INTER-TEMPORAL VARIATION IN THE MARGINAL DISUTILITY OF TRAVEL TIME AND TRAVEL COST

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Abstract

The marginal disutility of time and cost are key parameters in most forecasting models used for applications. Since valuation of infrastructure investments requires prediction of travel demand for future evaluation years, it is important to know how the marginal disutilities of time and cost develop over time. Using two identical stated choice experiments conducted with an interval of 13 years, 1994 and 2007, we estimate the inter-temporal variation in marginal utilities of travel time and cost. We find that the marginal disutility of time has remained constant across the samples. The marginal disutility of cost has, on the other hand, decreased. The decrease of the marginal disutility of travel cost is explained by income increases. We find little evidence to support recommendations on changing the travel time parameter in travel demand forecasting models, but clear evidence to support a recommendation that the income elasticity of the cost parameter should be assigned the relevant income elasticity of the value of travel time.

1. INTRODUCTION

Benefits from infrastructure investments are long-term by nature. Evaluation therefore requires prediction of travel demand for future evaluation years. The marginal disutility of time and cost are key parameters in most forecasting models used for applications. Consequently, it is important to know how the marginal disutilities of time and cost develop over time. This study aims at enhancing our understanding of how the marginal disutilities of time and cost vary inter-temporally.

This paper is based on two essentially identical stated choice surveys carried out in 1994 and 2007, designed to measure the trade-off between travel time and travel cost. Our results did not find changes in the marginal disutility of time over this period. The marginal disutility of cost, on the other hand, has been found to decrease.

The first survey was carried out in 1994 as a part of the Swedish value of time study (Algers et al 1995). A replication of this survey for car drivers was carried out in 2007. Care was taken to use exactly the same questionnaire and survey method as in 1994. The sampling of drivers was carried out in the same way, and at the same places. The design of the stated choice experiments was exactly the same, with one exception: the cost levels were increased by 40 percent, approximately corresponding to income growth and inflation since 1994.

It is a well known observation that value of travel time (VTT) increases with income in cross-sectional samples (Wardman, 2001a). A reasonable expectation is therefore that values of time increase also over time, as income tends to grow over time. Whether the VTT also changes over time for other reasons than income growth has been a source of debate. To shed some light on this topic, it is relevant to explore whether the VTT changes over time only because of changes in marginal disutility of cost or if also the marginal disutility of travel time changes over time. For exclusive interest in VTT for CBA purposes, this is less of an issue (although it might be), but for implementation in forecasting models, it is a central issue.

The marginal disutility of travel time is composed of the direct disutility of time spent travelling and the opportunity cost of travel time (De Serpa, 1971). Gunn (2001) and Tapley et al. (2007) discuss some possible causes for a possible inter-temporal variation in these two components of travel time savings. Possible causes that they mention are greater ability to use travel time productively, comfort improvements, worsening travel conditions, and longer or shorter working hours. The marginal utility of cost reduction is normally assumed to decrease over time as the income level increases. The income elasticity is often assumed to be unity.

The common assumption implemented in most forecasting models is that the travel time parameter remains stable over time, but that the cost parameter decreases over time. There are also forecasting models that assume that the time parameter increases over time, but that the marginal utility of cost remains constant. There is little empirical support for either practice.

Only three previous studies have collected stated choice data at two points in time in order to estimate the inter-temporal variations in the VTT. In all cases the replication used essentially the same questionnaire and survey methods. The first study used data collected in the Netherlands in 1988 and 1997 (reported in Gunn et al., 1999). The second study used data collected in Britain 1985 and 1994 (reported in Wardman 2001b) and the third study used data collected in Britain 1994 and 2006 (Tapely et al. 2007).

In the first study it was found that the marginal disutility of cost had remained stable within each income group, but that that there was a significant trend in the marginal disutility of travel time to decline between the survey years. The income increase was large enough to cancel out the declining trend in VTT in each real income level, such that the real VTT remained unchanged between the survey years. The second and third studies both gave the puzzling result of a slight trend decline in the VTT. It was speculated that the trend decline was caused by a decreased marginal disutility of travel time. Still, none of the three studies have explicitly investigated the inter-temporal variation in the marginal utility of time and cost in detail. These studies have only focused on the inter-temporal variation in the VTT.

