The Danish Value of Time Study

Final report

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Preface

Larger Danish transport projects are routinely subjected to cost-benefit analysis. For most infrastructure investments, the time savings evaluated by the value of travel time constitute the major part of user benefits. Thus, the value of travel time is often decisive for whether a project yields a positive or a negative economic benefit. It is therefore vital that the value is not only sound but also credible as its impact lies in the information that is given to policy makers concerning the projects analysed.

As a consequence, The Ministry of Transport and Energy has asked the Danish Transport Research Institute to carry out a study, leading to new values for travel time to be incorporated into the Ministry's guidelines for economic appraisal of transport projects.

Leading up to the present study was first a pre-study that lead to a phase 1 study in which a dataset was designed and collected. The present phase 2 study undertakes the econometric analysis of the data, leading to the value of travel time estimates to be used in future project evaluation.

The current report presents an overview of the methodology and summarises the main findings. Detailed documentation is available in four notes covering various parts of the study. These notes are available from DTF's home page.

Kgs. Lyngby, 2007

Niels Buus Kristensen
Director

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Summary

Larger Danish transport projects are routinely subjected to cost-benefit analysis. Typically, the main content of such an analysis is to compare the monetary investment and maintenance costs of a project to the accumulated time savings of a large number of travellers. Thus the value that is used in converting time to money is of crucial importance for the result of such analyses. It is vital that the value is not only sound but also credible as its impact lies in the information that is given to policy makers concerning the projects analysed.

Therefore the Ministry of Transport and Energy has asked the Danish Transport Research Institute to carry out this study, leading to new values for travel time to be incorporated into the Ministry's guidelines for economic appraisal of transport projects.

The present study builds first on a pre-study that lead to a phase 1 study in which a dataset was designed and collected. The resulting effective sample is very large, comprising close to 6000 respondents. This provides a firm basis for establishing new values of time.

The task of the present phase 2 study was to undertake the econometric and economic analysis of the data. This report presents the final results of the study, which has been carried out by Mogens Fosgerau, Katrine Hjorth and Stéphanie Vincent Lyk-Jensen (project leader).

The study has benefited from a concurrent research project carried out by Mogens Fosgerau, which means that the study defines the current state of the art in several ways. The methodology has been presented and discussed in papers at a number of scientific conferences and the papers are now finding their way into scientific journals. Moreover, we thank our two experts, Andrew Daly, UK, and Bill Waters, Canada, for reviewing the econometric analysis. They have contributed to a high level of quality assurance. However, the responsibility for any errors remains ours.

A main point of this final report is to highlight a number of points where decisions had to be made to bridge the gap between what can be confidently determined scientifically and the final values. These points are put forward explicitly to make it clear what the decision points were and why the particular decisions were made. These decisions were made based on

our recommendations by the steering group for the project within the Ministry of Transport and Energy.

Business trips were excluded from the analysis as the pre-study concluded that these values were better calculated based on the direct costs of the employer.

The main finding is a central value of 67 DKK per hour (2004 prices) to be applied to in-vehicle travel time for non-business trips in all transport modes. Some comparisons may be given for this value. It is higher than the previous average value of 48 DKK per hour (2004 prices) in the cost-benefit guidelines of the Ministry but still less than the average after tax hourly wage of Danish travellers of around 100 DKK per hour. The value of 67 DKK per hour is well within the range of 60 to 85 DKK per hour indicated for Denmark in a recent meta-analysis of a large number of European value of time studies (Shires and de Jong 2006).

In addition, the report recommends factors to be used in scaling the values of other time components such as interchange time, headway etc. to the central value of in-vehicle time. The recommendations are summarised in Table 1 below.

Table 1: The Danish values of time (2004 DKK)

	Car	**Public Transport**	
In-vehicle-time (IVT)	**67 DKK**		
Relative values			
Congested Time(1)	1*IVT		
Parking search time	1.5*IVT		
Access/Egress	1.5*IVT	1.5*IVT	
Interchange		6 min	**7 DKK**
Headway H; H=12 minutes* Low headway <12 minutes High headway >12 minutes		 1*H*IVT (12*1+0.4*(H-12))*IVT	
Interchange waiting Time		1.5*IVT	

(1) Note that the factor used in the official guidelines of the Ministry of Transport and Energy is 1.5, as it includes the travel time variability due to congestion, while the Danish value of time study focuses only on additional driving time due to expected delays.

This table gives a highly aggregate view of the information that is contained in the study. In addition to the overview presented in this report, it is possible to consult the notes that have been prepared on various parts of the study. These are:

- The Danish Value of Time Study: Data description. Danish Transport Research Institute, Note 4, 2007.
- The Danish Value of Time Study: Results from experiment 1. Danish Transport Research Institute, Note 5, 2007.
- The Danish Value of Time Study: Results from experiment 2. Danish Transport Research Institute, Note 6, 2007.
- The Danish Value of Time Study: Transfer Pricing. Danish Transport Research Institute, Note 7, 2007.

Contents

1 Introduction

This report presents a summary of the Danish value of time study, emphasising the methodology, the main decisions that were made, and the resulting values of travel time to be used in cost benefit analysis within the Danish transport sector.

Danish transport projects are routinely subjected to cost-benefit analysis. For most projects, the main benefit is constituted by travel time savings. The role of the value of travel time (VTT) is to convert these time savings into monetary units such that they can be compared to the costs of the projects. Of course, time losses are converted using the same value. The VTT is often decisive for whether a project yields a positive or a negative economic net benefit. It is therefore crucial that values are well-founded and credible.

As a consequence, The Ministry of Transport and Energy has launched the Danish value of time study. The results from this project are summarised in the present report.

A number of aspects of the methodology are new. They reveal and resolve a number of issues with the previous state of the art methodology for estimating the value of travel time. The report emphasises these issues as they are important for assessing the validity and credibility of the results.

As will always be the case, there is a gap between what can be established scientifically and the resulting values to be applied in cost-benefit analysis. A number of decisions had to be made to fill this gap. These decisions were made by the steering group for the project within the Ministry of Transport and Energy. The report presents the case for these decisions in order to make clear the role of the decisions.

Finally, of course, the report presents the resulting estimates of the value of travel time to be used in future transport project appraisals.

The overall study has comprised three phases:

- Phase 0: A preliminary study determining the methodology and providing recommendations for data collection and analysis.[1]

- Phase 1: Data collection and preliminary analysis.[2]

- Phase 2: Establishment of the official value of travel time.

