario e will also involve inflated personal values because of the consideration of others and appropriate adjustment would also have to be made for the sharing costs.

In scenario c, where everyone in the group decides but one person bears the cost, the value of time will be higher than for both scenarios a and b since others are being more fully considered and there is an incentive for group members to maximise the benefits to them. Whilst the value exceeds the decision makers personal value, it only reflects a value of time for the group if there is no other source of willingness to pay within the group. In scenario f, the valuation will be higher than in scenario c because of the contributions of other group members. This value of time may well be the group valuation of the time saved for the group, that is the sum of personal values of each group member, although this will depend on the precise form of the decision making process and the process of sharing costs.

There are a number of other important issues which arise when dealing with group travel. These include the nature of group decision making and how this process varies across different types of group, how and to what extent household income is allocated amongst its members, to what extent inter-personal externalities count, especially regarding children, whilst the disutility of travel time can be expected to be influenced by travelling with others. Whilst these are all complicating factors, they are not central to our main point.

The main point is that it is often unclear which type of valuation is implied by individuals' RP or SP choices. Even with studies whose explicit purpose is to estimate the value of time, it is not always clear which category group travellers are in and indeed there will be differences across the sample of group travellers. Even if the sharing of costs are appropriately handled, we have seen that the implied value of time is very much different across the different scenarios.

Measures ought to be taken to identify the benefits being valued when the purpose is to estimate values of time, although the requirements in respect of forecasting will be different. In an RP exercise, this would involve suitable questions but an advantage of the SP approach is that instead of relying on a context where there is uncertainty as to what is being valued it could more closely control the benefits that the respondent is valuing.

Whilst there may be uncertainty within many of the studies in our review as to the benefits being valued, an additional problem is that often costs are not handled appropriately. This occurs where there is no distinction between solus and group travel and also where no allowance is made for cost sharing.

Let us suppose that we have two types of traveller: a solus traveller and a group traveller who pays all the costs. If both alternatives relate to car, there would be no need to make any adjustments to car costs since they are the same for each. However, if one alternative is car and the other is public transport, it would be necessary to adjust the public transport costs for group travellers to represent the group cost. If this is not done, and it is typically the case that single public transport fares are entered into the model, the public transport cost variable will be too low and hence its coefficient too high, and this will reduce the value of time estimate.

Even if a distinction is made between alone and group travel, it is necessary to adjust the cost variables to the extent costs are shared. This is so even if both alternatives are the same since the specification of costs which are too high will lead to a cost coefficient which is too low and hence will inflate the value of time estimate.

A further point to note is that the value of time might vary between solus and group travel, quite independently of any effect of companionship on the disutility of time spent travelling, to the extent that groups are more sensitive to public transport costs.

Few studies have examined the issue of solus and group travel in any great detail. In a recent study for the Department of Transport, Steer Davies Gleave (1994) found that group size reduced the propensity of leisure travellers to use rail, whilst other models were examined where the rail cost variable related to the group cost although with only a single coefficient estimated for alone and group travellers.

The recent value of time study offered the main SP exercise to both car drivers and passengers and distinguished between them in the model. Presumably the study aimed to estimate personal values, although the SP exercises did not provide any instructions in this respect. In addition, respondents were asked if costs were shared but the effect of this on the cost coefficients and hence on the value of time does not seem to have been examined. However, the problem of personal and group costs which arises when one alternative is a public transport mode and the other is car does not arise here since both alternatives related to car. The value of time was estimated to be significantly higher for passengers than drivers on business travel, but the values were similar for commuting trips whilst drivers had marginally higher values for trips for other purposes. Gunn and Rohr (1996, p18) state that, "..... it is evident that the drivers are not taking full account of their passengers' values".

We are aware of research based on SP models which has been conducted for British Rail which has examined group and solus travel. For example, it is an important issue for policies relating to railcards which offer discounts to family groups. However, the results of this research is not available to us.

We are aware of two RP mode choice models which have estimated separate cost coefficients for those travelling alone and in groups and where the latter was specified as a per person cost. The implicit assumption was that everyone in the group experiences travel time and hence the cost coefficient has been put on the same basis in order to yield per person values. However, for the reasons discussed above, it is not clear that these are per person values even though some attention has been paid to the issue of group travel.

The values of time are given in Table 29. It can be seen that there no consistency between the results in the two studies. This might be because the information needed to specify the models correctly and to interpret the results was not collected. We conclude that further research into group and solus travel, and their impact for both valuation and forecasting, is warranted, and that models are better specified with respect to the issues involved in group travel.