Using data from the recent Swedish Value of Time Study, the evolution of the value of travel time over time and its relation to income has also been analysed using the econometric model described in Fosgerau (2006). That work is presented in a separate paper (Börjesson et al. 2009). Since the VTT is estimated directly in that specification, however, that analysis provides no insight into the development of trends in time and cost parameters of forecasting models.

Results of the present study indicate that the marginal disutility of travel time does indeed remain unchanged, while the marginal disutility of travel cost has decreased. We find further that the income elasticity on the marginal disutility of cost is about unity for travellers with income above the median. For travellers with income below the median the income elasticity on the marginal utility of cost is not significantly different from zero. Börjesson et al. (2009) find exactly the same pattern for the income elasticity of the *value of time*. The correspondence supports the conclusion that VTT has changed over time only because higher income decreases the marginal disutility of travel time.

The paper is organized as follows. Section 2 introduces the data and section 3 estimates the inter-temporal variation in marginal disutility of travel time and travel cost. Section 4 focuses on the inter-temporal income elasticity on marginal disutility of travel cost, while section 5 concludes the paper.

2. DATA

Survey method

The data originate from the Swedish VTT studies. In the present paper we consider only private trips made by car drivers. As mentioned, the data collection was undertaken in two waves, the first in 1994 and the second in 2007. The 2007 replication was collected using exactly the same questionnaire and survey method as in 1994, except for the adjusted cost level in the stated choice design.

The drivers were recruited by roadside number plate registration at the same places in the two survey years. The study was designed as a telephone survey, introduced by mailing out an introductory letter and some material to support the stated choice experiment. Socio-economic information of the respondent and her household and responses to stated choice experiments was collected in telephone interview.

The 1994 sample consists of 605 complete interviews. The 2007 sample was dimensioned to make it possible to significantly identify a proportional change in the VTT. In that sample, 514 complete interviews were obtained.

The response rate was 65 percent 1994 and 55 percent 2007. Each interview included eight repeated stated choices.

The total sample consists of 4923 and 3927 observations from 1994 and 2007, respectively. Observations from individuals who report that somebody else paid the trip were discarded from the sample. This left 4321 and 3627 observations from 1994 and 2007, respectively.

Experimental Design

The stated choice experiment comprises choices between alternatives differing in two dimensions: travel time and travel cost. The games were designed so that the respondent was presented with one base alternative and one alternative where the travel cost and travel time had been changed in different directions. This had the advantage that the design did not contain dominant alternatives.

Travel times and travel costs in the base alternative originated from the reference travel time and distance, i.e. the travel time and distance of the trip on which the driver was observed. Respondents were also asked to refer to this trip while stating their choices. If the time and cost in the base alternative would correspond exactly to the reference trip, this could lead to inertia bias, i.e. it would be easier for the respondents to escape to a “no change“ choice. To reduce this problem, the reported data of the reference travel time and travel cost in the base alternative were randomly multiplied by 0.9 or 1.1. The base alternative was still constant within each individual. To reduce this problem further, by avoiding to subscribe the base alternative in any particular focus or statues, the base alternative was referred to as the “C“ alternative rather than the “A” alternative. The “C” alternative was then to be compared to different alternatives randomly denoted A, B, D, E etc. The time and cost differences in each choice were drawn from a previously decided schedule. Different schedules were used depending on the reference travel time and distance.

The same experimental design was used for the two survey years, with the sole change of increasing cost levels by 40 percent in the 2007 survey, approximately corresponding to real income growth and inflation. Table 1 summarises the characteristics of the design in the final estimation sample for the two survey years. The costs are given in € converted from SEK using the conversion rate 0.1 in the table and throughout this paper. The time differences are almost identical, whereas the mean cost difference is 48 percent larger in the 2007 sample. The mean cost difference is larger than the increase of the cost levels in the design because the reference travel times are longer in the 2007 survey.

