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THE INCOME ELASTICITY OF THE VALUE OF TRAVEL TIME IS NOT ONE NUMBER

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Abstract

Based on two essentially identical Stated Choice experiments conducted at an interval of 13 years, this paper provides new evidence on the evolution of the value of travel time (VTT) over time and its relation to income. Results indicate that the income elasticity of the VTT is not uniform over income but increasing in income. As a consequence, the average rate at which the VTT increases with income in the cross-sectional samples has itself increased between the two survey years and can be expected to increase further over time. The estimation results support the idea that the income elasticity of the value of time has remained constant at each real income level. This confirms that it is not so much the relationship between income and the value of travel time that has changed over time as it is the level and distribution of income in the samples that has changed.

1 INTRODUCTION

This paper is based on two essentially identical Stated Choice surveys carried out in 1994 and 2007, designed to measure the value of travel time (VTT). Analysis of these data indicates that the income elasticity is not constant over individuals but an increasing function of income. This function does not change significantly from 1994 to 2007, indicating that the relationship between income and the VTT may be thought to be quite stable. An implication of these findings is that the aggregate income elasticity of the VTT can be expected to increase as average income grows.

The first survey was carried out in 1994 as part of the Swedish value of time study (Algers et al 1995). Here we use data for car drivers. A replication of this survey 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, namely the cost levels, which were increased by 40 percent, corresponding to real income growth and inflation since 1994.

The VTT is an important number in several ways. It is a central driver in predictions of travel demand and time savings usually constitute the main benefit of transport infrastructure investment (Hensher, 2001; Mackie et al., 2001).

Decisions concerning transport infrastructures are of a long-term nature. Prediction of demand and calculation of benefits must have a similarly long horizon. Therefore it is important to know how the VTT can be expected to develop over time. The standard approach has been to estimate or assume an income elasticity of the VTT, under the restriction that there is just one income elasticity.

From the simplest model one finds that VTT equals the marginal after-tax hourly wage, which has also been the most common assumption in practice. An early and influential discrete choice application in the field is Train and McFadden (1978), who formulate a mode choice model in connection with the choice of the optimal number of working hours. They show that also in this model, the income elasticity of the VTT is one.

Now, according to Wardman (2001b) who reviews a large number of (primarily British) studies, the general finding is that the income elasticity of the VTT is less than one. A few studies have quantified the cross-section elasticity by adopting meta-analysis of a large amount of value of time evidence, i.e. pooling the data and applying regression analysis describing the influence of GDP (or GDP/capita) on the value of time. Using evidence from British studies conducted during 1980-1996 Wardman (2001a) obtains an estimate of 0.51 and t statistics of 1.70. The low t statistics was attributed to a clustering in of values around 1988 and 1994, creating too little variation in the data. Wardman (2001b) obtains an estimate of 0.6, employing studies from 1963-2000 that creates more variation in the data than the previous study. Wardman (2004) obtains an estimate of 0.72 employing the same studies from 1963-2000 but including more details, while Shires and de Jong (2006) find an income elasticity of VTT of 0.62 for private passenger transport, using evidence from many countries and points in time, in most cases from 1990 and later.

Using the more recent Danish value of time survey, an average income elasticity of 0.90 has been found, which is considerably larger than previous estimates and not significantly different from unity (Fosgerau, 2005).

Almost all studies on the income elasticity on the value of time are cross-sectional, apart from the meta-analysis referred to above. Now, there has then been a discussion concerning whether cross-sectional income elasticities, (or elasticities estimated adopting meta-analyses) are the same as those that hold across time. As shown below, there is no strong reason why this should be the case.

Only three previous studies have collected similar Stated Choice data at two points in time in order to estimate an intertemporal relationship between income and VTT. In all cases the replication used essentially the same questionnaire and survey methods. The first of these studies was conducted 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 VTT had decreased within each income group, which points to an income elasticity less than 1. The income increase was large enough to cancel out the trend decline such that the real value of time remained unchanged between the survey years.

The second and third studies both indicated the puzzling result of slight trend decline in the value of time. It was speculated that one cause of trend decline could be decreased marginal utility of travel time (opportunity cost and disutility of the time spent travelling), which was attributed to shorter working hours and the use on mobile phones and laptops while travelling.

