Monograph:
Wardman, M. (1998) A Review of British Evidence on the Valuations of Time and Service Quality. Working Paper. Institute of Transport Studies, University of Leeds , Leeds, UK.

Working Paper 525

Published paper
Mark Wardman (1998) *A Review of British Evidence on the Valuations of Time and Service Quality.* Institute of Transport Studies, University of Leeds, Working Paper 525

A REVIEW OF BRITISH EVIDENCE ON THE VALUATIONS OF TIME AND SERVICE QUALITY

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April 1998

DRAFT FINAL REPORT

Prepared for:

Department of the Environment, Transport and the Regions

Office of Passenger Rail Franchising

Passenger Demand Forecasting Subscription Service

GLOSSARY OF TERMS

IVT:	In-vehicle time
OVT:	Out-of-vehicle time (walk, wait and access time)
Access Time:	Time spent accessing a main mode
Headway:	Interval between trains or buses
Search Time:	Time spent searching for a parking space
Delay Time:	Time spent driving in congested conditions
Late Time:	Late arrival at destination
RP:	Revealed Preference
SP:	Stated Preference
GDP:	Gross domestic product
EB	Employer's Business trips

1. INTRODUCTION

1.1 Objectives of this Review

This study builds upon the review of in-vehicle time (IVT) values reported in Wardman (1997) and its principal objective is to conduct a review of British empirical evidence regarding the valuations of the following variables:

- walking time
- access time
- waiting time
- search time
- late time
- departure time adjustments
- congested travel time
- public transport headway
- public transport interchange

A number of other service quality variables have not been included in this review for various reasons. In some cases the range of effects discerned by a variable varies dramatically across studies, with mode specific constants providing a good example, whilst in others, such as with travel time variability or railway rolling stock, the precise nature of the variable being valued varies widely. For other variables, there is the problem that there is as yet insufficient empirical evidence or else there are problems of commercial confidentiality. Examples include the valuations of terminal facilities, advance purchase requirements and safety and cleanliness factors, but hopefully these problems will diminish over time and large scale quantitative reviews can be conducted in the future.

The valuations are obtained from disaggregate behavioural models developed since 1980 which have been estimated to Revealed Preference (RP) or Stated Preference (SP) data. The proposal specified a maximum level of disaggregation according to journey purpose and mode. This is because other segmentations, such as by income or household type, are not conducted on a consistent basis and analysis of their effects would have involved considerable additional resources. Nonetheless, future review studies might tackle such issues.

The aim of the research is to review how the valuations of the time and service quality attributes listed above and to examine how they vary according to key socio-economic and trip characteristics. Two approaches are adopted to examine the influence of these variables.

The first approach concentrates on variations in valuations across studies. In particular, the aim is to develop regression models which explain variations in the valuations listed above. This is termed inter-study analysis and its principal attraction is that it makes use of the large amount of empirical evidence that is available.

The second approach is termed intra-study analysis and it examines a number of specific issues in more detail by conducting analysis of variations in valuations that are apparent within studies. Whilst an attraction of analysing intra-study variations is that it provides a greater control of extraneous influences, thereby reducing the problems of confounding effects, this control comes at the cost of much lower sample sizes.

1.2 Inter-Study Analysis

This aspect of the research develops regression models to explain the variation in the valuations of the above listed attributes as a function of key explanatory variables. Not only do we wish to explain the money value of the various attributes but we also wish to examine variations in time valuations. Two different forms of model can be developed. One involves the development of specific regression models for valuations of each of the attributes listed above provided that there is sufficient data to support worthwhile analysis. This turned out to be the case for walk time, wait time, access time, departure time variations, headway and interchange. In contast, there are insufficient search time, late time and delay time valuations to support the estimation of a robust regression model for each. The other approach involves pooling the data for the different attributes in a single model with appropriate specification of the independent variables in order to detect the key differences across valuations. Amongst other things, this would allow analysis of the data relating to IVT collected in the previous review to be analysed alongside the additional data collected in this study. The proposal stated that we expected that such a model would contain in excess of 1000 valuations and this has turned out to be the case.

1.3 Intra-Study Analysis

There are a number of important issues which warrant more detailed analysis by reviewing the evidence that is available from within studies. The factors which we have examined using this procedure include the correspondence between Revealed and Stated Preference values, the impact of journey purpose and the relative weights of walk and wait time and of earlier and later departure time changes. It was beyond the scope of this review to examine more specific intra-study evidence, such as how a particular valuation varied with detailed socio-economic factors.

1.4 The Issues to be Examined

The research proposal set out two sets of issues to be examined which were termed either general issues or specific issues.

General Issues

The general issues are simply those which apply to all the valuations, and it is particularly important to be able to explain the values of various aspects of time and of public transport service quality in terms of the key variables used in the previous review of the value of IVT. These variables include distance, GDP, journey purpose, mode, type of data, choice context, means of presenting an SP exercise and location. Further data was collected in this study to allow the analysis of the additional general issues of:

- the impact of the number of attributes in an SP experiment on the valuations obtained.

- the influence of attribute levels and the variation in them on the estimated valuations.

- the extent to which the valuations obtained depend upon whether the specific purpose of the study was to estimate these valuations.

Specific Issues

In addition, there are more specific issues which we propose to address in this research. These are:

- Is the widespread convention of valuing walk and wait time at twice the rate of IVT consistent with the large amount of empirical evidence?

- Does the valuation of service headway vary with the level of headway and are the recommendations in the Passenger Demand Forecasting Handbook regarding service interval penalties consistent with the empirical evidence?

- Are the conventions regarding the valuation of interchange according to distance as contained in the Passenger Demand Forecasting Handbook supported by empirical evidence?

- The previous review obtained disappointing results with respect to the impact of GDP on the value of IVT. In theory, the impact of GDP should be similar across different monetary valuations. The addition of the other monetary valuations of interest to this study therefore allows further analysis of the impact of GDP and of how valuations vary over time.

- Comparisons of Revealed and Stated Preference valuations have concentrated on those obtained for IVT and the extent to which the two approaches yield similar monetary valuations of other aspects of time and service quality has been a neglected aspect of research. This study would examine whether the close correspondence between Revealed and Stated Preference values of IVT is repeated for other monetary valuations.

- We are aware of some high values for headway in mode choice contexts which contrast with the values obtained solely for public transport users in mode specific contexts and the cause of this should be examined. For example, are car users particularly sensitive to headway which would imply that this might form a significant barrier in attempts to attract more people to use public transport.

1.5 Transferability of the Findings

There can be difficulties in translating the experiences and evidence obtained in one country to another country, and the evidence that is reviewed here was obtained solely in the British context. The problems are most acute in translating absolute monetary valuations, and a remaining attraction of expressing monetary valuations as a proportion of the wage rate is to facilitate transferability.

The results obtained here can be transferred to a broader context in two respects. Firstly, this review aims to explain how monetary valuations vary across socio-economic and trip characteristics. These relative money values are inherently more transferable than absolute valuations. Secondly, the review allows the valuation of a number of attributes to be expressed in terms of the value of IVT. Such relative values would also seem to be reasonably transferable, and the common practice in many countries of valuing walk and wait time at twice IVT is testimony to this. Given that the value of IVT is that which is most widely estimated and in which most confidence can be placed in many countries, and that the valuations in time units are transferable, there is thus a firm basis for deducing in these other countries the values of the attributes covered in this study by reference to local values of IVT.

1.6 Limitations of this Review

Although the aim of this study is to provide a wide ranging review of the valuations of a number of time and service quality attributes, it is not generally well suited to the analysis of detailed issues. For example, whilst we have collected information on the mean level of attributes and the magnitude of the variation in them, in order to examine whether these factors influence the estimated values, the averaging inherent in this approach reduces the chances that statistically significant effects can be discerned and may well dampen any effect that is discerned. There are a number of reasons why analysis of certain issues is not possible within this review.

- There is no evidence relating to a particular issue. For example, we have not uncovered studies which demonstrate how the valuation of interchange varies according to the consequences of missing a connection, or how the value of walk time varies with walking conditions.

- There is some evidence but it is insufficient to form the basis of robust empirical analysis. For example, for many of the time and service quality variables there is little evidence on how their values vary with the levels they take.

- There is some evidence but it is not regarded to be sufficiently reliable. This is the case with the variances of the estimated values, where they are reported, since they may have been influenced by the number of choice observations per individual in the estimated model, the extent to which the errors in these choices are correlated and the nature of any adjustments or remedial measures that were adopted.

- There is evidence but it cannot be fully exploited. For example, some studies have estimated non linear utility expressions but the potential insight that these could provide into how valuations vary is lost because of the absence of key information on the levels of relevant variables.

- There is evidence but it is quite disparate and not readily drawn together for analysis purposes. This is the case with income segmentations which vary with the form of income used, the income bands used and the manner in which the segmentation is undertaken. Given that the emphasis of this study is on collecting a large number of valuations in order to provide a firm basis for quantitative analysis, the resources involved in collecting evidence on these factors and transforming it into a form suitable for analysis were beyond the scope of this study.

- There is evidence but the effect in question is sufficiently small that there is little or no chance that a statistically significant effect can be estimated, even if a large sample of valuations is obtained. This is particularly so in the presence of a relatively large amount of noise which is anticipated, and indeed observed, in data sets containing values from a wide range of circumstances.

The variables about which we have collected information cannot possibly cover all the sources of variation in the valuations of the time and service quality attributes covered in this review. We have collected information on what we believe to be the principal influences on these valuations. It is assumed that the net effect of unexplained variation in the valuations is randomly distributed across the sample obtained. Techniques such as multiple regression analysis, which is here widely used, recognise that we cannot observe and measure all possible influences on the variable to be explained and these omitted effects are accounted for by the specification of an error term.

1.6 Outline of the Report

Section 2 provides the background to the research reported here whilst section 3 describes the nature and quantity of the data that has been collected. Section 4 provides an overview of the valuations, listing variations by key variables where the sample size is sufficiently large to support segmentation. The inter-study analysis is reported in section 5 and section 6 contains the intra-study analysis. Conclusions and recommendations are provided in section 7.

2. BACKGROUND

We have recently completed a review of a very large amount of British empirical evidence relating to the monetary valuation of IVT derived from disaggregate choice models (Wardman, 1997). This review was based on 105 studies undertaken since 1980 which yielded 444 value of time estimates at a maximum level of disaggregation according to journey purpose and mode.

A number of important findings emerged from this study, particularly from the regression model which explained variations in the value of time across studies as a function of key variables such as journey purpose, mode valued and mode used, source of data, choice context and distance. Some of the main findings of the study were:

- The value of non working time currently recommended by the Department of Transport for project appraisal is in line with the large body of empirical evidence.
- Recommending different values for commuting and other types of non working time would be justified.
- There was an encouraging degree of similarity between the values of time derived from Revealed Preference and Stated Preference data.
- There were strong variations in the value of time according to purpose, mode and distance.
- The regression model that was developed can be used to estimate values of time for situations where it would not be practical to obtain estimates by other means.

The results of this research have formed the basis of recent amendments to the value of time chapter in the Passenger Demand Forecasting Handbook.

One of the recommendations of our review of empirical evidence relating to the value of IVT was that the analysis should be extended to cover other forms of travel time and various aspects of service quality associated with public transport modes. There are two principal reasons for this.

Firstly, the value of IVT has tended to receive much more attention than the valuations of other travel attributes. In addition to our previous review, there have been a number of other studies which have reviewed the value of IVT (CEC, 1994; Steer Davies Gleave, 1997; Waters, 1995). Walk and wait time are often included alongside reviews of IVT evidence but in lesser detail (CEC, 1994; MVA et al, 1987). A notable exception to this is the extensive review of walk time valuations provided by Axhausen and Polak (1991), although the 34 valuations from 11 studies are far fewer than are contained in this study. We are not aware of an extensive review of the other attributes covered in this study.

Secondly, many of the 105 studies contained in our previous review of the value of IVT yield estimates of the monetary values of a range of variables. Our previous study did not collect information on such valuations since its purpose was to concentrate exclusively on the value of IVT and this in itself proved to be a much larger task than we had originally envisaged. In addition, there are a number of other studies which do not provide valuations of IVT, and hence which were not included in the previous study, yet which provide estimated valuations of other aspects of time and of service quality and which therefore could be included in a review of such valuations.

3. DATA COLLECTION

3.1 Information Collected

In the previous review of the value of IVT, information was collected on the following variables:

- Year and quarter of data collection and associated GDP and RPI
- Sample size
- Distance and urban, suburban or inter-urban context
- Type of data
- Journey purpose
- Choice context
- Mode used and mode valued
- Unit of cost presented
- Location
- Omission of non traders and use of logic checks
- Purpose of the study
- Means of presenting the SP exercise

Ideally, we would have also collected information on the standard error of the valuation. However, few studies provide this figure and hence sample size is used where we want a proxy for the efficiency with which the valuation is estimated.

In addition to collecting the same information as listed above for the additional time and service quality valuations covered in this study, we have also collected data relating to a range of variables potentially relevant to explaining variations in these valuations. Some of these variables are common to all the different valuations whilst others are specific to particular valuations.

3.1.1 Common Variables

Information regarding the following variables was collected for all valuations:

Number of Variables in an SP Design

Where an SP experiment was used we recorded the number of variables which were used to characterise the alternatives amongst which choices were made. It can be hypothesised that the valuations obtained from SP models will depend on the number of attributes, although the direction of the effect is not clear.

The addition of attributes could lead to variables being increasingly ignored. This would lead to lower monetary valuations given that money is the attribute least likely to be ignored, although valuations expressed in units of time are not necessarily affected. On the other hand, it is argued that SP methods are less suspect to strategic bias, compared with willingness to pay and stated intention questions, because they offer trade-offs across a number of variables and it is less apparent how to strategically bias responses as the number of attributes increase. However, it is not clear how strategic bias would influence the valuations obtained. Thus the issue of identifying even the sign of the effect from the number of variables is one that can only be resolved empirically.

Aim of the Empirical Study

In the case of estimation using SP methods, we recorded whether the aim of the study was the estimation of the valuation of the particular variable in question. This allows us to test whether the valuations have been influenced because respondents realised the purpose of the experiment they were undertaking. It can be expected that there is an incentive to overstate valuations of an attribute where the perceived purpose of the study is quite transparent.

Mean Level of Variable

We recorded the mean value of the variable being valued where this could be discerned from the study report. This data allows an assessment of whether the valuation of a particular variable is dependent upon the level of the variable.

We also collected some information on the use of dummy variables to estimate parameters for different levels of a variable. Whilst such practice was common in the early applications of SP in marketing research, this piecewise estimation method has been undertaken far less in transport than we had anticipated.

Variation in Variable

Information on the variation in the variable being valued was obtained where an SP experiment was used and sufficient details of the statistical design were provided in the study report. This allows analysis of whether the degree of attribute variation offered to respondents influences the valuations obtained.

In the case of a choice experiment where the valuation is constrained to be the same across alternatives, which forms the vast majority of cases, the variation takes the form of the mean absolute difference in the attribute between alternatives. In the case of a ranking exercise, the variable takes the form of the mean absolute difference across all the pairwise comparisons of alternatives that could be made. In the few cases where alternative specific coefficients were estimated in a choice experiment, the variation is represented by the mean absolute deviation around the average value of the variable in question.

3.1.2 Specific Variables

Information was collected on variables which were of relevance to specific valuations and we list these for each of the valuations in turn.

Walk, Wait and Access Time

We collected information on whether the study estimated a value to walk time, access time or a combined walk and wait time. The valuations of these different types of time may differ. Access time denotes that the time valued was that spent in vehicular modes accessing the main mode, although in most cases access time included walk time.

We also recorded whether an SP estimate of the value of walk/access time was a common valuation estimated to car and another mode. This is because we had a feeling that car walk time valuations might be affected by the unrealism of offering variations in this variable, thereby leading to lower valuations as a result of a tendency for it to be ignored. The exception to this is where car walk time variations in an SP exercise were due to choices between different parking spaces or different destinations.

No additional information specific to wait time was collected. Any reported wait time values which were derived as a proportion of headway were converted to headway and analysed as part of such values. Hence the wait time valuations relate solely to actual wait time.

Search Time

No additional information specific to this valuation was collected.

Late Time

Information was collected on whether the late time valuation was estimated to an amount of late time or an expected late time. The latter is obtained as the product of the probability of being late and an amount of late time. The valuation obtained may depend on whether the respondent is confronted with a certain amount of late time or a probability of being late.

Departure Time Adjustments

Three pieces of additional information were collected for departure time variations. We identified whether the departure time change being valued was for earlier departure times, later departure times or a combination of the two on the grounds that this may be a source of variation in the valuation of departure time shifts.

