Paper Presented at Transportation Research Board Annual Conference 2013

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Value of Time Multipliers: A Review and Meta-Analysis of European-Wide Evidence

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Abstract

This paper is different in that it provides a review of time multipliers in contrast to the much more common reviews of monetary values. There are a number of attractions of analysing what are essentially within-study valuations of the time related attributes expressed in equivalent units of in-vehicle time rather than deducing the multipliers from analysis of more disparate monetary valuations.

We here provide the most comprehensive review of time multiplier evidence yet conducted, covering 12 attributes on a European wide scale. We have assembled 1389 multipliers drawn from 244 studies and covering 18 European countries and have estimated a model to explain variations in these multipliers as a function of a large number of candidate explanatory variables.

The multipliers considered are walk and wait time, access to public transport and waiting at interchange locations, time spent searching for a parking space and in congested traffic conditions, departure time shift, headway, schedule delay early and late, the standard deviation of travel time and late time.

The main influences on the time multipliers are journey distance, mode and journey purpose. Whilst we observe quite appreciable but plausible variations in some multipliers across contexts, the variation is less than is observed in reviews of monetary valuations. The results seem to be transferable across Europe and will provide a valuable resource, not least in allowing money values of a range of attributes to be deduced from the more widely available money values of in-vehicle time.

1. INTRODUCTION AND OBJECTIVES

Of all the various types of time associated with travel, it is in-vehicle time (IVT) that has received by far the most attention in valuation studies. Indeed, values of IVT savings are, alongside price elasticities of demand, the most critical parameters of transport planning and policy and there is a 50 year history of their estimation. Some of the most significant valuation studies have been what have become known as national studies (Algers et al., 1995; Axhausen et al., 2008; Börjesson and Eliasson, 2012; Fosgerau et al. 2007; Hague Consulting Group 1990, 1998; Hague Consulting Group et al., 1999; MVA et al., 1987; Ramjerdi et al., 1997; Ramjerdi and Flügel 2010). These have unsurprisingly tended to focus on IVT. Nonetheless, these and many other studies have yielded monetary valuations of a wide range of time attributes other than IVT, to the extent that there have been some reviews and meta-analyses of these monetary values although not to the extent apparent for IVT.

This paper is different in that it is not concerned with monetary valuations of time attributes but rather with 'time multipliers' which are their valuations in equivalent units of IVT. Attributes such as walking time, waiting time and service headway are important determinants of the attractiveness of public transport whilst even for car travel there are issues surrounding time spent searching for parking spaces or in congested traffic conditions. In addition, the reliability of travel time and departure time choice are of increasing concern across all modes.

Whilst there have been notable reviews of the multipliers associated with walk and wait time (McKnight, 1982, Waters, 1992; Wardman 2004; Australian Transport Council 2006; Abrantes and Wardman, 2011), travel time variability (Carrion and Levinson, 2012; Li et al., 2010; Tseng, 2008), headway and delays (Wardman, 2004; Australian Transport Council, 2006), congested travel time (Wardman and Ibáñez, 2012) and standing time (Wardman and Whelan, 2011), we are not aware of a comprehensive review let alone a meta-analysis of time multipliers, and certainly not on the European-wide scale reported here.

This paper is structured as follows. Section 2 sets out why evidence on time multipliers is important and the background to some established conventions. Section 3 provides and appraises descriptive statistics relating to the very large data set that we have assembled covering a wide range of time multipliers. A meta-analysis of this data is reported in section 4 and section 5 provides some illustrative multipliers implied by the estimated meta-model. Concluding remarks and recommendations are provided in section 6.

2. THE NEED

There are a number of reasons why it is important to have the better understanding of time multipliers that this paper seeks to provide:

- Whilst many countries have direct evidence on values of IVT, or else can deduce them from labour costs, as for business travel, or conventions on how non-business values relate to the

wage rate[1], and indeed valuing walk and wait time at twice IVT is common practice and transferable[2], there are numerous other important attributes that are here covered for which there are no established multiplier conventions and where, in very many countries, evidence on monetary valuations is sparse or non-existent.

- Although there are now several studies that compare money values, almost always of IVT, across countries, they have to confront issues relating to exchange rates and real income/cost of living differences. Time multipliers can reasonably be expected to be more transferable across countries, which aids analysis of their variation and their application across different contexts[3].

- Time multipliers naturally drop out of meta-analyses covering monetary valuations of IVT and non-IVT variables as the ratios of the relevant equations (Abrantes and Wardman, 2011). However, these equations cover separate studies and therefore other unaccounted for variations across studies could have a bearing. The explicit analysis of within-study time multipliers, as is here reported, provides a more controlled context.

- The conventions relating to the multipliers for walk and wait time have been around for a long time, and as such it is healthy to query whether these continue to apply.

- If for no other reason, there is now a perhaps surprisingly large body of evidence on time multipliers and it warrants better understanding. In particular, any insights into how these multipliers vary according to methodological, temporal or contextual factors would therefore be most welcome and indeed novel.

