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Public Transport Values of Time

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FOREWORD

This is one of a series of papers prepared under DETR contract PPAD9/65/79, 'Revising the Values of Work and Non-Work Time Used for Transport Appraisal and Modelling'.

The views expressed in these papers are those of the authors and do not necessarily reflect the views of the DETR (now DTLR).

Working Papers 561-566 were originally prepared in May 2001 and formed the basis for Working Paper 567 which reports on the evidence and was prepared in August 2001. Working Papers 568 and 569 on policy and practicality were written subsequently.

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1. OBJECTIVES

The objectives of this aspect of the study are to provide recommended valuations of:

- Public transport in-vehicle time (IVT)
- Walk time
- Wait time/headway

with appropriate modifiers according to key factors such as:

- Mode user type
- The mode to which the value relates
- Journey distance and inter urban or urban context
- Journey purpose

A recommended procedure for updating values of time over time is also required. Although this issue is touched upon in this paper, a more detailed analysis is the subject of a separate aspect of the study and is reported in Working Paper 566.

The Accent and Hague Consulting Group study did not cover public transport. Nor is this study conducting fresh empirical research. We must therefore base our recommendations on other existing studies. Fortunately, there is a wealth of British evidence on the value of time.

Section 2 provides some background to the valuations of time for public transport users and the valuation of attributes which are important aspects of public transport use. Section 3 details the additional data that has been collected to enhance our previous data sets upon which we have conducted meta-analysis (Wardman, 2001) whilst Section 4 presents tabulations of the money values of time, and the time values of walk, wait and headway, disaggregated as far as is sensible by purpose, mode and whether the journey is urban or inter-urban.

Section 5 describes the principal approach that we have adopted to explain the values of time obtained from the many different studies that are available to us.

Section 6 is concerned with a regression model estimated to the money values for all travellers. From this model are extracted the money values of time and the IVT equivalent values of walk time, wait time and headway for public transport users. The IVT values can be expressed as absolute values or as relative to car users' values. The latter is useful where recommended public transport values are derived as a series of modifiers to car users' values.

As a check of the IVT values of walk, wait and headway implied by the model estimated to money values, we report in section 7 a model estimated solely to the IVT values of walk, wait and headway. Concluding remarks are provided in section 8. Recommendations and comparisons with other aspects of the study are a feature of Working Paper 567.

2. BACKGROUND

A particular feature of public transport is that walk and wait time can represent a significant addition to generalised cost and that savings in these types of time can be expected to be valued more highly than IVT savings. Traditionally, transport economists have placed most emphasis on the value of IVT, in large measure because of the importance of car travel and the way in which road investments are evaluated.

What might be termed national value of time studies (Gunn and Rohr, 1996) have been conducted in Great Britain, the Netherlands, Norway, Sweden, Finland, New Zealand and the United States. Some of these did not consider public transport (Calfee and Winston, 1996; Hague Consulting Group et al., 1999; Hensher, 2001; Small et al, 1999) whilst those that did placed the emphasis firmly on IVT rather than the other aspects of journey time (Dillen and Algers, 1999; Gunn et al., 1999; Hague Consulting Group, 1990; MVA et al., 1987; Pursula and Kurri, 1996; Ramjerdi et al., 1997) A hierarchy of importance is clearly apparent from value of time studies. Car users' valuations of IVT are most important followed by public transport users' valuations of IVT and then valuations of walk and wait time. Not surprisingly, review studies have focussed on the value of IVT and where walk and wait time are reviewed it is very much secondary to the value of IVT (Hensher, 1978; Jennings and Sharp, 1978; Bureau of Transport Economics, 1982; Steer Davies Gleave, 1997; Booz Allen and Hamilton, 2000).

Given that the focus of this paper is public transport, we therefore provide in this section a summary of the position relating to walk and wait time values. Headway values are covered in this paper, but there is no conventional practice to be reviewed. We also provide an overview of the value of public transport IVT.

2.1 Definitions and Interpretations

This paper deals with values of walk time, access time, wait time and headway, in addition to the value of IVT. We must at the outset define these terms and interpret what the values of these attributes obtained from empirical studies actually represent.

The meaning and interpretation of the values of walk time are here straightforward. Walk time covers time spent walking to and from the main mode of the journey which is primarily a public transport mode but can be car. Time spent walking as a mode in its own right is not covered. The interpretation of the values is clear since in the data assembled for the purposes of this study we have to the greatest extent possible separated walk time from other aspects of out-of-vehicle time. The data we analyse also contains values of access to and egress from public transport modes by other vehicular modes, and values which represent varying mixtures of the latter and walking. These are defined as access time.

Values relating to headway and wait time to some extent overlap and can serve a similar purpose. We therefore need to discuss what they mean and their interpretation as far as the meta-analysis reported below is concerned.

Headway represents the interval between public transport services and is a measure of how frequent the services are. Waiting time occurs either prior to the arrival of the first vehicle or during the course of a journey when interchange is required. The majority of wait time values are of the former type in the meta-analysis data set.

We must make it clear that, wherever possible, the values of wait time used in the meta-analysis were estimated to actual measures of wait time and values of headway were based on headway measures. Where, for example, wait time values were estimated to wait times derived as half the service headway, we have with appropriate adjustment used such values as evidence of the value of headway. The exception to this is in some early RP studies where it is not clear whether the value of wait time was estimated to some measure of actual wait time or to a measure deduced from service headway. Given that this will tend to overstate wait times, on the grounds that the convention is to derive wait time as half the service interval yet arrivals at boarding points are not entirely random, the values of wait time obtained by this means will be too low. This should be borne in mind in the interpretation of results where this has had a bearing.

Car offers essentially infinite frequency since, in itself, it does not impose any schedule delay due to constraints on when the journey can be made and it does not involve any waiting prior to journey departure, although of course interactions with other travellers and activities can lead to wait times and the inconvenience of not departing at the desired time.

Although in some circumstances public transport frequency is sufficiently high to approximate the conditions that characterise car travel, in general this is not the case. There is therefore schedule delay and wait time associated with public transport headway[1].

Public transport travellers can sometimes choose between planned and random arrivals at their boarding point. Planning to a catch a specific departure will involve an inevitable element of waiting time, which acts as a safety margin, whereas the expected wait time will be half the service headway for random arrivals. Planned arrivals might also involve information and organisation costs.

Where service frequency is high, random arrivals will tend to dominate and schedule delay will be low. As service headway increases, schedule delay will increase and so will waiting times under random arrivals. Due to the latter, planned arrivals will become increasingly attractive. Given arrivals are planned, subsequent increases in headway will not increase wait time but will have an adverse effect on schedule delay.

If most journeys involve planned arrivals, with fixed waiting time at the boarding point before the scheduled departure time, the headway variable reflects schedule delay effects. An exception is in the case of interchange, where higher frequencies reduce the risks involved in interchange. However, matters are not so clear cut. Firstly, very few studies indicate the precise departure times associated with different headways, and hence the headway valuations cannot be taken as

[1] With hindsight, this study should have also covered the valuation of departure time shifts, as in our previous review of service quality valuations (Wardman, 2001). However, it is fair to say that there is more evidence relating to headway valuations than to the valuations of departure time shifts and headway does have impacts over and above the implications for wait time and schedule delay.

an exact representation of schedule delay. Secondly, in some studies, particularly where mode choice is concerned and RP data is used, consideration is likely to have been made of the return journey and, because of timing constraints, these tend to be more associated with random arrivals and hence the valuations of headway variations are likely to contain a greater element of wait time effects.

It is quite appropriate to interpret the values of wait time covered in the analysis below as reflecting willingness to pay to save wait time. There is, however, an issue as to whether they incorporate an element of wait time unreliability. This is more likely to be apparent in RP based values where mean wait times are used, since SP exercises present a fixed level of wait time, and will lead to higher values than otherwise.

The value of headway is not a direct measure of schedule delay[2] but our feeling is that in the studies covered in this review it largely covers a convenience effect. We propose that the value of headway is used to evaluate the benefits of changes in headway for fixed levels of wait time. The wait time values can be used to evaluate differences in wait time between alternatives or changes in wait time. Where service frequencies are high, it is more appropriate to evaluate changes in headway in terms of changes in wait time.

Clearly, values of walk time, wait time and headway can be expected to vary across the different conditions in which they are incurred, let alone across different individuals. Walk time values can be expected to vary strongly according to the weather, local environment and the time of day, whilst wait time values will depend on the environment in which the wait time is spent and on whether the time can be put to some worthwhile use. Such influences on the values are not routinely isolated in empirical studies. However, this is not materially different to the situation relating to the value of IVT where a diverse range of unmeasured influences on the value of time can be expected to exist.

2.2 The UK Literature on Walk and Wait Time Values

The first study in Britain to estimate walk and wait time values was that of Quarmby (1967). He found that, "walking and waiting times are worth between two and three times in-vehicle time". Subsequent re-analysis of Quarmby's data by Daly and Zachary (1975) found that wait and walk time were respectively valued 2.6 times and 1.6 times a generic car-bus value of IVT. However, when the value of IVT was allowed to be alternative specific, the respective weights were 6.9 and 3.5 for car time and 3.2 and 1.6 for bus time, providing early evidence that the IVT value of walk and wait can vary across circumstances.

Davies and Rogers (1973) is a source of a large number of wait and walk time valuations relative to IVT. The average weight attached to wait time was 2.7 across seven valuations whilst it was 2.4 for walk time across eight valuations. Daly and Zachary (1977) estimated the value of waiting and walking time to be 3.5 and 0.9 times public transport time.

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[2] Wardman (2001) reports a mean valuation of departure time shifts relative to the value of IVT of 0.72 from 56 separate observations. The corresponding value of headway was 0.80 from 145 observations.

A number of points can be made about these pioneering studies. Firstly, they were all based on RP data, and in some cases the sample sizes were small. Secondly, the car-bus choice context features heavily. This is not generally a particularly good context upon which to develop RP models. Thirdly, some studies used estimation techniques that would not now be regarded to be robust. Fourthly, there was greater reliance on using engineered rather than perceived data than is now the custom, and in particular different value of time estimates could be obtained according to the assumptions made about car costs.

Nonetheless, what does emerge from the findings is that they do not support the convention of valuing wait time at twice the rate of IVT. It is difficult to see how this convention arose, other than on the basis solely of Quarmby's findings, and how it remained unchallenged in the light of subsequent evidence. In contrast, there seems to be more justification for the practice of valuing walk time at twice IVT.

Since the early studies, the emphasis has switched to SP data. Some studies have specifically aimed to value walk, wait and headway, whereas other studies obtained values as by-products of the development of demand models whose main purpose was forecasting.

A little reported study focusing on walk and wait time values was conducted as part of the first British value of time study (Fowkes and Johnson, 1985). It involved SP exercises offered to rail and coach commuters. The IVT values of walk time, wait time and, for rail users, interchange connection time are given in Table 2.1. Little variation was apparent according to work arrival time constraints or income. It was concluded that, "The investigation would suggest that the current practice of weighting walk and wait time at twice the in-vehicle figure overstates their importance". Nonetheless, the study itself (MVA et al., 1987) concluded that the available evidence did not warrant a departure from the convention of weighting walk and wait time as twice in-vehicle time.

Table 2.1: Walk and Wait Time Values for North Kent Commuters

	Rail	Coach
Walk Time	1.28	1.43
Wait Time	1.05	1.36
Connection Time	1.67	n/a

Source: Fowkes and Johnson (1985)

Much subsequent British evidence is covered in the meta-analysis reported in Wardman (2001). This was based on values largely obtained from SP studies and undertaken between 1980 and 1997. It was found that the values of walk and wait time were, on average, valued at 1.66 and 1.47 times IVT.

We might expect the values of walk and wait time to depend upon the circumstances in which the walking or waiting is undertaken and we can point to a number of interesting findings.