We also recorded whether the departure time shift contained in an SP exercise was an explicitly defined variable or whether the respondent had to evaluate the implied departure time shift arising from different service patterns or departure time restrictions. It may be that the valuations obtained depend upon how departure time changes were offered. Explicit valuations may lead to too much emphasis being placed on departure time changes, particularly where they are implicit in real life, and this could be expected to lead to exaggerated values. On the other hand, having to calculate the implied departure time changes in the artificial environment of an SP exercise my increase the chances that this variable is ignored or that the full implications of the changes are not fully appreciated. This would cause the estimated valuations to be too low. Hence even the direction of this effect requires empirical determination.

The estimated value of departure time shifts may also depend on whether they relate to the outward journey or the return journey because the opportunity costs and time constraints may differ by direction of travel and there are also greater uncertainties about the preferred departure time of the return journey. Hence we have identified whether the valuation relates to the outward leg of a journey, the return leg of a journey, whether no specific leg of the journey was specified or whether a single valuation was obtained for both legs of the journey combined.

Congested Travel Time

In addition to collecting information on the average level of the variable in an SP exercise, which is common to all the variables being reviewed, we also collected information where possible on the average amount of uncongested travel time. This then allows a test of whether the value of congested travel time depends on the proportion that it forms of overall travel time.

Public Transport Headway

No additional information specific to this valuation was collected.

Public Transport Interchange

No additional information specific to this valuation was collected.

3.2 Amount of Data Collected

The data collected relates primarily to the valuations of time and service quality which are the main focus of this study, although some additional information relating to the value of IVT was also collected. The latter consists of 27 studies which have become available or apparent to us since the first review or which have recently been conducted and these have yielded a further 95 values of IVT. The total number of IVT valuations is therefore 539 obtained from 132 studies.

With regard to the attributes which are of specific interest to this study, Table 1 reports on the number of studies and valuations given a maximum level of disaggregation according to journey purpose and mode.

The total number of valuations available is 641, although it is not possible to analyse all these together since in some cases only a time valuation was obtained and in others only a money valuation was obtained. In 516 cases both a money and a time valuation was obtained whilst a time valuation was available in 580 cases and a money valuation was available in 577 cases.

Allowing for the fact that some studies provide evidence on more than one variable, this review of service quality valuations contains 110 studies, compared to the 105 studies in the previous review. Taking both data sets together, and including the additional studies that have been uncovered, we have collected information from 143 studies and these contain 1180 valuations. This satisfies the target number of observations in excess of 1000 set out in the proposal.

Table 1: Studies and Valuations

Variable	Studies	Values
Walk Time	43	142
Access Time	19	53
Wait Time	13	35
Walk and Wait Time	20	64
Search Time	6	11
Late Time	5	18
Departure Time Changes	13	97
Delay Time	7	21
Headway	49	149
Interchange	23	51

4. OVERVIEW OF VALUATIONS

We here describe the main characteristics of the data collected. In particular, we demonstrate how the values vary according to the key variables of journey purpose, mode used, context and the type of data used in estimation where there are sufficient valuations to undertake such disaggregations. This is the case for walk time, access time, wait time, departure time changes, headway and interchange. Descriptive statistics are provided for the overall valuations alone for search time, late time and delay time where the samples are smaller.

Although confounding effects will of course be at work here, such as a higher proportion of business trips being made by rail users, the figures illustrate a number of interesting relationships. The more sophisticated analysis reported in subsequent sections aims to isolate confounding effects to a greater degree and indeed this is precisely the aim of the analysis of intra study variation in valuations reported in section 6. The results also suggest avenues of analysis in developing regression models to explain variations in the valuations.

The descriptive statistics we have presented are the mean, the standard deviation (SD), the standard error or standard deviation of the mean (SE), the 10th (10%), 50th (50%) and 90th (90%) percentiles, a measure of the skewness of the valuations (Skew) and the number of observations in each category (Obs). These statistics are presented for both the monetary valuations and the valuations expressed in units of IVT.

The purpose categories used are empoyer's business (EB), commuting and peak period travel combined (CommP), leisure and off-peak travel combined (LeisOP) and the remaining purposes (Rest). The latter is largely composed of a category where the valuation was not disaggregated by purpose, and this relates to commuting and leisure combined in the vast majority of cases. With regard to mode used, the other category represents valuations for various combinations of users and rail here contains underground users.

4.1 Walk Time

The walk time valuations are presented in Table 2. Walk time money valuations vary little by purpose, although there are no employer's business valuations. The higher time valuations for LeisOP presumably reflects the lower values of IVT for these trips.

The money valuations of walk are higher for car users than bus users, which is to be expected, although not to a degree that makes the time valuation higher. Whilst the RP money values are somewhat higher than the SP values, we should avoid placing too much emphasis on this result since there are only two RP valuations. The impact of distance on the value of time is not clear from these figures since there are few valuations for inter-urban trips. Nonetheless, given that we have observed a positive distance effect on the value of IVT (see Table 10), we would therefore expect the time valuation of walk to fall with distance, since the money value of walk time is little different across the three contexts, and the results are here consistent with this.

At this stage, we can conclude that the data does not support the convention of valuing walk time at twice the rate of IVT, although it would also seem to be inappropriate to use a constant ratio. For all 140 valuations, the mean ratio of 1.66 has a 95% confidence interval ranging from 1.54 to 1.78 and hence it is significantly different from two.

4.2 Access Time

Access time valuations are presented in Table 3. In money terms, access time is on average valued much more highly than walk time. One of the reasons for this is that the access valuations include employer's business trips which are absent from the walk time sample. Nonetheless, it can be seen that the access valuations for CommP, LeisOP and Rest are higher than the corresponding walk time values. This may at first sight seem surprising, since access time includes travel by car and bus which is generally taken to be less highly valued than walk time. However, the involvement of car and bus to access stations may introduce increased uncertainty due to potential unreliability which incurs a penalty. Furthermore, there may be other factors, such as parking problems, interchange and monetary costs, which have not otherwise been explicitly accounted for and which would operate to inflate the valuation of access time relative to walk time. Whilst it could be reasoned that using car or bus to access a station necessarily implies that this has a lower generalised cost than walking, even after including the monetary costs of access, the scenarios covered would involve relatively long distances where walking would not be a practical option or where it may well be much more highly valued than for the 5 and 10 minute walking times typically represented by the walk time valuations in Table 2.

Access time valuations in money units are higher for car users than bus users, although the valuation for rail users will be strongly influenced by the relatively large proportion of business trips. The higher time valuations for bus users is a reflection of their relatively low money value of IVT whilst the lower time values for rail users stem from their relatively high valuation of IVT.

The RP valuations in both time and money units are lower than the SP valuations, although again the distribution of business trips is influencing the results. It would also seem that a distance effect is at work, on both the time and money valuations, although again business trips form a significant proportion of inter-urban trips and these will be affecting the results.

Despite the higher money value of access than walk time, the mean time valuation of 1.81 is less than the weight of 2 typically attached to access time although the difference is not statistically significant. Whilst the time valuation is higher than for walk, it is a far lower proportionate increase than for the money values and this is because the IVT's are longer in the sample of access time values and, as is clear from Table 10, the value of IVT increases with distance.

4.3 Walk and Wait Time

The valuations reported in Table 4 are based on the results of studies which combined walk and wait time into a single term, although it was not feasible to try and identify the proportions of each type of time when we collected the data.

Walk and wait time is valued more highly than walk time in monetary terms but less highly in time terms, although it is only the difference in the money valuations which is statistically significant. Both the money and time valuations are valued more highly by car and rail users but there is little difference according to journey purpose. Given that the valuations relate entirely to urban and suburban trips, little can be said about possible distance effects, whilst there are no RP valuations against which comparisons can be made.

The mean time valuation of walk and wait time of 1.46 is somewhat below the conventional value of two and the difference is highly statistically significant.

4.4 Wait Time

Table 5 presents results for the wait time valuations. The overall mean monetary value is very similar to that obtained for walk time and the two data sets are alike in having no business trips. Wait time values are higher for commuting than leisure, as is expected, and very much higher for rail than bus. However, the time valuation of wait is higher for bus than rail users and this stems from the larger money valuations of IVT for rail users. Nonetheless, the contrast between the time and money valuations of wait time for bus and rail are large and the relatively small sample size could here be a contributory factor.

The RP monetary values are higher than the SP values although the difference is not significant (t=1.19) and here the small number of RP values does not help. The same applies to the time valuations. We might expect wait time values to be lower for SP if respondents do not accept variations in wait time, for example, because they would always turn up a short while before expected departures, and hence they have ignored it. The absence of many inter-urban trips means that it is not clear whether any distance effect is apparent on the wait time valuations.

We again observe that the conventional weighting is not empirically supported. The mean valuation of wait time in units of IVT is 1.47 which is highly significantly different from 2.

Of the four sets of values discussed so far, all have time values less than the conventional weight of 2 and in all but one case the difference is statistically significant. When we combine all these values, the average valuation in time units is 1.62 with a very precise 95% confidence interval ranging from 1.53 to 1.71. If we focus solely on walk time, wait time and the two combined, the mean valuation is 1.58 with a narrow confidence interval from 1.49 to 1.67. We therefore conclude that time spent waiting for and accessing public transport should not be valued at the current convention of twice IVT.

4.5 Departure Time Changes

It is for departure time changes that the valuations expressed in time and money units have the least correspondence. Of the 97 valuations of departure time changes, there are 74 monetary values and 56 time values, and in only 33 cases (34%) do we have both money and time valuations. This is because there has been a tendency in the SP studies used to value departure time changes to avoid offering trade-offs amongst many variables in an attempt to keep the SP exercise relatively simple, and hence there are a relatively large number of studies which do not contain both IVT and cost.

The results for the departure time change valuations are given in Table 6. The overall money value is heavily influenced by the large valuation for business trips, which is also the cause of the large valuations for rail, although business travellers appear to have relatively low time valuations of departure time. The time valuations are somewhat higher for commuting, which is not surprising given the greater time constraints involved, and this is so even though commuting has been found to have a higher valuation of IVT than the other non-business trips.

Although most of the money values relate to inter-urban trips, the results suggest a positive distance effect. However, the distance effect on the time valuations is not clear. We have here distinguished between values which relate to earlier departure times, later departure times or both. There is no evidence to suggest that early and late time are valued differently, and this is strongly confirmed by subsequent analysis reported in sections 5.3 and 6.3.

The mean departure time variation expressed in units of time is 0.72, with a 95% confidence interval ranging from 0.54 to 0.90. These valuations largely relate to planned changes in departure times, such as the extent to which car travellers are prepared to leave home at a different time or else rail travellers are willing to change the train they plan to catch. Hence the valuations do not relate to wait times, as would be the case for departure time changes confronting those with random arrivals at a station or bus stop. In such cases, it would be expected that departure time changes in time units have a value greater than one. However, for the travellers covered by the valuations contained in this review, there is no reason why departure time changes in time units should have a value greater than one.

4.6 Headway

The descriptive statistics for headway valuations are reported in Table 7 and this is the largest of our data sets. As expected, the overall mean valuation of headway is less than one, moreso for the non business journeys. If travellers turned up at random, whereby wait time would be half the service interval, and wait time was valued at twice IVT, the time valuation of headway would be one. Whilst this does not account for convenience factors, the evidence from this review is that wait time is valued somewhat less than twice IVT whilst it not the case that travellers turn up randomly for train or bus services.

Business travellers have by far the highest monetary values, and this will have influenced the value for rail. We had suspected that car users would have higher headway values than others, yet this is not the case for either the money or time valuations, and this issue will subsequently be further explored.

Noticeably the RP values are higher than the SP values. Although the difference is not significant for either the money or the time values, with t ratios of 1.04 and 0.65 respectively, this relationship between RP and SP values is evident in subsequent analysis. There is evidence of a distance effect on the money values, and this is consistent with the absence of any real effect on the time valuation since the effect of distance on the money value of headway has been found to be reasonably similar to the effect of distance on the value of time.

Table 2: Walk Time Valuations

	Money Value								Time Value							
	Mean	SD	SE	10%	50%	90%	Skew	Obs	Mean	SD	SE	10%	50%	90%	Skew	Obs
All	4.78	2.89	0.25	1.82	3.99	8.30	1.46	131	1.66	0.71	0.06	0.90	1.52	2.67	0.40	140
EB								0								0
CommP	4.66	3.07	0.47	1.80	3.54	9.00	1.60	43	1.52	0.61	0.09	0.65	1.45	2.31	0.23	46
LeisOP	4.68	3.29	0.57	1.77	3.75	9.95	2.10	33	1.82	0.78	0.13	1.03	1.61	2.83	1.19	36
Rest	4.93	2.51	0.33	1.81	4.85	8.07	0.56	55	1.68	0.73	0.10	0.89	1.55	2.73	0.91	58
Car	4.91	2.55	0.29	1.83	4.57	8.31	0.64	79	1.57	0.68	0.08	0.84	1.43	2.60	0.56	78
Bus	3.30	2.21	0.42	1.38	2.97	5.76	2.69	27	1.87	0.71	0.13	1.13	1.58	2.86	0.96	32
Rail								0	1.31	0.04	0.03					2
Other	5.96	3.84	0.76	2.69	4.15	12.65	1.69	25	1.69	0.78	0.14	0.77	1.54	2.77	1.54	28
RP	6.31	3.50	1.42	1.45	7.13	10.50	-0.34	6	1.51	1.12	0.46	0.74	1.48	2.11	0.13	6
SP	4.76	2.88	0.25	1.82	3.99	8.24	1.48	125	1.67	0.71	0.06	0.93	1.52	2.67	0.92	134
Urban	5.01	3.59	0.54	1.65	4.04	10.73	1.79	44	1.86	0.84	0.13	0.89	1.95	2.82	0.40	45
Suburban	4.69	2.49	0.27	1.87	3.88	8.23	0.67	85	1.59	0.62	0.07	0.94	1.44	2.32	1.13	91
Inter	4.91	1.52	1.07					2	1.16	0.31	0.15	0.72	1.24	1.43	-1.42	4

Table 3: Access Time Valuations

	Money Value								Time Value							
	Mean	SD	SE	10%	50%	90%	Skew	Obs	Mean	SD	SE	10%	50%	90%	Skew	Obs
All	15.31	15.58	2.29	2.32	10.51	43.81	1.50	46	1.81	0.75	0.10	0.88	1.88	2.70	0.92	52
EB	37.84	18.26	6.08	11.37	39.74	53.51	-0.33	9	1.95	0.65	0.20	0.90	1.88	2.97	0.06	10
CommP	7.72	6.89	1.99	1.15	4.71	20.26	1.04	12	1.62	0.54	0.16	0.69	1.96	2.15	-0.71	12
LeisOP	13.28	10.26	2.57	2.32	9.92	28.91	0.41	16	2.13	0.93	0.22	0.89	2.04	3.75	0.91	17
Rest	6.48	3.99	1.33	1.38	7.18	11.13	0.10	9	1.43	0.54	0.15	0.64	1.40	2.19	0.02	13
Car	7.69	5.74	1.39	1.16	7.06	15.67	0.64	17	1.54	0.54	0.13	0.78	1.64	2.13	-0.33	16
Bus	3.36	0.28	0.13	3.08	3.34	3.73	0.27	5	1.98	0.15	0.07	1.72	2.03	2.08	-2.12	5
Rail	22.37	16.13	9.31	7.85	19.51	39.74	0.77	3	1.31	0.43	0.21	0.87	1.25	1.92	0.96	4
Other	23.29	18.29	3.99	2.66	22.23	54.70	0.76	21	2.00	0.88	0.17	0.88	1.88	3.21	0.74	27
RP	7.46	4.49	1.84	1.38	9.20	11.28	-0.64	6	1.38	0.59	0.18	0.59	1.25	2.19	0.31	11
SP	16.48	16.32	2.58	2.58	10.73	51.92	1.32	40	1.91	0.75	0.11	0.89	1.95	2.94	0.97	41
Suburban	5.14	3.81	0.88	1.16	3.26	11.68	1.03	19	1.46	0.56	0.13	0.61	1.37	2.11	-0.16	18
Inter	22.46	16.77	3.23	3.48	20.58	53.81	0.91	27	2.01	0.78	0.14	0.94	1.95	3.07	0.98	34