3. THE DATA

This paper covers 12 multipliers. Time spent in congested traffic and time spent searching for a parking space are specific to car whilst service headway, wait time in general and wait time at interchange stations are specific to public transport. Access to public transport covers a mix of modes but walking time almost invariably relates to public transport. The remaining attributes are concerned with departure times, which are specific to the origin, or relate to travel time variability, which in terms of empirical evidence is specific to destination arrival times. Variations in departure time, either earlier or later, incur inconvenience but apply to journey planning decisions and are not associated with travel time variability. The empirical evidence relating to travel time variability covers: schedule delay early (SDE) and schedule delay late (SDL), which represent the average across a number of journeys of early or late arrivals at the destination relative to the preferred arrival time; the standard deviation of travel times, which when expressed relative to the mean is commonly

[1] The conventional wisdom of the 1960s and 1970s seems to have been that the value of non-work time is 25% of the wage rate but with some suspicion of under-reporting of evidence that did not fit this viewpoint. A value of around 33% can now be regarded as a typical central estimate.

[2] This convention, one of the oldest and most common of transport planning practices worldwide, seems to stem from the UK Department of the Environment's pioneering Mathematical Advisory Unit Note 179 (McIntosh and Quarmby, 1970).

[3] Nonetheless, we here test the extent to which multipliers vary across countries

termed the reliability ratio (Black and Towriss, 1993); and late arrival time, which is the mean arrival lateness widely used to represent unreliability in the rail market in Great Britain.

3.1 Data Collection and Characteristics

We have collected data from 244 European studies that yield 1389 time multipliers. Given this study builds upon four previous UK meta-analyses of monetary valuations of time-related attributes (Abrantes and Wardman, 2011) but only one smaller such study of mainland European values (Wardman et al., 2012), UK valuations inevitably form the largest proportion (63%) of the evidence. Having said that, the UK has a long history of extensive use of valuations of a wide range of travel attributes in transport planning and policy that is unmatched in the rest of Europe.

We extract multiple observations per study either because the values relate to different attributes or else they are separate values for the same attribute but segmented by key influential variables such as distance, mode, journey purpose or data type. A majority (60%) of studies yield 5 or fewer multipliers with only 5% yielding more than 15. The average is 5.7 per study.

Published evidence forms around half of the valuations and studies, with journal articles less than a fifth. Note, however, that some of the conference papers and government/operator commissioned reports from which we took the evidence have been subsequently published in peer reviewed journals. Our impression is that this might increase the proportion of studies and valuations from journal articles to more than a third.

It is informative to examine trends in the focus of empirical investigation over time. Given that we have collected multiplier data for 12 attributes, it is not sensible to provide cross-tabulations of each by time period. We therefore pool the attributes into homogenous groupings. Multipliers for congested time and search time, both unique to car travel, are grouped (Time) whilst out-of-vehicle time (OVT) covers the four, mainly public transport, attributes of walk time, wait time, interchange time and access time. Departure time shift (Dep) and particularly headway have appreciable evidence bases. The remaining reliability related attributes are combined into a single group (RELY). The trends are presented in Table 1.

Table 1: Attributes by Time Period (Column Percentages)

Variable	Up to 1980		1981-1990		1991-2000		After 2000	
	Study	Values	Study	Values	Study	Values	Study	Values
Time	0 (0%)	0 (0%)	6 (9%)	15 (7%)	10 (6%)	40 (6%)	16 (15%)	44 (9%)
OVT	8 (89%)	32 (97%)	35 (52%)	120 (53%)	88 (53%)	353 (56%)	31 (30%)	147 (29%)
Headway	1 (11%)	1 (3%)	18 (26%)	48 (21%)	51 (31%)	152 (24%)	33 (32%)	128 (26%)
Dep	0 (0%)	0 (0%)	5 (7%)	30 (13%)	7 (4%)	38 (6%)	4 (4%)	39 (8%)
Rely	0 (0%)	0 (0%)	4 (6%)	12 (5%)	10 (6%)	52 (8%)	20 (19%)	138 (28%)
Total	9	33	48	225	109	635	78	496

The earliest period provides only 4% of studies, with the remaining periods accounting for 19%, 45% and 32% respectively. The pattern in the valuations is little different at 2%, 16%, 46% and 36% respectively. We would expect some increase over time but it might be argued that an element of saturation has been achieved, particularly with attributes other than those relating to reliability, on the grounds that the cumulative knowledge base reduces the need for further studies.

In the early years, the OVT multiplier dominates but this diminishes significantly over time. The number of headway multipliers has, after the earliest years, remained a very similar proportion of the total. To a lesser extent this is so for the departure time shift evidence. Noticeable, however, is the significantly increased prominence of reliability multipliers in the most recent decade, to be expected given the prior dearth of evidence in this area and an increasingly unreliable world.