Figure 1 shows the nature of the choices facing the interviewees.

Table 1: Summary of the stated choice design in the final estimation sample

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Travel time diff 1994 [min]	2	5	10	17	20	80
Travel time diff 2007 [min]	0	5	10	18	25	80
Travel cost diff 1994 [€]	0	0.3	0.5	1.3	1.5	12.7
Travel cost diff 2007 [€]	0	0.4	0. 8	1.9	2.1	16.8

Alternative C	Alternative A, B, D,...
Travel time 45 min Travel cost €5	Travel time is 5 minutes longer Travel cost is €1 less

Figure 1: Survey question.

To make it possible to capture the well known valuation gap between gains and losses, the design comprises two types of choices, namely 'willingness to pay' *WTP*-choices and 'willingness to accept' *WTA*-choices. The *WTP*-choice is presented as a choice between one alternative close to the reference and one faster and more expensive alternative. The *WTA*-type of choice is the exact opposite, including one alternative close to the reference and one alternative slower but less expensive. The two types of choices were presented equally often (4 times each in each game). The first choices were randomly of *WTP*- or *WTA*-type, to avoid bias due to anchoring to the initial question.

Descriptive statistics

Respondent's real after-tax average income is 36 percent higher (59 percent in real terms) in the final estimation sample 2007, as compared to the 1994 sample. During the same period the real after-tax income growth per capita in Sweden has been lower, about 29 percent (Statistics Sweden, 2009). The gap between real after-tax income growth per capita in Sweden and in the sample might have several causes. First, the income defined in the survey questionnaire included income from labour, study allowances and pension, but not other subsidies, such as extra allowances for children or income from capital. The numbers are therefore not directly comparable. Second, the difference could be due to local and regional differences in income growth, since we have recruited drivers at some particular points. Third, correlation over time between travel distance and income growth could potentially explain this gap, although correlation between income and travel distance is rather weak in the present cross-sectional samples (about 0.1).

Income growth among travellers in relation to disposable income or GDP is important in forecasting, but is not the issue in the present paper.

Figure 2 compares the income distributions of the yearly samples visually. Income is given in real terms. It is evident from the figure that the shape of the income distribution has become more skewed.

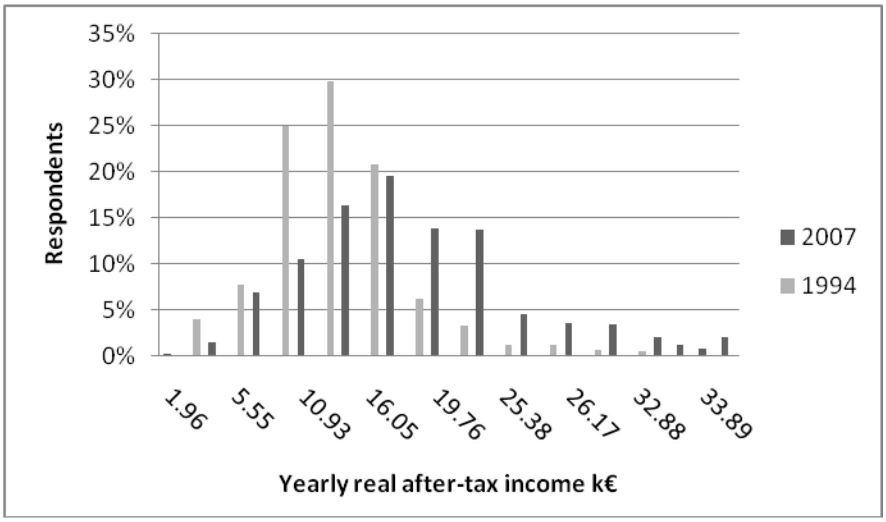

Figure 2: Nominal income distribution.

Table 2 shows that the mean travel time is longer in the 2007 sample. The distance has decreased somewhat between the years, but it is clear the distance distribution is also more spread out in the 2007 sample. A more detailed description of the socioeconomic composition is found in Börjesson et al. (2009), showing that most socioeconomic variables, except income, remain relatively unchanged but that the share of retired drivers has increased.