Wardman and Shires (2001) found walk time at rail stations to be valued at 1.7 times IVT when it involved a change of trains on the same platform but to increase to 2.7 times when it involved crossing to a different platform by means of a bridge or subway. Walk time was valued more highly by females and those with luggage whilst the presence of good or very good facilities for interchanging reduced the value of walk time. The same study valued waiting time at stations, and found it to be higher for females and those on employer's business trips and to be lower where use could be made of the wait time, where the facilities for waiting were rated as good or very good and for those in the 45-60 and over 60 age groups.

London Transport has commissioned several pieces of research which have addressed how values of walk and wait time vary under different conditions in which they are endured. LT (1985) found the value of 'unnecessary' waiting (queuing) to be around three times that of IVT. LT (1977) estimated walking up and down stairs or escalators to be respectively valued at 4 and 2½ times the value of IVT. A more recent study (LUL, 1990) found the weights for walking up and down escalators to be 4.2 and 2.8 and walking up and down fixed staircases to be 4.4 and 3. Similar values were obtained by LT (1985). Higher weights of around 5½ and 4 were obtained for walking up and down emergency stairs (LT, 1995b).

Wardman et al. (2000) covered walking as a main mode as well as time spent accessing a main mode. The latter was valued at 1.9 times IVT in contrast to the 2.7 times IVT when walking time is the main mode. This may reflect non-linearities in the value of walk time with regard to the amount of walk time.

2.3 Other Literature on Walk and Wait Time Values

This section does not aim to provide a comprehensive account of international evidence on the values of walk and wait time but rather a flavour of what has been obtained for comparison with British evidence.

One of the first studies to estimate values of waiting and walking time was Merlin and Barbier (1965). This obtained values of around three times IVT for waiting time and around 1.75 times for walking time. Another early study (Hensher, 1972) estimated the values of wait time and transfer time at twice and 1.5 times IVT respectively.

At a later stage, Bruzelius (1979) observed that walking and waiting time are often valued from two to three times more than IVT. Of the ten disaggregate studies providing walk and wait time values covered in a review of international evidence (TRRL, 1980), walk time was on average valued close to twice IVT and, excepting a study with a very high valuation, wait time was valued around three times IVT.

Bureau of Transport Economics (1982) reviewed evidence from a number of countries on the relationships between the values of walking, waiting and in-vehicle time. She stated that, "Early work (see Hogg, 1970) indicated that waiting and walking times were valued around twice in-vehicle times as they were the more 'distressing' activities for an individual. This notion has prevailed through later work and generally only slight variations to these factors occur, although their adoption is only rarely confirmed by empirical analysis before use". Table 2.2 reproduces the evidence cited by Bureau of Transport Economics.

Table 2.2: Relationship between Values of In-Vehicle, Walking, Waiting and Transfer Times

Author	Source	Year	Walk	Wait	Transfer
Merlin & Barbier	France	1965	1.75	3	2
Quarmby	UK	1967	2		
Hogg	Aust	1970	2	3	2
Veal	UK	1971	1.7		1.7
Hoinville & Johnson	UK	1971	2	2	1
Hensher	Aust	1971		2	1.5
Hensher	Aust	1972		2	1.5
LGORU	UK	1973	2.9	1.6	
			2.6	3.6	
			2.5	2.5	
			3.5	3	
Ben-Akiva	USA	1973	0.25	0.25	
			0.26	0.26	
			0.47	0.47	
Beesley	UK	1974	2	2	
DOE	UK	1974	2	2	
Richards & Ben-Akiva	USA	1975	2		
Algers, Hansen & Tegner	USA	1975		12	
				3	
LGORU	UK	1975	2	3	
			1.5	2	
Train & McFadden	USA	1976	1.4	8-11	
DTP-DOE	UK		2	2	
BTE	Aust	1978	2	1.5	

Source: Bureau of Transport Economics (1982) Table 8.4.

The early evidence as in Britain seems to indicate that waiting time is more highly valued than walk time and that the convention of valuing walk time as twice IVT is more justified than for wait time. Although we have covered some of the material elsewhere, the wait time evidence cited in the review conducted by Waters (1992) also seems to support wait time values in excess of twice IVT.

In a more recent review of empirical evidence from a number of countries, Steer Davies Gleave (1997, p23) conclude that, "walking time is usually valued at between 1.8 and 2.4 times IVT. An average of 2.0 is recommended for simplicity" and that "Waiting time is sometimes valued higher than walking time, up to 4.5 times higher. A ratio of 3 times is recommended".

The more recent national value of time studies conducted in Norway, Sweden, Finland and the Netherlands cast some light on the valuations of walk and wait time.

Subsequent to the main SP experiment conducted in the first Dutch value of time study, a follow-up survey was undertaken relating to public transport users' values of walk time, interchange time, delays due to schedule failure and a value of wait time based around half the service headway (Gunn and Rohr, 1996). The estimated IVT valuations of these attributes are given in Table 2.3.

Table 2.3: Public Transport Components of Journey Time

	Commuting	Business	Other
Walk time	1.0	1.6	1.3
Interchange Time	2.1	1.6	1.6
Failed Schedule	3.0	1.4	1.4
Half Headway	1.3	1.4	1.7

Source: Gunn and Rohr (1996) Table 5.

Since not all travellers arrive randomly at their boarding point, half the service headway will overstate the amount of waiting time and hence the figures in Table 2.3 will understate the value of wait time. If wait times are a third of headway, and ignoring any convenience benefit of more frequent services, then the value of wait time would be 50% larger than the figures in Table 2.3.

Rather than treating the half-headway term as a value of wait time and for comparison with the headway values reported below, the figures can be halved. Thus the time value of headway is in the range 0.65 to 0.85.

It was concluded that, "Broadly, then, traditional preconceptions (i.e. the experience of previous studies as interpreted by the majority of planners) that components of journey time other than scheduled in-vehicle time are relatively more 'important' than in-vehicle time are borne out by this experiment. Traditional weightings, usually a factor of 2 for walking and 3 for wait, seem rather too high".

Pursula and Kurri (1996) report a model based on bus users' choices containing time, headway, walking time, transfer walking time and transfer waiting time. Unfortunately, the time valuation relates to total time and hence it is not clear how the values of walk and wait time relate to IVT.

Algers et al. (1996) found the IVT value of transfer time to vary between 1.4 and 2.5, being lower in airports where the transfer is more pleasant than for local bus where it is less pleasant. The time valuation of headway varied between 0.5 for the highest frequency to 0.1 for the lowest frequency. The value of 0.5 seems relatively low, but the highest frequency covered was only two services per hour. The results would suggest that higher values more in line with other studies would be obtained where services are more frequent.

The only non-IVT values estimated by Ramjerdi et al. (1997) were delay and headway. The money value of headway diminished as headway increased for both leisure and business travel.

This diminishing effect is consistent with the findings of Algers et al. (1996). The IVT value of headway across ferry, rail and air was 0.37 for leisure journeys less than 50 km but only 0.21 for journeys longer than this. The corresponding figures for business travel were 0.64 and 0.30.

2.4 Public Transport Values of In-Vehicle Time

Many studies in Britain provide estimates of public transport values of IVT whilst one of the strongest effects present in the body of empirical evidence is that there is strong variation in values of time both within public transport and between public transport and car. Two important points must be borne in mind in this context of the value of time and mode.

Firstly, it makes little sense to assess evidence on public transport values independent of the evidence for car users. Secondly, it is essential that we distinguish between two quite separate issues relating to mode. One is that we might expect the value of time to vary across users of different modes, not least because of income variations. We refer to these as User Types. The other is that the value of time may vary according to the mode in which the time is spent, due to differences in the comfort and conditions of travel. We refer to this as Mode Valued. The latter relates solely to IVT although the former relates to all monetary values.

Most of the national value of time studies have estimated public transport values of IVT alongside values for car drivers and we will restrict our attention here to the performance of the various national studies in their treatment of the user type and mode valued issues.

The results for the first British study are reproduced in Table 2.4. The figures are not as informative as they might be due to the estimation in some cases of generic coefficients across modes and the inability of RP models to segment by user type. The values denoted by * and + represent generic coefficients obtained from the same model. The results would seem to indicate that bus users have the lowest values and car users the highest values in the urban context, and the differences are quite substantial. This relationship is consistent with user type effects dominating mode valued effects. However, the pattern is different and less clear for inter-urban travel. The higher value for rail than bus and car for inter-urban leisure would suggest that the user type effect dominates the mode valued effect, whereas the relationship between the bus and car values suggests that mode valued effects are strong. Subsequent analysis (Wardman, 1988) found the bus value for inter-urban commuters to be 17% higher than for train travel.

Table 2.4: First British Value of Time Study: Values by Mode (Mid 1985 prices p/min)

	Car	Bus	Rail
Urban Commute	3.6 & 3.7	2.4*	2.4*
Urban Leisure	4.5	1.25	
Inter Commute		3.6 & 4.0+	3.6 & 4.0+
Inter Leisure	3.8	4.0	5.9

Source: Table 7.1 MVA et al. (1987)

The most comprehensive account of value of time variation according to both user type and mode contained in a national value of time study is provided in the first Dutch study (Gunn and

Rohr, 1996). Table 2.5 indicates how values of IVT vary by user type and mode relative to the value of car IVT for car users.

A car driver's value of IVT on a commuting train journey is therefore 1.492 (1.327 × 1.124) times higher than the value of IVT for a car trip. Train users value car IVT as 1.284 (1.142 × 1.124) times higher than car drivers. Train as a mode is here found to have a higher value than car, with what seem like reasonable variations across journey purpose. It is noticeable that user type has a lesser influence than mode, and whilst this could well be plausibly explained in this context, the inclusion of bus and air users might be expected to lead to more influence from user type.

Table 2.5: Dutch Values of Time Relative to Car Driver Value of Time Amongst Car Drivers

	Commute	Business	Other
Train Mode	+32.7%	+20.4%	+1.7%
Train User	+14.2%	-2.7%	+1.2%
Rejected Mode	+12.4%	+7.7%	+1.0%

Source: Table 6 Gunn and Rohr (1996)

Gunn and Rohr (1996) also report separate SP analysis where, compared to the value of IVT for car drivers in urban traffic, train users had a value of train time which was 6% larger for commuting, 18% lower for business travel and little different for leisure travel. These figures are not entirely consistent with the findings in Table 2.5. For bus and tram users, the values were 9% lower for commuting, 22% lower for business and 25% lower for leisure, indicating the dominance of user type over mode.

An RP mode choice model specified alternative specific time coefficients for car and train. The train coefficient was 30% lower for commuting trips, 37% lower for business trips and 4% higher for leisure travel. These seem inconsistent with the SP based evidence in Table 2.5, particularly when it is borne in mind that the train time appears to cover the total journey and not just IVT.

The second Dutch study (Gunn et al., 1999) does not seem to have examined user type and mode valued in as much detail as the first study. What seem to be values specific to the same user type and mode are reported in Table 2.6. The pattern is quite clear: the values are highest for car users, followed by train users with the lowest values for bus and tram users. The variations in values are quite substantial, but contrast with the results of the first study reported in Table 2.5 in that they support the user type effect dominating the mode valued.

Table 2.6: Second Dutch Study: Values of IVT (1997 guilders)

	CAR	TRAIN	BUS/TRAM
Commute	14.47	10.93	9.93
Business	21.16	13.55	9.01
Other	8.03	7.10	6.66

Source: Gunn et al. (1999) Table 4.6.

The Swedish value of time study (Algers et al., 1996) offered car and public transport users SP exercises relating to both their chosen mode and an alternative in order to examine variations in the value of IVT by mode. However, analysis which distinguishes variations in the value of IVT according to user type and mode valued is not reported. The estimated values of IVT, segmented by what seems to be mode valued, are reproduced in Table 2.7. The lower values for car than train and bus, at least for the shorter journeys, are presumably because the effect of mode valued is greater than user type. This might also explain through a fatigue effect the relatively high car value for longer distance trips. However, the distinction between user type and mode valued is not adequately addressed in the above report[3].