Phase 1, called DATIV (Danish Value of Time in Danish) has been realised by a consortium composed by TetraPlan, Rand Europe and Gallup. The sample both encompasses interviews conducted via Internet and Face-to-Face Computer Assisted Personal Interviews (CAPI). The output of Phase 1 is an effective sample comprising more than 6000 Stated Preference (SP) interviews concerning non-business trips, together with some preliminary analyses and a weighting procedure designed to obtain representative values for the whole Danish population.[3]

The dataset is exceptionally large, enabling results to be computed with a high degree of confidence. The questionnaire design is state-of-the-art and draws heavily on the experiences from a number of previous European national VTT studies.[4]

Phase 2 was carried out by Mogens Fosgerau, Katrine Hjorth and Stéphanie Vincent Lyk-Jensen from the Danish Transport Research Institute (DTF) and concentrates on the statistical and economic analysis. The output, summarised in this report, is the official values of time to be used in cost benefit analysis of transport projects. The phase 2 study has benefited from reviews carried out by professor Andrew Daly, Rand Europe and University of Leeds, and professor Bill Waters, University of British Columbia. Of course, the responsibility for the content and any errors remains ours.

DTF has undertaken a separate research project, funded by the Danish Social Science Research Council, concerning value of time estimation. The results from this research project are used extensively in the Phase 2 project. As a result, the methodology defines the current state-of-the-art in several respects. The methodology has been presented in papers at a number of scientific conferences and, so far, two papers have been accepted in scientific journals. The scientific dimension is thus an important part of the

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[1] Danish Ministry of Transport (2003), and Fosgerau and Pilegaard (2003).
[2] Danish Ministry of Transport and Energy (2005).
[3] TetraPlan: "Opregningssystem for SP-interview I tidsværdistudiet", document no. 1100651-024.
[4] UK 1994-96, the Netherlands 1988 and 1997-98, Sweden 1994, Norway 1995-96, Switzerland 2004, New Zealand 1999 and 2000, and the Australia 2001.

overall project, contributing quality assurance and credibility of the results.

2 Background

The overall dataset encompasses four experiments:

- Experiment 1 (SP1): *Abstract time-cost exercise* examines trade-offs between in-vehicle travel time and cost;

- Experiment 2 (SP2): *Disaggregated time components* examines trading between hypothetical alternatives of the chosen mode and contains both in-vehicle and out-of-vehicle journey components (e.g. interchanges, access-egress, parking search).

- Experiment 3 (SP3): *Alternative mode exercise* considers time/cost trading for an alternative mode (i.e. not the chosen mode).

- Experiment 4 (SP4): *Transfer price questions*.

Data were collected for the following transport modes: car driver, car passenger, bus, metro, S-train and train.[5] Business trips were not included.

Analysis of data from experiment 3 was excluded from the project at its inception due to resource constraints.[6] We also found the data from experiment 4 to be problematic[7] and these data are not used for estimating the VTT.

This report therefore focuses on the analysis of data from experiment 1 and 2.

- Experiment 1 is used to estimate the central value of in-vehicle travel time. This analysis is reported in section 3.

- Experiment 2 is used to estimate the values of other time components relative to the central value of in-vehicle travel time. This analysis is reported in section 4.

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[5] Data were also collected for ferry passengers. As these data turned out to be unreliable, they are not included in the analysis.
[6] Fosgerau (2005).
[7] Fosgerau, Hjorth, V. Lyk-Jensen and Marott (2007).

3 In vehicle time values

This section concerns the analysis of SP1 data, used to provide the central values of in-vehicle time (IVT).

3.1 SP1 data

All respondents in the experiment had to choose between two alternatives, described by travel time and travel cost. All choices were designed relative to a recent actual trip respondents had made. The recent trip was taken as the reference situation and choice situations were generated by varying the travel time and cost around the reference. Four types of choices were generated:

- Willingness to pay (WTP), comparing the reference to a faster but more expensive trip
- Willingness to accept (WTA), comparing the reference to a slower but cheaper trip
- Equivalent gain (EG), comparing trips that are either faster or cheaper than the reference
- Equivalent loss (EL), comparing trips that are either slower or more expensive than the reference

Each subject was presented eight choice situations, two of each type of choice in random sequence. Respondents were furthermore presented with a dominated choice situation, where one alternative was both faster and cheaper than the other.

The eight choice situations were generated in the following way.

- Eight choices were assigned to choice types at random.
- Two absolute travel time differences were drawn from a set, depending on the reference travel time, in such a way that respondents with short reference trips were only offered small time differences. Thus there is no asymmetry in the size of the time differences up and down. Both travel time differences were applied to the two situations assigned to each of the four choice types.

- Eight trade-off values of time were drawn at random from the interval [2; 200] Danish Crowns (DKK) per hour, using stratification to ensure that all respondents were presented with both low and high values. The absolute cost difference was then found for each choice situation by multiplying the absolute time difference by the trade-off value of time.

- The sign of the cost and time differences relative to the reference were determined from the choice type. The differences were added to the reference to get the numbers that were presented to respondents on screen. Travel costs were rounded to the nearest 0.5 DKK.

Finally, it should be noticed that alternatives differ only with respect to time and cost, so that issues such as heterogeneous preferences for various transport modes play no role.

Unrealistic answers from the respondents concerning travel distance, main mode journey time, travel cost, calculated speed, share of travel time due to congestion or travel group size led to exclusion of respondents. Respondents who chose the dominated alternative (the one being slower and more expensive) in the check question were excluded. Moreover, we excluded all choice situations with a dominant alternative regardless of the answer – the dominated choices are only used to identify respondents with irrational answers and contain no information of the value of time. This resulted in the following effective sample sizes shown in Table 2. These sample sizes are high and allow for a high degree of confidence in results.

Table 2: Effective sample sizes in SP1

	Car driver	Car passenger	Bus	Metro	S-train	Train
Respondents	2167	502	1257	248	615	1008
Choices	16791	3837	9690	1875	4738	7881

The background variables available from the interviews are socio-demographic characteristics (e.g. age, income, sex, household status etc.) together with details of the actual trip. Missing values of personal and household income are supplemented with income information from Gallup, when available. Note that respondents stated their gross annual income grouped into intervals of 100,000 DKK up to 1 million DKK. We have computed net annual income by applying national tax rates to interval midpoints.

3.2 The econometric approach

The conventional model for such data is the mixed logit model specified with random marginal utilities of time and cost. The random VTT is then the ratio of these marginal utilities. Based on Fosgerau (2007) we instead formulate a mixed logit model directly in terms of a random VTT. This allows us to work directly with the VTT distribution rather than a ratio of distributions.

We specify the log of the VTT as a linear index of covariates plus an additive random component representing unobserved heterogeneity. The VTT is then restricted to be positive, and is composed of a systematic part depending on characteristics x of the subject and the choice situation, and a random part, that varies across individuals, but is constant across choices of the same individual. That is, $VTT = e^{\beta_0+\beta' x+u}$, where u is a person-specific random variable with mean zero, and x and u are independent.

As a starting point we take the random u to follow a normal distribution. Using the approach in Fosgerau and Bierlaire (2007) we generalise this distribution such that we are able to test the normality assumption. We use the generalised distribution instead whenever the normal distribution is rejected, such that the distribution used to calculate the mean VTT always fits the data.

It is common to find a gap between the willingness to pay and the willingness to accept, whereby the willingness to pay is often much smaller than the willingness to accept. The equivalent gain and the equivalent loss lie somewhere in between. The present study is no exception.