Table 2: Summary of the reference travel times and distances in the 1994 and 2007 samples

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Ref. travel time 1994 [min]	10	30	50	106	120	855
Ref. travel time 2007 [min]	3	30	60	117	150	940
Ref. travel distance 1994 [km]	3	27	55	122	140	1250
Ref. travel distance 2007 [km]	1	20	50	132	185	800

3. VARIATION IN MARGINAL DISUTILITY OF TRAVEL TIME AND COST

In this section we will present estimation results from a series of econometric models, which all include yearly specific marginal utilities of time and money. We examine which parameters that have changed between the years and which parameters that have remained stable. We make the examination by employing a number of different specifications, to make sure that the conclusions are robust. All models are kept reasonably simple for the sake of generality and because the sample sizes are not large enough to allow comparison of a large number of yearly specific parameters across years.

Model formulation

Model specification 1 is the simplest model and the difference in utility between the left and right hand alternatives in each the binary choice takes the form:

$$\Delta V = \alpha_{94}\Delta T_{94} + \alpha_{07}\Delta T_{07} + \beta_{94}\Delta C_{94} + \beta_{07}\Delta C_{07},$$

where ΔT_{94} and ΔT_{07} denote the travel time difference between the left and the right alternative in the two yearly samples and ΔC_{94} and ΔC_{07} denotes the corresponding travel cost differences. α_{94} and α_{07} denote the marginal disutilities of travel time for the 1994 and the 2007 samples, respectively. Similarly β_{94} and β_{07} denote the marginal disutility of travel cost for the 1994 and the 2007 samples. The key point of interest in the estimation of model 1 is to explore if α_{94} and α_{07} are significantly different and if β_{94} and β_{07} are significantly different.

Let *y* be a dummy indicator for the choice of the left hand alternative. Then, y takes unit value if:

$$\Delta V + \varepsilon \geq 0.$$

The error term ε is taken to be i.i.d. standard logistic, such that a logit model results. The VTT for each year can be computed as the ratio of marginal utility of travel time and the marginal utility of travel cost.

The comparison of model parameters between years requires that we make the implicit assumption that the variance of ε, the response scale, is equal in the 1994 and 2007 samples. The reason is that it is not possible to observe the marginal utility of time or cost directly, but only the marginal rate of substitution between the parameters. We think constant response scale is a reasonable assumption, since the survey techniques are identical the two survey years. Results from the model estimations further strengthen this assumption, which will be further discussed below.

None of the models estimated in the paper include any treatment of the 'repeated measures' property of stated choice data. This is likely to lead to an underestimation of the standard error of the parameter estimates, but not to major bias in the central estimates of the parameters themselves.

Model specification 2 takes into account the possibility that individuals partaking in experiments such as the present are subject to perceptual thresholds, which is a well known phenomenon in experimental economics. It is typically found that individuals take increasing financial concerns and become increasingly rational when stakes rise (Smith and Walker, 1993; Levitt and List, 2007). When decisions are less important individuals become more influenced by social considerations, heuristic rules and randomness. Part of the explanation is that the relative importance of decision cost decreases as stakes increases. If respondents need a significant improvement merely to start consider choosing an alternative different form the base alternative, an inertia bias would be induced in the responses. In the second model, this is incorporated in the model by adding a dummy variable for the left hand alternative, which is always the alternative closest to the respondent's reference trip. We include vintage inertia parameters, denoted $\theta_{inertia}$, such that ΔV takes the form:

$$\Delta V = \theta_{inertia94} + \theta_{inertia07} + \alpha_{94}\Delta T_{94} + \alpha_{07}\Delta T_{07} + \beta_{94}\Delta C_{94} + \beta_{07}\Delta C_{07}.$$

The inertia bias is closely related to the well known issue of small time savings. That is, the valuation per time unit of small travel time savings, ΔT, are usually found to be significantly smaller than larger travel time savings in stated choice experiments. The present data are not strong enough to identify inertia bias and lower valuation of small travel time saving separately, since the inertia bias dominates for small travel time and cost savings.