Table 2.7: Swedish Values of IVT (Swedish Crowns per hour)

	Car	Air	IC Train	X2000	Reg Train	LD Bus	Reg Bus
Comm <50km	34				54	47	43
Other<50km	27				43	38	28
Trips > 50km	81	88	74	102	70	65	50

Source: Algers et al. (1996)

Ramjerdi et al. (1997) adopted the same approach as the Swedish study in order to examine variations in the value of IVT by mode. Hence each respondent was offered two SP exercises, one relating to their actual mode and the other to an alternative mode. The explicit purpose of this "…. was to evaluate the mode specific differences of the VoT's". The data was pooled and separate utility functions estimated by mode. The results reported by mode, which presumably relate to mode valued, are reproduced in Table 2.8. Given that the values are lowest for bus and highest for air, user type is clearly having an influence. However, the report fails to distinguish clearly between user type and mode valued.

[3] It has been pointed out to us that analysis of the Swedish data separately for chosen and rejected modes has been conducted and the differences in values were small, implying that user type is the predominant source of variations in values by mode.

Table 2.8: Norwegian Values of IVT by Mode (NOK/hr)

Km	CAR		RAIL		BUS		AIR	
	Leis	EB	Leis	EB	Leis	EB	Leis	EB
<50	38	131	54	124	31		120	151
50-100	101	377	108	104	51		172	
100-300	97	207	68	201	53	70	170	258
300+	77	137	50	105	38	40	151	324

Source: Ramjerdi et al. (1997) Tables 7, 8, 14 and 15.

Pursula and Kurri (1996) conducted separate SP exercises for bus users and car users. The values for bus users relate to total time and were between 10 and 20 FIM/hr depending upon income. The values of time for car users varied between 25 and 50 FIM/hr depending upon road class. As expected, the value of time is higher for car users and the difference is large.

2.5 Current UK Recommendations[4]

Although individual organisations and companies within the railway industry are free to adopt their own recommendations regarding the value of time, walk time, wait time and headway, the great majority of them use the recommendations set out in the Passenger Demand Forecasting Handbook (ATOC, 1997).

As far as the value of time is concerned, the Handbook adopts the model reported in Wardman (1998a). The latter is a regression based model which explains the money value of time in terms of mode used and mode valued, journey purpose, type of data and distance. It is recommended, although without any empirical support, that the values are amended over time in line with GDP.

The value of walk and wait time involved in access and egressing rail stations is weighted at twice IVT, although time spent accessing the rail network by other modes can have different weights in part influenced by whether there are any money costs involved. An exception to the double weighting of walk and wait time is the connection time at an interchange station. For what appear to be pragmatic reasons relating to application, connection time is given the same weight as train time, although the interchange penalty used not only represents the inconvenience and risks involved in having to interchange but also an element to cover the premium valuation of walk and wait time.

The value of headway used is influenced by the proportion of random arrivals, which is higher for more frequent services, and by a ‘planning penalty’ for those who do not arrive at random. The latter includes an adjustment time element, because rail travellers cannot generally depart precisely when they want to, along with waiting time and the transaction costs of having to find out train times. The time valuation of headway therefore varies across routes and different levels of headway. For all flows, the headway valuation in units of IVT is one for headways of 10

[4] A number of reviews exist of the practices adopted elsewhere (Waters, 1992; Nellthorp et al., 1998; Booz Allen and Hamilton, 2000)

minutes or less. At a 30 minute headway it is around 0.8 minutes, falling to around 0.55 and 0.43 for hourly and two-hourly services.

Our understanding is that Transport for London is in the process of reviewing the values of time it uses. The current recommendations are relatively sophisticated, reflecting the unique features of the London Underground in the British context, and are set out in the LT Business Development Manual (LT, 1995a) which specifies weights for different elements of time relative to the value of IVT. Relevant walk and wait time values are set out in Table 2.9.

Table 2.9: LT Weights for Walk and Wait Time

Wait in Uncongested Conditions	2
Wait in Congested Conditions	2 + CF
Acceptable Wait	2
Unacceptable Wait	3
Walk Unimpeded	2
Walk in Congested Conditions	2 + CF
Walking Downstairs or Escalators	2.5
Walking Upstairs or Escalators	4

Note: CF represents the congestion factor which is related to the density of travellers on stations.

As far as the value of IVT itself is concerned, these are also set out in LT (1995a). The LUL value is based on the Department of Transport research reported in MVA et al. (1987) with allowance for higher London wages. The LTB value is based on studies relating to bus and is only around a third of the LUL value. At October 1995 prices, the LUL values for working and non-working time were 17.5 and 8.9 pence per minute respectively, whereas the LTB value for non-working time was 3 pence per minute. The latter figure based on DETR recommendations and therefore corresponding to the LUL figures would be 5.5 pence per minute.

2.6 Implications for Our Research

This review of empirical evidence and of recommended values used in evaluation has a number of implications for further research in general and for the direction of this study in particular. These implications are:

- There are doubts surrounding the widely used convention for valuing walk and wait time. In particular, there is evidence that wait time is more highly valued than walk time, and its value might exceed twice the value of IVT, although valuing walk time at twice IVT seems more justified. However, there appears to be a conflict, particularly in the British evidence, between the higher values in the earlier largely RP based studies and the lower values in the more recent and largely SP based studies. The analysis to be conducted in this study will examine the evidence from a large number of studies.

- The weights to be attached to walk and wait may well vary across different situations, and in part this may have contributed to the different results apparent across studies. The money values of walk and wait time may vary with journey purpose, user type, journey length and the levels that walk and wait time take. We are not aware of studies which have examined non-linearities in the values of walk and wait time. In addition, the weights to be attached relative to the value of IVT will also vary according to factors which influence the latter numeraire. We will examine variations in the money and IVT valuations of walk and wait time as far as our data will permit.

- Official recommendations do not cover headway yet this is important in evaluating schemes involving public transport options. We will examine British evidence relating to headway values to support the provision of a set of recommended values. The intention is again to examine variations in these values.

- There have been many studies which have yielded public transport values of IVT. However, these cannot be examined in isolation to determine a set of recommended values. It is important that they are compared with car values and the differences between them attributed to the factors that it is possible to incorporate in analysis. This requires analysis of the results of a large amount of empirical evidence. Moreover, for practical application purposes, it may be useful to determine a series of modifiers to obtain public transport values of IVT and values for walk and wait time as a function of car values.

- Although variations in values of IVT by mode are one of the strongest effects apparent in empirical studies, and there have been attempts to distinguish variations in the value of IVT that are due to user type and mode valued, further analysis of these issues, particularly in the British context, is certainly warranted. Meta-analysis provides a means of exploring this issue.

- Current recommendations do not contain variations in values of time by journey length and journey purpose, but this is a less contentious area than the 'equity' issues that surround mode. Whilst there is a wealth of evidence that these effects exist, there is no consensus on how they impact on values of time. We would argue that meta-analysis is the most appropriate means of obtaining a consensus view.

3. DATA ASSEMBLY

The research reported here builds upon the meta-analysis reported in Wardman (2001) by covering more studies over a larger number of years. The main reason for collecting more information was in order to obtain a more precise estimate of the effects of GDP variations on the value of time. The previous study obtained a GDP elasticity estimate of 0.51 but, with a t statistic of 1.7, this was not as precise as we would wish. Extending the years covered beyond the period 1980-1997 could be expected to be beneficial in two ways:

- Additional data will, in general, lead to more precise coefficient estimates. The variance of the coefficient estimates is inversely related to the number of observations in the model.

- Covering more years will provide more variation in the GDP data and could reduce correlations with other independent variables. The variance of a regression coefficient estimate is inversely related to the amount of variation in the variable to which it relates but is adversely affected by increases in correlation with other variables. In the previous data set, three-quarters of the observations related to the period 1988 to 1994 in which a recession limited the amount of GDP variation.

Table 3.1 lists the number of money values of IVT, walk, wait, access and headway contained within the previous and current data sets. The dominance of valuations of IVT is immediately apparent. Some studies specified an access time term which relates to a combination of walk time and time spent accessing the main mode by means other than walking. As previously, the maximum level of segmentation of values in the data set was mode and journey purpose.

The pre 1980 studies tended to be based on mode choice and to include wait time rather than, as is now more common, a headway variable. This explains the large proportionate increase in wait time values. The data set now contains 719 money values of IVT for analysis purposes, and 1167 values of all the attributes listed in Table 3.1. The 1167 values were obtained from 171 studies. The 38 additional studies covered are listed in Appendix 1.

Table 3.1: Sample of Money Values

	Previous	Now	%Δ
Time	539	719	33%
Walk	131	174	33%
Wait	33	61	85%
Access	46	54	17%
Headway	140	159	14%

Table 3.2 shows the increases in the number of available valuations of walk time, wait time and headway expressed in units of IVT. Not all studies contain IVT and cost coefficients and hence not all contain both IVT and money values of these variables.

Table 3.2: Sample of IVT Values of Walk, Wait, Access and Headway

	Previous	Now	%Δ
Walk	140	183	31%
Wait	34	62	82%
Access	52	60	15%
Headway	145	164	13%

The distribution of money values of IVT, walk, wait, access and headway across the years in which the data was collected is given in Table 3.3 for the previous and current data sets. The increased data has certainly impacted upon the amount of variation in the measure of income. In the previous data set, the variance of the real GDP per capita measure was 27327. The 31% increase in the data set from 889 to 1167 observations has increased the variance of the GDP measure more than fourfold to 117760.

Table 3.3: Distribution of Money Values

Year	Previous	Now	Year	Previous	Now
63		3 (0.3%)	87	4 (0.4%)	4 (0.3%)
64		8 (0.7%)	88	21 (2.4%)	21 (1.8%)
67		3 (0.3%)	89	72 (8.1%)	72 (6.2%)
68		3 (0.3%)	90	128 (14.4%)	128 (11.0%)
69		12 (1.0%)	91	80 (9.0%)	80 (6.9%)
70		16 (1.4%)	92	136 (15.3%)	136 (11.7%)
74		3 (0.3%)	93	126 (14.2%)	126 (10.8%)
75		8 (0.7%)	94	108 (12.1%)	108 (9.3%)
80	3 (0.3%)	3 (0.3%)	95	75 (8.4%)	75 (6.4%)
81	4 (0.4%)	19 (1.6%)	96	35 (3.9%)	45 (3.9%)
82	5 (0.6%)	5 (0.4%)	97	26 (2.9%)	37 (3.2%)
83	10 (1.1%)	10 (0.9%)	98		54 (4.6%)
84	5 (0.6%)	9 (0.8%)	99		54 (4.6%)
85	21 (2.4%)	21 (1.8%)	00		74 (6.3%)
86	30 (3.4%)	30 (2.6%)			

4. OVERALL VALUES OF TIME

We here present average values of time from our data set, segmented by the key variables of user type, journey purpose and whether the context is one of urban or inter-urban journeys given that the overall average will be strongly influenced by the composition of the sample. The figures provide a general impression of the range of the data and the impact of key variables prior to formal analysis.

The values of IVT are reported in Table 4.1 and are expressed in year 2000 quarter 3 prices. Two sets of figures are given according to the elasticity used to account for differences in real GDP per capita across values. One adjustment uses an elasticity of one as used by DETR in its recommended procedures. The other adjustment involves an income elasticity of 0.5, in line with cross-sectional evidence from the first British value of time study (MVA et al., 1987), the second British value of time study (Hague Consulting Group et al., 1999), studies in the Netherlands (Gunn, 2001) and our previous time series evidence from meta-analysis (Wardman, 2001).

A number of relationships are apparent within the figures presented in Table 4.1. Inter-urban trips have generally somewhat higher values than urban trips and, as expected, employer's business trips have higher values than trips for other purposes. For urban trips, commuting journeys have higher values than leisure trips for all modes other than car. For inter-urban trips, there is little difference between the values of time for commuting and leisure.