In examining the multiplier evidence across the different European countries, which is an important dimension of this study, we retain the grouping of attributes of Table 1. The cross-tabulations are provided in Table 2. It is noticeable that those countries where so-called national value of time studies have been conducted (Denmark, Netherlands, Norway, Sweden, Switzerland and the UK) provide not only a large proportion (91%) of the valuations (and 76% of the mainland European values) but also, generally, a large number of valuations per study.

Table 2: Valuations and Studies by Country

Country	Overall		Time		OVT		Headway		Dep		Rely	
	Study	*Value*	*Study*	*Value*	*Study*	*Value*	*Study*	*Value*	*Study*	*Value*	*Study*	*Value*
Austria	1	11	1	4	1	5	1	2	-	-	-	-
Belgium	3	7	1	1	1	2	-	-	-	-	1	4
Denmark	8	99	5	27	6	45	5	19	-	-	3	8
Finland	1	2	-	-	1	2	-	-	-	-	-	-
France	3	20	1	1	1	8	-	-	-	-	2	11
Germany	4	14	2	5	3	9	-	-	-	-	-	-
Greece	1	3	1	1	-	-	-	-	1	2	-	-
Ireland	2	3	-	-	1	1	1	2	-	-	-	-
Italy	5	15	-	-	4	14	1	1	-	-	-	-
Latvia	1	4	1	4	-	-	-	-	-	-	-	-
Netherlands	13	111	1	1	4	14	2	6	3	18	5	72
Norway	12	76	-	-	9	30	5	15	1	8	4	23
Portugal	2	6	-	-	1	3	1	3	-	-	-	-
Serbia	1	5	1	5	-	-	-	-	-	-	-	-
Spain	9	36	1	2	5	12	5	18	-	-	1	4
Sweden	13	62	1	3	7	28	4	13	-	-	5	18
Switzerland	6	41	2	5	3	11	5	25	-	-	-	-
UK	160	874	15	40	113	468	72	225	11	79	14	62
Total	244	1389	33	99	160	652	102	329	16	107	35	202

Denmark is the only country other than the United Kingdom to provide a large number of Time values whilst Scandinavian countries account for a large proportion (57%) of the OVT values. The Netherlands and United Kingdom dominate the departure time choice evidence whilst the major contributions (87%) to reliability values are made by Norway, Sweden, the United Kingdom and

especially the Netherlands. Multipliers for Eastern Europe are, unfortunately, conspicuously rare for all attributes covered here!

3.2 Summary Multiplier Statistics

Table 3 provides multipliers for all the attributes about which we have assembled evidence, with disaggregation by the key factor of journey purpose. The reported figures respectively denote the mean multiplier ratio, the standard error of the mean and the number of observations.

Focussing first on the overall multiplier values, walk and access time have the same means whilst wait time and interchange wait time are also similar. These are to be expected. Whilst all are less than the widely used multiplier of two, and indeed all the differences bar that for interchange wait are statistically significant, they are not large.

Car time spent in congested conditions is around 50% higher than time spent in free flow traffic. This seems reasonable and is very much in line with the review of international evidence contained in Wardman and Ibáñez (2012). The multiplier for parking search time, which is also specific to car, would seem to be a car driver's equivalent of a public transport user's waiting time.

If arrivals at stations or bus stops were random events, we would expect the headway to translate into half as much waiting time. Given the conventional wait time multiplier or indeed the mean in Table 3, this would imply a headway multiplier of around one. However, not all arrivals at stations and bus stops are random, whereupon the headway multiplier can be expected to be less than one. This is indeed found to be the case. Another way of expressing this is that we expect the ratio of the headway and wait time multipliers to be less than 0.5 which is indeed the case. There will be an element of waiting time but for planned journeys the headway multiplier reflects the inconvenience of not being able to travel at the desired time.

The departure time shifts do relate to journey planning and the inability of being able to travel at the desired time. Unlike headway, this does not contain wait time (except what might be regarded as wait time at the home or workplace origin) and it is not restricted to public transport modes. Departure time shifts mean either later than desired arrivals at the destination or earlier than desired departures. We might expect earlier departures to be less highly valued than later ones, and whilst this turns out to be the case overall the difference is slight and not significant. The multiplier is around 0.6, less than headway as might be expected to the extent that the latter incorporates a wait time element.

Turning to the SDE and SDL multipliers, the latter is valued more highly than IVT given arriving late incurs inconvenience and perhaps some penalty. We would expect the SDE multiplier to be less than one given that arriving earlier than desired is preferable to time spent in-vehicle.