Table 4: Combined Walk and Wait Time Valuations

	Money Value								Time Value							
	Mean	SD	SE	10%	50%	90%	Skew	Obs	Mean	SD	SE	10%	50%	90%	Skew	Obs
All	6.61	4.97	0.64	1.69	4.77	14.43	1.15	61	1.46	0.79	0.10	0.61	1.31	2.43	0.93	64
EB	4.41	2.11	1.49					2	1.29	1.29	0.15	1.14	1.15	1.60	1.73	3
CommP	6.22	5.49	2.24	1.50	4.00	14.55	0.90	6	1.54	1.29	0.49	0.16	1.16	2.99	0.56	7
LeisOP	6.48	4.36	1.17	1.61	4.17	13.40	0.53	14	1.61	0.98	0.25	0.25	1.34	3.58	0.93	15
Rest	6.83	5.29	0.84	1.68	5.41	14.98	1.27	39	1.40	0.64	0.10	0.61	1.39	2.17	0.74	39
Car	7.11	4.76	0.74	1.73	6.68	14.76	0.60	41	1.55	0.89	0.14	0.39	1.53	3.18	0.70	44
Bus	3.33	0.23	0.14	3.12	3.29	3.59	0.76	3	1.14	0.61	0.36	0.69	0.90	1.85	1.51	3
Rail	6.23	3.72	1.12	2.77	4.79	13.30	1.04	11	1.39	0.38	0.11	1.14	1.21	2.18	1.67	11
Other	5.53	8.79	3.58	1.40	1.71	23.42	2.41	6	1.06	0.59	0.24	0.60	0.86	2.17	1.61	6
Urban	7.77	5.41	1.10	1.50	8.30	16.02	0.32	24	1.60	1.03	0.21	0.19	1.61	3.50	0.47	24
Suburban	5.86	4.58	0.75	1.74	3.58	11.87	1.98	37	1.37	0.61	0.09	0.65	1.27	2.16	1.27	40

Table 5: Wait Time Valuations

	Money Value								Time Value							
	Mean	SD	SE	10%	50%	90%	Skew	Obs	Mean	SD	SE	10%	50%	90%	Skew	Obs
All	4.76	2.92	0.51	1.26	4.27	9.75	0.96	33	1.47	0.52	0.09	0.94	1.33	2.19	1.45	34
EB								0								0
CommP	5.58	3.55	0.98	1.75	4.49	11.56	0.77	13	1.51	0.41	0.11	1.01	1.38	2.19	0.74	14
LeisOP	4.31	2.56	0.64	1.24	4.45	9.09	0.67	16	1.28	0.44	0.10	0.80	1.17	2.03	1.27	16
Rest	3.85	1.62	0.81	1.67	4.05	5.59	-0.80	4	2.07	0.80	0.40	1.63	1.69	3.27	1.96	4
Car								0								0
Bus	2.17	0.99	0.35	1.22	2.05	3.94	0.20	8	1.70	0.75	0.25	0.90	1.63	2.38	1.05	9
Rail	7.05	2.39	0.72	4.34	5.70	10.12	0.19	11	1.16	0.13	0.04	0.99	1.16	1.37	0.43	12
Other	4.42	4.42	0.73	1.27	3.96	9.08	2.01	14	1.58	0.44	0.12	0.87	1.65	2.22	-0.18	13
RP	6.81	3.81	1.56	4.22	5.29	12.47	1.87	6	1.75	0.43	0.21	1.31	1.69	2.34	0.93	4
SP	4.47	2.74	0.50	1.25	3.94	9.59	0.82	27	1.43	0.53	0.09	0.91	1.31	2.05	1.67	30
Urban	5.35	3.09	0.75	1.26	4.72	9.93	0.33	17	1.44	0.60	0.15	0.96	1.20	2.55	2.12	17
Suburban	3.40	1.48	0.39	1.25	3.38	5.59	-0.11	14	1.49	0.42	0.11	0.80	1.53	2.04	-0.54	13
Inter	9.08	4.76	3.93					2	1.47	0.59	0.29	1.05	1.25	2.34	1.72	4

Table 6: Departure Time Adjustment Valuations

	Money Value								Time Value							
	Mean	SD	SE	10%	50%	90%	Skew	Obs	Mean	SD	SE	10%	50%	90%	Skew	Obs
All	22.77	35.36	4.11	1.05	10.24	81.56	2.69	74	0.72	0.64	0.09	0.30	0.50	1.30	2.60	56
EB	59.68	49.63	10.83	12.14	36.47	141.3	0.98	21	0.57	0.31	0.09	0.31	0.47	1.28	2.04	12
CommP	13.98	7.06	1.82	2.71	14.07	24.31	-0.26	15	1.03	1.08	0.29	0.12	0.55	3.15	1.50	14
LeisOP	4.93	3.25	0.73	0.46	5.05	9.35	0.41	20	0.58	0.52	0.15	0.13	0.40	1.75	2.43	12
Rest	6.86	5.05	1.19	0.46	6.81	15.21	0.26	18	0.69	0.32	0.07	0.23	0.65	1.21	0.29	18
Car	5.34	8.89	0.27	0.32	1.71	24.60	1.96	11	0.61	0.72	0.13	0.17	0.42	1.29	3.23	31
Bus	0.35	0.19	0.13					2	0.34	0.19	0.13					2
Rail	26.65	37.69	4.83	4.72	11.91	88.75	2.43	61	0.90	0.51	0.11	0.45	0.79	1.75	1.84	23
Urban	0.99	0.70	0.23	0.21	0.88	1.94	0.44	9	0.44	0.23	0.09	0.21	0.44	0.84	1.08	6
Suburban	12.65	12.22	6.11	1.62	11.67	25.63	0.14	4	1.06	1.26	0.42	0.08	0.50	3.50	1.31	9
Inter	13.17	10.61	1.81	4.01	9.67	29.36	1.67	34	0.82	0.41	0.09	0.43	0.74	1.25	1.64	20
Any								0	0.58	0.48	0.10	0.33	0.42	1.00	3.59	21
Early	25.24	38.01	7.31	2.64	9.53	104.7	2.18	27	0.64	0.59	0.12	0.35	0.50	1.53	3.11	23
Late	27.16	42.15	8.11	1.06	14.07	90.31	2.60	27	0.69	0.71	0.14	0.15	0.45	1.33	2.89	24
Both	13.52	16.42	3.67	0.47	7.96	47.72	1.73	20	1.03	0.58	0.19	0.42	0.89	2.50	2.41	9

Table 7: Headway Valuations

	Money Value								Time Value							
	Mean	SD	SE	10%	50%	90%	Skew	Obs	Mean	SD	SE	10%	50%	90%	Skew	Obs
All	4.27	5.98	0.50	0.71	2.56	9.90	4.18	140	0.80	0.46	0.04	0.27	0.70	1.41	1.18	145
EB	13.94	11.93	2.98	2.43	10.11	41.23	1.66	16	0.91	0.49	0.12	0.28	0.73	1.66	0.64	16
CommP	3.11	2.63	0.46	0.99	2.33	5.85	2.77	32	0.78	0.45	0.08	0.29	0.66	1.52	1.11	32
LeisOP	3.26	2.85	0.42	0.69	2.66	6.48	2.08	46	0.84	0.47	0.07	0.27	0.80	1.51	0.89	47
Rest	2.71	3.12	0.46	0.61	1.81	5.56	4.09	46	0.74	0.46	0.06	0.24	0.66	1.37	1.84	145
Car	3.19	3.23	0.40	0.89	2.29	6.20	3.21	64	0.82	0.48	0.06	0.21	0.72	1.44	1.17	64
Bus	1.38	1.08	0.20	0.43	0.93	2.78	1.80	28	0.73	0.45	0.08	0.25	0.61	1.59	1.02	31
Rail	5.13	4.14	0.86	1.80	3.42	13.68	1.58	23	0.80	0.45	0.10	0.33	0.69	1.45	0.96	23
Other	9.46	10.77	2.16	1.86	5.61	30.39	2.33	25	0.82	0.45	0.09	0.38	0.68	1.39	1.81	27
RP	5.82	4.23	1.49	2.11	5.50	15.54	2.04	8	0.91	0.60	0.18	0.41	0.68	2.23	1.82	11
SP	4.17	5.99	0.52	0.69	2.43	9.88	4.25	132	0.79	0.45	0.04	0.26	0.70	1.38	1.08	134
Urban	2.36	2.81	0.62	0.44	1.75	4.13	3.36	20	0.75	0.55	0.11	0.20	0.53	1.81	1.63	23
Suburban	3.14	3.26	0.36	0.69	2.25	6.21	2.95	80	0.85	0.44	0.05	0.28	0.78	1.49	0.88	80
Inter	7.59	9.25	1.48	1.38	4.89	15.73	2.77	40	0.72	0.45	0.07	0.26	0.59	1.35	1.60	42

Table 8: Interchange Valuations

	Money Value								Time Value							
	Mean	SD	SE	10%	50%	90%	Skew	Obs	Mean	SD	SE	10%	50%	90%	Skew	Obs
All	296	282	42	27	213	625	1.28	44	31.29	22.94	3.34	8.18	22.50	67.45	1.16	47
EB	657	317	112	281	625	1334	1.43	8	32.36	13.46	5.08	14.49	37.60	47.10	-0.26	7
CommP	47	17	5	32	43	88	2.41	10	14.25	5.26	1.58	7.58	13.00	23.92	0.79	11
LeisOP	184	178	49	24	146	510	1.08	13	35.13	25.28	7.29	5.58	32.17	79.21	0.66	12
Rest	377	189	52	34	433	543	-1.02	13	39.17	26.67	6.49	6.97	38.80	77.54	0.85	17
Car	108	134	67	38	43	309	1.99	4	13.91	5.64	1.99	7.40	13.25	21.30	0.51	8
Bus	45	12	5	27	45	61	-0.40	6	20.83	9.36	3.82	13.00	18.30	38.80	1.84	6
Rail	367	215	52	79	400	683	0.06	17	36.80	20.07	5.56	12.56	37.60	72.79	0.59	13
Other	357	350	85	22	401	849	1.29	17	37.79	27.53	6.16	4.43	36.17	79.84	0.76	20
RP	345	214	80	23	400	547	-0.48	7	43.08	32.86	10.39	4.72	41.57	102.26	0.58	10
SP	287	295	48	27	183	677	1.43	37	28.10	18.81	3.09	8.18	22.00	51.22	1.02	37
Suburban	61	70	17	23	41	179	3.23	17	16.22	8.41	1.84	7.46	13.60	30.24	1.12	21
Inter	445	264	51	110	437	734	1.23	27	43.46	23.80	4.66	12.31	42.05	76.43	0.57	26

4.7 Interchange

The interchange valuations relate to the need to change train or bus in the course of a journey. Interchanges as part of multi-modal journeys or accessing a main mode have not been covered in this review. The interchange valuation does not relate to the time spent changing trains or buses and in the studies we have covered it represents a fixed penalty to interchange in addition to any wait time penalty. However, any particular value will of course be influenced by conditions and facilities at the interchange location and other factors such as the chances and consequences of missing a connection. These effects are regarded to be random effects across the valuations we have obtained.

The interchange values relate to the need to change train or bus in the course of a journey. Interchanges as part of multi-modal journeys or accessing a main mode are not covered in this review. The interchange values do not relate to the time spent changing trains or buses and in the studies we have covered it represents a fixed penalty to interchange in addition to any wait time. However, any particular value will of course be influenced by conditions and facilities at the interchange location and other factors such as the chances and consequences of missing a connection. These are assumed to be random effects across the valuations we have obtained.

Although interchange as defined here is different in nature to the other attributes covered in this review, because it is a fixed penalty rather than an amount of time spent interchanging, it has been included because it can be an important influence on travel choices whilst the data can be readily collected alongside the other information necessary for this review.

The interchange valuations are reported in Table 8. In money units, the valuation for business trips is far higher than for other purposes. The interchange valuation for commuting is low, and a likely explanation of this is that there is a familiarity effect at work whilst the relatively high service frequencies associated with commuting reduce the consequences of missed connections. The time valuation of interchange amongst commuters is also lower than for the other purposes and, as a result of their high valuations of IVT, business travellers have the same time valuations of interchange as leisure and other travellers. We had expected car users to have relatively high interchange valuations, and the results split by mode may have again been influenced by the large proportion of business travellers for rail. The RP valuations in both money and time units are higher than the SP valuations. Although the differences are not statistically significant, with t ratios of 0.62 and 1.38 for the money and time valuations respectively, a trend seems to be emerging with regard to the RP and SP valuations which warrants more detailed analysis and this is reported in subsequent sections.

The segmentation according to suburban and inter-urban trips indicates that there is a strong positive relationship between the interchange valuation, in both time and money units, and distance, although there may be confounding effects with commuting. A positive distance effect would be consistent with the recommended interchange penalties contained in the Passenger Demand Forecasting Handbook which is used by most of the train operating companies in Great Britain.

4.8 Search, Late and Delay Time

There are insufficient observations of search, late and delay time to conduct disaggregations to the same degree as in the preceeding tables. Table 9 provides descriptive statistics for the overall money and time valuations of these variables.

Search time, which relates to the amount of time searching for a parking space, is valued on average 38% higher than IVT and the difference is significant (t=2.23). Similarly, time spent travelling in congested traffic conditions is valued 48% more highly on average than time spent driving in free flow traffic. The mean valuation of delay in time units has a precise confidence interval ranging from 1.34 to 1.62, and a t statistic of 6.86 is obtained for the test of the hypothesis that the time value is actually one.

Table 9: Search, Late and Delay Time Valuations

	Mean	SD	SE	10%	50%	90%	Skew	Obs
	Money Values							
Search	5.80	3.45	1.15	1.32	7.06	12.32	0.41	9
Late	23.62	15.58	3.67	7.41	17.79	49.44	0.72	18
Delay	8.07	3.42	0.75	4.98	7.05	11.19	1.46	21
	Time Values							
Search	1.38	0.52	0.17	0.79	1.22	2.26	0.84	10
Late	7.40	3.86	1.16	1.94	8.00	14.00	0.19	11
Delay	1.48	0.32	0.07	1.04	1.43	2.01	0.40	21

Late time was distinguished according to whether respondents evaluated an expected late time or an actual late time. The time valuation data set is entirely composed of expected late time. For the money valuations, 14 related to expected late time and 4 to actual late time. Although this is a small sample, we found the expected late time valuations to average 26.79 pence, with a standard error of 4.33, which is much higher than the mean valuation of actual late time of 12.51 with a standard error of 2.44. The difference in these mean valuations is significant (t=2.87) and it does not seem to be attributable to journey purpose or mode used.

Whilst we would not wish to draw firm conclusions on the basis of this small sample of observations, there is some evidence that the reactions to expected changes are not the same as to equivalent actual changes, indicating that the implied dispersion of the late time is important as well as its mean. It may be that the valuation of late time is highly non-linear with respect to late time and this warrants further analysis in studies specifically focussing on this issue.

It can be seen that late time is very highly valued in time units. A minute of late time corresponds to 7.40 minutes of IVT, although this mean valuation does have a relatively large confidence interval ranging from 5.08 to 9.72.

5. INTER-STUDY ANALYSIS

The preceeding tables have examined the impact on the valuations of only one variable at a time. Whilst some interesting findings have emerged with regard to the segmented valuations, as well as the overall valuations, and these provide guidance for further analysis, we need to isolate the confounding effects that were apparent and also obtain more general models relating valuations to the various factors which influence them and about which we have information. This is achieved by multiple regression analysis of the valuations and this section reports on the various regression models that have been developed.

Section 5.1 reports an updated IVT regression model on the basis of the additional IVT valuations obtained in this study. Sections 5.2 to 5.5 report separate regression models calibrated to the money valuations of those variables for which we have sufficient data to support such analysis. These are a combined model for the out-of-vehicle time (OVT) attributes, and separate models for departure time changes, headway and interchange. Section 5.6 provides a summary of the findings of analysis of the monetary valuations prior to reporting in section 5.7 a regression model which is calibrated to all the money valuations obtained to provide a comprehensive model of time and service quality valuations. Section 5.8 reports a model which uses the evidence from the previous models based on monetary valuations and aims to explain the time valuations of the variables covered in this study.

The regression models take the same basic form regardless of whether the dependent variable (V) is the money or time valuation:

$$V = \alpha \prod_{i=1}^{m} X_i^{\beta_i} e^{\sum_{j=1}^{n} \sum_{k=1}^{p-1} \lambda_{jk} D_{jk}} \qquad (1)$$

Continuous variables are denoted by X_i, and the form of the model is such that the coefficients associated with these m variables (β_i) denote the proportionate effect on the valuation after a given proportionate change in the variable in question. The other n variables are categorical in nature and are represented by dummy variables. If there are p categories of a variable, p-1 dummy variables are specified and their coefficients (λ_{jk}) are, for each categorical variable, interpreted in relation to the arbitrarily omitted category. In this formulation, the λ_{jk} denote the proportionate effect on the valuation of level k of the j'th categorical variable. The parameters are estimated by applying ordinary least squares regression to a logarithmic transformation of Equation 1.

5.1 Updated In-Vehicle Time Regression Model

The previous review (Wardman, 1997) developed a regression model to explain variations in the value of IVT. Given that we have obtained information on an additional 95 IVT valuations from a further 27 studies, we have taken the opportunity to update the IVT regression model. It takes exactly the same form as previously and the models based on the two data sets are reported in Table 10.