Model specification 3 controls for the well known gap between *WTP* and *WTA*. Previous analysis with the sample from 1994 (Hultkrantz and Mortazavi, 2001) observed the gap between *WTP* and *WTA*, implying that the respondents value travel time gains higher that travel time losses of the same absolute magnitude. An appealing idea is therefore to estimate different models on the *WTP* and *WTA* questions. To be able to control for the *WTP-WTA* gap, time and cost parameters specific for *WTA* choices are added to the model, α_{WTP} and β_{WTP}. The model is specified as:

$$\Delta V = \theta_{inertia} + \alpha_{94}\Delta T_{94} + \alpha_{07}\Delta T_{07} + \beta_{94}\Delta C_{94} + \beta_{07}\Delta C_{07} + \alpha_{WTP}\Delta T_{WTP} + \beta_{WTP}\Delta C_{WTP},$$

where ΔT_{WTP} equals ΔT for *WTP* choices and zero otherwise. ΔC_{WTP} equals ΔC for *WTP* choices and zero otherwise. We assume that the α_{WTP} and β_{WTP} parameters are the constant across years, implying that the size of loss aversion phenomenon does not change between the years.

In terms of value functions, α_{WTP} allows for different slopes of the value function for gains and losses of travel time relative to the reference. β_{WTP} allows for different slopes of the value function for gains and losses of travel time in the cost dimension. The differences of the slopes between gains and losses are taken to be constant between the yeas.

Model specification 4 investigates if the inertia bias is different in *WTP* and *WTA* choices. Model 4, includes different inertia parameter for *WTP* and *WTA* choices:

$$\Delta V = \theta_{inertiaWTP} + \theta_{inertiaWTA} + \alpha_{94}\Delta T_{94} + \alpha_{07}\Delta T_{07} + \beta_{94}\Delta C_{94} + \beta_{07}\Delta C_{07} + \beta_{WTP}\Delta T + \beta_{WTP}\Delta C\ .$$

Model specification 5 estimates yearly specific inertia parameters of *WTP* and *WTA* choices, but is otherwise identical to model 4.

$$\Delta V = \theta_{inertiaWTP94} + \theta_{inertiaWTP07} + \theta_{inertiaWTA94} + \theta_{inertiaWTA07} + \alpha_{94}\Delta T_{94} + \alpha_{07}\Delta T_{07} + \beta_{94}\Delta C_{94}$$
$$+ \beta_{07}\Delta C_{07} + \beta_{WTP}\Delta T + \beta_{WTP}\Delta C.$$

Estimation results

Results of model 1-5 are shown in Table 3.

Model specification 1. The only significant change between the years is that of the cost parameter – the t-statistic for the difference β_{07} - β_{94} is 2.63. The marginal disutilities of time are identical across the years. In absolute terms, the cost parameter decreases 25 percent between the years.

Model specification 2. The conclusion remains the same compared to model 1: only the cost parameter changes significantly between the years. The t-statistic for the difference β_{07} - β_{94} is 2.83. Just as in model 1, the α parameters are virtually identical between the two years. Interestingly, so are the inertia parameters (with a size equivalent to 9 minutes of travel time).

Model specification 3 shows that the parameter β_{WTP} is very close to zero and insignificant, whereas the α_{WTP} is significantly smaller than zero, implying that the marginal utility of time is lower for *WTP* choices than *WTA* choices. Hence, we find loss aversion in the time dimension but not in the cost dimension. This is consistent with the finding of De Borger and Fosgerau (2007), who find more evidence for loss aversion in the time dimension than in the cost dimension.

The parameters of model 3 are very similar to the parameters of model 2. The mean value of *WTA* and *WTP* of model 3 is identical to the VTT computed with model 2.

Table 3: Model estimates of specifications 1-5.