Table 3: Multipliers by Journey Purpose

Attribute	All	Commute	Leisure	Business	Other
Congested Time	1.56:0.06:75	1.62:0.14:23	1.63:0.09:24	1.56:0.13:15	1.34:0.11:13
Walk Time	1.68:0.04:344	1.69:0.07:119	1.70:0.09:81	1.52:0.25:7	1.65:0.07:137
Access time	1.68:0.07:144	1.68:0.13:34	1.82:0.14:46	1.66:0.17:17	1.55:0.11:47
Wait Time	1.80:0.07:138	1.83:0.11:56	1.76:0.14:37	1.54:0.32:5	1.84:0.11:40
Interchange Wait	1.84:0.10:26	1.59:0.12:11	1.99:0.27:5	1.28:0.0:1	2.12:0.16:9
Search Time	1.85:0.21:24	2.29:0.42:10	1.41:0.17:11	2.41:0.0:1	1.85:0.00:2
Headway	0.71:0.03:329	0.67:0.05:68	0.71:0.04:95	0.74:0.07:37	0.71:0.05:129
Departure Time Early	0.56:0.07:44	0.59:0.14:18	0.63:0.22:8	0.50:0.06:7	0.50:0.02:11
Departure Time Late	0.65:0.08:47	0.74:0.017:19	0.43:0.08:9	0.64:0.14:7	0.67:0.11:12
Departure Time Both	0.74:0.14:16	1.63:0.87:2	1.00:0.0:1	1.00:0.00:1	0.55:0.08:12
Late Arrival	4.10:0.44:37	4.94:0.81:10	6.17:0.94:10	2.40:0.42:4	2.38:0.29:13
SDE	0.81:0.07:54	0.77:0.08:30	0.60:0.10:10	1.18:0.23:9	0.77:0.23:5
SDL	1.70:0.11:66	1.69:0.15:31	1.77:0.31:14	1.21:0.23:12	2.24:0.27:9
SD	0.91:0.10:45	0.97:0.19:11	1.20:0.23:13	1.10:0.30:4	0.60:0.13:17

Late time is particularly highly valued, perhaps because offering explicit late times rather than a distribution of arrival times places more focus on lateness and makes it quite clear what the actual amount is. The railway industry in Britain has long used a value of 3. As far as the multiplier for the standard deviation of travel time is concerned (SD), we note that Bates et al. (2001) is widely cited on this issue and for the reliability ratio they conclude that "values around 1.3 appear plausible for car travel; somewhat higher values may be appropriate for scheduled public transport but values above 2 are unlikely".

There is little variation in the OVT multipliers by purposes but commuters and business travellers particularly dislike search time. The congested time and headway multipliers vary little by purpose and the same is generally true for departure time shifts except for where there are small sample sizes. The reliability multipliers show more, and not entirely consistent, variation. Leisure travellers appear to have notably large late time values but their valuation of SDL is average. On the other hand, business travellers have low values of late yet value SDE almost the same as SDL. The results here might reflect the inherently greater difficulties in valuing reliability related variables.

A key part of our study was to examine multipliers across countries, and these are reported in Table 4. With the exception of Denmark, the time related multipliers exhibit remarkably little variation across countries. As for the country specific OVT valuations, there is a broad level of agreement except for the noticeably lower values in Denmark and the UK which do happen to provide the vast majority of the observations. Nonetheless, all the reported mean multipliers are in a relatively narrow and plausible range.

Table 4: Multipliers by Countries

	Time	OVT	Headway	Dep	SDE	SDL/Late	SD
Denmark	1.95:0.16:27	1.64:0.07:45	0.59:0.07:19	-	-	2.02:0.20:8	-
Netherlands	1.37:0.0:1	2.02:0.17:14	0.36:0.05:6	0.52:0.07:18	0.86:0.09:32	1.82:0.16:31	0.60:0.09:9
Norway	-	1.87:0.15:30	0.89:0.22:15	0.52:0.09:8	0.71:0.29:4	2.44:0.30:13	0.19:0.03:6
Sweden	1.46:0.03:3	2.00:0.13:28	0.45:0.07:13	-	0.76:0.19:5	2.88:0.56:10	0.58:0.19:3
Switzerland	1.52:0.24:5	2.14:0.39:11	0.53:0.06:25	-	-	-	-
Spain	1.40:0.0:2	2.16:0.19:12	0.53:0.10:18	-	0.48:0.0:1	2.10:0.23:2	0.98:0:1
UK	1.52:0.06:40	1.62:0.04:468	0.76:0.03:225	0.67:0.06:79	1.20:0.46:4	4.09:0.50:32	1.22:0.14:26
All Other	1.54:0.20:21	2.11:0.13:44	0.40:0.09:8	0.36:0.21:2	0.53:0.07:8	1.13:0.10:7	-

The headway valuations are also broadly consistent, and we could reasonably expect the differences to be explained by transport rather than country specific factors. Likewise, the departure time shift evidence varies little across the three countries providing 98% of the evidence.

With regard to SDE and SDL/Late, the notable outlier is the United Kingdom. The contributory factor here are some large values of late time and it may be that strategic bias and protest response have had a bearing here. The SD multipliers are higher for the United Kingdom and lower for Norway, although sample sizes here are small. A contributory factor is that few of the United Kingdom SD values were estimated alongside SDE/SDL values.

It would be illuminating to tabulate variations in multipliers by key factors such as journey distance, data type used in estimation and mode, amongst others, but space precludes a detailed discussion.