The purpose here is not to describe the reasons for including this particular set of variables in the model but to establish the impact of the additional data on the attributes. Appendix 1 provides a description of the variables included in the model. It can be seen that the inclusion of an additional 95 observations of IVT has hardly any impact on the coefficient estimates, with the exception that the SP-Rank variable now has a negligible influence on the value of time estimate. The t statistics tend to be higher, as is to be expected, and the goodness of fit has also improved. The stability of the coefficient estimates and the t statistics in the light of the additional data is consistent with the absence of collinearity problems.

We have also provided simplified models in Table 11 which contain only the key variables of distance, purpose, whether the valuation was derived from SP data and the mode used. The mode used and mode valued variables were specified separately, but none of the coefficient estimates relating to the mode being valued was significant and hence this distinction was not maintained. This is consistent with our previous conclusions based on the variables in Table 10, which are combinations of mode used and mode valued, that mode used is a more important influence on the value of time than the mode being valued. Given that the estimated GDP elasticity was implausibly low, due to the sort of collinearity problems discussed in subsequent sections, it was also removed. In applying the model, a GDP elasticity would have to be assumed and it is common practice to uplift money values in line with growth in GDP.

Table 10: Value of In-Vehicle Time Regression Models

		Initial Model			Updated Model		
VARIABLE	CATEGORY	Coeff	t ratio	Effect	Coeff	t ratio	Effect
GDP		0.075	2.67		0.048	2.00	
Distance		0.210	7.76		0.214	8.93	
Numeraire	Toll Charge	-0.292	2.00	-25%	-0.264	1.86	-23%
Purpose	EB-U	0.671	3.41	+96%	0.686	3.69	+99%
	EB-I	0.935	6.05	+154%	1.048	8.57	+185%
	EB-1	1.552	7.01	+372%	1.615	8.34	+403%
	EB-Val	-0.288	1.72	-25%	-0.377	2.63	-31%
	Comm-Lse	0.301	3.00	+35%	0.335	3.63	+40%
	Comm-Oth	0.133	1.87	+14%	0.130	2.00	+14%
	NoDist	0.139	2.09	+15%	0.197	3.48	+22%
Unit	Cost-RT	-0.151	2.09	-14%	-0.151	2.29	-14%
Type of Data and Choice Context	SP-Mode	-0.176	2.38	-16%	-0.135	2.14	-13%
	SP-Rank	-0.167	1.86	-15%	-0.019	0.26	-2%
	SP-Rank4	0.179	1.54	+20%	0.269	2.51	+31%
Study Aim	G-Val	-0.142	1.74	-13%	-0.186	2.64	-17%
SP Presentation	Cards	0.214	2.72	+24%	0.204	2.79	+23%
	Computer	0.063	1.22	+7%	0.100	1.78	+11%
Mode Used and Mode Valued	Car	0.546	6.42	+73%	0.620	8.44	+86%
	Rail-Rail	0.813	6.48	+125%	0.829	7.40	+129%
	RailAir-Rail	1.552	4.53	+372%	1.516	4.73	+355%
	Rail-RailAir	1.024	3.56	+178%	0.958	3.61	+161%
	UG-UG	0.946	6.01	+158%	1.046	7.24	+185%

	PT-PT	0.242	1.64	+27%	0.226	1.83	+25%
	All	0.712	7.04	+104%	0.821	8.97	+127%
	Obs	444			539		
	Adj R^2 *	0.616			0.638		

Note: * This is the adjusted R^2 when the model contained the intercept. The GDP index in quarter 4 1994 is 103.7.

The results are largely as we would expect given the simplification over the updated model in Table 10. The difference between the two reported models is that one distinguishes between inter-urban trips and other trips and the other contains distance. The model containing an inter-urban dummy is reported because it is not uncommon in evaluation studies that separate valuations are required for inter-urban and urban travel. Inter-urban trips are estimated to have values of time which are 61% higher in the absence of any distance effect.

Table 11: Simplified In-Vehicle Time Model (1994 Q4 Prices)

VARIABLE	CATEGORY	Coeff	t ratio	Effect	Coeff	t ratio	Effect
Intercept		0.248	1.68		0.634	4.61	
Distance		0.216	9.58				
Inter Urban					0.478	8.23	+61%
Purpose Base is Leisure/Off-Peak	EB	1.032	9.58	+181%	1.075	9.82	+193%
	EB-1	1.667	9.41	+429%	1.821	10.17	+518%
	EB-Val	-0.456	3.53	-37%	-0.501	3.81	-39%
	Commuting	0.159	2.69	+17%	0.126	2.11	+13%
	NoDist	0.219	3.84	+24%	0.207	3.56	+23%
Type of Data	SP	-0.114	1.06	-11%	-0.145	1.32	-13%
Mode Used Base is Bus	Car	0.629	8.17	+88%	0.644	8.21	+90%
	Rail	0.836	8.75	+131%	0.969	10.38	+164%
	UG	0.872	6.85	+139%	0.999	7.67	+172%
	Air	1.348	4.18	+284%	1.728	5.34	+462%

	Car&PT	0.690	6.00	+99%	0.746	6.39	+111%
	Bus&Rail	0.223	1.73	+25%	0.245	1.86	+28%
	All	0.797	7.09	+122%	0.795	6.93	+121%
	Obs	539					
	Adj R^2	0.614			0.599		

The omitted purpose category is almost entirely made up of leisure and off-peak travellers. As expected business travellers (EB) have much higher valuations and the valuations are very much higher for first class business travellers (EB-1st). Where the purpose of the study was valuation, the business values are lower, and our previous review concluded that this was to an extent proxying for cases where business travellers were expressing a personal rather than company willingness to pay.

Combining Comm-Lse and Comm-Oth from Table 10, which denote commuting in London and the South East and ommuting elsewhere and peak travel respectively, the single commuting category is associated with a lower value than the category which represents valuations where no distinction was made by purpose (NoDist). This is surprising, given that the latter category is largely made up of commuting and leisure trips. Nonetheless, it remains that the value of IVT is higher for commuting than leisure travel.

Although the variable denoting whether the value of IVT was obtained from SP data is not statistically significant, it denotes that SP valuations tend to be less than corresponding RP values and the coefficient is retained for use in a wider comparison of RP and SP across different attributes.

The results relating to mode used are highly plausible and generally highly significant. The omitted mode is bus and, as expected, all other categories of mode used are associated with higher values of time. The highest valuation is for air users, although it should be noted that these all relate to business travel. Rail and underground users have similar values and the second highest valuations followed by valuations obtained from users of all modes. Car and rail users will be well represented in the latter category and hence it has a relatively large value. Car&PT denotes valuations derived from car and bus or car and rail users combined. Given that the higher values of rail users can compensate for the lower values of bus users, and that again rail users will here be well represented, the relationship between the Car&PT and Car valuations is reasonable. The valuation of bus and rail users combined (Bus&Rail) is closest to the value of bus users alone and this is not surprising since we would expect bus users to dominate this sample.

These results indicate that air users have the highest money valuations, followed by rail users, car users and bus users. This is consistent with the operation of strong income effects on the value of time.

Given that the mode being valued is an attempt to capture variations in the value of time due to the different travel conditions across modes, such as train being more comfortable than bus, it is not of significance to travel attributes such as walk time, wait time, access time, headway and departure time shifts. Whilst access time values may vary by mode, the level of detail necessary to conduct such analysis is unavailable. Search and delay time are specific to car whilst mode being valued cannot reasonably be expected to proxy for different conditions of interchange. Thus regardless of the fact that mode valued was found to be a much less important influence on the value of IVT than mode actually used, we would not expect the former to be a key factor in explaining variations in the time and service quality attributes which are the main focus of this study. We have not therefore included this variable in our subsequent analysis.

5.2 Out-of-Vehicle Time Regression Model

The valuations of walk, access and wait have been combined into a single model since they are essentially very similar in nature and we would expect similar effects on each from a number of explanatory variables. Combining the valuations therefore allows analysis to be based on a larger data set, which will yield more precise coefficient estimates, whilst it remains possible to specify separate terms for any explanatory variables where there is reason to suspect that it has a different impact across the valuations. The estimated regression model is presented in Table 12.

Table 12: Money Value of Out-of-Vehicle Time Model

Variable	Model I	Effect	Model II	Effect
Constant	-5.896 (1.86)			
Distance	0.200 (3.29)		0.190 (3.12)	
GDP	1.503 (2.11)		0.186 (3.10)	
Access	0.251 (1.75)	+29%	0.280 (1.96)	+32%
EB	0.836 (3.53)	+131%	0.864 (3.64)	+137%
UseAll	0.503 (2.45)	+65%	0.559 (2.74)	+75%
UsePT	0.248 (1.27)	+28%	0.214 (1.09)	+24%
UseRailUG	0.588 (3.33)	+80%	0.627 (3.56)	+87%
UseCar	0.515 (4.39)	+67%	0.555 (2.74)	+74%
SP-QCC	-0.346 (1.72)	-29%	-0.181 (1.79)	-17%
Adaptive	-0.839 (2.22)	-57%	-0.740 (1.97)	-52%
Adj R^2	0.32		n/a	
Obs	271			

Although the goodness of fit measure of adjusted R^2 is not particularly good, a number of significant and plausible coefficient estimates have been obtained. Dummy variables were entered which denoted whether wait, walk and wait combined or access time were valued differently to walk time. The former two were far from significant, with t statistics of 0.53 and 0.21, yet as expected from the results discussed in section 4, access time is valued more highly than the other attributes. However, access time is estimated to be valued only around 30% higher than the other OVT attributes which is much less than implied by a simple comparison of the overall monetary valuations in Tables 2, 3, 4 and 5. This confirms the previous conclusion that a key influence upon the high overall access time valuations is the relatively large number of business trips since the models in Table 12 have isolated the business effect through the specification of a variable relating to business travel.

Business travel (EB) was the only journey purpose which had a significantly different valuation. As expected, it denotes that business travellers value OVT much more highly. However, no additional effect was attibutable to first class business travellers, although there are few of these in this data set, whilst business travel valuations were not lower where the purpose of the study was valuation.

The estimated variations in values of time according to mode used are plausible. Rail and underground users (UseRailUG) had similar coefficients and a combined term has therefore been estimated for these. Public transport users (UsePT) include rail and bus users who cannot be separately distinguished and these have valuations nearest to the base category of bus users. Car users (UseCar) have relatively high values whilst UseAll denotes combined public transport and car users for whom a valuation was estimated and its coefficient is consistent with the other coefficients.

Dummy variables which denoted the use of cards, a computer or a questionnaire to present the SP exercise had broadly similar coefficients and hence these have been combined into a single term (SP-QCC). This term indicates that SP exercises tend to provide lower valuations of walk, with the figure varying between 17% and 29% according to model form. The exception to this is the use of adaptive SP exercises, which were discredited by Bradley and Daly (1993) due to various problems introduced into the error structure of the estimated model, and in such cases the valuations are estimated to be very much lower than equivalent RP valuations.

The distance elasticity shows a positive effect which is very similar to that estimated for IVT. As in our previous review of the value of IVT (Wardman, 1997), the GDP elasticity suffers from strong correlations with the constant term of around -0.9. This would mean that across a sample of repeated independent trials, there would be a tendency for larger GDP coefficient estimates to be associated with smaller estimates of the constant. Hence the lower GDP elasticity after the removal of the constant term is entirely expected. Since the constant represents the base level of all the categorical variables, the removal of the constant term does not overcome the collinearity problem since the GDP elasticity will discern its effects. The coefficient estimates of the GDP terms in both of the reported models cannot therefore be regarded to be reliable.

No effects on the valuations could be discerned from the aims of the study, the number of variables in an SP exercise, the mean level of the variables or the amount of variation in them. Nor was the value of walk time lower when a common value was estimated to car and another model which was an issue we specifically wished to examine as discussed in section 3.1.2. Analysis was conducted which allowed various effects to differ between walk, access and wait time but these did not lead to improvements in the model.

5.3 Departure Time Change Regression Model

The regression models based on the monetary departure time changes are presented in Table 13. The valuations were all obtained from SP models and all but two relate to rail or car travellers who were confronted with changes in the departure times of the mode they used.

Table 13: Money Value of Departure Time Change

Variable	Model I	Effect	Model II	Effect
Constant	-25.513 (3.07)			
Distance	0.195 (1.91)		0.101 (0.97)	
GDP	5.540 (3.09)		0.056 (0.43)	
EB	1.883 (7.36)	+557%	1.866 (6.88)	+546%
CommP	0.794 (2.94)	+121%	0.877 (3.07)	+140%
Exp	0.430 (1.67)	+53%	0.497 (1.82)	+64%
UseCar	-0.648 (1.76)	-48%	-0.927 (2.45)	-60%
Mean	0.007 (1.81)		0.010 (2.73)	
Adj R^2	0.67		n/a	
Obs	74			

The goodness of fit is quite reasonable, although in the model with the intercept it has only been possible to obtain coefficients which are statistically significant at the usual 5% level for three variables. One of these is the GDP elasticity which again suffers from very high correlation with the constant of around -0.9 and is quite clearly implausible in both the reported models. The very large variation in the GDP elasticity after the removal of the constant is a symptom of this correlation.

The most noticeable feature of the results is the very large valuations associated with employer's business trips. These have valuations which are around 2½ to 3 times higher than for commuters and peak travellers (CommP). This was apparent in the figures presented in Table 6, although the very high monetary values for business trips did not translate into high time values. In turn, commuters and those travelling in the peak have values which are more than double those of the remaining categories of traveller. Whilst the magnitude of these effects is perhaps surprising, the order of the effect is not.

We have included a term (Exp) to denote whether the SP exercise offered explicit departure time shifts as opposed to departure time shifts which are implicit amongst changes to travel restrictions or timetables. It was found that departure time changes are estimated to have higher valuations when they are explicitly offered, although the effect is not quite statistically significant in either of the models reported. Whilst we cannot be sure about the cause of the higher valuations, our feeling is that offering implicit departure time changes leads to a tendency for them to be ignored and hence too low valuations rather than an overemphasis upon departure time changes when they are offered explicitly. However, this would seem to be an issue for further research.

Car users have somewhat lower valuations of departure time changes than rail users, although there may be an influence here from the generally shorter trips than for rail. The distance effect in model I is similar to that for IVT and OVT. However, it is halved, and much less significant, when the constant is removed, despite a low correlation between the distance term and the constant. It seems reasonable to conclude that the distance effect is not stronger than the previous models and it may well be weaker, and we shall return to this issue in the analysis of all the monetary valuations in a single model in section 5.7.

The model includes a measure of the average departure time shift used in the SP experiments (Mean). This is the only continuous variable which is not entered in logarithmic form since this provided a better fit. The estimated coefficient in the model with no constant denotes that a 30 minute increase in departure time shift increases the per minute valuation by 35%.

A number of other variables were examined but none of them possessed coefficient estimates which approached significance at the usual 5% level. These included whether the departure time change related to the outward, return or both legs of a journey, whether the main aim of the study was to value departure time changes and the number of variables in the SP exercise, whilst the sample is too small to allow any firm conclusions to be drawn regarding the impact of different means of presenting an SP exercise. We might hypothesise that later departure time shifts have a higher value than earlier departure time shifts for commuting and business travel on the outward leg, due to arrival time constraints, and that earlier departure time shifts have higher values than later shifts for business travellers and commuters on the return leg of a journey, due to the constraints surrounding meetings and work times. No significant difference was found between early and late departure times overall or by purpose for the outward direction of travel. This is consistent with the results reported in Table 6 and further analysis reported in section 6.4. There were too few observations to test variations between earlier and later departure time changes by purpose for the return leg of the journey.

5.4 Headway Regression Model

The results for the regression model based on the money values of headway are given in Table 14. The goodness of fit denotes that there is a relatively large amount of variation in the headway valuation which remains unexplained, although a number of plausible and significant effects have been estimated.

Table 14: Money Value of Headway Model

Variable	Model I	Effect	Model II	Effect
Constant	-9.116 (1.44)			
Distance	0.107 (1.63)		0.110 (1.66)	
GDP	2.176 (1.57)		0.185 (2.54)	
EB-1st	2.664 (3.54)	+1335%	2.736 (3.63)	+1443%
EB-Std	1.139 (5.31)	+212%	1.156 (5.38)	+218%
UseCar	0.939 (3.48)	+155%	1.010 (3.80)	+175%
UseRailUG	0.497 (3.00)	+64%	0.503 (3.02)	+65%
SP-QCC	-0.557 (2.06)	-43%	-0.540 (1.99)	-42%
Adaptive	0.578 (1.45)	+78%	0.591 (1.48)	+81%
Adj R^2	0.470		n/a	
Obs	140			

The distance elasticity is not sensitive to the inclusion or not of the constant term and is lower than for IVT and the various out-of-vehicle times. It is in line with the distance elasticity in the departure time change model which excludes the constant but is lower than the estimate when the constant is included. The GDP elasticity again suffers from correlation problems and exhibits large variation between the models with and without a constant term.