This raises the issue of which value to use in cost benefit analysis. De Borger and Fosgerau (2006) propose a solution by showing how an underlying reference-free VTT may be recovered from reference-dependent choices. Their solution is based on prospect theory rather than conventional utility theory.[8] Under this theory, respondents evaluate choices not in terms of the absolute position they reach with the choice but in terms of changes from the reference where loss aversion implies that a loss costs more "value" than an equal sized gain.

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[8] Prospect theory was developed by Kahneman and Tversky in a number of papers, notably Kahneman and Tversky (1979) and Tversky and Kahneman (1991), to explain behavioural deviations from expected utility maximisation.

We apply the De Borger and Fosgerau approach by letting the VTT enter a reference-dependent utility function, which allows for loss aversion in the perceived values of travel time and cost.

In binary choices, respondents choose the alternative with the higher reference-dependent utility (the lower generalised cost), though with the chance of making errors. The errors are assumed to be logistic, which makes our model a special case of a mixed logit model.

We assume that errors are multiplicative relative to the VTT, such that people with low VTT make errors of smaller absolute magnitude than people with high VTT (Fosgerau 2007).

Thus u represents unobserved taste heterogeneity between individuals and the distribution of u determines the distribution of the VTT conditional on x.

This model specification works well, and has several advantages:

- With present data, the model formulation yields considerable gains in model fit at low estimation cost.
- Reference-dependence is easily allowed for and can be tested.
- Errors are multiplicative such that the scale of the attributes of the alternatives does not affect choice probabilities.
- We work directly with the VTT distribution instead of having to derive the mean of a ratio of random variables correlated in some unknown way.
- We are able to test the distributional assumption for the random component of VTT by specifying generalised (flexible) distributions and testing against these.
- We are able to provide a check of the identification of the VTT distribution.
- Furthermore, the model allows us to estimate a large number of significant parameters for the parameterisation of the VTT.

The note on the analysis of the results from the SP1 study (Fosgerau, Hjorth and Vincent Lyk-Jensen, 2007b) reports on the specification and estimation of the model for SP1. A large number of model formulations have been tested, using with different socio-demographics, trip related variables and design variables. We will not go through all these results here. In general the findings concerning the influence of these background variables on the VTT are intuitive and plausible.

The analysis of the SP1 model has resulted in a final model specification including estimates of parameters for the index determining the location of the individual VTT as well as an estimate of the distribution of the individual specific random component u. These results have been used to produce estimates of the VTT distribution for the sample.

The procedure for converting these estimates to the final value to be used for cost-benefit analyses comprises a number of steps, which are detailed in the remainder of this section.

First we describe in section 3.3 the background for choosing to truncate the estimated distributions. Then in section 3.4 we discuss how to take account of the fact that the estimated VTT depends on the size of the time saving presented to respondents. Finally, we discuss the weighting procedure in section 3.5 while section 3.6 details the averaging and correction for income that has taken place in order to arrive at a central estimate of a common mean VTT for in-vehicle time.

3.3 Truncating the VTT distribution

The prevailing wisdom at the time the experimental design was prepared was that the design should concentrate around the expected mean value of time. As a mean VTT around the previous official value of 57 DKK per hour for commuting trips was expected, the experimental design of DATIV presented VTT trade-offs to respondents from the interval [2: 200] DKK per hour. The upper bound of 200 DKK per hour was considered a high value.

As a consequence of research carried out in connection with the present project (Fosgerau 2006), this practice has been revealed to be problematic. Our econometric technology allows us to avoid specification of a specific distribution for the VTT, instead the distribution is estimated. The benefit is that we avoid distributional assumptions that may be wrong and lead to completely misleading results. The cost is, however, that we need to be able to identify the whole VTT distribution from data. However, as can be seen from Table 3 below, a significant share of respondents have a VTT higher than the maximal trade-off value they were asked to consider. Therefore our data do not allow us to identify the right tail of the VTT distribution without further assumptions.

We could have chosen to continue the distribution above 200 DKK per hour in some parametric fashion. Such assumptions cannot however be verified and can result in any estimated mean VTT beyond a certain minimum (Fosgerau 2006). Although we are not able to make a strong statement about this, we conjecture that the problem of the missing tail is common to many stated choice experiments, reducing the robustness of results quite considerably as they become dependent on arbitrary assumptions on the shape of the missing tail.

Table 3: Share of respondents accepting the highest trade-off values by mode

	Share of respondents accepting max trade-off values
Car driver	17%
Car passenger	14%
Bus	6%
Metro	8%
S-train	7%
Train	17%
All	13%

Note: The maximal trade-off value differed by respondents. Not all were presented with 200 DKK per hour.

This is an important reason for choosing to parametrise the VTT. The parametrisation of log VTT as a linear index of covariates representing observed heterogeneity and an independent random component representing unobserved heterogeneity allows us to extend the "observed" support of the independent random component to a wider range by using the variation in the linear index together with the variation in the VTT trade-offs presented to respondents.

Thus, the identification problem is largely resolved, but at the cost of assuming independence between the index and the random component. This has as a consequence that the right tails of the estimated distributions become quite long; in other words, that a non-negligible share of people have a very high VTT.

Figure 1 shows the estimated VTT distribution for the car driver segment. As is evident, the estimated distribution extends considerably beyond 200 DKK per hour. The independence assumption allows us to estimate the shape of the distribution beyond this point.

Figure 1: Approximated VTT cumulative distribution function for the car driver sample (non weighted)

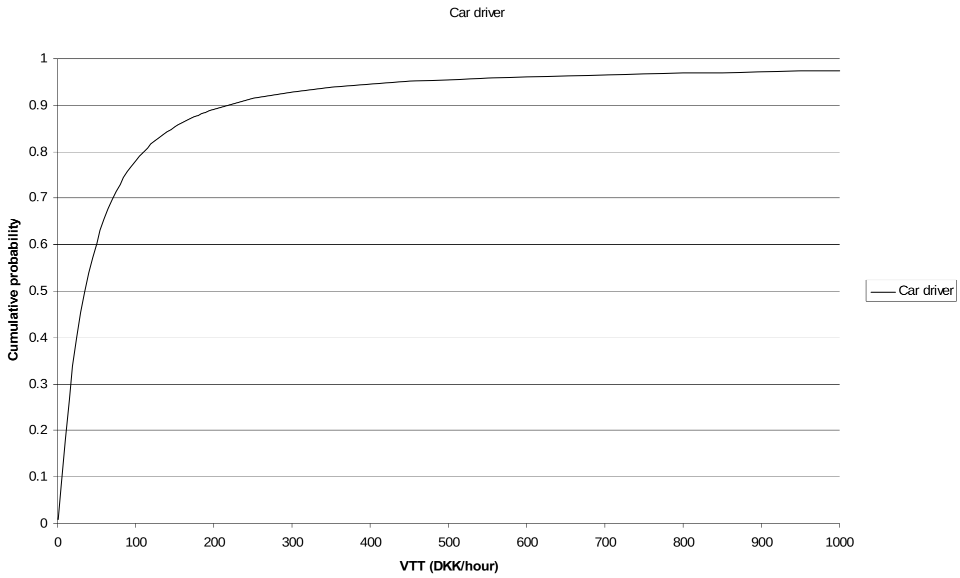

Table 4 reports the estimated mean VTT, as well as different quantiles of the VTT distribution and also some truncated means of the distribution as well as the 99% quantile of the estimated VTT distribution. The numbers in the table are computed using the size of the time saving for which the VTT becomes constant (more on this in section 3.4)