Table 4.1: Overall Values of IVT

		Income Elasticity = 1		Income Elasticity = 0.5		
Context	Mode	Mean	Std Error	Mean	Std Error	Sample
Urban Commute	Car	6.0	0.4	5.5	0.4	64
	Bus	4.2	1.0	3.8	0.8	17
	Rail	7.2	0.9	6.2	0.7	17
	UG	9.2	0.9	8.2	0.8	5
	Car&PT	7.6	0.7	5.8	0.4	44
Urban Leisure	Car	6.5	0.5	5.8	0.4	73
	Bus	2.6	0.3	2.4	0.3	22
	Rail	6.5	1.0	5.7	0.8	14
	UG	7.3	0.7	6.5	0.6	16
	Car&PT	4.7	0.5	4.3	0.4	25
Urban Business	Car	13.2	3.6	11.7	3.1	11
	Rail&UG	19.2	9.0	17.8	8.3	8
Urban Other	Car	6.4	0.4	5.8	0.4	84
	Bus	3.2	0.3	2.9	0.3	27
	Other	6.4	0.8	5.5	0.6	29
Inter Commute	Car	10.5	1.8	10.0	1.7	11
	Rail	12.6	0.8	11.5	0.8	21
	Other	9.1	1.0	7.7	0.9	9
Inter Leisure	Car	9.2	1.1	8.2	1.0	23
	Rail	13.3	1.2	12.0	1.1	44
	Car&PT	13.7	1.5	11.8	1.4	10
	Air	77.2	19.2	74.2	18.6	4
	Other	11.7	1.3	10.0	1.1	8
Inter Business	Car	18.3	2.6	17.6	2.6	16
	Rail	32.2	3.5	29.3	3.3	34
	Rail1st	52.3	5.7	46.0	5.4	17
	Car&PT	13.7	1.5	11.8	1.4	11
	Air	90.2	19.3	82.4	19.3	12
Inter Other	Car	7.4	0.5	7.4	0.6	10
	Rail	17.6	1.5	15.3	1.3	18
	Other	8.6	0.9	7.6	0.8	15

The values of time vary quite appreciably according to the mode used. For urban journeys, underground (UG) users appear to have the highest values whilst, not surprisingly, air travellers have the highest values amongst inter-urban travellers. Bus users have the lowest values. The figures seem to indicate that rail users have higher values than car users, particularly for inter-urban trips although there may be a distance effect at work here since inter-urban rail trips tend to be longer than inter-urban car trips.

DETR recommended values of time (DETR, 2001) for a number of categories are contained in Table 4.2. These are behavioural values and hence directly comparable with those contained in Table 4.1. They have been adjusted from mid 1998 prices and income to 2000 quarter 3 prices and income using the recommended income elasticity of one.

Table 4.2: DETR Values of Time

Business – Driver	39.7	Business – UG	48.1
Business – Rail	57.3	Non Work	8.5

As far as non-work travel is concerned, the DETR recommended values seem to be far too high for urban trips yet too low for inter-urban trips. Across all trips, however, the recommended non-work value compares favourably with the large amount of evidence. The DETR value is clearly an average across different journey lengths, and the findings in section 6 point conclusively to a strong distance effect on the value of IVT. Clearly, the recommended value bears little resemblance to the values by mode, but this is a consequence of using an equity value.

The recommended business values are much higher than the relevant averages in our data set. However, the latter contains valuations obtained for business trips which are based on the employee's rather than the employer's willingness to pay. We provide some evidence on the difference between the two in section 6.

Table 4.3 provides summary statistics for the IVT values of walk time in the data set. Unlike the value of IVT, there are few cases for inter-urban travel and hence an overall value is given. For urban travel, the values appear to be less than the convention of twice the IVT value, but otherwise, there seems to be little pattern in the average values. The inter-urban values on average fall well short of two, indicating that walk time is relatively less important on longer journeys. However, we must recall the evidence in section 2 that RP values are higher than the SP dominated values in Table 4.3. This is borne out in the results presented in section 6.

Table 4.3: Overall IVT Values of Walk

Context	Mode	Mean	Std Error	Sample
All	All	1.68	0.05	183
Urban Commuting	Car	1.37	0.12	29
	Bus	1.67	0.14	10
	Other	1.99	0.16	29
Urban Leisure	Car	1.74	0.15	25
	Bus	1.66	0.23	13
	Other	1.97	0.35	9
Urban Other	Car	1.55	0.10	34
	Bus	2.02	0.22	13
	Other	1.37	0.17	8
Inter	All	1.51	0.14	13

Table 4.4 lists the average values of wait time in the sample. Again there are too few inter-urban values to support meaningful segmentation by mode and purpose and it does not make sense to segment the urban values by journey purpose. Underground users appear to have relatively low values of wait time, but overall the value of wait time is little different to the widely used recommendation of twice the value of IVT. However, the results in section 6 indicate that, as expected on the basis of the evidence in section 2, the value of wait time is particularly strongly influenced by whether it is obtained from RP or SP models.

Table 4.4: Overall IVT Values of Wait

Context	Mode	Mean	Std Error	Sample
All	All	1.76	0.10	62
Urban	Bus	1.59	0.22	11
	UG	1.17	0.04	11
	Car&PT	2.06	0.14	30
Inter	All	1.70	0.28	10

Mean values of headway relative to IVT are given in Table 4.5. The IVT valuations of headway appear to be lower for commuting trips, presumably because these have higher values of IVT. There is little difference between car and bus users. Whilst we might expect car users to be more averse to headway, they may also be more sensitive to IVT changes such that overall there is little difference in the IVT valuation of headway compared to bus users.

Table 4.5: Overall IVT Values of Headway

Context	Mode	Mean	Std Error	Sample
All	All	0.77	0.04	164
Urban Commuting	Car	0.85	0.11	18
	Bus	0.84	0.20	6
	Other	0.70	0.17	5
Urban Leisure	Car	1.00	0.13	19
	Bus	0.97	0.17	12
	Other	0.84	0.12	10
Urban EB	All	1.22	0.25	5
Urban Other	Car	0.63	0.07	22
	Bus	0.61	0.08	13
	Other	0.75	0.03	4
Inter Commuting	All	0.47	0.09	7
Inter Leisure	All	0.52	0.07	17
Inter EB	All	0.69	0.11	14
Inter Other	All	0.95	0.17	12
Inter	Car	0.63	0.14	7
	Rail	0.49	0.08	16
	Other	0.78	0.09	27

Those on business value headway relatively highly, although the sample is small. There is also strong evidence that headway is less important for inter-urban trips. In part this could be because the sensitivity to IVT variations increases with distance and in part because travellers are more likely to plan inter-urban journeys and do not expect frequencies to be as high as for urban travel.

These overall figures provide some useful insights into the values of IVT, walk, wait and headway. However, there could be confounding effects at work which such simple disaggregations of the sample fail to detect. A quantitative model which aims to explain variations in individual values of time as a function of relevant socio-economic and trip characteristics would provide a significant advance upon these relatively simple tabulations. It is to such a model that we now turn.

5. META-ANALYSIS: MODELLING APPROACH

In addition to the money and time valuations of the attributes, information has been collected on a range of factors which might explain variations in the valuations. These included the year and quarter of data collection and associated income and retail price indices, sample size, journey distance, type of data upon which the model was estimated, journey purpose, choice context, user type, mode valued, numeraire, location, the omission of non traders and use of logic checks, the means of presenting an SP exercise and the number of attributes in it, the mean level of the attributes and the purpose of the study. It is assumed that the variation in the values which cannot be explained by the above key variables is randomly distributed across the sample.

The variables about which we have collected information are either continuous or categorical. The form of model used to explain variations in the monetary values (V) takes the form:

$$V = \tau \prod_{i=1}^{n} X_i^{\alpha_i} e^{\sum_{j=1}^{p} \sum_{k=1}^{q-1} \beta_{jk} Z_{jk}} \tag{1}$$

where there are n continuous variables (X_i) and p categorical variables having q categories (Z_{jk}). We specify q-1 dummy variables for a categorical variable of q levels and their coefficient estimates are interpreted relative to the arbitrarily omitted level. A logarithmic transformation of equation 1 allows the estimation of the parameters by ordinary least squares.

The α_i coefficients are interpreted as elasticities, denoting the proportionate effect on the valuation after a proportionate change in X_i. The exponential of β_{jk} denotes the proportionate effect on the valuation of a level of a categorical variable relative to its omitted level.

The τ term is a scale factor which applies to all of the values. Its absolute value will depend upon the scale used for the continuous variables such as GDP per capita and distance, although of course the scale used will not affect the elasticities estimated to the continuous variables or the output of ‘forecast’ values of time.

In the models reported in this paper, the dependent variable of equation 1 can take the form of money values of time (section 6) or IVT valuations of walk, wait and headway (section 7).
A simple example of the application of the model based on the units used in this study is given in section 6.1.

6. META-ANALYSIS OF VALUES OF TIME: EMPIRICAL FINDINGS

The analysis reported here is essentially an extension of that previously reported (Wardman, 2001) to incorporate a larger data set, although given the emphasis on IVT, walk time, wait time and headway, we have removed the other valuations relating to departure time changes, search time, late time and time spent in congested conditions. With the exception of departure time changes, the number of observations for these latter values is small. In any event, no additional data was collected for the values of these attributes.

Section 6.1 considers the models estimated to the money values. We then use these models to calculate values of time for a range of scenarios and these are presented in section 6.2

6.1 The Models

Table 6.1 presents models estimated to the data set of IVT, walk, wait and headway valuations and to just the IVT values. The former model contains 1167 observations and the latter 719 observations.

A preferred form of model from many that were tested was identified for the data set relating to all the values. For comparison purposes, the walk, wait and headway values were removed and an otherwise identical model was estimated to the values of IVT alone.

The model is estimated to money values in units of pence per minute and expressed in quarter 4 1994 prices.

Two broad types of variable were examined which we term main effects and interaction effects. Main effects relate to the independent effect of a particular variable, such as distance or mode, on the value of time. Interaction effects are essentially the product of two main effects, thereby permitting, say, the effect of distance to depend upon the mode in question.

The main effects examined in this study were:

- The attribute to which the value relates, which is IVT, walk time, wait time, access time or headway
- Gross domestic product (GDP) per capita in real terms
- Distance in miles, with a further distinction as to whether the journey was over 30 miles and hence classified as inter-urban
- Journey purpose, which covered employer's business, commuting, various leisure categories and also combinations of these and studies where no distinction was made by purpose

- User type which covers car, bus, train, underground and air along with values estimated to various combinations of these users
- The mode to which the value relates, which covers the same categories as user type
- The cost numeraire of parking cost, toll or road user charge, petrol cost, public transport fare or combinations of them
- Whether the value was obtained from Revealed Preference (RP) or Stated Preference (SP) data and whether the SP exercise took the form of a ranking or choice exercise
- Location, which distinguished between London, the South East, metropolitan areas, other conurbations, market towns and rural
- Whether the main purpose of the study was value of time estimation, a valuation study in general or demand forecasting
- Whether public transport cost was presented in single or round trip units
- The choice context of route choice, mode choice or abstract choice
- The means of presenting an SP exercise, which covered the pen and paper method, computer presentation and the use of cards[5]
- The number of variables in the SP exercise
- The mean level of walk time, wait time and headway in the study in question
- Whether respondents were removed from the data set on the grounds of rationality tests or the absence of trading.

The interactions which we have examined were:

- User type with mode valued, journey purpose, attribute, journey distance, GDP and location
- Mode valued with journey purpose and distance
- Journey purpose with attribute, distance and GDP
- GDP with attribute and distance
- Attribute with distance, means of presenting the exercise and number of variables in an SP exercise

Table 6.1 contains effects that are correct sign and plausible in magnitude, and are either statistically significant or else not significant at the usual 5% level but are considered to merit retention and have t statistics which are not unreasonably small.