We have been able to distinguish different effects between first and standard class travellers, with first class travellers having much higher values as a result of their more senior status, higher incomes and presumably greater time pressures. Whilst it could be argued that the estimated value for first class business travellers is implausibly high, since it is some 4½ times larger than for standard class business travellers, it is as well that they have been separated out rather than estimating a single business value coefficient. Standard class business travellers have much higher values than non business travellers, yet the difference between the remaining journey purposes is very minor.

Rail users have higher values than car users in the preceding models yet it is here quite clear that car users have higher valuations of headway than rail users. We had suspected that this might be the case, from our impressions of the findings of a number of studies, and it is presumably because car users are used to the flexibility of departing when they want and indeed this may be one of the reasons why they are a car user. This effect was not apparent in Table 7 but we are here allowing separately for the business travel effect. Nonetheless, rail users have higher values than the remaining categories of users.

We again found a reasonably similar effect on the estimated value from questionnaire, computer and card presentation of SP exercises and hence specified the SP-QCC variable to represent these. Its coefficient denotes that these forms of SP obtain valuations which are around 40% lower than the RP values. We return to the issue of the correspondence between RP and SP values in section 6.1. The adaptive SP design approach now provides very much higher values of time than would be obtained from an RP model in contrast with the findings in Table 12. The results from the analysis reported in Tables 12 and 14 seem to confirm the conclusions of Bradley and Daly (1993) regarding the unreliability of adaptive SP exercises.

A number of other variables have been examined which turned out to have effects which were far from significant. These included whether the main aim of the study was to estimate headway and the number of variables in the SP exercise. We compared the value of rail and bus headway but found the two to be very similar. We also felt that the value of headway would vary with the level of headway, being higher where services are less frequent and hence improvements are more welcome. However, this variable was far from significant and the averaging involved in obtaining representative headway figures may have had a bearing on this. Nor was there any discernible effect from the size of the variation in headway.

5.5 Interchange Regression Model

The interchange regression model is reported in Table 15. The distance elasticity is here particularly strong and highly statistically significant. The passenger demand forecasting handbook recommends a strong relationship between the interchange penalty and distance and this is here confirmed.

We again observe a strong correlation of around -0.9 between the GDP elasticity and the constant, an implausibly large GDP elasticity when the constant is included and a large reduction in the GDP elasticity when the constant is removed.

Table 15: Money Value of Interchange Model

Variable	Model I	Effect	Model II	Effect
Constant	-10.943 (1.72)			
Distance	0.532 (5.05)		0.485 (4.59)	
GDP	3.197 (2.33)		0.843 (7.89)	
EB1	1.112 (1.75)	+204%	0.921 (1.18)	+151%
EB2	0.748 (1.99)	+113%	0.770 (1.99)	+116%
CommP	-0.705 (1.92)	-51%	-0.719 (1.90)	-51%
UseCar	0.503 (1.11)	+65%	0.545 (1.17)	+72%
SP	-0.526 (1.56)	-41%	-0.542 (1.56)	-42%
SouthEast	-0.654 (1.51)	-48%	-0.766 (1.75)	-54%
Adj R^2	0.64		n/a	
Obs	44			

A difference between first class (EB1) and standard class (EB2) business travellers is apparent and these values are higher than for leisure travel to a plausible degree. On the other hand, commuters and those travelling in the peak (CommP) were found to have lower values than leisure travellers and this is in line with the values reported in Table 8. This is presumably due to a familiarity effect whilst the higher frequencies facing commuters and peak travellers means that the consequences of missed connections are less and the inconvenience in terms of lower wait times, which may have crept into valuations, is also less. We tested whether the effect discerned by commuting was really a distance related effect but commuting values were lower than for the other purposes when the sample was constrained solely to urban and suburban trips.

Car users were estimated to have higher values of interchange, although the effect is not statistically significant at the usual 5% level. However, there was no higher valuation for rail users. It would seem that interchange may well be a strong deterrent to train travel.

There was insufficient data on the different means of presentation to distinguish the SP exercise by this variable. Instead, a single SP dummy variable was specified and this denotes that SP methods provide interchange valuations which are around 40% lower than RP values. We shall bring together the various pieces of evidence on the valuations obtained from SP methods compared to RP methods in section 6.1.

The final variable denotes whether the value of interchange was estimated to travellers in the South East. Although the coefficient is not significant at the 5% level, it denotes that those in the South East seem to be more tolerant of interchange to the extent that they value it about 50% less than those who live elsewhere. There may be a familiarity and frequency effect at work here, whilst it may also be that interchange facilities and conditions are better in the South East along with an appreciation of a more integrated transport system which uses interchange to promote a wider range of journey possibilities within a relatively high quality and large network. We tested whether the South East effect really was a commuting effect but those making business and leisure trips in the South East also had lower values of interchange.

No significant difference was apparent between bus and rail interchanges whilst there were no significant effects from the number of variables in the SP exercise and whether the main purpose of the study was to estimate interchange valuations.

5.6 Summary of Money Value Regression Models

Table 16 provides a summary of the key findings across the regression models based on money values. Whilst this is of interest in its own right, since the analysis of the various attributes has so far been conducted independently, it also informs the analysis of all the money values within a single model which is reported in section 5.7.

In general, the GDP elasticities are either too high when the constant is included (GDP_a) or too low when the constant is omitted (GDP_b) and this is a symptom of the collinearity problem. There is a strong relationship of the expected form between the constant term and the GDP_a elasticity. Indeed, the relationship is monotonic and even extends to a negative GDP_a elasticity associated with a large positive constant.

The business travel values are higher than the other values, with a further increase in the case of first class travellers. For standard class business travellers, the values tend to be around 100% to 200% higher than for leisure travellers, with the noticeable exception of the very high values business travellers assign to departure time changes.

Table 16: Estimated Parameters across Money Value Models

	IVT	OVT	DEP	HEAD	INT
GDP_a	-0.58	1.50	5.54	2.18	3.20
GDP_b	0.05	0.19	0.06	0.19	0.84
CONSTANT	+2.90	-5.90	-25.51	-9.12	-10.94
EB	-	+131%	+557%	-	-
EB1	+429%	-	-	+1335%	+204%/+151%
EB2	+181%	-	-	+212%	+113%
COMMUTING	+17%	0%	+121%/+140%	0%	-51%
DIST	0.22	0.20	0.20/0.10	0.11	0.53
SP	-11%	-29%/-17%	n/a	-43%	-41%
RAIL	+131%	+80%	0%	+64%	0%
CAR	+88%	+67%	-48%	+155%	+65%

Note: The reported figures are for the model which includes the constant unless there is a large difference between the model which excludes the constant whereupon both are given. SP is SP-QCC where it is reported.

The results for commuting are interesting. The values differ little from the leisure values with two exceptions. In the case of interchange, the commuting values are much lower, which we have attributed to familiarity effects and more favourable circumstances for interchanging. Commuters have somewhat higher values of departure time shifts and this is not surprising given greater constraints and pressures associated with commuting trips. Although it might be argued that the values should generally be higher for commuting, because of the less favourable travelling conditions and greater time pressures, this could be offset by the operation of income effects due to the higher frequency of commuting than of making specific leisure trips. If the leisure values related to a willingness to pay for time savings on all leisure trips, rather than on a particular trip which is generally the focus of an SP exercise, then income effects might also come into play.

Since the distance variable relates to the length of the entire journey, it can discern non-linearities in the value of IVT with respect to the levels of IVT and cost. In contrast, the distance variable cannot perform such a function for the other time and service quality attributes. Nonetheless, it does seem that longer distance trips tend to have higher values for all attributes, quite apart from non-linear relationships between the value of an attribute and the level it takes. This may be because longer distance trips tend to be of a different, and presumably more important, nature whilst they tend to be made less frequently which may lead to a lesser sensitivity to cost variations on these trips along the lines of the income effect argument.

The distance elasticities are fairly similar, with the exception of the figure for interchange where a much stronger effect is apparent which is broadly consistent with the values recommended in the passenger demand forecasting handbook. We have detected the latter effect in addition to estimating a lower interchange value for commuting where the distances travelled tend to be relatively short.

In each of the four cases where SP values can be compared with RP values, the SP values were found to be less than the RP values, and for headway and interchange at least the magnitude of the difference is a cause for concern.

There is no clearcut relationship between the values of rail and car users, although both tend to have higher values than the other users[1]. However, for attributes common to rail and car, rail has higher values. For headway and interchange which are unique to public transport, car users have much higher values than rail users. It is not surprising that car users value these attributes relatively highly.

5.7 Overall Money Regression Model

5.7.1 Estimated Effects

This section draws together the data relating to the various money values and reports on the estimation of a single model to this data. There are a number of reasons for estimating a single model to the data relating to the various attributes.

- it provides a single, comprehensive model of money valuations containing IVT alongside the other attributes which are the primary focus of this review.

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1 For departure time changes, there are only two valuations for bus users. Hence the results essentially indicate that car users have lower values of departure time shifts than rail users.

- it allows more precise estimates to be obtained. We have seen that there are several similar effects across attributes, such as the influence of distance on the values of IVT, OVT, departure time shifts and headway. A more parsimonious formulation constrains similar coefficients to be the same by combining variables within a single model.

- the values relating to search, late and delay time, for which the estimation of separate models was not feasible, can now be entered into a model, although the relatively small sample sizes for these attributes clearly limits the detail in which they can be analysed.

- the large data set supports worthwhile analysis of what are expected to be relatively minor effects which cannot be readily discerned within the attribute specific regression models. This requires us to assume that a variable has the same proportionate effect on the values of different attributes, thereby constraining coefficients to be the same and increasing the degrees of freedom, and in many instances such an assumption seems quite reasonable.

Table 17 presents a model estimated to all the money values of the time related variables. The interchange values are excluded since they relate to the need to interchange rather than the time spent interchanging. The model therefore contains 1072 valuations and takes the basic form represented by equation 1.

Given the disparate range of circumstances in which the values were estimated and that there are a wide range of influences, many unique to a particular study, which it is either impossible or impractical to collect information for, the adjusted R^2 measure of goodness of fit seems quite reasonable. We have retained some variables whose coefficients are not significant at the usual 5% level given that their effects on the valuations are reasonable, their t ratios are not especially low and their removal implies a coefficient of zero. We did not recover a statistically significant coefficient estimate of the wrong expected sign.

We have money valuations for ten attributes, and hence we can specify dummy variable terms for nine attributes given the presence of a constant term. The coefficients of these dummy variables alongside the intercept term indicate base values around which the money values of the attributes vary. For example, the base value (V) for the arbitrarily omitted attribute or any other attribute whose dummy variable is not retained is:

$$V = e^{\alpha_0} \qquad \textbf{2}$$

where α_0 is the intercept. For any attribute i for which a dummy variable term is specified, its base value is:

$$V = e^{\alpha_0 + \alpha_i} \quad \mathbf{3}$$

where α_i is the coefficient estimated to the dummy variable representing attribute i.

Attribute Specific Variables

The arbitrarily omitted category was IVT. The coefficients on the dummy variables for walk, wait, the combined walk and wait term, access and headway were all far from significant, as was a combined dummy variable representing all the OVT attributes. Given the relatively small sample sizes for wait and access time and that walk, wait and access are similar attributes, the OVT attributes are combined in subsequent analysis in order to simplify matters. The implication of this is that they will have the same valuations. The combined OVT term is denoted by the letter O where necessary, with I, H, S, D and L denoting IVT, headway, search time, delay time and late time.

The coefficient representing whether the valuation was of departure time shifts (ID-Dep) was a large negative number which will have a strong deflatory effect on any value of departure time shift estimated by the model. However, as we shall see, there are a number of compensating effects on this valuation within the model. The ID-Late coefficient denotes that late time will have a large valuation, which is consistent with the figures presented in Table 9, although again there are offsetting effects within the model which in this instance takes the form of a fairly strong negative distance effect. Significant coefficient estimates were also obtained for the dummy variables representing search time and delay time. Given that search and delay time both relate solely to car travel and are in some respects quite similar, subsequent analysis of these valuations is based on a combined term in the light of their small sample sizes.

Variations in Values over Time

The GDP elasticity was found to be 0.44, with a t statistic of 1.43, and there was again a very high correlation with the constant term of around -0.9. Using a linear time trend term, with a value of zero for the first year of 1980, provides a slightly better fit, its coefficient has a higher t statistic and the correlation with the constant term of -0.47 is somewhat lower than for the GDP elasticity. Hence the model containing the time trend is preferred.

The time trend denotes that the money values grow by, on average, 1% per year. It would imply that the values have increased by 20.6% between 1980 and 1997. This constrasts with GDP growth of around 47%, implying a GDP elasticity of 0.49. Estimating separate time trend terms or GDP elasticities by journey purpose or by attribute valuation did not prove to be worthwhile.

Table 17: Overall Money Valuations Regression Model

VARIABLE	CATEGORY	Coeff (t ratio)	Effect
Intercept		0.859 (4.91)	
Attribute	ID-Dep	-4.167 (5.52)	-98%
	ID-Late	3.111 (6.43)	+2144%
	ID-Search	0.811 (3.39)	+125%
	ID-Delay	0.634 (2.69)	+89%
Trend		0.011 (1.72)	
Distance	D-IODep	0.125 (4.00)	
	D-Late	-0.322 (2.52)	
	Inter	0.190 (2.56)	+21%
Purpose	EB-IOHSDL	0.956 (10.22)	+160%
	EB-Dep	2.415 (11.37)	+1019%
	Comm-Ivt	0.158 (2.33)	+17%
	Comm-Head	0.238 (1.97)	+27%
	Comm-Dep	1.323 (6.50)	+275%
	Comm-Late	0.740 (2.15)	+109%
	Rest-Ivt	0.139 (2.20)	+15%
	Rest-Dep	1.366 (4.95)	+292%
Business	EB-1IH	0.676 (3.99)	+97%
	EB-Val	-0.377 (3.06)	-31%
Mode	Car-IO	0.396 (4.67)	+49%
	Car-Head	0.547 (4.98)	+73%
	Car-Dep	-0.751 (5.19)	-53%
	RailUG-IO	0.746 (8.49)	+111%
	Rail-Head	0.300 (1.83)	+35%
	UG-Head	1.013 (5.62)	+175%

	CPT-IO	0.585 (5.39)	+79%
	PT-IO	0.206 (1.86)	+23%
	All-IO	0.550 (4.86)	+73%
	All-Head	0.437 (1.99)	+55%
	Air	0.967 (3.32)	+163%
SP	SP-IO	-0.160 (1.80)	-15%
	SP-Head	-0.449 (2.68)	-36%
Departure Time Shifts	Exp	0.453 (2.31)	+57%
	Ret	0.651 (3.50)	+92%
Level	Mean-OVT	0.181 (7.25)	
	Mean-Dep	0.923 (4.91)	
	Mean-Head	0.077 (1.48)	
Numeraire	Toll	-0.523 (3.07)	-41%
	Cost-RB	-0.316 (4.10)	-27%
	Cost-CPT	-0.216 (3.42)	-19%
Context	Route	0.291 (1.94)	+34%
Non Traders	Omit	-0.109 (2.24)	-10%
Location	MetConTown	-0.168 (3.41)	-15%
Unit	Cost-RT	-0.071 (1.34)	-7%
	Obs	1072	
	Adj R^2	0.615	

Note: In contrast to previous models, the term relating to first class travel (EB-1IH) is to be added to the business travel effects.

These are amongst the most respectable estimates we have obtained of how the money values vary over time and they appear to be highly consistent with cross sectional evidence relating to variations in the value of time across different income groups. The first British national value of time study (MVA et al., 1987; p122) claimed that, "...... we have clearly demonstrated the existence of an income relationship, which has never been done before with any conviction" and that "the value of time as a proportion of income is a decreasing function of income, rather than a constant as has hitherto been assumed". The second British national value of time study (Accent and Hague

Consulting Group, 1996; p31) concluded that, "The findings of this study, supporting those reported in The Netherlands, are that VOT is indeed related to income, but the relationship is not one of proportionality. Rather, income elasticities of around 0.5 have been found."

Distance Effects

The estimated distance elasticities for IVT, OVT and departure time were 0.13, 0.12 and 0.14 respectively and hence they have been combined into a single term (D-IODep). The lower distance effect on IVT and OVT than was previously apparent is due to the inclusion of the variable denoting whether the valuation was estimated in the context of an inter-urban journey (Inter). It was possible to estimate a statistically significant effect for inter-urban valuations, in addition to the distance effects, which denotes that these values are 21% higher. A single coefficient across all attributes was estimated for Inter on the grounds that we have uncovered widespread evidence that attribute values in general are higher for inter-urban trips and because coefficients for the Inter variable segmented by attribute were not statistically significant.