A constant cross-sectional income elasticity of the VTT implies a linear relationship between log income ($\log I$) and log VTT ($\log w$). The same holds for the intertemporal income elasticity. But there is no particular reason why these relationships should be linear. In general, we may expect a nonlinear relationship $\log w = f(\log I)$ between log income and log VTT at the individual level in a cross-section. Say that incomes in some cross-section vary over the interval A. The income elasticity at income I is then the derivative $f'(\log I)$. The income elasticity in the cross-section will thus attain values in the interval $f'(\log A)$. Even though the "true" relationship is nonlinear it is possible to estimate a linear relationship whereby $\log w = \alpha \cdot \log I + \varepsilon$. However, then the value of α may attain any value in the interval $f'(\log A)$, depending on how incomes are distributed in A.

Say now that the average income in the cross-section increases over time and that we measure the average VTT as a function of average income. Then again, this aggregate intertemporal income elasticity may attain any value in the interval *f'(log A)*, depending on how incomes and income growth are distributed in *A*.

It is then clear that the cross-sectional "average" income elasticity α and the aggregate intertemporal income elasticity might be different. It is possible to take this into account using cross-sectional data by estimating a flexible relationship between income and the VTT. The results of this paper indicate that this relationship is not linear, but increasing in income.

However, this leaves open the possibility that the cross-sectional relationship *f* is not stable over time. We are able to address this issue by using two identical Stated Choice data sets that were collected with an interval of 13 years. Results indicate that *f* may indeed be assumed to be constant over time.

As the whole income distribution shifts upwards, the average VTT will hence grow at an increasing rate. The aggregate income elasticity of the VTT will therefore be increasing.

The paper is organized as follows. Section 2 introduces the data and section 3 sets out the econometric model. Estimation results are presented in section 4, while section 5 concludes the paper.

2 DATA

2.1 Survey method

The data originate from the Swedish value of time studies, and consist of car drivers. Only private trips are included. 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.

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, in which socio-economic information of the respondent and her household and responses to Stated Choice experiments was collected.

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. 514 complete interviews were obtained.

The response rate was 65 percent 1994 and 55 percent 2007. Each interview included 8 repeated SP choices.

2.2 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 with a change from the base alternative. This had the advantage that the design did not contain dominant alternatives.

Travel time and travel cost in the base alternative originated from the reference travel time and travel distance, i.e. the travel time and distance of the trip on which the driver was registered. 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 actual 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 on actual time and cost in the base alternative were randomly multiplied by 0.9 or 1.1. To reduce this problem further, by avoiding to put the base alternative in any particular focus, the base alternative was referred to as the “C“ alternative rather than the “A alternative. The “C” alternative was then to be compared to A, B, D, E etc. The time difference and cost differences in each choice were drawn from a previously settled schedule. Different schedules were used depending on the observed trip time and cost. The table below summarises the characteristics’ of the design and the reference trips.

Table 1: Summary of the Stated Choice design

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
Travel time diff 1994 [min]	-80	-10	2	-0.59	10	80
Travel time diff 2007 [min]	-80	-10	0	-0.75	10	80
Travel cost diff 1994 [min]	-120	-5	0	-0.41	5	127
Travel cost diff 2007 [min]	-168	-7	0	-0.58	7	168
Trade-off value 1994 [SEK/h]	2	18	34	51	67	270
Trade-off value 2007 [SEK/h]	1	24	45	70	93	378
Reference travel time 1994	10	30	50	106	120	855
Reference travel time 2007	3	30	60	117	150	940
Reference travel distance 1994	3	27	55	122	140	1250
Reference travel distance 2007	1	20	50	132	185	800

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

Alternative C		Alternative A, B, D,...
Travel time	45 min	The trip takes 5 minutes more
Travel cost	50 SEK	The trip costs 10 SEK 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 choices between one alternative close to the reference and one alternative faster but more expensive. 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.

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, corresponding to real income growth and inflation.

2.3 Descriptive statistics and data cleaning

On average, the real after-tax income is 36 percent higher in the 2007 sample than in the 1994 sample in the final estimation sample (the data cleaning prior to the model estimation is described below). During the same period the real after-tax income growth per capita in Sweden has been lower at 26 percent (Statistics Sweden, 2009). The growth in GDP per capita has been 43 % in real terms. The gap between real after-tax income growth per capita and this sample mean increase might have several causes. First, in the survey we only asked for income from labour, study allowances and pension, but not other subsidies, such as general extra allowance 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).

For observations collected in 1994 personal income is coded into eleven income intervals. For observations collected in 2007 the intervals were identical but the number of intervals was extended to fifteen, to cover higher income groups. Before-tax income has been set at interval midpoints and then transformed to after-tax income using the tax rates that prevailed in 1994/2007. The incomes in the 2007 data were deflated in line with the changes of the consumer price index 1994 - 2007. Observations with missing income information have been discarded.