Variables removed as not having a significant effect were all the interactions listed above except interactions between user type and mode valued, distance and attribute, user type and attribute, type of data and attribute and limited interactions between purpose and attribute and mode and purpose. It can be seen, therefore, that most interactions relate to differences in valuations across IVT, walk, wait and headway. Main effects that were not significant were numeraires relating to petrol cost, parking charge and public transport fare, locations other than the South East, the main purpose of the study, the choice context, the type of SP exercise, the means of presenting the SP exercise other than the pen and paper method, the number of variables in the SP exercise,

[5] With hindsight, we should have also identified studies where 'As Now' was a strong feature of the SP design, as discussed in Working Paper 561, and to have distinguished between SP exercises which offered respondents absolute levels of attributes or changes to the current situation.

the mean level of headway and whether the value was estimated to data sets where respondents had been removed on the grounds of rationality tests or non-trading.

In order to be able to use the model to calculate values, the GDP per capita index has to be known. In 2000 quarter 3, the period for which we subsequently calculate values, this is 3451. In addition, converting from the 1994 period 4 prices in which the model is calibrated to the 2000 period 3 values that we report below requires the values to be multiplied by 1.174 to allow for inflation.

The money value of IVT (VoT) in 2000 quarter 3 prices and income for a commuting journey of 25 miles by train in the South East is calculated as:

$$VoT = 1.174(e^{-5.179+0.634+0.100+0.147} 3451^{0.723} 25^{0.184}) = 10.43p/\min$$

where:

- 1.174 is the adjustment to 2000 quarter 3 prices from the 1994 quarter 4 prices of the estimated model
- -5.179 represents the scale factor (constant term in the estimated model)
- 0.634 denotes the rail effect
- 0.147 relates to journeys in the South East
- 3451 is the 2000 quarter 3 GDP index and 0.723 is the GDP elasticity
- 0.184 is the distance elasticity for rail applied here to a 25 mile journey

Other effects apparent in the model and reported below in Table 6.1 do not represent genuine influences on the value of time.

The goodness of fit achieved seem quite respectable, and a large number of statistically significant, correct sign and plausible variations in the values of time have been estimated. The model based solely on the value of IVT achieves a somewhat better fit and, despite the somewhat smaller data set, the precision with which its coefficients are estimated compares favourably with those obtained in the larger data set. This is presumably because values of time tend to be estimated more precisely than values of other attributes.

We discuss the findings for each principal explanatory variable in turn, focusing on the results of the model estimated to the IVT, walk, wait and headway valuations.

Table 6.1: Valuation Regression Models

	IVT, Headway, Walk, Wait		IVT	
Variable	**Coeff (t)**	**Elasticity or Effect**	**Coeff (t)**	**Elasticity or Effect**
Intercept	-5.179 (4.2)		-5.944 (4.6)	
Attribute Specific				
Head	-0.237 (1.7)		n/a	n/a
Inter Urban				
Inter	0.258 (3.5)	+29%	0.282 (3.7)	+33%
Distance				
Miles	0.184 (6.3)	0.184	0.168 (5.4)	0.168
+Miles-Head	-0.197 (4.1)	-0.197	n/a	n/a
+Miles-WalkWait	-0.073 (3.1)	-0.073	n/a	n/a
+Miles-Car	0.075 (3.6)	0.075	0.043 (1.9)	0.043
User Type-Mode Valued (IVT)				
Car-CarRail	0.379 (4.8)	+46%	0.439 (5.7)	+55%
Car-Bus	0.714 (4.0)	+104%	0.594 (4.2)	+81%
Car-CarPT	0.447 (5.7)	+56%	0.449 (6.2)	+57%
Rail-Rail	0.634 (7.8)	+89%	0.695 (8.9)	+100%
UG-UG	0.482 (3.5)	+62%	0.622 (4.5)	+86%
All-CarPT	0.517 (6.9)	+68%	0.554 (7.9)	+74%
Air-RailAir	1.680 (8.0)	+437%	1.782 (9.0)	+494%
RailAir-RailAir	1.403 (5.6)	+307%	1.461 (6.3)	+331%
User Type (NON IVT)				
Car-Wait	0.789 (2.5)	+120%	n/a	n/a
Car-Walk	0.694 (3.9)	+100%	n/a	n/a
Car-Head	0.464 (4.1)	+59%	n/a	n/a
Rail-Walk	0.368 (1.5)	+44%	n/a	n/a
RailUG-Wait	0.612 (3.0)	+84%	n/a	n/a
RailUG-Head	0.755 (5.2)	+113%	n/a	n/a
PT-WalkWait	0.199 (1.5)	+22%	n/a	n/a
CarPT-Walk	0.232 (2.4)	+26%	n/a	n/a
CarPT-Head	1.378 (6.6)	+297%	n/a	n/a
All-Walk	0.317 (1.8)	+37%	n/a	n/a
All-Head	0.879 (4.4)	+141%	n/a	n/a
Purpose				
EB	0.498 (5.6)	+65%	0.559 (6.8)	+75%
+EB1st	0.754 (5.2)	+113%	0.643 (4.7)	+90%
+EBFore	0.470 (4.3)	+60%	0.411 (3.9)	+51%
Comm	0.100 (2.7)	+11%	0.164 (3.7)	+18%
Income				
GDP	0.723 (4.6)	0.723	0.823 (5.0)	0.823
Purpose Specific				
EB-Head	0.211 (1.5)	+23%	n/a	n/a
Mode and Purpose				
Comm-UG	0.520 (2.8)	+68%	0.238 (1.9)	+27%
Data				
RP-Walk	0.379 (2.4)	+46%	n/a	n/a
RP-Wait	0.886 (5.2)	143%	n/a	n/a
Numeraire				
Toll	-0.212 (2.2)	-19%	-0.148 (1.6)	-14%
Units				
Round	-0.076 (1.8)	-7%	-0.130 (2.6)	-12%
Level				
WalkTime	0.271 (8.2)	0.271	n/a	n/a
Wait Time	0.157 (2.4)	0.157	n/a	n/a
Region				
LSE	0.147 (3.6)	+16%	0.068 (1.5)	+7%
Presentation				
PaperIVT	-0.141 (3.1)	-13%	-0.160 (3.7)	-15%
Adj R^2	0.620		0.669	

Attribute Specific Variables

Dummy variables were specified for walk time, wait time, access time and headway to determine whether, after accounting for the influences of the other variables in the model, there is any remaining difference in the values of these attributes in relation to each other and to IVT.

The coefficients relating to walk time, wait time and access time were far from statistically significant. We have retained a term for headway (*Head*) whose effect is not far from significant at the usual 5% level.

Distance Effects

Variations in the value of time are due to variations in the marginal utility of time or money, and there are a number of possible distance related influences on the value of time.

The disutility of a unit of travel time may increase with journey duration, as fatigue, boredom and discomfort set in. Time savings on longer distance journeys will therefore be more highly valued. There may also be a relationship between the values and levels of walk time, wait time and headway. For example, the disutility effect could well operate in the context of progressively longer amounts of walk time. However, this is not specific to the distance of the overall journey and we shall return to this issue below.

The opportunity cost of time spent travelling is presumably greater for longer distance journeys. The activities being pursued must have relatively high utility or importance otherwise their pursuit would not warrant the time and expense of long distance journeys. In addition, there are more pressures on the total time budget where longer amounts of time are spent travelling.

Shorter distance trips tend to be made more frequently. To the extent to which the SP exercise is taken to apply to all trips of the type in question, then a given payment for a time saving implies a larger income effect for more frequent trips. The larger income effect may mean traveller's are more sensitive to cost variations whereupon shorter distance journeys might have lower values.

Travellers may value variations in cost or time in line with the proportion that they form of total cost or time. However, the effect on the value of time is indeterminate. If the proportionality effect is stronger upon cost (time) then the value of time will increase (fall) with distance, but theory provides no clear indication here. In empirical studies, a logarithmic formulation of the terms in the utility function would be consistent with the proportionality concept[6], and this has met with a degree of success (Gunn, 2001). However, whilst it has the potentially desirable property of allowing the value of time to increase with distance, it also exhibits the undesirable property that, for any individual, larger costs will increase the value of time.

The proportionality argument may also apply to walk and wait time, whereupon variations on longer journeys form a smaller proportion of total journey time and are less highly valued.

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[6] If the utility function of a choice model contains the variable X in the form $\alpha \ln X$, then the marginal utility of X is α / X.

Given that congested travel conditions will form a greater proportion of urban travel time, and that this is relatively highly valued but that studies tend not to distinguish between different types of time, then the value of IVT for shorter distance journeys would be higher.

We might expect headway to be less highly valued for longer distance journeys. In part this might be an issue of expectations, since travellers would not regard low frequencies to be unreasonable on longer distance journeys but may well do so on shorter distance journeys. It may also be because longer distance journeys tend to be more planned and hence the convenience of high frequencies is less important.

There may also be an additional effect that leads to lower values of headway at longer distances. At short distances, frequencies are higher and hence random arrivals will be more common. The headway valuation therefore reflects wait time to a greater extent. At longer distances, frequences are lower and the headway value is dominated by schedule delay. Given that wait time is valued more highly than schedule delay, it is not unreasonable that the value of headway is lower for longer distance journeys. However, this is only proxying for the true effect which relates to the level of headway, and we should point out that a significant effect from the mean level of headway on the value of headway could not be obtained.

There might be factors which are correlated with distance and which are not otherwise explicitly accounted for which we can regard as confounding effects. Those with higher incomes may travel longer distances and hence a positive correlation between the value of time and income will become apparent where, as in this study, there is no segmentation of the values of time by income. Other socio-economic characteristics may vary with distance, such as the gender and age distribution and the precise journey purpose within the leisure and business categories. Insofar as males and more senior employees feature more strongly in longer distance travel, the value of time might be expected to increase with distance. However, without far more detailed analysis we cannot draw firm conclusions as to the likely direction of the effect.

Providing that the pattern of correlation with confounding variables remains constant in future, and that the effects of the latter which are discerned by distance are not additionally entered into the evaluation process by some other means, their inclusion within the distance effect does not cause any particular problems. Similarly, the omission from meta-analysis of variables which have only a random effect on the valuations obtained in the different studies is not a cause for concern. However, there may be confounding effects which are a more serious problem because they will influence our conclusions in a misleading way. An example in this context of distance is given by Gunn (2001, p185)

> *For example, suppose 'distance' is an explanatory factor in a meta-analysis of many studies. Suppose some studies are of short-distance choices, some of long-distance. If all the studies examined which had long-distance contexts used large time variations and all the studies examined which had short-distance contexts used small time variations, then a meta-analysis could associate an effect which was truly related to size-of-time-saving wrongly to distance.*

One of the strongest and most consistent findings in empirical studies related to the value of time is that the value of IVT is higher for longer trip duration or distance (Thomas and Thompson, 1970; Heggie, 1976; Algers et al., 1996; Hague Consulting Group and Accent, 1999; Gunn, 2001), although admittedly the evidence is not always clearcut (MVA et al., 1987) and indeed sometimes conflicts with the mass of evidence (Ramjerdi et al., 1997).

Most studies simply estimate different models for urban and inter-urban trips or for different time bands, and hence little evidence on the source of the variation is obtained. Some studies allow departures from the conventional linear-additive utility functions. In the context of mode and destination choice, Gunn (2001) reports the log-cost formulation to perform better, implying the value of time to increase with journey duration, although a similar formulation of the time term is not reported. Four reasons were advanced why the log-cost specification performed better. Gunn (2001, p169) concluded that, "All four potential 'explanations' of the non-linearity concern distance-based imperfections in the relationship between measured data, behavioural model and actual behaviour, either in terms of information uncertainty to the traveller, or to the modeller". Appropriate allowance for these effects would reduce the apparent distance effect but not necessarily remove it. However, the distance effect is here proxying for other effects and is not a pure variation in the value of time due to journey duration or cost. Ben-Akiva, Daly and Gunn (1987) do introduce a genuine duration based effect by arguing that due to more binding time budgets the utility function with regard to time might be expected to be convex in contrast to the concavity of the cost term.