The only other significant distance effect relates to late time where a fairly strong negative effect was apparent (D-Late). This is not a journey purpose effect since separate terms are entered which discern these. Presumably, the constraints surrounding shorter distance trips are greater whilst being late may be regarded to be less unacceptable for longer distance journeys.

The distance effect on headway which was not quite significant in the headway specific model reported in Table 14 now becomes very minor and far from significant. In part this is due to the inclusion of the Inter variable but, as is discussed below, the inclusion of the mean value of headway also had a bearing.

Journey Purpose

A number of effects from journey purpose are reported in Table 17. We have four purpose categories of business (EB), commuting and peak travel (Comm), leisure and off-peak travel and the remaining categories (Rest) where no distinction was made. The latter largely relate to commuting and leisure trips where no distinction between them was made. The arbitrarily omitted category is leisure trips.

Business trips are invariably found to have higher values than other trips. This is entirely expected, although the degree of similarity between almost all of the effects was very noticeable. The coefficients for the impacts of business travel on the values of IVT, headway, OVT and the combined values of search, delay and late were 0.96, 1.00, 0.89 and 0.90. The consistency between these effects is not surprising given the results reported in Table 16. Hence a single term was specified (EB-IOHSDL) which denotes that these attributes have valuations which are 160% higher for business travel than leisure travel.

The remaining business travel effect relates to departure time variations. It is estimated that business travellers are particularly averse to departure time changes, with money valuations over 11 times those of leisure travellers and around 3 times those of commuters. These findings are very much in line with the results of intra-study analysis of the effect of journey purpose reported in Table 27.

Significant effects were discerned from commuting on the money values of four attributes. IVT is estimated to have values 17% higher for commuting trips whilst headway values are estimated to be 27% higher for commuting. Departure time shifts are valued much more highly than for leisure travellers, presumably due to the greater constraints faced by commuters, whilst similar reasons explain the very much higher values of late time for commuters than leisure travellers. No effect from commuting was apparent on the value of OVT which is consistent with the previous findings reported in Table 12.

It was not possible to obtain significant effects from commuting on the valuations of search and delay time, and this could well have been due to the small sample sizes for these values. Rather than conclude that commuting has no effect on the valuations of these attributes, and given that they are a variant of IVT, we recommend that the Comm-Ivt effect is also used for search and delay time.

It is necessary to isolate possible differences between the Rest category and the base category of leisure travel. Two significant effects were estimated and these indicated that IVT is valued more highly for the Rest category than for leisure travellers, but it is slightly lower than for commuters, and that departure time shifts are valued more highly even than for commuters. The latter is due to the Rest category in this instance being largely made up of cases where no distinction was made between business and leisure travellers.

Business Travel Specific Effects

Two significant effects have been estimated which all relate to business travel and the specification of them is such that they are to be added to the two business travel effects reported above. The business travel specific effects represent first class travellers (EB-1IH) and whether the business valuation was obtained from a study whose purpose was to estimate valuations rather than to forecast (EB-Val).

The only two attributes for which there are first class business values are IVT and headway and the coefficients estimated to these attributes were 0.67 and 0.71 respectively. Hence a single term was estimated which indicates that these attributes are valued 97% more highly by first class travellers, presumably as a result of their more senior status and higher incomes. We find it reasonable to assume that such travellers have similarly higher money values of the other attributes.

The value of business travel time is made up of the employer's and the employee's willingness to pay to save time. Whilst some studies are clear that the respondents behavioural response is to be conditioned by perceived company policy (Wardman, Holden and Fowkes, 1992) or by personal preferences and circumstances (Accent and Hague Consulting Group, 1996), the instructions given to business travellers in SP exercises were not identified, primarily due to the general difficulties in collecting this information, and therefore it is unfortunately unclear whether the valuations obtained relate to the individual or the company. Whilst RP values will tend to reflect company valuations, there are insufficient of these to conduct separate analysis. What is clear, however, is that the business travel values can be taken to represent briefcase travellers, such as those attending a business meeting, course or seminar or visiting a client.

Our previous review (Wardman, 1997) concluded that business travel values obtained from studies where the purpose was forecasting as opposed to valuation were more likely to reflect the employer's valuation since our feeling is that respondents are more likely to have been instructed to consider company policy in such studies. Indeed, not only was it found that the business values were somewhat higher when the purpose of the study was forecasting, but these values were very much in line with the employers' valuations estimated in the then recently completed second British national value of time study (Accent and Hague Consulting Group, 1996).

Our previous review found business travel values to be 25% lower when the purpose of the study was valuation. This increases to 31% lower in the updated model reported in Table 10. Table 17 indicates that for all attributes the business travel values are 31% lower (EB-Val) when the purpose of the study was valuation rather than forecasting. The correspondence between the figure based solely on IVT and the figure estimated for all the attributes is encouraging and we again conclude that the business values obtained from studies whose purpose was forecasting are to be taken to represent employers' valuations.

<u>Mode</u>

The categories of mode between which we have made a distinction are car, rail, bus, underground (UG), air, rail and bus combined (PT), car and public transport combined (CPT), and cases where the valuation was for a combination of car, rail and bus users (All). Bus is taken to be the base category.

A large number of effects from mode on the estimated valuations have been discerned. A striking feature of the results is that the effects on IVT and OVT are very similar. The coefficients initially estimated to IVT and OVT were 0.40 and 0.38 for car users, 0.80 and 0.83 for rail users, 0.75 and 0.65 for underground users, 0.52 and 0.64 for CPT, 0.18 and 0.22 for PT and 0.57 and 0.52 for the All category. Combined terms for the effects of mode on IVT and OVT have therefore been specified, with additionally combined terms for rail and underground. These similarities could well be because mode is a reasonable proxy for income and we might expect the values of IVT and OVT to vary in a similar manner with income. Although the same argument would apply to headway, a confounding effect here is that headway is specific to public transport modes.

The variations in the values of IVT and OVT according to mode are as expected. The effects on headway are lower than for IVT and OVT for Rail, All, CPT and PT, and indeed in the latter two cases they were insignificant and hence removed. Headway values are relatively highly valued by car users, and we have argued that this is because car users are used to the flexibility of departing when they want. The high value of headway for underground is not surprising. Underground users generally expect a high frequency service whilst changes in headway will lead to changes in relatively highly valued wait time given that random arrivals for underground trains tend to be more common than for buses and trains which generally operate at lower frequencies.

The air users are all business travellers and they have high values presumably as a results of their more senior status and higher incomes. The air coefficient relates to IVT, OVT and headway since there were insufficient observations to support feasible segmentation of the air effect by attribute. It would seem reasonable that such travellers also have higher values of the other attributes.

Given that the departure time valuations effectively relate to car or rail, the Car-Dep figure denotes that car users have lower values of this attribute than rail users. Delay and search time are specific to car users and there were no significant effects from mode on late time values, although the small sample of late values is a serious handicap to this analysis.

Stated Preference Data

The analysis of the effects of the valuations being estimated to SP data collected using the questionnaire, card or computer means of presentation (SP-QCC) are broadly in line with the previous findings, with the exception that the adaptive coefficients are no longer statistically significant which is presumably due to the additional variables in this overall model discerning effects previously attributed to the adaptive variable. The coefficients for IVT and OVT were -0.13 and -0.17 respectively and hence they have been combined into a single term (SP-IO) which denotes that these attributes are on average 15% lower when estimated using SP methods. Headway valuations based on SP data (SP-Head) are estimated to be 36% lower.

Departure Time Shifts

There was again no significant difference between early and later departure times overall. In section 5.3 we hypothesised that later departure time shifts might be expected to have a higher value than earlier departure time shifts for commuting and business travel on the outward leg, due to arrival time constraints, and that earlier departure time shifts might be expected to have higher values than later shifts for business travellers and commuters on the return leg of a journey, due to the constraints surrounding meetings and work times. However, there were no differences between the values of earlier and later departures by purpose for the outward direction of travel whilst there were insufficient observations for the return journey to segment by purpose.

The use of explicit departure time shifts in the SP exercise (Exp) were again estimated to have led to somewhat higher valuations whilst a term denoting whether the valuation related to the return leg of the journey (Ret) indicated that these values are somewhat higher. Our feeling is that this is more a function of the uncertainties surrounding the return journey and perhaps the added complexities of an SP exercise which covers the return leg, rather than different constraints on behaviour operating on the return leg. It is important that such effects are isolated rather than estimating an average across the outward and return legs which would lead to a higher estimated valuation for the outward leg than otherwise would be the case.

<u>Attribute Levels</u>

Some interesting results have emerged from analysis of the effect of the mean attribute level on the valuations of OVT (Mean-Ovt), departure time shifts (Mean-Dep) and headway (Mean-Head). Although information on distance travelled proxies for the level of IVT, as well as for the level of cost, the previous study did not collect corresponding data for IVT to support the same analysis as is reported here. The variables are all entered in logarithmic form, since this achieved the best fit, and are therefore interpreted as elasticities. The largest effect is for departure time changes and we find it reasonable that it is this attribute's valuation which is most sensitive to the level it takes. Although we would expect the value of OVT to become somewhat higher at larger levels, for example in line with the large reduction in the number of walking trips as walking times increase, the range of values covered by the studies contained in this review are in a relatively narrow range at relatively low levels.

One interesting consequence of specifying Mean-Head is that the distance effect on headway becomes very minor with a very low t ratio and hence it is removed from the model, although its effect was not quite significant in the headway specific model reported in Table 14. Since headways are usually larger at longer distances, there is a correlation between a positive distance effect and headway being more highly valued as headway increases. Whilst Mean-Head is not itself significant at the usual 5% level, it does provide a better fit than when the distance term for headway is included. Moreover, a distance effect on the value of headway is retained through the Inter term.

<u>Common Effects</u>

We now turn to the results from the analysis of a range of variables which was made possible by the much larger data set for all attributes combined and by constraining the effects of these variables to be the same across attributes. Where the effects are expected to be relatively minor, such analysis is not worthwhile on the attribute specific data sets. The opportunity was taken to test the impact of all the variables about which we have collected information. The variables for which significant effects have been estimated relate to the numeraire, choice context, location, unit of cost and whether non traders were omitted.

We have examined the impact of the numeraire used on the estimated money values of time. Dummy variables were specified denoting whether the cost coefficient used in calculating the money values related to toll charge or some form of road pricing charge (Toll), rail or bus fare (Cost-RB) or whether a generic coefficient was estimated across car and public transport costs (Cost-CPT). Petrol costs tend to feature heavily in the cost coefficients covered by Cost-CPT. The omitted category represents car specific cost coefficients based on petrol cost, parking charge or a combination of the two.

Inter-study analysis reported in our previous review of IVT (Wardman, 1997) found that values of IVT estimated in toll units were lower than for other values whilst the intra-study analysis concluded that the greatest sensitivity to cost was for toll charge, followed by both parking charge and public transport fare, with least sensitivity to petrol cost variations. Hence values expressed in toll units will tend to be lowest and those expressed in petrol cost units will tend to be highest. The low sensitivity to petrol cost changes is because motorists tend to disregard it. Petrol costs may not be known with any degree of precision, they may be regarded more as a fixed cost or else there may be unaccounted for contributions to petrol costs by others or by an employer. The high sensitivity to toll charge is presumably due to protest responses and strategic bias, particularly where toll charges are presented in contexts where there is in practice no charge for the use of road space.

It is therefore unsurprising that the valuations in toll charge units were estimated to be lowest and the valuations for the omitted category where petrol cost is prevalent were highest. It is presumably the inclusion of petrol cost which leads to Cost-All values to be higher than Cost-RB values. Note that the inclusion of these variables relating to the numeraire had little impact on the estimated effects from mode and hence they are not simply discerning a modal effect.

Valuations obtained from route choice exercises were higher. In part this may reflect a car user effect but it may also be an indication that SP exercises for car users which involve choices between routes are more realistic than those involving choices with other modes. The omission of non-traders leads to values which are 10% lower. This is a relatively minor effect, and it is an encouraging finding since, along with the insignificant effect for a variable representing whether logic or consistency checks were used, it suggests that estimated values are not particularly sensitive on average to what might be regarded to be controversial procedures of excluding data.

We examined whether the valuations obtained for urban and suburban trips varied by location. The base location is London and the South East with a few values relating to rural trips. There were too few of the latter to specify separately whilst Inter represents the inter-urban trips. Dummy variables were specified for urban and suburban values obtained from Metropolitan areas, other conurbations and freestanding towns, all of which were outside the South East. The coefficient estimates for these were -0.17, -0.18 and -0.17 respectively and hence a single term (MetConTown) has been specified. This is highly significant and indicates that values in these locations are 15% lower than values obtained in the South East. This is presumably due to an income effect.

The final coefficient estimate (Cost-RT) relates to whether a round trip cost was presented in an SP exercise. We are concerned that the presentation of attributes in different units may have an effect on the valuations obtained. This most often occurs for public transport in the inter-urban context where the round trip ticket is that most commonly purchased yet journey time is most realistically presented in one-way units. This may lead to respondents trading-off between time and cost as if they were both in the same units. If this occurs, it will lead to lower money values. This has indeed turned out to be the case, although the effect is not significant at the usual 5% level and it is smaller than was estimated solely to IVT. Nonetheless, this remains an issue which needs to be dealt with carefully.

5.7.2 Variations in Money Values

This section illustrates how the money values of various attributes can vary on the basis of the findings presented in Table 17. In all the examples reported, we specify that the values relate to quarter 4 1994, the numeraire is a cost term relating to all modes (Cost-CPT), the choice context is not route choice, non-traders are not omitted, the values are obtained from RP data, single trip costs were presented and the location of any value relating to urban or suburban trips is a Metropolitan area, conurbation or freestanding town outside of the South East. The base value would then be 1.88 pence per minute in 1994 quarter 4 prices.

Table 18 shows how the values of IVT, OVT, departure time shifts, headway and late time could vary according to the levels of key variables. The levels of these variables are chosen to demonstrate the very large amount of variation that could occur in the values, although of course the amount of variation in many practical circumstances will be much less than that portrayed in Table 18. Clearly, there would be additional variation in the attribute values if the other variables contained in the model had been varied across the various scenarios.

Table 18: Variations in Money Values of Attributes (1994 Q4 Prices)

Attribute	Miles	Purp	Class	Mode	Exp	Level	Value
IVT	2	Leis	n/a	Bus	n/a	n/a	2.1
	2	Leis	n/a	Car	n/a	n/a	3.0
	10	Comm	n/a	Car	n/a	n/a	4.4
	50	EB	n/a	Car	n/a	n/a	14.3
	100	EB	1st	Rail	n/a	n/a	43.6
	200	EB	1st	Air	n/a	n/a	59.3
OVT	2	Leis	n/a	Bus	n/a	10	3.1
	2	Leis	n/a	Car	n/a	5	4.1
	10	Leis	n/a	Car	n/a	15	6.1
	50	EB	n/a	Car	n/a	15	23.4
	100	EB	1st	Rail	n/a	30	80.7
	100	EB	1st	Rail	n/a	60	91.5
	200	EB	1st	Air	n/a	60	124.4
Departure Time	2	Leis	n/a	Car	No	30	0.3
	2	Leis	n/a	Rail	No	30	0.7
	10	Comm	n/a	Rail	No	60	6.4
	50	EB	n/a	Rail	No	60	28.1
	50	EB	n/a	Rail	Yes	60	44.3
	100	EB	1st	Rail	Yes	60	94.9
	200	EB	1st	Air	Yes	120	272.2
Headway	Urban	Leis	n/a	Bus	n/a	15	2.3
	Urban	Comm	n/a	Car	n/a	15	5.1
	Inter	Comm	n/a	Car	n/a	30	6.5

	Inter	EB	n/a	Rail	n/a	60	10.9
	Inter	Leis	n/a	Rail	n/a	60	4.2
	Inter	EB	1st	Rail	n/a	120	22.7
	Inter	EB	1st	Air	n/a	120	44.2
Late	2	EB	n/a	Any	n/a	n/a	87.8
	10	EB	n/a	Any	n/a	n/a	52.3
	50	Comm	n/a	Any	n/a	n/a	25.1
	100	Leis	n/a	Any	n/a	n/a	9.6
	200	Leis	n/a	Any	n/a	n/a	7.7

5.8 Regression Model of Valuations in IVT Units

5.8.1 Estimated Effects

Although the results presented in Table 17 for the money valuations can be used to derive weights to be applied to the valuations of time and service quality which are the main focus of this study to convert them into equivalent IVT units, this is not a straightforward procedure because of the large number of variables which enter the monetary valuation model and which influence the money values of the different attributes in different ways. Given this, and the widespread practice of expressing valuations of walk time, wait time and headway in equivalent IVT units, it would be useful to have a model which explained the key factors which influence time valuations.