Table 4: Moments and quantiles of the estimated VTT distributions (DKK per hour) and mean hourly after tax wages for the sample (2004 DKK)

	Car driver	**Car pass.**	**Bus**	**Metro**	**S-train**	**Train**
Median	35	34	23	61	29	81
99% quantile	3445	978	250	543	254	781
Truncated means:						
-At 200 DKK	62	61	35	80	43	98
-At 400 DKK	77	74	36	90	45	117
-At 600 DKK	86	80	37	93	45	124
-At 800 DKK	93	84	37	94	45	126
-At 1000 DKK	**98**	**86**	**37**	**94**	**45**	**128**
-At 99% quantile	136	86	35	92	44	126
Mean	232	96	37	95	45	130
Mean net hourly wage	**110**	**93**	**84**	**104**	**100**	**94**

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We note that the mean is generally larger than the median, indicating that the estimated distributions are skewed to the right. We note also that this feature is very pronounced in the car driver segment, where the 99% quantile of the estimated distribution is very large and the resulting mean is also larger than 200 DKK per hour. The differences between modes cannot be explained by differences in the average after tax hourly wage.

We have therefore computed the mean VTT where the VTT distributions have been truncated at a range of points. The truncated means increase with the truncation point. Except for the car mode, the truncated means stabilise at a value not much different from the untruncated mean. Only for the car driver segment is there a large difference between the truncated means and the untruncated mean.

It is thus apparent that the high untruncated mean found for car drivers is largely determined by the extreme tail of the estimated distribution. There are no data underlying the extreme tail and the result is thus determined by functional form. Therefore we cannot consider the extreme tail to be reliably estimated.

Furthermore, a value of 1000 DKK per hour is very large. Based on income statistics and rough assumptions on taxes and the number of hours worked annually it can be assessed that less than 0.03% of the Danish population have an after tax hourly wage of more than 1000 DKK.

On our recommendation, the steering group for this project has therefore decided to use mean values from the estimated VTT distributions truncated at 1000 DKK per hour.

The consequences for most segments are minor. The exceptions are car passengers and particularly car drivers, where truncation reduces the mean considerably in relation to the untruncated mean. This reduction is intended, since the very high untruncated mean for car drivers is caused by the extreme tail of the VTT distribution.

We note again that the problem of the missing tail is not specific to our approach and data. The fact that the variation in the trade-offs presented to respondents is not sufficient to identify the whole VTT distribution is in all likelihood equally true for other previous studies. It is rather the case that our approach makes the problem clearly visible and we are able to make an informed decision about what to do about it. This must be regarded as an advantage.

3.4 The choice of the size of the time saving

Recall that subjects had to choose between two alternatives differing in travel time and cost. Our analysis shows that the VTT as measured by the econometric model increases significantly with the difference in travel times. Thus, in the data the VTT per minute is smaller when the difference in travel times is, e.g., 3 minutes than when the difference is 15 minutes.

The VTT may depend on the size of the travel time difference under Hicksian preferences. The VTT corresponds to an arc on an indifference curve, such that the VTT will increase with the travel time difference in one direction and decrease in another. But we find that the VTT increases with the size of the travel time difference regardless of the direction, such that the effect is not explained by classical utility theory.

Our analysis has revealed that the increase of the VTT with the size of travel time difference may be assumed to stop at some travel time difference. For each mode, we have estimated the minimal threshold, $T*$, at which the increase may be assumed to end.

Table 5 illustrates the effect of different level of time savings on the mean calculation. Numbers in bold indicate where the mean VTT can be assumed to be constant. The means are obtained after truncating the VTT distribution for the respective segment at 1000 DKK per hour as explained above.

Table 5: Mean VTT (in DKK per hour) for different levels of time savings (Δt)

	Mean VTT						
	|Δt|=3	|Δt|=5	|Δt|=10	|Δt|=15	|Δt|=20	|Δt|=30	|Δt|=45
Car driver	50	55	66	81	**98**	**98**	**98**
Car passenger	38	40	47	55	64	**86**	**86**
Bus	22	24	30	**37**	**37**	**37**	**37**
Metro	35	41	62	**94**	**94**	**94**	**94**
S-train	28	31	37	**45**	**45**	**45**	**45**
Train	40	42	48	56	64	85	**128**

For time differences in the range 3 to $T*$ minutes, the unit value of travel time increases with the size of the time difference. Hence a 10-minutes time saving is worth more than two 5-minutes time savings. This is not unexpected, as the same pattern was found in the Dutch and British Value of Travel Time studies.[9] When evaluating transport projects, however, a lower unit VTT for small time changes is not appropriate, and a constant unit

[9] Gunn (2001) and Van de Kaa (2005).

value should be assigned to all time changes.[10] Otherwise the evaluation of a transport improvement would depend in an illogical way on whether the project was evaluated as a whole or as a series of smaller projects each resulting in smaller time savings.

Hence the mean VTT we wish to calculate must not depend on the size of the time change. This means we have to choose a level of time change for which to evaluate the mean VTT. This choice is a crucial point in the mean calculation: Since the effect of the size of the time change is quite large, different choices of time saving sizes are likely to produce very different mean VTT values.

The distribution of time differences within the sample is a result of the experimental design and not a feature of the underlying population. It is therefore not appropriate to use an average over the sample to account for the size of the time difference.

In accordance with the British Value of Travel Time study (Mackie et al. 2001 and 2003), we shall base our choice on the assumption that the observed lower unit VTT for small time changes is not a “true feature” of the value of travel time, but is caused by the artificial nature of the experimental design. This assumption rests on the following propositions regarding the observed low unit value of small time changes:

- When making choices in an experiment, people ignore time savings that are too small to “matter” – i.e. that are negligible compared to the entire journey time or to the variation in journey time (delays) they experience from day to day. This type of effect can also be thought of as editing in the sense of Kahneman and Tversky (1979), whereby subjects simplify the choice task prior to choosing.

- People may find that small time savings are of very little value, because it is not possible for them to reschedule their activities in order to make use of the extra time. This is a short-run perspective, and we expect that a permanent time saving would over time be incorporated into people’s schedules, such that they would eventually benefit from it. However, the experiment has a tight focus on an actual trip recently made by the subject (subjects are explicitly instructed to imagine that they should undertake this same trip again), and this focus on a single trip may cause people not to consider long term consequences. Another important feature of our data is that the reference trip is not a frequently made trip. In 57% of the cases it is a trip made once a month or less frequent. It is

[10] E.g. Wartburg and Waters (2004), section 2.8.4.

likely that this makes it even more difficult for people to imagine the long term consequences of a change in travel time.