	Model 1		Model 2		Model 3		Model 4		Model 5	
# par:	4		6		7		8		10	
# obs:	7948		7948		7948		7948		7948	
LL	-5140		-5016		-5006		-4910		-4909	
Rho^2:	0.067		0.089		0.091		0.109		0.109	
Name	Value	*t-test*	Value	*t-test*	Value	*t-test*	Value	*t-test*	Value	*t-test*
β_{07}	-0.023	*-13.1*	-0.025	*-13.7*	-0.025	*-11.3*	-0.027	*-11.6*	-0.026	*-11.4*
β_{94}	-0.031	*-13.5*	-0.033	*-14.1*	-0.034	*-12.2*	-0.036	*-12.7*	-0.036	*-12.7*
α_{07}	-0.039	*-16.3*	-0.042	*-17.0*	-0.050	*-14.0*	-0.070	*-16.6*	-0.069	*-15.5*
α_{94}	-0.039	*-16.9*	-0.042	*-17.6*	-0.050	*-13.9*	-0.071	*-16.5*	-0.073	*-16.2*
θ					0.267	*8.0*				
$\theta_{inertia07}$			0.370	*10.4*						
$\theta_{inertia94}$			0.377	*11.6*						
β_{WTP}					-0.002	*-0.7*	0.001	*0.3*	0.001	*0.3*
α_{WTP}					0.013	*3.0*	0.020	*4.3*	0.020	*4.3*
$\theta_{inertia\ WTA}$							-0.220	*-4.5*		
$\theta_{inertia\ WTP}$							0.724	*15.0*		
$\theta_{inertia\ WTA07}$									-0.189	*-2.8*
$\theta_{inertia\ WTA94}$									-0.244	*-4.0*
$\theta_{inertia\ WTP07}$									0.671	*9.9*
$\theta_{inertia\ WTP94}$									0.769	*12.3*
VTT 2007 [€/h]	8.7		8.7							
VTT 1994 [€/h]	7.7		7.6							
WTA 2007 [€/h]					10.4		13.6		13.3	
WTA1994 [€/h]					8.9		11.8		12.0	
WTP 2007 [€/h]					7.3		10.0		9.7	
WTP 1994 [€/h]					6.3		8.7		89	
t-value β_{07}-β_{04}	*2.63*		*2.83*		*2.47*		*2.63*		*2.70*	
t-value α_{07}-α_{94}	*-0.06*		*-0.03*		*-0.08*		*0.18*		*0.64*	

Model specification 4 clearly shows that the inertia bias exists only in *WTP* choices. In *WTA* choices we find a small bias working in the opposite direction. The values of time increase as the inertia parameters are not restricted to be the same for *WTP* and *WTA* choices. The key point of interest here is still to compare the estimated marginal utilities of time and cost across the years. The comparison gives the same results as the previous models: the marginal disutility of time remains stable whereas the marginal utility of cost decreases. The t-statistics of β_{07} - β_{94} is 2.63.

Model specification 5 shows that signs and sizes of the inertia parameters remain stable across years.

The observation that the parameters for marginal disutility of travel time, inertia and loss aversion remain stable supports the hypothesis that the response scale indeed is similar in the two yearly samples.

Recall that the cost difference in the design was increased by 48 percent in real terms. The absolute value of the marginal disutility of travel cost has decreased considerably less than the ΔC in the CS design, which points to the fact that the attenuation of the cost parameters has not been induced by the change of the design.

4. INCOME ELASTICITY ON THE MARGINAL DISUTILITY OF TRAVEL COST

In the previous section we found evidence for a trend decline in the marginal disutility of cost but a stable marginal disutility of travel time. In this section we discuss the income elasticity on the marginal disutility of travel cost, since this is very important in the forecasting context.

Taking the marginal disutility of time as constant over time, the income elasticity on the marginal disutility cost equals the negative of the income elasticity of the VTT. The inter-temporal income elasticity on the VTT is the topic of Börjesson et al. (2009), applying a model specification that is appropriate for this issue, and is thus not the main topic in the present paper. Börjesson et al. find that the trend increase of the VTT can be explained entirely by income differences and that the income elasticity on the VTT is increasing with income. We will next establish that we can recover the results obtained in Börjesson et al. (2009) in terms of income elasticity on the marginal disutility of travel cost.

Taking 17 percents inflation into account, the decrease in the cost parameter found in section 3 reduces to approximately 10 percent, to be compared to the real income increase between the samples 36 percent. This implies very low income elasticity on the marginal disutility of cost.