Bates et al. (2001) is widely cited on the issue of travel time variability and, with regard to the reliability ratio, they conclude that “values around 1.3 appear plausible for car travel; somewhat higher values may be appropriate for scheduled public transport but values above 2 are unlikely”. Our figures in Table X are at odds with their assessment, denoting lower reliability ratios. Indeed, for car travel by car users, and excluding cases where SDE/SDL were also specified in the estimated model, the mean ratio is 0.80 (0.09). The corresponding values for rail and bus are 0.74 (0.18) and 0.83 (0.21).

Bates et al. (2001) also state that typical relativities from the literature for mean time, SDE and SDL are 1.0:0.8:3.0. Our evidence for the mean SDE multiplier across our entire sample of 0.81 is highly consistent with that view, but the mean SDL multiplier of 1.70 certainly challenges it. When we removed cases where SD was also specified alongside SDE/SDL, the figures increase to 0.86 and 1.82.

4. META-ANALYSIS

Meta-analysis involves assembling large data sets of variables of interest, here time multipliers, and conducting appropriate quantitative analysis to explain how they vary across the studies from which they are drawn. We aim to explain variations across our assembled multiplier evidence according to:

- Attribute type
- Mode used
- Journey Purpose and Distance
- Data type, covering Revealed Preference (RP) and varying forms of Stated Preference (SP)
- Model type and estimation method
- Year of data collection
- Choice context
- Features of the SP exercise, such as number of alternatives, number of variables and number of repeat choices
- Method of presenting the SP exercise
- Aim of the study and whether it would be transparent to respondents
- Sample size and the number of values per study
- Source of the evidence
- Fixed effects specific to studies and countries

The form of the estimated model reported is multiplicative as set out in equation 1 which relates the multiplier (m) to n continuous variables (X_i) and p categorical variables (Z_{jk}) where there are q-1 dummy variables for a categorical variable of q levels.

$$m = \tau \prod_{i=1}^{n} X_i^{\alpha_i} e^{\sum_{j=1}^{p} \sum_{k=1}^{q-1} \beta_{jk} Z_{jk}} \qquad (1)$$

The α_i denote elasticities of the multiplier with respect to the X variables. The β_{jk} are interpreted relative to the arbitrarily omitted level, and the exponential of β_{jk} denotes the proportionate effect on a multiplier of level k of the j'th categorical variable relative to its omitted category. Note however that the parameters can vary across multipliers, and indeed that the initial, exploratory models segmented every multiplier by all the categories listed above prior to developing more parsimonious formulations which tended to group incremental effects according to the broad categories used in section 3 of Time, OVT, Headway, Dep and Rely.

The multiplicative model of equation 1 performed better than the equivalent additive version. A logarithmic transformation of it allows parameter estimation by ordinary least squares. The results are presented in Table 5.

The adjusted R^2 goodness of fit of 0.66 is very respectable given the diverse nature of the studies and that we have not removed what might be termed 'outlier' observations. Given 244 studies, we created 243 dummy variables to discern the 'fixed effects' associated with specific studies that are not accounted for by the explanatory variables and also to allow, to some extent, for the variably multiple observations per study. We retained only those with a t ratio of at least 1, of which there were 97, although in any event their inclusion does not greatly affect the results.

At the outset, we should note that we would not expect time multipliers to exhibit anything like the same degree of variation as their monetary equivalents from which they are largely drawn. Nonetheless, we have recovered a number of plausible effects. These are generally significant at the 5% level although we have retained some others that are less precisely estimated but in line with what we might expect. We discuss each of the findings in turn.

Constant

After taking into account the fixed study specific effects, but ignoring the country specific effects, the overall constant term is a little different at 1.015 rather than 1.116.

Attribute Specific Effects

The arbitrary base was set at walk time, simply on the grounds that it forms the largest number of observations. Specific terms for wait time, access time, interchange wait time and congested time were not significantly different from the walk time and therefore enter the base. This is not particularly surprising, given the ratios in Table 3, although other estimated coefficients will lead to variations in these multipliers across specific categories. As expected the constant for headway indicates it to have a multiplier somewhat less than the collective base, as is the case for the departure time shift attributes and SDE. As might also be expected, SDL is relatively highly valued, despite not in itself being significant, as is Late time.

Some reliability studies specified models containing both SDE/SDL and SD and we have allowed for this since we might then expect the values to be lower. These incremental effects are SDE_SDInc and SDL_SDInc, which denote the impact on the SDE and SDL coefficients from specifying the SD term, and SD_SDE&SDLInc representing the effect on the SD valuation of specifying the SDE and SDL terms. These have a negative sign and would imply, as expected, very large reductions in valuations when the unreliability effect is spread across more attributes

Mode Specific Effects

The reported model contains four modifiers to the multipliers according to mode. Bus users were found to have larger values of walk time (BusWalk), and in turn car users had yet higher values (CarWalk). Whilst we might expect car users to have relatively large values of walk time, we might also expect them to have higher values of a number of multipliers but we only detected an effect for departure time shifts (CarDepTime) where values are 28% higher. Those using metro or LRT have headway multipliers some 28% larger (Metro/LRTHeadway), presumably because high frequency urban modes will attract those with high values of headway whilst such users may have accustomed themselves to the high frequency levels generally offered by these modes, say with random arrivals, and hence value service headway highly.