- Even if there are certain time savings that are too small to be of use, because most activities take a certain “minimum” time, Fowkes (1999) shows that a procedure taking this into account and only valuing time savings if they contribute to disposable time intervals of a certain size, will yield the same average value of time as a constant unit value procedure.

In the British Value of Travel Time Study, Mackie et al. (2001 and 2003), estimate a model where VTT depends on dummies for each size of time change, and find that time changes of less than 10 minutes have very small VTT. Based on this, they estimate a model where VTT is constant for time changes greater than or equal to 11 minutes, and is allowed to vary with the size of the change for changes less than 11 minutes. The mean VTT is based on the latter model and evaluated at what corresponds to a time change of 11 minutes.

Adopting the same procedure as in the UK, our results indicate thresholds that vary by mode. The minimum threshold that we estimate is 15 minutes and the largest is 45 minutes. We would however not feel comfortable in recommending these thresholds, since we cannot rule out that they are affected by the distribution of travel time differences presented to subjects. The travel time difference presented was a function of the actual travel time such that changes both up and down relative to the reference trip would be meaningful. This implies that the large travel time differences occur only for long trips. The share of long trips varies considerable by mode. Thus we have many long trips by train where we also estimate the largest threshold. Conversely we have mostly short trips by bus, metro and S-train where we also estimate the lowest thresholds.

We cannot rule out that the fact that we are able to accept a threshold where the effect of the travel time difference disappears is a consequence of the data and that the estimated thresholds would have been higher if we had more observations of long trips. This points towards using lower values for the travel time difference.

On the other hand the travel time difference should be large enough to eliminate “disturbance” from the effects discussed above. We feel that this requires at least a difference of 10 minutes in accordance with the UK results, and possibly more since we estimate higher thresholds.

Consequently we have recommended to the steering group that a level for the time difference of between 10 and 20 minutes should be used to compute the mean VTT for cost benefit analyses. The steering group has then chosen a time difference of 10 minutes on the grounds that this is the conservative choice. This value is used for all computations in the following.

Finally, we note that the issue concerning the value of small travel times is still not satisfactorily resolved and remains an important topic for future research.

3.5 The weighting procedure and correction for income

3.5.1 Weighting

At this stage we have computed the average VTT for each subject in the sample, using a travel time difference of 10 minutes and truncation at 1000 DKK per hour. In order to compute average values for the population it is necessary to weight the sample before averaging. For this purpose we employ the Danish national travel survey using data from 2002 and 2003.

It must be decided which population the average VTT should be representative for. The relevant options to consider are

- The average kilometre
- The average trip
- The average traveller

The resulting average VTT will depend on this choice since the VTT is generally higher on long trips and since people with higher incomes tend to make longer trips. Thus the decision on how to weight the sample embodies a view on the distribution of resources between travellers and between travellers and non-travellers, which is why we emphasise the issue.

We take the view that the weighted average VTT should represent the average VTT of traffic using projects to be evaluated. The likelihood that a given traveller will use a given facility depends on the distance travelled. Therefore it is appropriate to compute the average VTT to be representative for the average kilometre. The values in the remainder of this report are computed in this way.

Note that we then to not make a distinction between short and long distance trips, the average is for all trips. This was an explicit wish from the Steering Group, since the segmentation by trip length is hard to handle in practical applications.

3.5.2 Average income

According to both theory and the estimated models, the VTT should depend on income. Moreover, people with different income tend to use different modes of transport. This implies that cost benefit analysis using VTTs that vary by mode will tend to favour projects for modes used by people with higher incomes.

The steering group has taken the view that this property is likely to cause policy makers to reject the results. Therefore it has been decided to remove the effect of income from the results. We have therefore estimated the values that would occur if all segments had the same average income. This is done using the estimated income elasticities from the econometric model, see Fosgerau, Hjorth and V. Lyk-Jensen, (2007b), Table 3 and 4.

Table 6 shows the mean VTT in groups defined by travel mode and purpose, before the correction for income. Recall that the weighting ensures that the averages correspond to average kilometres. The highest mean VTT is found for car driving commuters while the lowest is found for people travelling for education purposes by bus.

Table 6: Mean of the VTT distribution (truncated at 1000 DKK and with 10 minutes time savings) without correction for income differences

	Commuter	Education	Leisure	Maintenance	All
Car driver	84	78	79	68	78
Car pass	54	45	52	50	52
Bus	34	24	31	28	30
Metro	82	50	56	59	62
S-train	37	30	37	33	35
Train	61	47	51	58	54
All	76	64	66	61	**67**

Table 7 shows the weighted average after tax annual income for the same groups. Like above, the highest average income is found per kilometre of car driving commuters while the lowest average income is found for people travelling by bus for education purposes. Using as a rough rule of thumb that people who work full time do so for about 1600-1700 hours per year, these figures translate into an after tax hourly wage of about 100 DKK per hour. The estimated average VTT of 67 DKK per hour is lower than this which gives confidence that the number is not too high.

Table 7: Weighted after tax income in 2004 DKK

	Commuter	Education	Leisure	Maintenance	All
Car driver	202,362	151,120	189,881	175,508	186,530
Car pass	169,436	42,882	123,562	123,145	124,725
Bus	156,027	78,072	117,083	123,239	122,148
Metro	195,814	82,739	159,468	185,805	167,093
S-train	186,353	88,311	144,739	148,197	150,726
Train	211,644	118,518	137,669	164,508	154,316
All	197,512	130,517	162,213	160,311	**167,292**

The mean VTT are adjusted using the estimated income elasticities for each segment.[11] The result of the income adjustment is shown in Table 8. Generally, the numbers change toward the overall mean. The overall mean is unchanged at 67 DKK per hour.

Table 8: Mean VTT at average income

	Commuter	Education	Leisure	Maintenance	All
Car driver	78	82	75	67	74
Car pass	54	96	62	59	61
Bus	34	30	35	31	33
Metro	75	72	58	56	63
S-train	35	41	39	35	38
Train	52	59	58	59	57
All	70	71	67	62	**67**

Note: The value for car passenger education trips is very high and their income is also very low as seen in Table 7. There are very few respondents in this segment.

3.6 Dimensions of the VTT

The final issue remaining is to decide on the dimensions along the which the mean VTT is to be applied. The previous values used for Danish cost benefit analyses embody a common value across modes and differences between different travel purposes. These dimensions carry the advantage that they are easily observed and also that they are present in most traffic models.

3.6.1 Segmentation by travel purpose

In the econometric model, the travel purpose turned out not to contribute significantly to explaining the VTT. This is probably because the model

[11] See Fosgerau, Hjorth and V. Lyk-Jensen, (2007b), Table 3 and 4. The estimated income elasticities for person income lie between 0.3 for bus to 0.7 for train.

contains a number of other variables correlated with purpose. Table 6 shows that there are differences across purposes within each mode. These differences are generally reduced to become quite small after correcting for income in Table 8.