Such a model is presented in Table 19 and was estimated to the 533 time valuations relating to OVT, search, late, delay, headway and departure time shifts. The interchange valuation is different in nature, since it relates to the penalty of having to interchange rather than the time involved, and therefore it is not included in this analysis.

The model takes the same basic form as is represented by equation 1. Although the goodness of fit is not as high as we would have wished, a number of interesting findings have emerged. For the same reasons as were given for the money value regression model in section 5.7, we have retained some variables whose coefficients were not significant at the 5% level. Again there were no instances of a statistically significant coefficient estimate which did not have the expected sign.
We would expect the valuations of the various attributes expressed in time units to vary less than values expressed in money units on the grounds that there are more factors which will influence the cost coefficient or which will influence it to a greater extent, including mode, GDP and purpose, compared to the coefficients relating to the time and service quality attributes. It has in fact turned out to be the case that, even after allowing for the absence of the IVT attribute, fewer significant variations in the time valuations have been discerned. However, a further contributory factor here will be the halving of the sample compared to that underlying the money value model reported in Table 17. It must also be noted that the money and time valuation data sets do not correspond exactly, since some studies did not contain a cost coefficient whilst others did not contain an IVT coefficient, and this should be borne in mind when comparing the results for the IVT and money values.

Constant Terms

Given that we have time valuations for nine attributes, we can specify dummy variables for eigth of them alongside a constant term. The arbitrarily omitted category was headway. The intercept was very low and insignificant (t=0.41) and was therefore omitted from the model. The coefficient estimates for the dummy variables relating to walk, wait, walk and wait combined, access and delay were 0.31, 0.39, 0.31, 0.36 and 0.34 respectively. Hence these were combined into a single term (ID-OD). This figure denotes that, with all the categorical variables set at their base levels and ignoring the effects of the continuous variables, these attributes are valued 40% higher than IVT. This is highly consistent with the previous findings reported in this study.

The dummy variable denoting departure time changes (ID-Dep) and late time (ID-Late) are both significant at the usual 5% level whilst that for search (ID-Search) is not far removed from significant. The coefficients for ID-Late and ID-Dep along with the other coefficients in the model indicate that the time valuations of these two attributes exhibit considerable variation. On the other hand, the only variable in the model which impacts on the search valuation or on the delay valuation is App, which denotes whether the value was affected by whether the purpose of the study was clearly to value the variable in question. The value of search time predicted by the model would therefore be either 25% or 49% higher than the value of IVT whilst the corresponding figures for delay time are 40% and 67%. These figures surround the central estimates of the IVT values of search and delay time reported in Table 9.

Significant distance coefficients were obtained for headway (D-Head), late time (D-Late) and OVT (D-Ovt). All other distance coefficients, including those specified for combinations of variables such as search and delay time, were far from significant.

The reduction in the IVT valuation of headway as distance increases is not surprising since Table 17 report a positive distance effect on the money value of IVT but there is no distance effect on the money value of headway. Similarly, the distance effect in the IVT specific regression model exceeds that in the headway specific model. We find it plausible that on longer distance journeys headway becomes less important relative to IVT, in part because headway is a lower percentage of generalised cost and because the unit disutility of travel time may well increase with distance whereas the corresponding impact on the value of headway would come from the level of headway rather than distance. In addition, travellers expect lower frequencies on longer distance journeys and hence may be more ready to accept it.

There is a small negative influence from distance on the IVT values of OVT, even though the distance effect on the money values of IVT and OVT were very similar such that the money value model in Table 17 constrains them to be the same. This discrepancy between the money and IVT value models could be accounted for by the presence of many additional variables in the money value model whilst the two data sets do not correspond exactly. Nonetheless, we do not find it unreasonable that the IVT valuation of walk, wait and access falls with distance for analagous reasons to those offered for headway.

Table 19: Overall Model for Valuations in IVT Units

VARIABLE	CATEGORY	Coeff (t ratio)	Effect
Attribute	ID-OD	0.337 (3.07)	+40%
	ID-Dep	-1.751 (2.51)	-83%
	ID-Late	3.596 (4.12)	+3545%
	ID-Search	0.226 (1.57)	+25%
Distance	D-Head	-0.102 (3.36)	
	D-Late	-0.667 (2.29)	
	D-Ovt	-0.077 (2.23)	
Purpose	EB-Head	0.278 (1.99)	+32%
	Comm-Dep	0.351 (2.16)	+42%
	Leis-Ovt	0.148 (1.98)	+16%
Mode	Car-Head	0.545 (3.02)	+72%
	Car-Dep	-1.229 (5.39)	-70%
	Car-Ovt	-0.182 (2.88)	-17%
	Rail-Ovt	-0.293 (1.58)	-25%
	PT-Ovt	-0.291 (2.58)	-25%
SP	SP-Head	-0.247 (3.11)	-22%
Departure Time Shifts	Exp	0.582 (2.85)	+79%
	Ret	1.251 (4.67)	+249%
Attribute Level	Mean-Ovt	0.071 (1.45)	
	Mean-Dep	0.307 (1.61)	
Aim	App	0.173 (1.74)	+19%

	Obs	533	
	Adj R^2	0.496	

Note: Adj R^2 is for the model which contained the constant.

The effect of distance on the time value of late time (D-Late) is particularly large which is consistent with the negative relationship between the money value of late time and distance and the positive distance effect on the value of IVT. It is estimated that a 10% increase in distance reduces the IVT valuation of late time by almost 7%. No effects from journey purpose on the IVT valuations of late time could be discerned, although the small sample of late time values does not help matters. It may be that the distance effect is discerning that commuters have particularly large values of late time and tend to make shorter journeys, although such a large effect should have been detected by purpose variable whilst offsetting this is that business travellers will have large values of late time yet they tend to make relatively long journeys. It may simply be that being late is less unacceptable for longer distance journeys and time constraints are generally more pressing for shorter distance trips.

Whilst it is conventional to weight the values of walk and wait time more highly than the value of IVT, with a figure of two being widely used, this is typically only done for non business travel time on the grounds that employers' are simply concerned to reduce travel time in order to increase productivity and it does not matter what type of time is being saved. On the other hand, it may be that employers' do in fact give more weight to reductions in walking and waiting time and this is reflected in, for example, a willingness to pay for relatively expensive taxis to reduce walking times. Even if a company does not weight OVT relatively highly, there may be freedom within its company travel policy which allows the individual business traveller to make choices which refect higher values of OVT than IVT and hence the higher weighting of OVT has a behavioural basis.

We have argued that the business travel values reflect employers' valuation when the purpose of the study was forecasting, and indeed the values are too high to be employee valuations. We have found no evidence that the higher weights attached to OVT for commuting and leisure travel do not also apply to business travel.

Only three statistically significant effects of journey purpose on the time valuations were apparent. he time valuation of headway (EB-Head) was found to be 32% higher for employer's business trips. We find it reasonable that headway is particularly important to business travellers but note the inconsistency with the money value model where the impact of business on the values of IVT and headway were very similar.

Commuters and peak travellers were found to have somewhat higher IVT values of departure time shifts (Comm-Dep) than leisure travellers. This is consistent with the findings for the money values, albeit with a lower effect here, whilst no effect on business travel has been discerned when one would be expected due to the very large effect apparent for the money values. A possible explanation of this is that the money and IVT valuation departure data sets coincide less for departre time shifts than any other attribute.

The time values for OVT were found to be higher by around 16% for leisure travel (Leis-Ovt) than for the other purposes. This is presumably because the money value of IVT is lower for leisure travel but this is not the case for OVT.

Significant variations in the IVT values of headway and departure time shifts for car users were obtained which are consistent with the findings from the analysis of the money valuations. In addition, car, rail and PT users were estimated to have lower IVT values of OVT, presumably as a results of bus users having low values of IVT and hence relatively large IVT values of OVT.

A significant effect on the value of headway was detected for values estimated to SP data. This indicates that the IVT value of headway is 22% lower when estimated to SP data. This is lower than for the analagous effect for the money valuations since the money value of IVT was also found to be lower when obtained from SP data.

As with the money valuations, the IVT valuations of departure time shifts were much higher where explicit changes were presented (Exp) and where the valuation covered departure time changes on the return leg of the journey. The effects are somewhat higher than for the money valuations and again the differences between the money and IVT valuation data sets may here be a contributory factor.

Mean-Ovt and Mean-Dep represent the average levels of Ovt and departure time shift. They are specified in logarithmic form and hence their coefficients can be interpreted as elasticities. Although they are not quite significant, they are retained since similar, albeit stronger, effects were discerned for the money values.

The final coefficient denotes whether we considered that respondents would have readily perceived that the primary aim of the study was the analysis of the variable in question. The IVT values were found to be higher where this was the case, although the effect is not particularly large. Whilst App is of no use when applying the model to obtained estimates of the various attributes in IVT units, we need to isolate such effects since otherwise they will influence the average values obtained when in fact we suspect that they do not represent a valid influence on the valuations.

5.8.2 Variations in Time Values

This section illustrates how the IVT valuations of OVT, departure time shifts, headway and late time can vary according to the influences of several of the variables contained in the model reported in Table 19. The values presented in Table 20 assume that the IVT valuations of the various attributes were obtained from RP data whilst App is also set at its base value. Whilst we have concluded that it would be inappropriate to weight walk and wait time at twice the rate of in-vehicle time, the results presented in Table 20 show that the weighting can vary considerably across different circumstances.

Table 20: Variations in Time Valuations of Attributes

Attribute	Miles	Purp	Mode	Exp	Level	Value
OVT	2	Comm	Rail	n/a	15	1.20
	2	Leis	Bus	n/a	15	1.87
	10	Comm	Car	n/a	5	1.10
	50	Comm	Rail	n/a	15	0.94
	100	Leis	Rail	n/a	30	1.08
	100	Leis	Bus	n/a	60	1.52
	200	Leis	Bus	n/a	60	1.44
Departure Time	Any	Leis	Car	No	30	0.14
	Any	Leis	Car	No	60	0.18
	Any	Comm	Car	No	60	0.25
	Any	Comm	Rail	No	60	0.87
	Any	Comm	Rail	Yes	60	1.55
	Any	Comm	Rail	Yes	120	1.92
Headway	2	Comm	PT	n/a	n/a	0.93
	2	EB	Car	n/a	n/a	2.12
	10	Comm	PT	n/a	n/a	0.79
	10	EB	Car	n/a	n/a	1.80
	50	EB	Car	n/a	n/a	1.53
	100	EB	PT	n/a	n/a	0.83

	200	EB	PT	n/a	n/a	0.77
Late	2	Any	Any	n/a	n/a	22.96
	10	Any	Any	n/a	n/a	7.85
	50	Any	Any	n/a	n/a	2.68
	100	Any	Any	n/a	n/a	1.69
	200	Any	Any	n/a	n/a	1.06

6. INTRA-STUDY ANALYSIS

This aspect of the study examines issues which can be analysed from variations in valuations that occur within studies. The attractions of the approach are that it provides the greatest level of control over extraneous influences and hence we can be confident that confounding effects have been isolated, although of course interaction effects may still be present whereby the relationship that has been isolated could be different according to the level of some other variable. For example, we might be confident that the difference between RP and SP values is solely due to the different types of data but the relationship between them could still differ according to, say, journey purpose.

Examination of intra-study variation by a wide range of socio-economic factors, such as income, age, gender, household type and working status was beyond the scope of this study. The issues which we have covered in this intra-study analysis are:

- i) Revealed and Stated Preference Valuations
- ii) Relative Valuations of Walk and Wait Time
- iii) Relative Valuations of Earlier and Later Departure Time Changes
- iv) Journey Purpose

6.1 Revealed and Stated Preference Valuations

6.1.1 Intra-Study British Evidence

Concerns regarding the validity of SP techniques were initially addressed by comparison of the relative valuations obtained from corresponding models within the same study. Indeed, one of the aims of the initial UK value of time study (MVA et al., 1987) was to compare RP and SP choice models in as controlled a manner as possible. This control meant that not only were the models based on the same choice context, but they were developed on the same individuals (Wardman, 1986, 1988). Table 21 presents the latter models and also other RP and SP models of which we are aware which were calibrated either to the same individuals or else to very similar sets of individuals in the same study.

Of the 24 comparisons of RP and SP values that can be made, 15 (62%) relate to IVT, 4 (17%) relate to delay time, 3 (13%) relate to headway and 1 (4%) relate to each of walk and wait time. Unfortunately, there are too few values to support separate comparisons of delay, headway, walk and wait. The most detailed analysis that we can conduct is according to whether the valuation relates to IVT or not.

Table 21: RP and SP Money Valuations (1994 Q4 Prices)

Study and Context	Variable	Mode and Purpose	RP	SP
Inter Urban	IVT	Car & All	8.06	7.43
Mode Choice	IVT	Bus & All	10.84	8.22
	IVT	Rail & All	5.06	7.46
	Head	Rail & Bus & All	5.46	
Oscar Faber TPA	Head	Rail All		4.43
(1993a)	Head	Bus All		3.71
Inter Urban	IVT	Car & All	5.91	6.25 & 5.11
Mode Choice	IVT	Rail & All	8.18	5.11 & 7.38
	IVT	Coach & All	1.59	3.18
	IVT	Rail & All	2.50	3.41
TPA (1992)	Head	Rail & All	7.04	7.04
Inter Urban	IVT	Rail Commuting	4.65	3.97
Mode Choice	IVT	Coach Commuting	5.44	4.99
	Walk	Rail & Coach Commuting	3.83	6.01
Wardman (1988)	Wait	Rail & Coach Commuting	12.50	5.73
Motorists' Route Choice	IVT	Car Commuting	7.70	4.97
	IVT	Car Leisure	5.51	6.45
Wardman (1986)	Delay	Car Commuting	8.23	6.94
	Delay	Car Leisure	6.06	9.40
Motorists' Route Choice	IVT	Car Commuting	3.76	3.36
	IVT	Car Leisure	6.36	2.75
HCG & Accent (1996)	Delay	Car Commuting	4.25	5.71
	Delay	Car Leisure	11.47	5.61

All the studies are based on inter-urban trips and the journey purposes are either commuting, leisure or a combination of business, leisure and commuting (All) trips. Given that there are few values other than of IVT, the comparison has focused on RP and SP monetary valuations.

Table 22 presents the average monetary valuations for all the data and for the IVT and non IVT valuations separately. In all three cases the differences in the mean values are not significant, although the sample sizes are limited, but the SP valuations are lower than the RP values and the discrepancy, in both proportionate and absolute terms, is greater for the non IVT terms.

Table 22: Average Monetary Values (1994 Q4 Prices)

	RP	SP	t (RP-SP)
All	6.41 (±1.08)	5.61 (±0.70)	1.24
IVT	5.98 (±1.24)	5.34 (±0.92)	0.83
Non IVT	7.14 (±2.02)	6.06 (±1.10)	0.94

Note: The figures in brackets are 95% confidence intervals. t(RP-SP) denotes the t statistic applied to the difference between the mean RP and SP values

We can observe in Table 21 that there seems to be a reasonable degree of correlation between the RP and SP values of IVT but that the same might not be the case for the other valuations. In any event, the mean RP and SP valuations could still be very similar even if there was actually no relationship between them. A formal test of the extent to which the SP values are dependent upon the RP valuations is to regress the SP values on the RP values. We therefore specify a model of the form:

$$VoT_{SP} = \alpha + \beta VoT_{RP} \qquad \textbf{4}$$

If RP and SP values coincide exactly then the constant (α) would be zero and the slope (β) would be unity and it is against these values that the model should be interpreted.

Separate models have been estimated to all values, the IVT values and the non IVT values. Unfortunately, the correlation between the estimated values of α and β is around -0.9 in all three cases. We have therefore omitted the constants terms from the reported regression models which are given in Table 23.

Table 23: Regression of SP Money Values on RP Money Values

	β	R^2
All	0.79 (±0.12)	0.20
IVT	0.84 (±0.13)	0.46
Non IVT	0.73 (±0.25)	0.00

Note: The figures in brackets are 95% confidence intervals. The R^2 figures relate to the model which contained the intercept.

The SP IVT valuations are 16% lower than the equivalent RP values. This is consistent with the previous evidence reported in Tables 11 and 17 where the RP and SP values are not restricted to being from the same study. The non IVT SP valuations are 27% lower than the RP values, which is again broadly consistent with the findings based on the regression models and summarised in Table 16, even though as a result of the limited sample size the estimated value of β is not significantly different from one. However, what is more alarming here is that the variation across the RP values does not provide any explanation at all of the variation in the SP values.

6.1.2 Summary of RP and SP Comparisons

Although the comparison of the RP and SP values would have benefitted from a larger number of RP values and some of the effects have not been estimated as precisely as we would have wished, some interesting findings have emerged.