Purpose Effects

We find that employers' business trips (EBOVT) have slightly lower values of time and this might be because time is time for business travellers regardless of what type it is and hence the premium applying for other purposes is not as strong here. Nonetheless, we find that headway does have a higher value for business travellers (EBHead). Whilst this is not surprising from a journey planning perspective, we also examined whether there was an additional effect for inter-urban rail where many are 'briefcase' travellers in senior management positions, but no effect was discerned. Commuters were found to have a slightly lower OVT multiplier (CommOVT) and this might stem from their relatively high value of IVT. Commuters are more averse to departure time shifts (CommDeptime) and this is not surprising, since it might involve getting up earlier in the morning or arriving at work late.

Table 5: Meta-Model Results

Variable	Coeff (t)	Effect	Variable	Coeff (t)	Effect
Constant	1.116 (11.6)		**Purpose**		
Attribute Specific			EBOVT	-0.162 (1.8)	-15%
Walk	Base	-	EBHead	0.155 (1.7)	+17%
Wait	n.s.	-	CommOVT	-0.061 (1.4)	-6%
Access	n.s.	-	CommDepTime	0.270 (2.5)	+31%
IntWait	n.s.	-	CommEBSearch	0.288 (1.6)	+33%
Congested	n.s.	-	LeisLate	0.626 (3.7)	+87%
Search	-0.629 (4.0)	-47%	NoDistCong	-0.290 (2.0)	-25%
Headway	-1.105 (8.1)	-67%	**Distance**		
DepTime Early	-2.021 (12.4)	-87%	DistOVT	-0.023 (1.9)	
DepTime Late	-1.885 (11.5)	-85%	DistHeadway	-0.209 (9.3)	
DepTime Both	-2.015 (9.3)	-87%	DistCong	-0.173 (5.8)	
SDE	-0.756 (8.4)	-53%	DistRely	-0.149 (4.5)	
SDL	n.s.	-	InterDepTime	0.519 (3.2)	
Std Dev	-0.999 (9.1)	-63%	**Data Type**		
Late	0.503 (4.3)	+65%	RP_TimeOVT	0.186 (2.9)	+20%
SDE_SDInc	-0.822 (4.1)	-56%	**Study Type**		
SDL_SDInc	-0.826 (5.8)	-56%	VoT	-0.146 (3.2)	-14%
SD_SDE&SDLInc	-0.378 (2.5)	+31%	**Country Specific**		
Mode			Norway_Headway	0.359 (2.5)	+43%
CarWalk	0.257 (4.2)	+29%	UK_Headway	0.232 (3.3)	+26%
BusWalk	0.132 (1.9)	+14%	UK_OVT	-0.247 (5.2)	-22%
Car DepTime	0.250 (1.8)	+28%	**Trend**		
Metro/LRTHeadway	0.244 (2.4)	+28%	TrendOVT	-0.011 (4.4)	
Observations	1389		**Adj R^2**	0.66	

Search time for parking spaces seems to be particularly disliked by commuters and business travellers (CommEBSearch) who separately had similar incremental effects. We do not find it surprising that they are more averse to it than leisure travellers. Where there was no distinction made between purposes, there was a lower value of congestion time (NoDistCong) but this might simply be a function of the sample obtained.

Finally, we specified an incremental effect for leisure travellers and late time (LeisLate) on the grounds that we had observed what seemed to be implausibly large multipliers in this category in the data set, notably for UK values. These values are 87% larger. Our view is that these multipliers are dominated by early studies of rail travellers presenting SP exercises where the purpose of the study would have been clear and where reliability would have been an issue. Hence the results could well have been influenced by strategic bias.

Distance Effects

One of the most common features of value of time studies, and indeed meta-analyses of such evidence, is that monetary values of time related variables increase with journey duration. That does not mean to say that multipliers vary with distance and indeed we would expect them to vary somewhat less as the ratio of two values each increasing with distance. However, we might expect some valuations to fall with distance.

We found that the combined OVT attributes exhibited a slight fall with distance (DistOVT), with an elasticity of -0.023. This is in line with the distance elasticities for monetary values apparent in Abrantes and Wardman (2011). The headway multiplier falls with journey distance (DistHeadway) which is not surprising since service frequency is much more of an issue for travellers making shorter and more regularly made journeys and high frequencies are not expected on longer distance journeys.