Table 29: Alone and Group per person Values of Time

	Toner and Wardman (1993)	Wardman et al. (1997)
Car Alone	4.50	12.48
Car Group	8.65	8.88
Train Alone	5.71	5.02
Train Group	7.00	4.19

Note: Values are in prevailing prices

7.CONCLUSIONS

This study has reviewed a large number of studies which provide estimates of the value of travel time. Central to this research was the development of a regression model which examined the influence of key variables on the value of time. This model explains the value of time as a function of:

- GDP
- Distance
- Toll charge numeraire
- Journey purpose
- Type of data and choice context
- Aim of study
- Means of SP presentation
- Mode used and mode valued

The estimated coefficients were largely plausible and statistically significant. Value of time estimates can be obtained for circumstances covered by this range of independent variables which is useful in situations where it would not be practical to obtain a value of time estimate by other means whilst it allows the results of a particular empirical study to be interpreted in relation to a large amount of previous evidence.

The most disappointing aspect of the model is that it was not possible to obtain a plausible and significant effect from variations in GDP over time on the value of time. No variations in the value of time attributable solely to location were apparent.

In addition to analysis which has examined variation in the value of time across studies, we selected a number of important issues for detailed analysis which concentrated on within study variation in the value of time.

A number of important findings have emerged from this review.

- The value of time currently recommended by the Department of Transport for non working time savings is in line with the large body of evidence reviewed. However, it does seem that a case could be made for distinguishing between commuting and other non working travel time.

- The average values of time obtained in the Department of Transport's recent value of time study are broadly consistent with the evidence we have reviewed.

- Whilst there is some variation in the performance of SP according to the choice context and the means of presentation, both the regression analysis and the detailed within study analysis indicate an encouraging degree of correspondence between RP and SP values of time.

- There are strong variations in the value of time according to distance, mode and purpose. The evidence indicates that it is the characteristics correlated with modal use, such as income, which have a stronger influence on the value of time than the characteristics of the modes themselves.

- There is strong evidence that the value of time is lower when expressed in toll units and it seems that there is some form of bias in SP responses against paying tolls. The findings indicate that the toll coefficient will be highest when tolls are introduced on existing, untolled routes followed by tolls on new routes with the least sensitivity where tolls are already in place on a route. There is also some evidence that the fuel cost coefficient is too low.

- The estimated value of time tends to be lower for gains in journey time than for losses and to be higher for larger changes in journey time. However, we are concerned that such results are to some extent an artefact of the SP method.

As a result of this review, we recommend further research in a number of areas:

- This study has concentrated on the value of in-vehicle travel time. However, there is also a large body of evidence relating to the values of other forms of time such as walking time, waiting time, idle time, search time, delay time and travel time variability. We recommend that this evidence is reviewed.

- How travellers respond to cost variations is clearly important as far as value of time estimation is concerned. There is a need for further research in this area to establish the extent to which cost coefficients for different types of cost calibrated to different forms of data are appropriate for use in estimating the value of time.

- There are a number of important issues which arise when dealing with group travel which have not received adequate attention. Few studies even distinguish between solus and group travel. As far as value of time estimation and group travel is concerned, it is important that a study identifies both the source of the willingness to pay to save time and the extent to which the benefits to the various individuals in the group count in the decision making process. Other issues surround the extent to which travelling companions reduce the disutility of travel time and the extent to which children are considered. The area of group travel and the value of time warrants further attention.

- Further research is needed into the effect of the size and the sign of the time variation on the estimated value. We need to be sure that results derived using SP methods are free from bias and respondents accurately account for the implications of time variations. There is here a role for methods other than SP and for in-depth qualitative research to accompany any quantitative research.

- Some straightforward research is required to establish whether and to what extent value of time estimates are influenced by offering round trip as opposed to one-way public transport costs. Similar analysis might also be directed at car costs where parking is a round trip cost and petrol is most naturally a one-way cost.

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Appendix 2: Correlation of Estimated Coefficients

The table below presents the correlations between the estimated coefficients in the regression model reported in Table 15.

	GDP	DIST	TOLL	EBU
GDP	1.0000	-0.5952	-0.0234	-0.0161
DIST	-0.5952	1.0000	-0.2326	0.0105
TOLL	-0.0234	-0.2326	1.0000	0.0068
EBU	-0.0161	0.0105	0.0068	1.0000
EBI	0.0283	-0.1701	-0.0279	0.4184
EB1ST	0.0806	-0.1850	0.0335	0.3574
EBVAL	-0.0262	0.0565	-0.0205	-0.4862
COMMLSE	-0.1509	0.0494	-0.0099	0.0662
COMMOTH	-0.2980	0.1842	-0.0654	0.1147
NODIST	-0.2595	0.0431	0.0625	0.1275
COSTRT	0.1452	-0.1570	0.0659	0.0272
SPMODE	-0.5693	0.2914	0.1615	-0.0414
SPRANK	-0.2020	0.1052	0.0665	-0.0817
SPRANK4	-0.0751	-0.0747	0.1323	-0.0693
GVAL	-0.1815	0.1778	-0.1474	0.0865
CARDS	-0.0667	-0.1385	0.1854	-0.0096
COMPUTER	-0.1959	0.0304	0.1747	-0.1424
CAR	-0.5649	-0.0062	-0.0746	-0.0519
RAILRAIL	-0.2582	-0.2686	0.1528	0.0080
RAILAIR-RAIL	-0.0181	-0.1994	0.0762	-0.1966
RAIL-RAILAIR	-0.0188	-0.1684	0.0365	-0.2028
UGUG	-0.1659	-0.1396	0.0743	-0.0596
PTPT	-0.2020	-0.1520	0.0614	-0.0274
ALL	-0.4445	-0.0755	0.0780	-0.0880