One reason for the seemingly low income elasticity on the cost parameter is that the VTT depends on the reference travel times and distances in the stated choice experiment, which are not identical in the two samples. We need control for changes of the reference trip between the years when computing inter-temporal elasticity.

The impact on the VTT time induced by the differences in reference travel time and distance across years can be assessed by use of the model estimated by Börjesson et al (2009). Controlling for income increases over time, the VTT is approximately 7 percent higher in the 1994 sample relative to the 2007 sample, only because travel time increases 10 minutes and travel distance decreases 5 km (which are the mean differences between the vintage samples). Assuming that reference travel time and distance primarily affects the disutility of travel cost, the cost parameter of the 2007 sample is, relative to the cost parameter of the 1994 sample , 7 percent higher than what is estimated. Taking this into account the cost parameter has reduced 17 percent between the years in real terms.

Now, the implicit income elasticity still appears to be low, and we define three models in the following subsection to shed some light on why.

Model formulation

Model specification 6 explicitly estimates the income elasticity on the marginal disutility of travel cost, *a*:

$$\Delta V = \theta_{inertiaWTP} + \theta_{inertiaWTA} + \alpha_{94}\Delta T_{94} + \alpha_{07}\Delta T_{07} + \beta_{94}Y^{a}\Delta C_{94} + \beta_{07}Y^{a}\Delta C_{07} + \beta_{WTP}\Delta T \ .$$

In this model, the incomes, denoted *Y*, in the 2007 sample are deflated in line with the growth of consumer price index 1994 – 2007, 17 percent.

Model specification 7 estimates different cost parameters and income elasticities for respondents above and below the median income (Y_{Median} is 13.9 thousand €/year after tax):

$$\begin{aligned}
\Delta V &= \theta_{inertiaWTP} + \theta_{inertiaWTA} + \alpha_{94}\Delta T_{94} + \alpha_{07}\Delta T_{07} + \beta_{WTP}\Delta T \\
&+ \beta_{94Inc1}Y^{a_{Income1}}(Y < Y_{Median})\Delta C_{94} + \beta_{07Inc1}Y^{a_{Income1}}(Y < Y_{Median})\Delta C_{07} \\
&+ \beta_{94Inc2}Y^{a_{Income2}}(Y >= Y_{Median})\Delta C_{94} + \beta_{07Inc2}Y^{a_{Income2}}(Y >= Y_{Median})\Delta C_{07}.
\end{aligned}$$

Model specification 8 estimates vintage specific $a_{income1}$ and $a_{income2}$ parameters in order to establish that the income elasticity on the marginal disutility of travel cost remains stable at each real income level. The model specification is otherwise the same as for that of model 7, except that β_{inc1} and β_{inc2} are restricted to be constant across years.

$$\begin{aligned}
\Delta V &= \theta_{inertiaWTP} + \theta_{inertiaWTA} + \alpha_{94}\Delta T_{94} + \alpha_{07}\Delta T_{07} + \beta_{WTP}\Delta T \\
&+ \beta_{Inc1}Y^{a_{94Income1}}(Y < Y_{Median})\Delta C_{94} + \beta_{Inc1}Y^{a_{07Income1}}(Y < Y_{Median})\Delta C_{07} \\
&+ \beta_{Inc2}Y^{a_{94Income2}}(Y >= Y_{Median})\Delta C_{94} + \beta_{Inc2}Y^{a_{07Income2}}(Y >= Y_{Median})\Delta C_{07}.
\end{aligned}$$

Estimation results

The sample size in this model is smaller when introducing income in the models, since the observations with missing income were discarded from the sample.

Table 4 shows the results of model 6-8.

Model specification 6 shows that the income elasticity on the marginal disutility of cost is estimated to be 0.3. Interestingly, the β now remains stable across the years, including income in the model. Hence, the income growth explains the whole decline in marginal disutility of cost. As in previous models, the α parameter remains stable across years.