Since differences between purposes are generally small there is little point in distinguishing between travel purposes. Moreover, the interviews concerned trips made between home and some activity which allows the travel purpose to be uniquely defined. But in reality many trips are between different out-of-home activities, which in many cases makes it difficult to define a meaningful travel purpose. Therefore we have suggested that the final VTT values do not distinguish between travel purposes. This recommendation was adopted by the steering group.[12]

3.6.2 Segmentation by mode

According to theory, the differences in VTT between modes for a given person should depend on the comfort of mode. Thus we would expect, e.g., bus to be less comfortable than driving a car and therefore the value of reducing travel time to be higher for bus. Such generic difference between modes would be appropriate to include in a cost benefit analysis. In general, however, the differences between modes that we observe are the opposite of what we would expect based on this explanation. This is not an uncommon empirical finding.

In the SP1 report (Fosgerau, Hjorth and Vincent Lyk-Jensen, 2007b) we have argued that self-selection into modes is a more likely explanation for the observed differences between modes. According to this explanation, people who for some unobserved reason have a high VTT use the fast and expensive modes while those who for unobserved reasons have a low VTT use the slow and less expensive modes.

In line with the discussion concerning income differences, the steering group for the project has expressed the view that the cost-benefit analysis will be considered most relevant by policy makers if the analysis treats

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[12] Our reviewer Andrew Daly made the following remark on this issue: "The finding of no variation with purpose is indeed unusual, but in fact the variations claimed in other studies are not very large and would be reduced by consideration of the covariates listed. Of course business travel, which is included in most other studies, would be a significant exception to this finding and the need to include purpose variation to accommodate business travel in other studies may have influenced the decision to include further purpose segmentation."

everybody equally. It has therefore been decided to use that grand average of 67 DKK per hour as the central value to be applied to all transport modes.

4 Relative values of time

This section presents the data, the econometric approach and the results from the second experiment SP2, which aims to produce relative VTTs for some different components of travel time. In the discussion of results we give recommendations on the use of the results for the future official cost-benefit guidelines. These recommendations have been discussed and approved by the steering group for the project.

4.1 SP2 data

Most of the subjects also participated in the second experiment (SP2), which was similar to SP1, except that several components of travel time were allowed to vary independently. In SP2 the presented alternatives were also described by absolute journey time, cost values and number of interchanges.

Depending on their reference trip, separate experiments were presented to car users, public transport users who use a single public transport mode (bus, metro, S-train or train) for their journey, and public transport users who use multiple modes for their journey (bus-metro; bus-train; metro-train[13]).

SP2 examines a number of both in-vehicle and out-of-vehicle journey components for car and public transport. The subjects that participated in the second experiment were presented with a total of eight choice situations based upon different experimental designs.

For car drivers/passengers the considered travel time components are free-flow driving time, additional driving time due to congestion, access/egress walk time, and time spent searching for a parking space. If any of the three components is not relevant for the subject, the variable is dropped. All alternatives have the same transport mode as on the reference trip (car driver or passenger).

For public transport users, travel time is decomposed into access/egress time (other modes than public transport, i.e, walking, cycling, taxi, etc., in-vehicle time (separate component for each transport mode), headway of the

[13] Notice that S-train is included in the train mode.

first used mode, number of interchanges between modes and associated waiting time (interchange waiting time).

In the single mode public transport experiment interchanges are between two vehicles of the same type, e.g. two busses. All alternatives used a single transport mode, which was the mode from SP1, namely the main mode of the reference trip.

For multiple-mode public transport users, the experiment is divided into two parts; In the first half of the experiment, variation in time are examined as the interchanges are held constant. It contains alternatives with the two public transport modes used for the journey to allow valuations to be obtained for in-vehicle times for each mode and out-of-vehicle time. Note that the main mode on the reference trip (the mode used in SP1) is always one of the two. The second part of the experiment allows the number of interchanges to vary by reducing one of the presented alternatives to use a single mode, allowing the value for between-mode interchanges to be valuated.

The attributes characterising the alternatives are the same as in the single-mode experiment, except that a separate in-vehicle time is stated for each used mode. There are no interchanges between vehicles of the same type; hence the number of interchanges is always zero for the alternatives using a single transport mode, and one for alternatives using two modes.

Data exclusion

The original sample of SP2 subjects is based on the SP1 subjects who were not excluded from the first experiment. Only few had to be further excluded from the analysis of SP2 (only when providing unrealistic answers). However, we observed that the data set encompasses some dominant choices, i.e. choices for which one alternative was both cheaper and fastest for all the time components; see (Fosgerau, Hjorth and Vincent Lyk-Jensen, 2007c).

In the car experiment, 32% of all choices were dominant choices.[14] These have been excluded from the current analysis, as well as all observations from subjects who chose a dominated alternative.

4.2 Econometric approach

The time values are inferred from binary choices between alternative routes characterised by their cost and a vector of travel time components. All al-

[14] This high proportion is due to an SP design error.

ternatives are obtained by varying some attributes of the reference trip in order to make the proposed alternatives seem realistic and familiar.

To estimate the values of different travel time components we modelled subject's choice behaviour using a mixed logit model. We began with a simple base model, which was then extended to take account of certain characteristics of the experimental design and to allow for reference-dependent preferences.

We assume that the values of the time components are positive, depend on observed characteristics of the subject and the trip, and are random over the population to allow for unobserved heterogeneity. We did not attempt to estimate a separate distribution for each time component. Instead we aimed at estimating the relative values of the components, assuming that all components share the same distribution, except for a scale factor. We analysed each mode or mode combination separately. (See Fosgerau, Hjorth and Vincent Lyk-Jensen, 2007c for further details)

4.2.1 Headway formulation

In our base model, we assume that the generalised cost of an alternative is linear in the time attributes, and hence each time component has a constant unit value for each individual. For attributes such as in-vehicle time or access/egress time, this is an acceptable assumption, as the attribute levels are amounts of time the subject must spend on the corresponding activities.

However, we cannot assume that the value of headway (time between departures) is linear in the attribute. We consider it likely that a change in frequency from one departure every 5 minutes to one departure every 10 minutes may have a relatively large cost, as the extra time between departures would cause people to wait longer at the station. However, we do not expect a change in frequency from 30 minutes to 35 minutes to have a similar effect: This is because a change in headway from 30 to 35 minutes will not cause much change in waiting time, and is more a question of planning.

We therefore generalise the base model by allowing the generalised cost to increase linearly with the time between departures, but with different slopes below and above a certain level of headway $H*$.

When asked about the reference trip, a small number of subjects have stated that they do not know the headway of their first used mode. Since there is no reference level for the presented headway attributes to vary around, these subjects are presented with headway values of 60 and 120 minutes.

However, headway levels of 60 and 120 minutes may seem unrealistic for some of these subjects, especially regarding high-frequency transport modes as city busses, metro, and S-train. We cannot predict how this would affect their choices, but we attempt to control for potential deviations by allowing subjects with missing headway reference to value headway differently.

For the metro segment, there are very few high headway values; we therefore had to simplify the headway formulation in the metro models.