	EBI	EB1ST	EBVAL	COMMLSE
GDP	0.0283	0.0806	-0.0262	-0.1509
DIST	-0.1701	-0.1850	0.0565	0.0494
TOLL	-0.0279	0.0335	-0.0205	-0.0099
EBU	0.4184	0.3574	-0.4862	0.0662
EBI	1.0000	0.6678	-0.7909	0.0807
EB1ST	0.6678	1.0000	-0.6956	0.0499
EBVAL	-0.7909	-0.6956	1.0000	0.0149
COMMLSE	0.0807	0.0499	0.0149	1.0000
COMMOTH	0.1237	0.0646	-0.0041	0.1966
NODIST	0.1585	0.1020	-0.0160	0.2410
COSTRT	-0.0276	-0.0156	0.0653	-0.0876
SPMODE	-0.0313	-0.0741	-0.0055	0.0375
SPRANK	-0.0537	-0.1165	0.0430	0.0895
SPRANK4	0.0013	-0.0078	-0.0079	0.1617
GVAL	0.1142	0.0665	-0.1778	-0.0320

CARDS	*0.0562*	*0.0359*	*0.0013*	*0.0469*
COMPUTER	*-0.0657*	*-0.0302*	*0.1318*	*-0.0280*
CAR	*-0.0287*	*-0.0155*	*0.0185*	*0.0175*
RAILRAIL	*-0.0036*	*0.0026*	*-0.0383*	*-0.0591*
RAILAIR-RAIL	*-0.3639*	*-0.3407*	*0.3627*	*0.0026*
RAIL-RAILAIR	*-0.4371*	*-0.4460*	*0.4242*	*0.0037*
UGUG	*0.0268*	*0.0292*	*0.0256*	*-0.0376*
PTPT	*0.0193*	*0.0189*	*-0.0207*	*-0.2498*
ALL	*-0.0737*	*-0.0483*	*0.0935*	*0.0275*

	COMMOTH	NODIST	COSTRT	SPMODE
GDP	-0.2980	-0.2595	0.1452	-0.5693
DIST	0.1842	0.0431	-0.1570	0.2914
TOLL	-0.0654	0.0625	0.0659	0.1615
EBU	0.1147	0.1275	0.0272	-0.0414
EBI	0.1237	0.1585	-0.0276	-0.0313
EB1ST	0.0646	0.1020	-0.0156	-0.0741
EBVAL	-0.0041	-0.0160	0.0653	-0.0055
COMMLSE	0.1966	0.2410	-0.0876	0.0375
COMMOTH	1.0000	0.3991	0.0371	-0.0407
NODIST	0.3991	1.0000	0.1185	-0.1305
COSTRT	0.0371	0.1185	1.0000	-0.2421
SPMODE	-0.0407	-0.1305	-0.2421	1.0000
SPRANK	0.0619	-0.0051	-0.0705	0.3370
SPRANK4	-0.1028	-0.0831	-0.3196	0.2212
GVAL	0.0411	-0.0770	-0.2243	0.2582
CARDS	-0.0535	0.1395	-0.0350	-0.1022
COMPUTER	0.0184	0.0855	-0.1077	-0.0130
CAR	0.0212	0.0677	-0.0637	0.1321
RAILRAIL	-0.0301	0.0300	-0.1433	0.1421
RAILAIR-RAIL	-0.0227	0.0191	-0.0568	-0.0797
RAIL-RAILAIR	-0.0090	0.0223	0.0584	-0.0917
UGUG	0.1285	0.2335	0.1959	-0.2447
PTPT	-0.0043	-0.1100	-0.0620	0.0872
ALL	0.0267	0.0106	-0.0408	0.0388