Congested time has a lower multiplier for longer distances (DistCong), and we attribute this to longer journeys having less congested conditions. Reliability seems to be less of an issue for longer distance journeys (DistRely). Quite apart from any purpose related effects, this might be because unreliability on longer distance journeys is less unacceptable than for short distances whilst even if the monetary valuation of unreliability is constant across distance it will fall in time units given the value of time increases with distance. We tested whether distance had a different effect on the SDE and SDL multipliers but none was apparent.

Finally, departure time shifts are much more of an issue for inter-urban travellers (InterDepTime) and this might be because longer distance trips involve more journey planning.

Data Type Effects

We specified incremental RP effects for all attributes where there was RP evidence. However, there is little RP evidence for the reliability and departure time shift terms whilst that for headway was not

significant. We have recovered a significant effect for the Time and OVT variables (RP_TimeOVT) combined, indicating that RP values are 20% larger.

Whilst we might expect SP responses to be influenced by strategic bias, and to operate to inflate monetary valuations where there is an incentive to do so, this does not mean that the time multipliers are biased. We attribute the here implied lower monetary SP values for Time and OVT variables to be related to problems in providing realistic variations in walk and wait time and such like in SP exercises such that respondents do not account for them to the fullest extent. Nonetheless, the effect is relatively minor at 20%.

Study Type Effects

We examined whether the multiplier varied according to whether the aim of the study was transparently to value the attribute in question and whether its primary purpose was forecasting, valuation in general or specifically value of IVT estimation. The only significant effect was whether the study was for the purpose of value of IVT estimation (VoT) and then the multiplier was only 14% lower. The cause of this could have been that value of time studies place undue emphasis on IVT and hence the multiplier is lower. Note that we tested whether national value of time studies produced different multipliers but none of the differences were remotely significant.

Country Specific Effects

A feature of this study is the pan-European context, and it is important to establish whether multipliers are transferable across different countries, even though we might expect time multipliers to be more readily transferable than monetary values. The dominance of UK values in the data set makes this more important.

Given evidence for some countries is sparse, we examine variations in Time, OVT, Headway, Dep and Rely for those countries where the number of observations was in double figures. From Table 2, this covers Time for Denmark and the UK, OVT for Denmark, Italy, Netherlands, Norway, Spain, Sweden, Switzerland and the UK, Headway for Denmark, Norway, Spain, Sweden, Switzerland and the UK, Dep for Netherlands and the UK and rely for France, Netherlands, Norway, Sweden and UK. Given that, overall, Germany and Austria had more than 10 observations, we also specified a combined effect for each of these countries. Additionally, we had observed what seemed to be large late time values for the UK and hence specified an incremental term to represent this.

Out of all these effects, only three were statistically significant, covering Headway for Norway and the UK and OVT for the UK. We therefore conclude that the multipliers are highly transferable at least across the more developed economies of Western Europe where almost all the evidence accrues. Nor did we detect any effect from whether a valuation was obtained from a national value of time study.

Trend Effects

We allowed for trend variations in all attributes. There seemed to be a reduction in the walk, wait, intwait and access multipliers over time and hence these were combined into a single term (TrendOVT). This implies a 1% reduction in the OVT multiplier per year. We attribute this to people being more favourably predisposed to walking and waiting for health reasons whilst improved service frequencies and lower implied wait times over time might also have had an influence. A significant effect was also apparent for Rely. However, we found it to be implausibly large and hence did not retain it.

5. APPLYING THE META-MODEL: ILLUSTRATIVE MULTIPLIERS

We have used the model reported in Table 5 to provide multipliers for a range of situations. In producing these multipliers, the country specific effects are ignored as is the study type effect. However, we do make use of the RP effect for Time and OVT variables (RP_TimeOVT). The implied multipliers are reported in Table 6 for a range of distances, the three main modes and the key journey purposes of commuting, business and leisure. In general, the implied multipliers seem reasonable.

For walk time, we observe a slight but plausible distance effect along with a purpose effect. The multipliers seem to surround the conventional wisdom of two. As far as wait time is concerned, the distance and purpose effects are the same, but there is evidence that wait time is valued a little lower.

Search time is particularly disliked by commuters and business travellers. Congested time is valued highly for urban trips and this might be because these are more congested. Wardman and Ibáñez (2012) provide convincing evidence that the value of time depends upon the degree of congestion and a figure exceeding two would not be out of the question in more congested urban networks.

The headway multipliers seem reasonable and fall with distance as expected. The departure time shift values exhibit higher values for commuters, which is not unreasonable, and somewhat larger values for inter-urban trips. The slightly higher value for later departures is believable.

The implied reliability multipliers seem plausible with what seems a reasonable reduction with journey length. There is, however, a conflict between the late and SDL multipliers. On the one hand the late time values might be regarded to be too high as a result of strategic bias induced by explicitly offering late time. On the other hand, not being explicit on late arrivals, as with SDL, could mean that respondents have failed to appreciate fully the extent of late arrivals. On balance, our preference is for the SDL figures, noting that it is much less of an issue for longer distance journeys where we can regard more expectation and accommodation of delays. In general, SDE has a lower value than IVT as expected.