4.2.2 Reference-dependent preferences

As in the analysis of SP1, we incorporate reference-dependent preferences in our model.

In the current experiment, all alternatives are obtained by varying some attributes of the reference trip. Subjects are instructed to imagine that they are to repeat the trip, only with different travel times and costs. With this focus, we expect that the reference trip becomes a base of comparison, such that a lower cost than the real is perceived as a gain, while a higher is perceived as a loss. We are thus able to control for loss-aversion in our model.

However, we must take into account that:

- Subjects may not have a reference; this is sometimes the case for the headway variable, as mentioned above. For these subjects, we set the perceived value of the headway attribute equal to the actual attribute value.

- There is not enough variability around the reference to identify the loss aversion parameter. For some time components, such as parking time or the number of interchanges, almost all attribute values are larger than the reference value. In this case it is not possible to identify the loss aversion parameter, and hence we just use the actual attribute values without controlling for reference-dependence.

4.2.3 Distance-specific parameters

To examine whether the values of the travel time components depend on the length of the trip, we estimated a model with separate time values for short and long trips.

We define, *D,* as the maximum distance for short trips. The choice of *D* is of course specific to the transport mode. We define short trips as trips shorter than the median trip length (rounded to the nearest 5 km). We also test whether the relative values of time components are distance-specific.

For the metro segment we do not estimate distance-specific parameters as it is a rather small segment and the reference trips are generally very short – the mean distance travelled is around 7.5 km.

The table below summarises the segmenting distance per mode.

Segment	***D***
Car	25 km
PT single-mode Bus	10 km
PT single-mode S-train	15 km
PT single-mode Train	50 km

The multiple-mode samples are too small to estimate distance-specific parameters.

4.3 Results

In the following we only present the final results, all details can be found in Fosgerau, Hjorth and Vincent Lyk-Jensen (2007c)

4.3.1 The car experiment

Table 9 reports the results for the car segment and provide 95% confidence intervals. Note that, the official value of free-flow driving time to be used in economic evaluation will be based on the results of SP1. Hence the reported value of free-flow time will not be used, and is reported only to show that the level is reasonable. When comparing to the values of SP1, one needs to take into account the distributional assumptions of the models: In SP1 we use a generalised VTT distribution instead of the lognormal, which results in a more right-skewed distribution and a much higher mean.

Table 9: Time values for the car segment

Value of free-flow driving time	DKK/minute	DKK/hour
Trip length <= 25 km.	1.64	98
Trip length > 25 km.	1.29	78
Relative values of time (unit is value of free-flow time)		**95%-confidence intervals**
Additional driving time due to congestion	0.88	[0.81 ; 0.97]
Egress walk time	1.55	[1.37 ; 1.76]
Parking search time	1.85	[1.59 ; 2.15]

We find that time spent searching for a parking place is valued almost twice as high as free-flow driving time, and that time spent walking to/from the car is valued around 50% higher. These results seem reasonable. The high value of parking search time may be partly due to the fact that it is a willingness-to-accept value and it was not possible to correct for reference dependence as the attribute of parking search did not vary enough around the reference. Another reason could be that subjects experience parking time as connected with some uncertainty, even though the attribute values in the experiment are certain amounts.

The estimated value of congested driving time is less than the value of free-flow time. This is clearly an undesirable result, as it is inconsistent with theory and findings from other studies.[15] A relative value of one for congested time is recommended as it can be argued that this value does not encompass uncertainty due to time variability.

From these results we need to extract values relative to the VTT of in-vehicle time. We propose to use rounded numbers so as not to suggest higher precision than we are able to achieve. Therefore we suggest setting the relative values of time as shown in Table 10. Notice that the chosen values are almost within the 95% confidence intervals.

Table 10: Recommended relative values of time for the car segment

Relative values of time	
Additional driving time due to congestion	1*IVT
Egress walk time	1.5*IVT
Parking search time	1.5*IVT

We recommend setting the relative value of parking search time at a lower value outside the estimated confidence interval, since we have observed that it is a willingness-to-accept value, implying that the estimate is on the high side.

It should be noted that the additional driving time due to congestion comprises expected delays. The current practice in the official guidelines of the Ministry of Transport and Energy is to use a mark-up of 1.5 to take into account travel time variability due to congestion. This practice may be continued and is not contradicted by the present findings.

[15] See e.g. Wartburg and Waters (2004)

4.3.2 PT Single-mode experiment

Table 11 presents the results from the single mode public transport experiment. We discuss the different time components in turn.

In contrast to the car modes, access/egress to public transport may use different modes including car. For metro, S-train, and short train trips, the value of access/egress time is about 30% more than the value of in-vehicle time. For bus the relative value is a little higher, while for long train trips it is lower than the value of in-vehicle time. Access/egress is only distance specific for train.

Table 11: Relative time values for the PT single mode experiment

	BUS	METRO	S-TRAIN	TRAIN	
Trip length (D)				<= 50 km.	>50 km.
H* (minutes)	20	None	10	15	15
Value of in-vehicle time					
DKK/minute	0.62	1	0.90	0.87	2.88
DKK/hour	37	60	54	52	173
Relative values of time (in minutes of IVT)					
Access/egress time	**1.77**	**1.32**	**1.26**	**1.29**	**0.88**
Confidence Interval	*[1.41 ; 2.22]*	*[0.82 ; 2.11]*	*[0.98 ; 1.61]*	*[1.01 ; 1.65]*	*[0.66 ; 1.17]*
Per interchange	**12.23**	**1.55**	**5.18**	**12.92**	
Confidence Interval	*[9.04 ; 16.53]*	*[0.08 ; 31.47]*	*[2.41 ; 11.13]*	*[8.63;19.36]*	
Interchange waiting time	**1.96**	**2.45**	**1.86**	**1.40**	
Confidence Interval	*[1.47 ; 2.61]*	*[1.46 ; 4.1]*	*[1.32 ; 2.63]*	*[0.87;2.27]*	
Headway (<= H*)	**1.09**	**1.32**	**0.70**	**1.59**	
Confidence Interval	*[0.84 ; 1.41]*	*[0.81 ; 2.16]*	*[0.36 ; 1.38]*	*[0.9 ; 2.83]*	
Headway (>H*)	**0.45**		**0.93**	**0.38**	
Confidence Interval	*[0.36 ; 0.56]*		*[0.72 ; 1.21]*	*[0.31 ; 0.48]*	

The estimated value of an interchange seems to depend very much on the type of mode: For high-frequency modes as metro and S-train an interchange is worth the same as 1.5 and 5.2 minutes of in-vehicle time, respectively, while for bus and train its value is equivalent to 12-13 minutes of in-vehicle time. The confidence intervals are however quite wide such that a range of values are consistent with the estimation results.

Except for S-train, the price of an extra minute of headway between departures is equivalent to 1.1-1.6 minutes of in-vehicle time, up to a certain point, after which it drops to 0.4 minutes (for metro, there is no such threshold, as high headway values are unrealistic). For S-train, the price is 0.7 minutes up to the threshold, after which it is 0.9 minutes. However, these values are not significantly different, and we may assume, as for metro, that the value of headway is constant for all headway levels. Possibly this is because S-train is also a high-frequency mode, such that data contain few high headway levels.