Model specification 7 reveals the result that we expected. The income elasticity on the cost parameter is -1.2 for the high income segment, and not significantly different from unity. For the low income segment, the corresponding elasticity has the wrong sign, but is not significantly different from zero. There might be many reasons for the wrong sign of the income elasticity on the cost parameter. Presumably income is a less relevant determinant of the VTT for low income persons, who might rely on the income of a spouse, personal wealth or other sources.

Model specification 8 shows that the vintage parameters $a_{income1}$ and $a_{income2}$ are not significantly different. Hence, we may conclude that the income elasticity remains stable at each real income level.

According to model 7 and 8, the mean income elasticity on the cost parameter is approximately -0.5 in the cross-section as well as over time. This is consistent with the mean income increase of 36 percent between the survey years and a mean decrease of 17 percent of the cost parameter.

Börjesson et al. (2009) find exactly the same pattern for the income elasticity of the VTT as is found here for the income elasticity on the marginal disutility of cost. Income explain the entire shift of the cost parameter, income elasticity on the cost parameter increase with income and the time parameter has remained stable over time. The correspondence supports the conclusion that VTT only changes over time only because higher income decreases the marginal disutility of travel time.

Table 4: Model estimates of specifications 6-8.

	Model 6		Model 7		Model 8	
# par:	8		11		13	
# obs:	7562		7562		7562	
LL	-4625		-4602		-4583	
Rho^2:	0.118		0.122		0.126	
Name	Value	*t-test*	Value	*t-test*	Value	*t-test*
a	-0.304	*-4.870*				
a_{Inc1}			0.185	*1.5*		
a_{Inc2}			-1.230	*-6.1*		
a_{Inc1_07}					0.255	*1.4*
a_{Inc1_94}					0.161	*1.3*
a_{Inc2_07}					-1.240	*-6.2*
a_{Inc2_94}					-1.140	*-4.6*
β_{07}	0.026	*12.120*				
β_{94}	0.027	*9.240*				
$\beta_{07\ Inc1}$			0.046	*5.3*		
$\beta_{94\ Inc1}$			0.059	*5.4*		
$\beta_{07\ Inc2}$			0.015	*6.0*		
$\beta_{94\ Inc2}$			0.014	*5.8*		
β_{Inc1}					-0.055	*-5.2*
β_{Inc2}					-0.015	*-6.2*
α_{07}	0.073	*17.980*	0.074	*17.8*	0.074	*17.9*
α_{94}	0.075	*18.240*	0.078	*18.7*	0.077	*18.6*
α_{WTP}	-0.018	*-4.800*	-0.019	*-4.9*	-0.019	*-4.9*
θ_{WTA}	-0.240	*-4.740*	-0.239	*-4.7*	-0.238	*-4.7*
θ_{WTP}	0.745	*14.920*	0.741	*14.8*	0.740	*14.8*

5. CONCLUSION

This paper is based on two essentially identical stated choice surveys carried out in 1994 and 2007, designed to measure the trade off between travel time and travel cost. The key interest has been to examine how the marginal disutility of time and cost has developed over time. This issue is highly relevant for travel demand forecasting.

We find that the marginal disutility of time has remained constant across the samples, as has inertia bias and loss aversion. This supports the idea that the response scale is very similar in the yearly samples. The marginal disutility of cost has, on the other hand, decreased.

Taking the marginal disutility of time to be constant, the income elasticity on the marginal disutility of cost equals the income elasticity on the value of time but with opposite sign. We find that the income elasticity on the marginal disutility of travel cost is not significantly different from zero for the sample with incomes below the median. For the sample of travellers with incomes above the median, the income elasticity on the disutility of travel cost is slightly above unity but not significantly different from unity. We find also that the income elasticity on the marginal disutility of cost remains stable at each real income level. It is therefore not far-fetched to extrapolate that the mean income elasticity will grow closer to unit, as the income levels increase.

The more general conclusion of this paper is that for travel demand forecasting modelling, we find little evidence to support recommendations on changing the travel time parameter, but clear evidence to support a recommendation that the income elasticity of the cost parameter should be assigned the relevant income elasticity of the VTT (with opposite sign).

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