Table 6: Implied Multipliers

	CAR				BUS				TRAIN			
	5	25	100	250	5	25	100	250	5	25	100	250
WALK												
Commute	2.32	2.24	2.17	2.12	2.05	1.98	1.91	1.87	1.80	1.73	1.68	1.64
EB	2.10	2.02	1.96	1.92	1.85	1.79	1.73	1.69	1.62	1.57	1.52	1.48
Other	2.47	2.38	2.31	2.26	2.18	2.10	2.03	1.99	1.91	1.84	1.78	1.75
WAIT												
Commute					1.80	1.73	1.68	1.64	1.80	1.73	1.68	1.64
EB					1.62	1.57	1.52	1.48	1.62	1.57	1.52	1.48
Other					1.91	1.84	1.78	1.75	1.91	1.84	1.78	1.75
SEARCH												
Commute	2.36	2.36	2.36	2.36								
EB	2.36	2.36	2.36	2.36								
Other	1.77	1.77	1.77	1.77								
CONGESTED												
Commute	2.52	1.90	1.50	1.28								
EB	2.52	1.90	1.50	1.28								
Other	2.52	1.90	1.50	1.28								
HEADWAY												
Commute					0.65	0.47	0.35	0.29	0.83	0.60	0.45	0.37
EB					0.76	0.54	0.41	0.34	0.97	0.70	0.52	0.43
Other					0.65	0.47	0.35	0.29	0.83	0.60	0.45	0.37
DEPSHIFTEARLY												
Commute	0.62	0.62	1.03	1.03	0.48	0.48	0.80	0.80	0.48	0.48	0.80	0.80
EB	0.47	0.47	0.79	0.79	0.37	0.37	0.61	0.61	0.37	0.37	0.61	0.61
Other	0.47	0.47	0.79	0.79	0.37	0.37	0.61	0.61	0.37	0.37	0.61	0.61
DEPSHIFTLATE												
Commute	0.70	0.70	1.18	1.18	0.55	0.55	0.92	0.92	0.55	0.55	0.92	0.92
EB	0.54	0.54	0.90	0.90	0.42	0.42	0.70	0.70	0.42	0.42	0.70	0.70
Other	0.54	0.54	0.90	0.90	0.42	0.42	0.70	0.70	0.42	0.42	0.70	0.70
LATE												
Commute	3.59	2.82	2.30	2.00	3.59	2.82	2.30	2.00	3.59	2.82	2.30	2.00
EB	3.59	2.82	2.30	2.00	3.59	2.82	2.30	2.00	3.59	2.82	2.30	2.00
Other	6.71	5.28	4.30	3.75	6.71	5.28	4.30	3.75	6.71	5.28	4.30	3.75
STDDEV												
All	0.80	0.63	0.51	0.45	0.80	0.63	0.51	0.45	0.80	0.63	0.51	0.45
SDE												
All	1.02	0.80	0.65	0.57	1.02	0.80	0.65	0.57	1.02	0.80	0.65	0.57
SDL												
All	2.17	1.71	1.39	1.21	2.17	1.71	1.39	1.21	2.17	1.71	1.39	1.21

Note: IntWait and Access have the same multipliers as Wait. Train and bus users have the same headway multipliers. The figures reported for train headway relate to Metro/LRT users.

6. CONCLUSIONS

This paper is different in that it provides a review of time multipliers in contrast to the much more common reviews of monetary values. There are a number of attractions of analysing what are essentially within-study valuations of the time related attributes expressed in equivalent units of IVT rather than deducing the multipliers from analysis of more disparate monetary valuations.

We here provide the most comprehensive review of time multiplier evidence yet conducted, covering 12 attributes on a European wide scale. We have assembled 1389 multipliers drawn from 244 studies and covering 18 European countries and have estimated a model to explain variations in these multipliers as a function of a large number of candidate explanatory variables.

The estimate model has provided a number of important insights, and we have used it to provide what seem to be plausible multiplier estimates across a range of circumstances. The key findings of our study are:

- The multipliers are found to exhibit sensible relationships with the attribute in question, mode, purpose, distance and some other factors.

- The multipliers implied by our estimated model generally seem very plausible

- Although we here provide variations in the walk multiplier according to mode and distance, a central estimate of 2, according with conventional wisdom, is supported.

- The figures for the wait time multiplier would suggest a figure a little lower than the walk time, with 1.75 being a reasonable number, but also with the caveat as for walk time that the multiplier does vary, in this case with distance.

- Our model provides multipliers for a range of attributes, such as departure time shift, congested time, headway and reliability, that to varying extents do not exist in many European countries and hence they provide an important policy relevant contribution to the knowledge base

- We have made every attempt to isolate country specific effects but few were apparent. We are therefore confident that the results are transferable at least across the broader European context. This is an important finding.

We conclude that the estimated model can be used to provide multipliers for a wide range of attributes, at least in the European context and particularly where little or no other evidence exists, as well as confirming and challenging some established conventions.

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