For bus and train, low headway levels are valued at a higher marginal rate than high levels, possibly because departures are so frequent that people do not bother to plan their arrival at the station/stop, meaning that the extra time between departures cannot be used for other purposes. This is the kind of result that was expected.

The value of waiting time associated with interchanges differs a lot between modes: From 1.4 to 2-5 minutes of in-vehicle time.

As for the general level of time values, subjects on long train trips have the highest value of time, while people taking the bus have the lowest[16]. This is in agreement with the results from SP1.

4.3.3 PT Multiple-mode experiment

The estimation results from the multiple mode public transport experiment are summarised in Table 12. From the table we notice that bus in-vehicle time is more expensive than metro or train in-vehicle time, and that metro in-vehicle time is more expensive than train in-vehicle time. These are probably comfort effects, as we know from the single-mode experiment that train passengers usually have higher value of time than bus and metro passengers, with bus passengers as the lowest.

[16] Here we do not take account of the fact that the value of time should be computed using a generalised VTT distribution for the bus segment. However, in SP1 introducing a generalised distribution decreases the mean VTT for the bus segment.

Table 12: Time values for the PT Multiple-mode experiment

	Bus-Metro	Bus-Train	Metro-Train
First Mode			
Unit of value of in-vehicle time	**Bus**	**Bus**	**Metro**
DKK/minute	0.57	1.79	0.82
DKK/hour	34	107	39
Relative values of time (in min of IVT) *			
Access/egress time	**1.07**	**0.95**	**1.17**
Confidence Interval	*[0.72 ; 1.6]*	*[0.79 ; 1.14]*	*[0.81 ; 1.7]*
Per interchange	**8.54**	**5.54**	**8.65**
Confidence Interval	*[5.28 ; 13.82]*	*[3.28 ; 9.33]*	*[5.29 ; 14.14]*
Headway	**0.63**	**0.47**	**1.21**
Confidence Interval	*[0.38 ; 1.05]*	*[0.39 ; 0.56]*	*[0.84 ; 1.75]*
In-vehicle time for the second mode	**0.79**	**0.79**	**0.88**
Confidence Interval	*[0.5 ; 1.22]*	*[0.7 ; 0.89]*	*[0.73 ; 1.07]*
Interchange waiting time	**1.07**	**1.39**	**1.67**
Confidence Interval	*[0.65 ; 1.78]*	*[1.11 ; 1.73]*	*[1.09 ; 2.54]*

*Note that relative values are relative to values of IVT of the first mode.

In general, the relative time values are lower than in the single-mode experiment: Access/egress time is worth the same as 1 - 1.2 minutes of in-vehicle time, the value of an interchange is 5.5 – 8.5 minutes, and the value of waiting time is 1.1 – 1.7 minutes.

For bus-metro and bus-train, headway is worth roughly half as much as a minute of in-vehicle time, while for metro-train it is worth 1.2 minutes. It seems the relative values are higher in the metro-train segment than the other, perhaps partly offsetting the low value of base in-vehicle time compared to the other segment including train passengers.

4.3.4 Relative values for Public Transport

As in SP1 we do not recommend to have specific values by mode as the definition of a bus or train is not always straightforward. We suggest deriving common values based on the results summarised in Table 11 and Table 12 and instead differentiate them according to low and high headways.

Access/Egress: Contrary to the car experiment, here access/egress can be achieved not only by walking but also with a taxi, a car or by bicycling. From Table 11 and Table 12 it can be seen that a factor of 1.5 of IVT can be accepted both for single mode PT and multiple-mode PT, except for long distance train and bus train. We suggest setting access/egress to 1.5 of IVT.

Interchange waiting time: A factor 1.5 of the IVT can be accepted both for single and multiple PT modes. However, multiple-mode subjects value interchanges lower than single mode subjects. One explanation for the differences between multiple and single mode can be interpreted as reflecting the gap between WTP and WTA, where WTP is usually lower than WTA, multiple-mode subjects being more used to change modes.

Interchanges: We obtain here the penalty by interchange measured in minutes. We have chosen 6 minutes as the results was ranging between 1.5 minutes for metro to almost 13 minutes for train. It is also half of our pivot headway value, H* (12 minutes).

Headway: The value that differentiates low headway from high headway is set to 12 minutes, which corresponds to 5 departures in one hour (The H* used in the estimation was ranging from none to 20 minutes). For headway less than 12 minutes we use a factor of 1 while for large headways (more than 12 minutes) we use a factor of 0.4.

This means that a headway of 50 minutes corresponds to 27.2 minutes of IVT (12*1 + 0.4*(50-12)), i.e. 30.4 DKK.

The recommendations are summarised in Table 13 below. These recommendations have been discussed and approved by the steering group for the project.

Table 13: The Danish values of time (2004 DKK)

	Car	**Public Transport**	
In-vehicle-time (IVT)	**67 DKK**		
Relative values			
Congested Time(1)	1*IVT		
Parking search time	1.5*IVT		
Access/Egress	1.5*IVT	1.5*IVT	
Interchange		6 min	**7 DKK**
Headway H; H=12 minutes*			
Low headway <12 minutes		1*H*IVT	
High headway >12 minutes		(12*1+0.4*(H-12))*IVT	
Interchange waiting Time		1.5*IVT	

(1) Note that the factor used in the official guidelines of the Ministry of Transport and Energy is 1.5, as it includes the travel time variability due to congestion, while the DATIV study focuses on additional driving time due to expected delays.

5 Conclusion

This report has argued in favour of using a single average VTT for an average kilometre of in-vehicle travel time.

An average kilometre of in-vehicle travel time, because the likelihood for a given traveller to use a given facility depends on the distance travelled. Therefore it is appropriate to compute the average VTT to be representative for the average kilometre.

A single average value because the different values for different modes do not reflect comfort differences as expected from the economic theory but rather self-selection, i.e. that people having high VTT tend to use the fast and expensive modes. Using the differentiated values will not treat everybody equally.

In contrast, to the previously used Danish values, there is no distinction between trip purposes, as the differences among purposes were small.

The results from the econometric analysis of the first SP experiment have lead to a central value of in-vehicle travel time of 67 DKK per hour (2004 DKK) based on the decisions explained in the report.

The recommendations regarding the relative values of in-vehicle and out-of-vehicle time components are based on the analysis of the second SP experiment. The recommendations are similar to the values currently in use, described in the "*Nøgletalskatalog*", June 2006. New time components have been estimated, like parking search time and access/egress (walking time for car drivers).

For public transport the factor used for interchange waiting time is lower than the previous factor, but then we now include a separate penalty for each interchange. The present report provides also a much simpler way to compute the different waiting time by directly using the headway and providing two headways levels that can be applied to all modes. Values for access/egress to the public transport by cycling, walking, taxi, car, etc. are now also provided.

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