Not all evidence points to the superiority of the log-cost formulation. In the context of rail and air mode choice, Wardman and Murphy (1999) found the logarithmic formulation to perform best for both cost and time in the business market, although the leisure market supported a logarithmic function of cost and a linear function of time, whilst RP analysis of choices between car and rail in the inter-urban context choice found support for a logarithmic formulation of both the car time and rail time variables but not of the cost variables (Wardman et al., 1997). The analysis conducted in this study, and reported in Working Paper 561, did not support the log-cost formulation.

Table 6.2 summarises the possible causes of variation in the values of time with distance, the expected impact on the values and the values which it is considered will be affected.

Table 6.2: Summary of Possible Distance Effects

Influence	Impact	Affects
Disutility Effect	Positive	IVT
Opportunity Cost/Time Constraint	Positive	IVT, Walk, Wait, Headway
Income Effects	Positive	IVT, Walk, Wait, Headway
Proportionate Effect	Indeterminate	IVT, Walk Wait, Headway
Congestion Effect	Negative	IVT
Expectations/Planning	Negative	Headway, Wait
Confounding Effects	Indeterminate	IVT, Walk, Wait, Headway
Misleading Effects	Indeterminate	IVT, Walk, Wait

Our previous meta-analysis and individual studies have found strong support for the values of IVT and other attributes increasing with distance. The distance elasticity relating to all valuations (*Miles*) is here found to be 0.184[7] and is precisely estimated. Three other significant effects of an *incremental* form were also detected.

Walk and wait time values do not vary as strongly as IVT, and the above discussion indicates that this is reasonable. The incremental distance elasticity for walk and wait time (*Miles-WalkWait*) implies a distance elasticity of 0.111 for the values of walk and wait time.

The incremental effect for headway (*Miles-Head*) implies a small negative distance elasticity of –0.013. As seems reasonable, headway becomes less important as journey distance increases.

An incremental effect was specified for car as a mode (*Miles-Car*) which shows that its distance elasticity is greater than for other modes. Presumably this reflects a fatigue effect and perhaps additional distance related discomfort which is not apparent for other modes. The distance elasticity for car is 0.259.

In addition to the distance elasticity, an improvement in fit was obtained by the specification of a term denoting inter-urban trips (*Inter*). All values are 29% higher when inter-urban travel is concerned.

We examined whether the distance elasticity varied by the other modes, by user type and by journey purpose, and also whether there were any differences in *Inter* by user type, mode valued, purpose or attribute, but none were statistically significant.

The distance effect estimated here is broadly consistent with what has been obtained in the re-analysis of the Accent and Hague Consulting Group SP data which is reported in Working Papers 565 and 567.

User Type and Mode Valued In-Vehicle Time Values

We set out the distinction between user type and mode valued in section 2.4. We might expect money values to vary according to user type, not least because of variations in income. We might also expect the value of IVT to vary according to mode, as the comfort and conditions of travel by different modes vary.

Unlike IVT, walk, wait and headway values are not expected to vary according to mode. Nonetheless, they are expected to vary across user types, and this is the subject of the subsequent section.

Given the correlation between mode valued and user type, the two effects could well be confounded if we simply specified a series of dummy variables relating to user type and a series

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[7] This increases to 0.231 with little change in the incremental distance effects when the dummy variable denoting inter-urban trips is removed.

of variables relating to mode valued. We therefore specify variables based on combinations of user type and mode valued.

Table 6.3 lists all the combinations of user type and mode valued. CarPT represents values relating to car and either bus or rail, PT denotes values for combinations of public transport modes and All denotes values relating to car, bus and rail.

Table 6.3: Combinations of User Type and Mode Valued

	Mode Valued								
		Car	Bus	Rail	UG	CarPT	PT	All	RailAir
User Type	Car	144	23	33	-	89	1	2	-
	Bus	1	30	11	-	-	28	-	-
	Rail	1	1	161	-	4	1	1	5
	UG	-	-		23	-	-	-	-
	CarPT	14	2	14	-	25	5	-	-
	PT	-	4	4	-	-	23	-	-
	All	16	4	5	-	1	12	14	-
	RailAir	-	-	3	-	-	-	-	4
	Air	-	-	6	-	-	-	-	4

For car users, we distinguish between whether they valued car IVT (*Car-Car*), bus IVT (*Car-Bus*), rail IVT (*Car-Rail*) or car and public transport IVT combined (*Car-CarPT*). The latter category also includes the three remaining car user valuations for which it would not be feasible to specify a separate category.

Bus users were categorised into those who valued bus IVT (*Bus-Bus*), those who valued rail IVT (*Bus-Rail*) which also contained the single value for car, and those whose value related to bus and rail IVT combined (*Bus-PT*).

Rail users were represented by a single category because of the few cases where rail was not valued (*Rail-Rail*) whilst our valuations for underground users all related to underground as a mode (*UG-UG*).

Values for car and bus or rail users combined were distinguished according to whether car IVT (*CarPT-Car*), car and bus or rail IVT (*CarPT-CarPT*) or rail IVT (*CarPT-Rail*) were valued. The few IVT values relating to bus and PT were assigned to the *CarPT-CarPT* category.
A single category for all PT users was specified, denoted *PT-PT,* since it contains values largely relating to PT. Where IVT values related to users of all modes combined, we distinguished between whether the value related to car (*All-Car*) or to the remaining modes (*All-Rest*).

The final two categories contain rail users and rail and air users combined for whom a value relating to rail or rail and air was estimated (*RailAir-RailAir*) and air users who valued either rail or rail and air time (*Air-RailAir*).

The base category was taken to be bus users valuing bus IVT (*Bus-Bus*) and dummy variable terms were initially specified for all the remaining categories listed above.

Bus-Rail and *Bus-PT* were both far from statistically significant and removed from the model, whereupon the base category is that of all bus users. Whilst this could provide an indication that it is user type rather than mode which is the more important factor of the two influencing the value of IVT, the relatively small samples within the bus user category should be borne in mind.

Nor were any of the values for the three categories of *Car-PT* users or the *PT-PT* category statistically significant. In the former case, the categories contain only a small number of observations and, whilst this is a contributory factor in the case of the *PT-PT* category, we might not expect the value of IVT for PT users to be greatly different from the base category of bus users. *All-Car* and *All-Rest* had almost identical coefficients and hence have been combined into a single variable which we have termed *All-CarPT*.

The largest values, as expected, relate to air travellers and combined rail and air travellers. This applies even after allowing for journey purpose and distance effects and is presumably because business travellers in these categories are more senior and the purpose of their journey is more important whilst the leisure travellers in these categories have relatively high incomes. There are not enough observations to distinguish these effects by journey purpose. Air users have higher values than combined rail and air users which is not surprising.

Of the more common modes of travel, rail users have the highest values, presumably because of their higher incomes. Underground users also value IVT on the underground relatively highly. Insofar as the latter have similarly higher incomes as other London and South East travellers, the income effect will have been detected by the variable (*LSE*) specified to represent this effect. Underground users may have higher incomes than users of other modes in the South East, but a further contributory factor is that travel in the underground may involve relatively high discomfort, unpleasantness and effort.

It is the car user sample which provides information on the relative disutilities of the different modes. For car users, the coefficients for rail and car were very similar and hence combined (*Car-CarRail*). However, this does not mean that these two modes are valued the same, since the *Miles-Car* coefficient provides an additional effect. We subsequently examine how this impacts on value of IVT relating to car travel (Table 6.4). The *Car-Bus* coefficient indicates that bus is regarded as being somewhat inferior to train and, except for long car journeys, to car travel.

Clearly, the relative disutilities of different modes will vary according to the type of car, bus and train in question and the facilities it provides. Allowing for this in practical evaluation would, however, be a major task. For example, the 'covariate analysis' reported in Hague Consulting Group and Accent (1999) unearthed a large number of effects on the value of time from socio-economic and trip characteristics but the particular features of the car was not one of them. These issues could also have a major bearing on inter-temporal variations in the value of time.

The *All-CarPT* coefficient seems plausible given the previous results and that car users will be well represented in this category.

It might be argued that RP data provides more evidence on variation by mode valued, since RP mode choice models cannot split by mode used, whereas SP data provides much evidence on variations in IVT by user type since SP models are often calibrated to particular types of users. It could then be concluded that there are confounding effects at work, with possible differences between RP and SP values influencing the findings for the user type and mode valued effects. However, we do not find this entirely likely, since the RP data contains some variation by user type, from route choice and other (within rail mode) choice contexts as well as from the specification of combined user type categories to represent the different modes upon which mode choice models were calibrated. Moreover, variations across SP based values of IVT demonstrate differences due solely to user type, solely to mode valued and to both.

User Type and Non In-Vehicle Time Values

We have addressed the possibilities that our data set can inform how the value of IVT varies according to user type and mode and it remains to examine how the values of walk, wait and headway vary across user type. We would not expect the mode to which walk, wait or headway relate to have a bearing on their valuations.

We would expect the income differences across users types to influence the monetary valuations of the non IVT attributes. However, there might be other factors that are correlated with user type which have an additional bearing on how the values of walk, wait and headway vary. For example, car users might be particularly averse to waiting because it is something which they are not used to or because their dislike of waiting contributed to their car purchase and use decisions.

The base category is bus users and the other categories are as in Table 6.3 with the exception of the *Air* and *Air-Rail* users for whom there were not sufficient values of any of the three attributes. Initially, separate terms were specified for each of walk time, wait time and headway for each user type of car, rail, underground, bus and rail combined (PT), car and bus or rail (CarPT) and all modes (All). Some categories were combined, whilst *PT-Head*, *CarPT-Wait* and *All-Wait* were far from significant and were removed.

Car users have high values of walk time (*Car-Walk*) and wait time (*Car-Wait*). As we have already stated, they are much less used to either than users of public transport modes, they have relatively high incomes and their higher values of walk and wait time may have contributed to them being a car user. Surprisingly, car users have a low value of headway (*Car-Head*) compared to most other categories of user. We have a concern that some car users fail to fully appreciate the concept of service headway. Indeed, in our experience it is often the public transport variable about which car users have the poorest information and the one for which the results in choice models tend to be least satisfactory.

We have no observations of walk time values for underground users, but their values of wait and headway were very similar to rail users and hence combined terms have been specified (*RailUG-Wait* and *RailUG-Head*). These show that rail and underground users value wait time relatively highly, in line with the findings for IVT, but lower than for car users given the particular aversion of the latter to wait time. Similarly, rail and underground users have relatively high values of headway, and the overall values we obtain for headway seem to be the result of a combination of much lower values for car users than rail and underground users. Rail users value walk time (*Rail-Walk*) more highly than bus users but less highly than car users.

For car, rail and bus users, the findings seems to be consistent with those for IVT in terms of the effects that income might be expected to have but with a moderating influence as a result of car users' particular aversion to out-of-vehicle time.

Of the remaining effects, the relatively low incremental effects for *PT-WalkWait*, *CPT-Walk* and *All-Walk* all seem plausible given the findings for the user types separately. However, it is not clear to us why *CPT-Head* and *All-Head* are so high.

Journey Purpose

The estimated journey purpose effects are much as we would anticipate. The base category was initially leisure travel but to this has been added categories representing a mix of purposes and cases where no distinction was made since these did not have a significant influence on the value of time.

The values for business trips (*EB*) are by far the highest. Additional effects are due to first class business travellers (*EB1st*) and where the purpose of the study was forecasting (*EBFore*). Our feeling is that studies whose purpose was forecasting were more likely to require the respondent to consider what their company would permit and hence these valuations will be closer to the employer's valuations. Whether the *EB* value was obtained from RP data would have served a similar purpose but there were two few cases to isolate this effect and they are included within *EBFore*.