	SPRANK	SPRANK4	GVAL	CARDS
GDP	-0.2020	-0.0751	-0.1815	-0.0667
DIST	0.1052	-0.0747	0.1778	-0.1385
TOLL	0.0665	0.1323	-0.1474	0.1854
EBU	-0.0817	-0.0693	0.0865	-0.0096
EBI	-0.0537	0.0013	0.1142	0.0562
EB1ST	-0.1165	-0.0078	0.0665	0.0359
EBVAL	0.0430	-0.0079	-0.1778	0.0013
COMMLSE	0.0895	0.1617	-0.0320	0.0469
COMMOTH	0.0619	-0.1028	0.0411	-0.0535
NODIST	-0.0051	-0.0831	-0.0770	0.1395
COSTRT	-0.0705	-0.3196	-0.2243	-0.0350
SPMODE	0.3370	0.2212	0.2582	-0.1022
SPRANK	1.0000	0.4094	0.0497	-0.2501
SPRANK4	0.4094	1.0000	-0.1656	0.2582
GVAL	0.0497	-0.1656	1.0000	-0.3644
CARDS	-0.2501	0.2582	-0.3644	1.0000
COMPUTER	-0.0619	0.0471	-0.1525	0.4215
CAR	-0.0218	0.0125	-0.0248	0.0248
RAILRAIL	-0.2646	-0.1625	-0.2862	0.0657
RAILAIR-RAIL	0.0048	0.0622	-0.0887	0.0930
RAIL-RAILAIR	0.0245	0.0200	-0.0821	0.0025
UGUG	-0.0529	0.0482	-0.5164	0.2512
PTPT	0.0275	0.0191	0.0722	-0.0123
ALL	0.0056	0.0676	-0.0719	0.1332

	COMPUTER	CAR	RAILRAIL	RAILAIR
GDP	-0.1959	-0.5649	-0.2582	-0.0181
DIST	0.0304	-0.0062	-0.2686	-0.1994
TOLL	0.1747	-0.0746	0.1528	0.0762
EBU	-0.1424	-0.0519	0.0080	-0.1966
EBI	-0.0657	-0.0287	-0.0036	-0.3639
EB1ST	-0.0302	-0.0155	0.0026	-0.3407
EBVAL	0.1318	0.0185	-0.0383	0.3627
COMMLSE	-0.0280	0.0175	-0.0591	0.0026
COMMOTH	0.0184	0.0212	-0.0301	-0.0227
NODIST	0.0855	0.0677	0.0300	0.0191
COSTRT	-0.1077	-0.0637	-0.1433	-0.0568
SPMODE	-0.0130	0.1321	0.1421	-0.0797
SPRANK	-0.0619	-0.0218	-0.2646	0.0048
SPRANK4	0.0471	0.0125	-0.1625	0.0622
GVAL	-0.1525	-0.0248	-0.2862	-0.0887
CARDS	0.4215	0.0248	0.0657	0.0930
COMPUTER	1.0000	-0.0359	-0.0125	0.1035
CAR	-0.0359	1.0000	0.6182	0.2080
RAILRAIL	-0.0125	0.6182	1.0000	0.2145
RAILAIR-RAIL	0.1035	0.2080	0.2145	1.0000
RAIL-RAILAIR	-0.1049	0.2473	0.2167	0.3259
UGUG	0.0341	0.4240	0.4082	0.1394
PTPT	0.0598	0.3844	0.3239	0.1281
ALL	0.1926	0.6404	0.4719	0.2330

	RAIL-RAILAIR	UGUG	PTPT	ALL
GDP	-0.0188	-0.1659	-0.2020	-0.4445
DIST	-0.1684	-0.1396	-0.1520	-0.0755
TOLL	0.0365	0.0743	0.0614	0.0780
EBU	-0.2028	-0.0596	-0.0274	-0.0880
EBI	-0.4371	0.0268	0.0193	-0.0737
EB1ST	-0.4460	0.0292	0.0189	-0.0483
EBVAL	0.4242	0.0256	-0.0207	0.0935
COMMLSE	0.0037	-0.0376	-0.2498	0.0275
COMMOTH	-0.0090	0.1285	-0.0043	0.0267
NODIST	0.0223	0.2335	-0.1100	0.0106
COSTRT	0.0584	0.1959	-0.0620	-0.0408
SPMODE	-0.0917	-0.2447	0.0872	0.0388
SPRANK	0.0245	-0.0529	0.0275	0.0056
SPRANK4	0.0200	0.0482	0.0191	0.0676
GVAL	-0.0821	-0.5164	0.0722	-0.0719
CARDS	0.0025	0.2512	-0.0123	0.1332
COMPUTER	-0.1049	0.0341	0.0598	0.1926
CAR	0.2473	0.4240	0.3844	0.6404
RAILRAIL	0.2167	0.4082	0.3239	0.4719
RAILAIR-RAIL	0.3259	0.1394	0.1281	0.2330
RAIL-RAILAIR	1.0000	0.1684	0.1182	0.2239
UGUG	0.1684	1.0000	0.1713	0.3682
PTPT	0.1182	0.1713	1.0000	0.3418
ALL	0.2239	0.3682	0.3418	1.0000