From the inter-study analysis, the SP money values have been estimated to be lower than the RP values by the following amounts:

- IVT: 11%-15%
- OVT: 15%-29%
- Headway 36%-43%
- Interchange 41%

From the intra-study analysis, the SP money values have been estimated to be lower than the RP values by the following amounts:

- IVT: 11%-16%
- Non IVT: 15%-27%

The degree of correspondence between the inter-study evidence and the intra-study evidence is quite striking. Whilst previous research has generally found a reasonable degree of correspondence between RP and SP values, this has been primarily based on the value of IVT. The findings here confirm that this is in fact the case. However, matters are a little different for the other attributes, particularly for headway and interchange, where the differences between the RP and SP values is a cause for some concern.

If RP and SP values are different, we would expect the SP values to be the lower. The following reasons are offered as an explanation of this.

- The presence of strategic bias is more likely to impact on the cost term. Travellers are used to costs varying and appreciate that they can be readily controlled by operators and relevant authorities. This reduces the disincentive to strategic bias and will result in a greater sensitivity to cost variations and hence lower monetary valuations.

- In order to simplify the task of completing SP exercises, respondents may ignore variables of lesser importance or which vary less. To the extent that cost is less likely to be ignored than other attributes, its coefficient will be relatively larger and hence the money values smaller. This might also be a reason why the divergence between the RP and SP values is greater for headway and OVT than for IVT.

- Attribute variations which are not realistic may be ignored, thereby reducing their coefficient estimate. This is more likely to apply to the non cost variables and hence will lead to lower values of time. In particular, walk time variations might be regarded as unrealistic whilst the removal of through services or indeed the introduction of through services may be regarded to be unrealistic on some routes.

- Our impression is that headway is one of the most problematic variables which enter RP models. For example, it is one of the main causes of data loss in RP mode choice models because of incomplete information and it tends to generate more suspicion about the reliability of the reported levels than other variables. Hence the divergence between the RP and SP values could in this instance stem from unreliable RP valuations of headway.

6.2 Relative Valuations of Walk and Wait Time

The widespread convention is to value both walk and wait time as twice IVT. We have here taken the opportunity to test whether walk and wait time do in fact have the same valuations by comparing estimates obtained from the same models. We have twenty four instances where we can compare walk and wait time values and Table 24 presents the mean values of walk and wait time, along with their associated standard errors, and also the mean of the ratio of the walk and wait time values with its standard error. The results are additionally segmented by the purposes of commuting, leisure and no distinction.

The mean values of walk and wait time are very similar and indeed far from being significantly different. Hence it is not surprising that the ratio of the values of walk and wait time averages close to one.

Table 24: Walk and Wait Time Valuations

Walk	Wait	Walk/Wait	Purp	Obs
1.48 (0.10)	1.56 (0.14)	1.06 (0.08)	All	24
1.43 (0.13)	1.48 (0.13)	1.04 (0.11)	Commuting	12
1.23 (0.09)	1.22 (0.16)	1.09 (0.13)	Leisure	8
2.07 (0.35)	2.45 (0.47)	1.04 (0.34)	No Dist	4

6.3 Values of Earlier and Later Departure Time Shifts

The regression analysis reported in sections 5.3 and 5.7 found no evidence that departure time changes which involved departing earlier were valued differently to those which involved departing later than the preferred time. This was so even after exploring the possibility that the relative values of early and late time might vary between the outward and return leg according to journey purpose.

We have here conducted more controlled analysis by comparing the values of earlier and later departure times obtained from within the same SP experiment. Since we are here concerned with the coefficients estimated to earlier departure times and later departure times regardless of whether a time or cost coefficient or both are estimated, we can make use of the data set which contains the total of 97 departure time shift valuations. This data set includes 37 cases where both early and late time valuations were obtained, all other things equal.

We regressed the ratio of the earlier and later departure time valuations on the independent variables of distance, amount of departure time change, journey purpose and mode. Purpose was represented by employer's business, commuting and leisure relative to an omitted category of no distinction whilst mode was represented by car relative to an omitted category of rail.

The only variable which had a t ratio in excess of one related to leisure trips. The estimated model is reported in Table 25 and denotes that earlier departure time shifts have a higher value than later departure time shifts for leisure travellers. Given that most of the valuations relate to the outward leg of a journey, we would expect business travellers and commuters to have relatively high values of later departure time shifts due to constraints surrounding arrival times, although offsetting this could be that earlier departure times for early morning departures might be particularly unattractive. However, we see no reason why leisure travellers should have relatively high values of earlier departure time changes.

Table 25: Regression of Ratio of Earlier and Later Departure Times

Constant	0.96 (8.26)
Leisure	0.44 (1.98)
R^2	0.10
Obs	37

Table 26 reports the mean and its standard error for the ratio of earlier and later departure time shifts for a number of categorisations. It can be seen that, with the exception of leisure travel, the ratio is close to one denoting that earlier and later departure time changes are valued similarly.
Indeed, the ratio is insignificantly different from one in all the cases reported.

Table 26: Mean Ratios of Earlier and Later Departure Time Shift Valuations

Category	Mean (SE)	Obs
Overall	1.07 (0.10)	37
EB	0.95 (0.09)	12
Commuting	1.00 (0.13)	10
Leisure	1.40 (0.28)	10
No Distinction	0.89 (0.35)	5
Car	1.14 (0.12)	13
Rail	1.04 (0.15)	24
Urban/Suburban	1.08 (0.11)	21
Inter Urban	1.07 (0.20)	16

The results of this more controlled analysis confirm the findings of the regression based analysis reported in section 5 that the values of earlier and later departure time changes are essentially the same.

6.4 Journey Purpose Valuations

We here report comparisons of attribute valuations obtained from the same study where the only difference between the values is according to journey purpose. Commuting includes peak travel whilst leisure includes off-peak travel, although we can note that peak and off-peak are only ever compared with each other.

Table 27 presents the different monetary valuations where there were sufficient observations to conduct a meaningful comparison. There tend to be more valuations where leisure trips are concerned because some studies included various categories of leisure travel and hence more than one comparison can be made per study. The mean valuations for each purpose and associated standard error are provided whilst the mean of the ratio of the two attribute valuations and its standard error is also given.

Table 27: Money Valuations by Purpose (1994 Q4 Prices)

Value	Purp	Value	Purp	Value	Ratio	Obs
OVT	Comm	6.26 (0.43)	Leis	5.20 (0.35)	1.36 (0.07)	90
OVT	EB	25.97 (3.69)	Leis	15.64 (1.67)	1.68 (0.21)	37
Dep Time	Comm	16.06 (1.38)	Leis	6.25 (0.78)	3.37 (0.68)	21
Dep Time	EB	69.51 (8.99)	Leis	5.92 (0.49)	12.00 (1.35)	27
Dep Time	EB	106.01 (6.75)	Comm	16.51 (0.86)	6.53 (0.47)	15
Headway	Comm	3.53 (0.39)	Leis	2.84 (0.37)	1.60 (0.16)	45
Headway	EB	11.54 (1.98)	Leis	4.33 (0.44)	2.88 (0.39)	33
Headway	EB	6.36 (1.91)	Comm	4.71 (0.71)	1.47 (0.48)	6
Intch	EB	482.81 (53.25)	Leis	189.88 (54.28)	2.24 (0.39)	12

The results are broadly in line with those obtained from the regression models, with employers' business values exceeding commuting values and in turn the commuting values exceeding leisure values whilst the key variation apparent here is for departure time variations which was also apparent in the regression models. The one inconsistency with the regression model results is that commuting is here seen to have higher values of OVT than for leisure travel yet this was not detected in the regression model.

Table 28 presents the different IVT valuations where there were sufficient observations to conduct a meaningful comparison. The results are again broadly consistent with those obtained in the IVT regression model reported in Table 19. For example, the most noticeable differences here are that leisure has the highest value of OVT, the departure time valuations are highest for commuting and headway is highest for employers' business trips, and these correspond with the key purpose effects apparent in Table 19.

Table 28: IVT Valuations by Purpose

Value	Purp	Value	Purp	Value	Ratio	Obs
OVT	Comm	1.48 (0.06)	Leis	1.51 (0.07)	1.04 (0.03)	94
OVT	EB	1.72 (0.11)	Leis	2.19 (0.16)	0.86 (0.05)	39
Dep Time	Comm	0.80 (0.19)	Leis	0.40 (0.04)	1.84 (0.36)	22
Dep Time	EB	0.49 (0.06)	Leis	0.42 (0.03)	1.19 (0.12)	21
Dep Time	EB	0.49 (0.06)	Comm	0.84 (0.20)	0.80 (0.06)	21
Headway	Comm	0.83 (0.07)	Leis	0.79 (0.07)	1.37 (0.18)	46
Headway	EB	1.23 (0.09)	Leis	0.88 (0.06)	1.64 (0.20)	33
Headway	EB	1.27 (0.26)	Comm	1.02 (0.10)	1.30 (0.30)	6
Intch	EB	39.83 (2.78)	Leis	53.71 (5.72)	0.81 (0.08)	12

7. CONCLUSIONS

The research reported here has, as far as we are aware, conducted the most comprehensive quantitative review of the valuations of a wide range of travel attributes. It builds upon the research reported in Wardman (1997), which focussed entirely on the value of in-vehicle time, and considers British empirical evidence relating to the values of walk time, wait time, access time, search time, late time, delay time, departure time changes, headway and interchange. In so doing, it has amassed a very large amount of empirical evidence with which it has been possible to examine a large number of possible influences on relative valuations.

In this concluding section, we set out what we regard to be the value of this research, summarise the main findings and present recommendations for appraisal procedures and further research.

7.1 Value of the Research

The research reported here casts light on a wide range of important issues. The development of regression models to explain variations in the valuations of the attributes under consideration is particularly useful where:

- theory gives little guidance as to even the sign (positive or negative) of an effect of a variable on a value of time or service quality. In certain instances, it could be argued that this is the case with respect to distance, and it also applies to the impact of, for example, the removal of non-traders from an SP data set or the impact of different means of presenting SP exercises.

- there is conflicting evidence across studies. This is to some extent the case for the impact of journey purpose on valuations and the degree to which walk time values exceed IVT values.

- the issue being addressed requires comparisons across studies, such as with how the valuations vary over time or across locations.

The research is also of significance because it provides:

- a means of estimating valuations for circumstances where it would not be possible to obtain estimates by other means. This could be a particularly attractive feature of some of the results, such as the valuation of the attributes in units of in-vehicle time, which could be expected to be transferable to countries where evidence regarding these valuations is sparce.

- a means by which the results of a particular empirical study could be interpreted in relation to a large amount of previous evidence.

- a means by which current recommendations and conventions could be appraised.

- insights into methodological issues.

Transport planners can often be placed in a situation of having to make a judgement concerning relative values, or even of updating models with limited available evidence. The models and evidence reported here could be of considerable use in informing any such procedure. A particularly important feature of research of this type is that it makes available the net outcome of a very large amount of British empirical evidence regarding a large number of travel attributes which many transport researchers would not otherwise have access to.

There are of course some limitations to research of this type. It is essentially an aggregate approach, providing insights into general relationships between average valuations and relevant socio-economic variables, and as such it cannot provide a detailed account of variations in valuations due to specific disaggregated characteristics of the traveller or the travel conditions. Nonetheless, it does support the investigation of an appreciable range of significant issues from which a number of important findings emerge. It is to a summary of these findings that we now turn.

7.2 Key Findings

It has been possible to develop a regression model which explains variations in the money values of the time and service quality attributes as a function a large number of variables, including journey distance, journey purpose, mode, attribute level, time trend, numeraire, location and type of data. Not only do the money values vary across different circumstances, but there can also be considerable variation in the valuations expressed in units of in-vehicle time.

Business values are, as expected, the highest although amongst these there is variation between first and standard class travellers and according to whether the main purpose of the study was valuation as opposed to forecasting. Commuting values tend to be higher than leisure values.

A large number of effects from mode were discerned which were broadly consistent with expectations. Car and underground users were estimated to have relatively high values of headway whilst there was a very strong degree of similarity in the modal effects on in-vehicle time and out-of-vehicle time.

The effect from distance on the money values was in most cases positive and very similar although not particularly strong. This is in addition to higher values for inter-urban trips of 30 miles or more. The main exception here was the negative effect from distance on the value of late time.

There is a reasonable degree of correspondence between RP and SP values of in-vehicle time. However, this correspondence is progressively weakened for out-of-vehicle time, headway and interchange. Indeed, the divergence between the RP and SP values for headway and interchange is a cause for some concern.

There is evidence that the values of out-of-vehicle time, headway and departure time changes are dependent upon the levels that their variables take. The effect upon departure time changes is particularly strong.

There is strong evidence that the money valuation of an attribute will vary with the numeraire used and this is in line with the evidence reported in the previous review (Wardman, 1997). Valuations expressed in units of toll charge are the lowest whilst those expressed solely in terms of car running costs are highest.

Although the analysis is by no means without its difficulties, our best estimate is that the values increase at around 1% per annum, which is equivalent to a GDP elasticity over the preiod in question of around 0.5. This is highly consistent with cross-sectional evidence.

We have found no evidence that the higher weights attached to out-of-vehicle time should not also apply to business travel.

The evidence presented in this study suggests that walk and wait time are valued less than the conventional rate of twice in-vehicle time. If a single weight is to be used, then a value around 1.5 would be more appropriate.

Walk and wait time were found to have similar values as were earlier and later shifts in departure times.

The value of interchange was found to be strongly related to distance in line with recommendations set out in the passenger demand forecasting handbook.

7.3 Recommendations

In a recent review of empirical evidence from a number of countries, Steer Davies Gleave (1997) conclude that, "walking time is usually valued at between 1.8 and 2.4 times in-vehicle time. An average of 2.0 is recommended for simplicity". With regard to waiting time, "A ratio of 3 times is recommended". The convention in Great Britain and many other countries is to weight walk and wait time at twice the rate of in-vehicle time.

We recommend that any appraisal procedure which recommends that walking and waiting time are valued at twice the value of in-vehicle time should instead recommend that these attributes are valued 50% higher than in-vehicle time.

Furthermore, given the variation in values across different circumstances, we recommend that the overall money value regression model that has been developed, along with the separate money value of interchange model, should be used to provide valuations of a range of attributes which are specific to particular circumstances.

We recommend that the business travel valuations should also be weighted according to the type of time that is involved.

We have obtained further evidence that, in general, non-working time values should distinguish between commuting and leisure.

The convention in Britain is to adjust money values in line with GDP. We would recommend that a lower GDP elasticity is used and a value of around 0.5 seems appropriate.

The convention of valuing walk and wait time the same can be retained, as can the practice of valuing earlier and later departure time shifts the same and of relating interchange penalty to distance.

7.4 Further Research

Our recommendations for further research are made on the basis of the findings of this study and distinguish between research which takes the form of reviewing existing evidence and further empirical research.

7.4.1 Further Review Research

The review has been based on British empirical evidence of which there is an abundance. It would be illuminating to extend the coverage of the review in the first instance to include other European countries and subsequently to countries worldwide.

The comparison of RP and SP values obtained some interesting findings. However, it would have benefitted from more precise estimates, particularly as a result of more RP data. It would therefore be sensible to add to the evidence reported here by including evidence from other countries.

The maximum level of disaggregation of the values collected in this review was according to journey purpose and mode. This is because other segmentations, such as by income or household type, are not conducted on a consistent basis and analysis of their effects would have involved considerable additional resources. Nonetheless, future review studies should tackle such issues. In addition to collecting the reported evidence, there would seem to be a case here for re-analysis of available data sets which did not report or conduct segmentation analysis.

7.4.2 Further Empirical Research

The review found evidence that the values of out-of-vehicle time, headway and departure time shifts depend on the levels that these variables take. Although the effects for headway and out-of-vehicle time were weak, the process of analysing the relationship between the average values and average levels of the attributes can be expected to have dampened the effects. Given that there has been relatively little research on how the value of in-vehicle time varies with the level of in-vehicle time, and even less on how the values of other attributes depend on their levels, further research in this area is strongly recommended. Whilst re-analysis of existing data sets could well be valuable, fresh data collection would ideally be involved.

Departure time shift valuations were found to vary considerably according to whether explicit or implict departure time shifts were involved. Further research is required to determine which is the more appropriate procedure.

Delay time is estimated to be valued somewhat more highly than time spent in free flow traffic. However, it is a somewhat vague concept, relating to driving in congestion conditions. Further research is required here to examine how this value might vary according to different levels of congestion, and in particular according to the different stress and frustration levels involved. Possible confounding effects from reliability would also be isolated.

Given that the Passenger Demand Forecasting Handbook recommends a forecasting procedure based on generalised time, which is made up of in-vehicle time, headway and interchange, the opportunity should be taken to recalibrate the generalised time elasticity using the in-vehicle time, headway and interchange valuations estimated in this review. The resulting model can then be compared with an equivalent model based on currently recommended weights for these attributes.

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