Commuters (*Comm*) have on average slightly higher values than the base category of leisure travellers. We regard commuting values which are, on average, only 11% higher than leisure values to be a surprising finding since it was our impression that studies tended to find larger differences. However, the finding is very much in line with the results of further analysis of the Accent and Hague Consulting Group SP data set which is reported in Working Papers 565 and 567.

We might expect commuting values to be higher because of worse travelling conditions and greater time constraints, although offsetting this is that income effects are greater for more frequently made trips and this would reduce the relative importance of time on commuting trips. No significantly different impacts of commuting on walk, wait or headway were discerned.

Income

The effect of income on the value of time was the subject of a separate aspect of this study, and the findings are reported in Working Paper 566. We therefore provide only a brief discussion here of the main findings.

The extension of our data set to provide much more variation in the GDP per capita measure of the influence of income has proved successful. We pointed out in section 3 that the additional data increased the variance of the GDP variable more than fourfold.

We are now able to estimate the GDP elasticity with a reasonable degree of confidence. Our previous meta-analysis (Wardman, 2001) obtained a GDP elasticity of 0.512 with a 95% confidence of ±118% of the central estimate. We now obtain a plausible GDP elasticity of 0.723 with a 95% confidence interval of ±43%

This time-series based GDP elasticity is greater than the large amount of cross-sectional evidence regarding the income elasticity. If, as is suggested by Gunn (2001), there has been a downward trend in the value of IVT independent of income, and given that GDP is sufficiently highly correlated with the time trend that it will discern any such effects, we can conclude that our GDP elasticity is consistent with a 'pure' income elasticity in excess of 0.723. If the downward trend in the value of time is attributable to increases in comfort, the GDP elasticity for IVT would be less than the GDP elasticity for all the attributes. However, comparison with the GDP elasticity estimated solely to the IVT values indicates the reverse to be the case.

Although there were some variations in the GDP elasticity by purpose and attribute, and indeed we can see that the GDP elasticity in the IVT model is higher, the incremental effects of attribute on the GDP elasticity were not significant whilst the GDP and journey purpose interaction was highly correlated with the variables representing purpose. We concluded that there was no particularly convincing reason to favour a model which specified incremental GDP elasticities.

Purpose Interactions

We had felt that the effect of journey purpose might vary across the different attributes. For example, commuting might impact more highly on IVT because of its association with the relatively large disutility of congested traffic conditions and delays whereas business travel might impact less on IVT than the other attributes since more productive use can be made of the IVT than walk and wait time.

It was therefore important to allow for interactions between journey purpose and attribute. However, only the interaction between employer's business travel and headway (*EB-Head*) was found to be estimated with any degree of precision. It indicates that headway is valued 23% more highly, other things equal, amongst business travellers. Although the effect is not significant at the usual 5% level, it is retained since we find it to be plausible.

We also regarded it to be important to allow for interactions between mode and purpose. For example, business travellers might find that train allows more productive use of time than other modes whilst crowding conditions on public transport will vary between commuting and leisure trips.

Again, only one interaction effect merited retention. This indicated that commuters on the underground have somewhat higher values. This is presumably because the various components of a journey all incur higher disutility in the crowded conditions of peak underground travel. This is consistent with London Transport's recommendations, outlined in section 2.4, that congested conditions increase the values of walk and wait time.

There might also be a number of other possible interactions. An example of an interaction between user type and journey purpose is that the seniority and precise purpose of business travellers might well vary across air, rail and car users whilst distance and purpose may interact again because the seniority and precise purpose of urban business travellers is different to inter-urban travellers. A range of further interactions were allowed for but no significant and plausible effects were obtained

Data

Our previous meta-analysis has found a strong degree of correspondence between the values of IVT obtained from RP and SP models but the differences in non-IVT values between RP and SP models were a cause for concern (Wardman, 1998a, 1998b). However, the amount of RP evidence relating to walk, wait and headway was very limited. Previously, the number of RP observations for walk, wait and headway were 13, 4 and 11 respectively. The corresponding figures are now 34, 22 and 11. Hence we have substantially more evidence for the walk and wait time values.

We have discerned significant effects from RP data on the values of walk time and wait time, although not on the value of headway. The relatively small amount of data may have been a contributory factor in the case of headway. The value of walk time is 46% larger when obtained from RP data whilst the value of wait time is 143% larger. This is consistent with our discussions in sections 2.2 and 2.3 that early work largely based on RP data tended to obtain larger values of walk and wait time values than more recent largely SP based research and also that the difference was greater in the case of wait time.

Although it could be claimed that the RP values are too low, because a substantial proportion of the evidence relates to early studies where the choice contexts, amount of data and modelling techniques would not generally be regarded to be as satisfactory as in recent studies, there is no real reason to suspect that this will have had a systematic influence on the values of walk and wait time obtained. Indeed, to the extent that early studies calculated wait time as half service headway, this would have actually operated to reduce the value of wait time if actual wait times are less than half the service headway.

There are, however, a number of factors which could cause SP values of walk and wait time to be too low. Firstly, more attention in SP exercises is paid to the realism of cost and IVT. Unrealistic walk and wait times may be ignored, which will lead to their coefficients being lower than they would otherwise be. Secondly, variations in walk and wait time may be introduced which are unrealistic and which are therefore ignored, yet this is less likely with IVT and cost. A good example is walking time to train stations and bus stops, which it is unrealistic to vary or which is varied without any proper explanation of why this could possibly occur. SP studies which have obtained values of walk time which are less than the value of IVT are not uncommon. Similarly, some travellers might always plan to arrive at the station or bus stop say one minute before the scheduled arrival of the service and hence specifying other amounts of wait time would be unrealistic and may well be ignored. Finally, SP exercises are artificial exercises and some attributes might receive less attention than they should in order to simplify the task required in making choices. If cost and IVT are more significant to choice, then the importance of other attributes might be understated in relation to them.

There is an argument that variations in wait time in SP exercises are interpreted to result from unreliability, that is, a failure of the service to adhere to schedule leads to wait times different than planned. If this is so, it is reasonable to argue that a premium valuation is attached to wait time to reflect the unreliability. However, this contrasts with the findings here that SP based valuations are too low. In any event, RP models use average wait times and values attached to these could reflect elements of the additional disutility of unreliability.

Levels of Walk and Wait Time

We collected data on the mean level of walk and wait time in an SP experiment or covered in an RP exercise. Although this is a highly aggregate means of exploring this issue, we are not aware of analysis of how the values of walk and wait time vary with their levels and indeed some interesting findings have emerged.

Our previous meta-analysis (Wardman, 2001) obtained a combined elasticity for walk and wait time with respect to their mean level of 0.18. We have here estimated separate significant elasticities for walk and wait time. These indicate quite plausible relationships between the value and level of these variables. A 10% increase in walk time would increase the value of walk time by 2.7% whilst a 10% increase in wait time would lead to a 1.6% increase in the value of wait time. It could be that to some extent such non-linearities explain the variation in walk and wait time values apparent in the findings reviewed in sections 2.2 and 2.3.

It is not surprising that the non-linearity is stronger for walk than wait time. It is consistent with the large reduction in walking trips as walking time increases and the findings of Wardman et al. (2000), cited in section 2.2, relating to walk time as access to a main mode and as a main mode.

The effect of the level of the mean headway on the value of headway was far from significant, although as was discussed above, the value of headway does fall as distance increases. We argued that we would expect headway to be less important for longer distance journeys. However, for a given distance, we might expect the benefits of improved headway to be greater where service frequency is poor than where it is good.

Other Issues

A number of other effects have been discerned covering the numeraire, the units in which cost variations are offered, region and the means of presenting the SP exercise.

We have seen that underground users have relatively high values. However, this is in addition to a London and South East effect (*LSE*) since when we specified regional variables it was only the latter which was statistically significant. It indicates that travellers in London and the South East have values which are 16% higher than other regions, presumably reflecting their higher average incomes and the more unpleasant, crowded and congested travelling conditions in the South East. Incremental effects by mode and attribute were not significant.

The numeraire is the unit in which the value of time is expressed. In our data set, the monetary numeraire can be coefficients estimated to petrol cost, parking charge, road price or toll, public transport fares or combinations of these. We might expect, for example, money values of time expressed in petrol cost units to be relatively high, on the grounds that petrol cost will be regarded as a fixed cost by some and thus it will not have the influence on choice that it would otherwise have. On the other hand, it is expected that charges to use road space, which could be road pricing or tolls, might attract protest responses in the SP studies dealing with it and this would result in lower values of time (Gunn and Rohr, 1996; Small et al., 1999). The only significant effect obtained was for toll charge and road pricing (*Toll*) where values of time are found to be 19% lower.

Three different forms of presentation of SP exercises are covered in our data set. These are the use of cards setting out each of the choices, computer presentation and the pen and paper method. We found that IVT values obtained from the latter method (*PaperIVT*) were 13% lower. We regard the pen and paper method as the least satisfactory means of presentation, both in terms of clarity of the layout and the extent to which the choices offered are clearly customised to the respondent's circumstances. With hindsight, it would have been interesting to have distinguished in the data set between designs which offer absolute levels of attributes and those which are based on changes to the current situation on the grounds that whilst the latter readily achieve customisation to the current situation it is widely regarded to be a less satisfactory means of presentation.

Finally, there was some evidence that offering public transport fares in round trip units leads to lower values of time. Whilst the return fare is the natural unit of cost for some public transport journeys, particularly inter-urban, presenting these alongside one-way journey times, which is the natural unit for this attribute, may lead to respondents trading the two amounts off as if they were in the same one-way units. Treating all the responses to have related to the round trip cost will reduce the estimated value of time. The model indicates that the values are 7% lower where public transport costs are presented in round trips units (*Round*).

Relationship with IVT Model

We have reported a model based solely on the 719 IVT valuations since it is IVT which is generally of primary importance in transport scheme appraisal and which tends to be most precisely estimated in empirical studies.

Comparison with the model which also contains walk time, wait time and headway indicates that the differences between them in the coefficient estimates for common variables tends to be minor. The largest difference is for *Comm-UG* which is much smaller in the IVT model. However, there was no support for splitting this attribute between IVT and the non-IVT variables in the combined model. The same points can be made about *LSE*.

Whilst it would be possible to adopt the IVT model as the basis for recommendations, and to use a separate model based on the IVT values of walk, wait and headway (see section 7) to obtain recommended values of walk time, wait time and headway as a function of recommended IVT valuations, the estimation of two separate models does not make most efficient use of the data available to us.

6.2 The Implied Values

Whilst the models in Table 6.1 indicate clearly how the monetary values vary, neither the absolute monetary values nor the IVT valuations of walk, wait and headway are immediately apparent. We therefore use the results from the combined model in Table 6.1 to provide illustrative figures for a range of circumstances for the money value of IVT and the IVT values of walk time, wait time and headway.

Table 6.4 provides the implied money values of IVT for a range of user types, modes and distances. Absolute values in pence per minute and 2000 quarter 3 prices are given as well as ratios of these values to car users' values of car IVT.