Figure 2 compares the income distributions of the two years visually. Income is given in nominal terms (for practical reasons), so it must be taken into account that inflation was 17 percent between the years. It is evident from the figure that the shape of the income distribution has become more skewed.

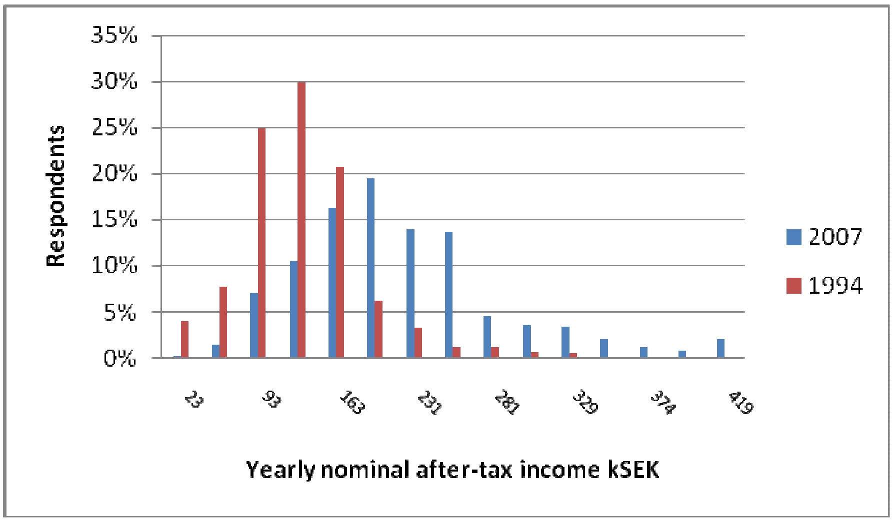

Figure 2 Nominal income distribution.

The income that was defined in the survey questionnaire does not take into account different subsidies, such as general extra allowance for children. Especially for the lowest income segment, bounded by zero, actual income may therefore be underestimated. The interval midpoint is further expected to be a less good indicator for this segment since persons with very low income often rely on the income of a spouse, personal wealth or other sources that makes income a less relevant determinant of the VTT. For this reason, the observations from the lowest income class are also discarded. Table 2 summaries the income statistics for the two survey years.

Table 2: Summary of tax income statistics in 1994 years price level, [kSEK/year].

	Min.	1st Qu.	Median	Mean	3rd Qu.	Max.
1994	56	91	126	130	161	329
2007	50	139	169	177	219	358
Total	50	109	139	151	196	358

Observations from individuals who report that somebody else paid the trip were excluded from the sample. This left 4260 and 3366 observations from 1994 and 2007, respectively. When observations with either missing income or income in the lowest income interval were discarded the number of observations dropped to 3974 and 3301 observations.

Table 3 compares descriptive statistics of the 1994 and 2007 samples. Most socioeconomic variables, except income, remain relatively unchanged. Note, however, that age has increased somewhat, as well as the share of retired drivers. Among the trip purposes it is evident that the share of maintenance trips has increased whereas the share of commutes has declined.

Table 3: Summary statistics.

	Mean 1994	Min 1994	Max 1994	Mean 2007	Min 2007	Max 2007

log(bid)	1.28	-1.85	3.34	1.45	-0.91	3.55
y	0.48	0	1	0.49	0	1
Female	0.40	0	1	0.36	0	1
Log travel distance	-0.68	-3.24	2.28	-0.75	-4.15	1.70
Log travel time	-0.60	-2.39	2.03	-0.60	-3.09	2.15
Log travel time difference	-0.45	-2.18	1.51	-0.42	-2.18	1.51
Age	46	16	83	52	19	87
Employed	0.71	0	1	0.71	0	1
Flexible working hours	0.23	0	1	0.31	0	1
Retired	0.17	0	1	0.24	0	1
Commuting	0.30	0	1	0.20	0	1
Recreation/Social/Give ride	0.38	0	1	0.37	0	1
Service/Shopping	0.18	0	1	0.30	0	1
School	0.02	0	1	0.01	0	1
Log Worked hours/week	2.60	0	4.43	2.60	0	4.38
Important not to be late	0.26	0	1	0.30	0	1
# of employed in household	1.37	0	2	1.35	0	2
Trip leg to trip purpose	0.55	0	1	0.64	0	1