Table 6.4: Implied Money Values of IVT

	Miles	ABSOLUTE VALUES						RELATIVE TO CAR USERS' VALUES OF CAR TIME				
Used		BUS	UG	RAIL	CAR	CAR	CAR	BUS	UG	RAIL	CAR	CAR
Valued		BUS	UG	RAIL	RAIL	BUS	CAR	BUS	UG	RAIL	RAIL	BUS
Comm	2	3.0	9.5	5.7	4.4	6.1	4.6	0.65	2.05	1.23	0.95	1.33
	10	4.0	12.7	7.6	5.9	8.2	7.0	0.58	1.82	1.09	0.84	1.18
	25	4.8	15.1	9.0	7.0	9.8	8.9	0.54	1.70	1.01	0.79	1.10
	50	7.0	n/a	13.2	10.3	14.3	13.8	0.51	n/a	0.96	0.75	1.04
	100	n/a	n/a	15.0	11.7	n/a	16.5	n/a	n/a	0.91	0.71	n/a
Leis	2	2.7	5.1	5.1	4.0	5.5	4.2	0.65	1.22	1.23	0.95	1.33
	10	3.7	6.8	6.9	5.3	7.5	6.3	0.58	1.08	1.09	0.84	1.18
	25	4.3	8.1	8.1	6.3	8.8	8.0	0.54	1.01	1.01	0.79	1.10
	50	6.4	n/a	12.0	9.3	13.0	12.4	0.51	n/a	0.96	0.75	1.04
	100	7.2	n/a	13.6	10.5	14.7	14.9	0.48	n/a	0.91	0.71	0.99
	200	8.2	n/a	15.5	12.0	16.7	17.8	0.46	n/a	0.87	0.67	0.94
EB	2	7.1	13.4	13.5	10.4	14.6	11.0	0.65	1.22	1.23	0.95	1.33
	10	9.6	18.0	18.1	14.0	19.6	16.7	0.58	1.08	1.09	0.84	1.18
	25	11.4	21.3	21.4	16.6	23.2	21.2	0.54	1.01	1.01	0.79	1.10
	50	16.7	n/a	31.5	24.4	34.2	32.8	0.51	n/a	0.96	0.75	1.04
	100	19.0	n/a	35.8	27.8	38.8	39.2	0.48	n/a	0.91	0.71	0.99
	200	21.6	n/a	40.7	31.5	44.1	46.9	0.46	n/a	0.87	0.67	0.94

It is assumed that the effects of *Toll*, *Round* and *PaperIVT* should not be allowed to enter into a calculation of the value of time, since these are discerning what we regard to be misleading effects. However, *LSE* is allowed to enter the values for underground users.

Car users' values of car are higher than for train and generally lower than for bus. Although car time does become more highly valued than bus time, this only occurs at long distances where in fact we have very few observations for bus travel. We are unable to test whether there is any positive incremental effect on the distance elasticity for bus journeys over long distances.

The distance and journey purpose effects are readily apparent as are the low values of bus users and the high values of rail users. The figures are in stark contrast to currently recommended values in that they exhibit a considerable amount of variation.

Table 6.5 presents the implied IVT values of walk and wait time. The values do not differ by journey purpose, but they will differ by distance, since the distance elasticity is lower for walk and wait than for IVT, and they will also vary by user type. The numeraire is the value of IVT for the same mode as user type. Hence the rail values reported (headed RAIL RAIL in the table) are rail users' money values of walk and wait time divided by rail users' values of rail IVT.

Table 6.5: Implied IVT Values of Walk and Wait Time

WALK WAIT	DIST	CAR CAR		BUS BUS		RAIL RAIL		UG UG	
		Walk	Wait	Walk	Wait	Walk	Wait	Walk	Wait
2	2	2.18	3.68	1.68	2.57	1.28	2.51	1.50	2.93
5		2.79	4.25	2.15	2.97	1.65	2.90	1.93	3.38
10		3.37	4.73	2.59	3.31	1.99	3.24	2.33	3.77
20		4.07	5.28	3.13	3.69	2.40	3.61	2.82	4.20
2	10	1.72	2.90	1.49	2.29	1.14	2.24	1.33	2.60
5		2.20	3.35	1.91	2.64	1.46	2.58	1.71	3.01
10		2.66	3.73	2.30	2.94	1.77	2.88	2.08	3.35
20		3.21	4.16	2.78	3.28	2.13	3.21	2.50	3.74
2	25	1.50	2.53	1.39	2.14	1.07	2.09	1.25	2.41
5		1.92	2.92	1.79	2.47	1.37	2.42	1.60	2.81
10		2.32	3.26	2.16	2.75	1.65	2.69	1.94	3.13
20		2.80	3.63	2.60	3.07	1.99	3.00	2.34	3.50
2	50	1.35	2.28	1.32	2.03	1.02	1.99	1.18	2.31
5		1.74	2.64	1.70	2.35	1.30	2.30	1.52	2.67
10		2.09	2.94	2.05	2.62	1.57	2.56	1.84	2.98
20		2.53	3.28	2.47	2.92	1.90	2.85	2.23	3.32
2	100	1.22	2.06	1.26	1.93	0.97	1.89	1.13	2.20
5		1.57	2.38	1.61	2.23	1.24	2.18	1.45	2.54
10		1.89	2.65	1.95	2.49	1.49	2.43	1.75	2.83
20		2.28	2.96	2.35	2.77	1.80	2.71	2.12	3.16
2	200	1.10	1.86	1.20	1.84	0.92	1.80	1.07	2.09
5		1.41	2.15	1.53	2.12	1.18	2.07	1.38	2.42
10		1.71	2.39	1.85	2.36	1.42	2.31	1.66	2.69
20		2.06	2.67	2.23	2.64	1.71	2.58	2.01	3.00

It is again assumed that the effects of *Toll*, *Round* and *PaperIVT* should not be allowed to enter into a calculation of the values but that *LSE* is allowed to enter the values for underground users. In addition, we have no evidence on walk values for underground users and hence for these users we have used the *Rail-Walk* coefficient.

The results for walk and wait time are strongly dependent upon the weight we attach to the RP evidence. The values in Table 6.5 are based on the RP evidence. If we relied solely on the SP evidence, the walk time values would all be 32% lower and the wait time values would all be 59% lower.

The most noticeable feature of the IVT values of walk and wait is that they vary considerably. In part this is because of differences in the money value of IVT by user type and mode, but there are other strong influences at work. The increase in the IVT values of walk and wait time as the levels of walk and wait time (denoted in the first column) increase is quite clear, as is the fall in the values as distance increases. For corresponding levels of walk and wait time and the same journey distance, the values of wait time tend to be greater than the value of walk time. This is consistent with the review of past evidence considered in sections 2.2 and 2.3. The figures do, however, suggest that the value of walk is more centred around the convention of twice the value of IVT than is the value of wait.

Table 6.6 provides the implied IVT values of headway across distance and purpose which are the factors which influence it. The strong distance effect is very apparent, with the headway valuation being much higher for shorter distance trips.

Table 6.6: Implied IVT Values of Headway

DIST	PURPOSE	CAR CAR	BUS BUS	RAIL RAIL	UG UG
2	EB	0.88	0.85	0.96	1.12
2	Non EB	0.71	0.69	0.78	0.91
10	EB	0.57	0.62	0.70	0.81
10	Non EB	0.46	0.50	0.57	0.66
25	EB	0.44	0.52	0.58	0.68
25	Non EB	0.36	0.42	0.47	0.55
50	EB	0.37	0.45	0.51	0.59
50	Non EB	0.30	0.37	0.41	0.48
100	EB	0.30	0.39	0.44	0.52
100	Non EB	0.25	0.32	0.36	0.42
200	EB	0.25	0.34	0.39	0.45
200	Non EB	0.20	0.28	0.31	0.37

7. VARIATIONS IN WALK, WAIT AND HEADWAY VALUES

We here report the development of a model to explain variations in the IVT valuations of walk time, wait time and headway. Although, as we have seen, such time valuations can be derived from the money value model reported in section 6, we felt that it would be prudent to test whether the same relationships were apparent when the analysis is focussed explicitly on the time valuations.

The form of the model is the same as that outlined in section 6, except that now the dependent variable is the logarithm of the IVT valuation of walk time, wait time or headway, and the results are reported in Table 7.1. The model contains 183 walk values, 62 wait values and 164 headway values. The total number of observations of 469 is much lower than the number contained in our money value model of Table 6.1.

The reported model contains variables which influenced the implied IVT values of walk, wait and headway in the monetary valuation model of Table 6.1 and which were either significant at the usual 5% level or had a t ratio which was not far removed from significant.

Table 7.1: Time Valuations of Walk, Wait and Headway Model

Variable	**Coeff (t)**	**Elasticity or Effect**
Intercept	-0.196 (1.8)	
Distance		
Miles	-0.044 (1.3)	-0.044
Miles-Head	-0.107 (1.9)	-0.107
User Type		
UG-Head	0.317 (2.1)	+37%
CPT-Head	0.616 (3.8)	+85%
Mode Valued (Numeraire)		
CarVal	0.196 (2.6)	+22%
Purpose		
EB-Head	0.252 (1.9)	+29%
Level		
WalkTime	0.238 (5.0)	0.238
WaitTime	0.205 (3.3)	0.205
Data		
RP-Walk	0.225 (2.0)	+25%
RP-Wait	0.571 (4.4)	+77%
Obs	469	
Adj R^2	0.449	

Not all of the factors which influenced the IVT values of walk, wait and headway in the money value model are sufficiently precise to warrant inclusion in this model. In particular, no significant variations according to user type were apparent. No doubt the somewhat reduced sample size will have had an influence in this respect. Nonetheless, there are a number of encouraging findings which corroborate the previous findings.

Although the results are not quite as strong as for the money value model, there is a positive influence on wait time (*RP-Wait*) and to a lesser extent walk time (*RP-Walk*) compared to the value of headway when the value is obtained from RP data. The effects from the levels of walk time (*WalkTime*) and wait time (*WaitTime)* on their respective values is also repeated, and the results are little different to those previously obtained.

The strong negative effect from distance on the IVT value of headway (*Miles-Head*) and the lesser negative effect on the values of walk and wait (*Miles*) are again evident, whilst employer's business trips are again found to have higher headway values (*EB-Head*). The lower disutility of car travel time will cause higher IVT values of walk, wait and headway (*ValCar*).

Although the model estimated exclusively to the IVT values of walk, wait and headway has been able to detect a number of significant and plausible influences, and these largely corroborate the results deduced from the model based on money values, we prefer the latter approach since its larger data set allows more precise estimates to be obtained and a larger number of influences to be discerned.

8. CONCLUSIONS

The aim of this document has been to develop a model based on evidence from British studies which will support the provision of recommended values of IVT for public transport along with recommended values of walk time, wait time and headway. This model also serves as a cross-check of the car users' values of car time obtained from re-analysis of the Accent and Hague Consulting Group SP data which was conducted as a separate aspect of this study and is reported in Working Papers 565 and 567.

The development of such a model has been set in the context of a review of previous work relating to public transport IVT and values of walk, wait and headway. This has indicated that the value of wait time appears to be larger than the value of walk time, and that at least for wait time the convention of valuing it at twice the value of in-vehicle time does not seem to be supported. There seems to be a divergence between the RP and SP evidence relating to walk and wait time values and there is a clear need to distinguish values of IVT between user type and mode used.

Additional data has been collected to support the estimation of more precise coefficients than in our previous meta-analysis. The models are based upon 719 monetary values of IVT and a further 448 monetary values of walk time, wait time and headway.

A model has been successfully developed to explain values of time in terms of a number of key variables, including user type, mode valued, distance, journey purpose, type of data, real GDP per capita and the mean levels of walk and wait time. This model has been used to provide illustrative money values of IVT, and IVT values of walk, wait and headway, for a range of circumstances. We take the values of headway to represent the effects of schedule delay rather than wait time.

Notable findings are:

- Plausible and significant GDP elasticities of around 0.75 have been obtained.

- The value of IVT increases with distance, with a larger increase for the car mode. Walk and wait time values do not increase as strongly with distance whilst headway becomes less important as distance increases.

- We have distinguished between user type and mode valued, at least within the car user category where it is most feasible to do so. This shows rail users to have higher values of IVT than car users, with bus users having the lowest values. As far as the modes themselves are concerned, bus has the highest value of IVT and rail the lowest.

- The values of walk, wait and headway also vary with user type. Car users are particularly averse to walking and waiting whilst bus users have the lowest values of these attributes.

- The values are only a little higher for commuting than leisure trips.

- As expected on the basis of the literature review, the values of walk time and particularly wait time are higher when obtained from RP data. The recommendations regarding walk and wait time will strongly depend upon whether the influence of the RP evidence is retained

- The values of walk and wait time vary with the levels they take. The variation seems plausible. For walk time the variations in the values seems to centre around twice in-vehicle time but they are higher for wait time.

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Appendix 1: Additional Studies from which Values have been Extracted

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