3 MODEL FORMULATION

We use the econometric model described in Fosgerau (2006), which has proven to fit well the present kind of data. Respondents make binary choices between trip alternatives that differ only by time and cost. In all cases, one alternative is faster but more expensive than the other. Denote the cost of each alternative as c_i and the total travel time as t_i. Denote the individual specific VTT as W and let y be a dummy indicator for whether the slower and less expensive alternative has been chosen. Let $V = (c_1 - c_2)/(t_2 - t_1)$ be the trade-off price of travel time implicit in the choice situation. The experimental design is such that $V>0$ for all observations. We call V the bid. Then an individual will choose the slow alternative if his VTT is smaller than the trade-off price of time, i.e. if $W<V$. Taking logs and adding an error term leads to the model

$$y = 1\{\log W < \log V + \mu\varepsilon\}. \tag{1}$$

The error term ε is taken to be iid standard logistic, such that a logit model results, when W is given. The parameter μ is a scale parameter. The VTT is parameterised as

$$W = \exp(\beta x + \delta), \tag{2}$$

where β is a vector of parameters, x is a vector of independent variables and δ is a constant, which may be individual specific and hence random. This formulation ensures that W is positive, while the ranges of β and δ are unrestricted. The ease with which covariates are incorporated is an important advantage of the present model.

We estimate four different specifications of this model. Specification A is a plain logit in which a minimal set of covariates is used. Specification B expands the set of covariates with more controls. Specification C allows δ to follow a normal distribution, such that δ is constant for each individual. Specification D allows the distribution of δ to be flexible using the approach of Fosgerau & Bierlaire (2007) with three additional terms that allow the distribution of δ to vary around the normal distribution. This set of specifications allows us to assess whether the findings from simpler specifications are robust with respect to the assumptions that the more flexible models relax.

The assumption that W is individual specific and varies randomly in the population takes care of the correlation of the unobserved heterogeneity arising from repeated observations of the same individuals. The error ε is still assumed to be independent and identically distributed also within individuals.

The assumption that x and δ are independent is central, implying that the distribution of the VTT is unaffected by a shift in x. This means further that if $x_k = \log I$, where I is income, then the corresponding β_k is the income elasticity of the VTT (conditional on x).

Each model specification is estimated on the 1994 and 2007 datasets separately as well as on the pooled data. This allows us to use the χ^2-test to see whether parameters can be assumed to be constant from 1994 to 2007.

All estimations are carried out using Biogeme (Bierlaire, 2003; Bierlaire, 2008).

3.1 MODEL SPECIFICATIONS

Model specification A is the minimal specification that comprises the central variables of interest. It uses a constant δ as well as three income variables to obtain a piecewise linear relationship with income with kinks at the median and at the .75 quantile. The specification of the joint income effect is $\beta_I \cdot min(logI, logI_{50})$ +

$\beta_{I50} \cdot (min(logI, logI_{75}) - logI_{50}) \cdot 1\{logI > logI_{50}\}$ + $\beta_{I75} \cdot (logI - logI_{75}) \cdot 1\{logI > logI_{75}\}$.

Preliminary models included also a kink at the .25 quantile. We decided to drop this kink, since the income elasticities were very close, both near zero, but one was (insignificantly) negative.

The specification also uses a range of variables that describe the choice situation, that previously have been shown to be important. The first is the log of the absolute value of the difference in travel time between alternatives (*log* Δt). This captures the effect that the measured VTT may vary with the size of the travel time difference. In particular, it allows for the effect that small travel time changes may have a smaller unit value. Specification A includes also the log of the trip distance and the log of the travel time. This allows the VTT to depend on these variables as microeconomic theory would lead one to expect. Finally, the model includes a dummy for WTP type choices, to allow for difference in the VTT between these and WTA type choices.

The Zheng-Fosgerau specification test, implemented in Biogeme, was run to check model A. The test is a residual test that looks for systematic deviations from zero in the difference between actual choices and predicted probabilities, in this case looking at the choice of the cheapest alternative. The test builds on a nonparametric regression of residuals against selected variables (Fosgerau, 2008). We chose the predicted probability, as well as the trade-off VTT and all other variables entering the parameterization of W. The test did not reveal significant misspecification.

Model specification B extends specification A by adding a number of controls. The controls include dummy variables for trip purposes, namely commute, recreation, school and service, using other trips as base trip purpose. Other dummy variables signify employed persons, employees with flexible working hours, women, need to be punctual at the destination and trip leg towards main purpose of the tour. Finally the controls included number of employed people in the household, number of working hours per week and log of age.

Model specification C extends specification A by allowing the intercept δ to follow a normal distribution, assuming it to be constant within individuals. An additional parameter β_σ measures the associated standard deviation.

Model specification D extends specification C by adding three terms, γ_1-γ_3, to allow the distribution of the individual-specific intercept to be flexible around the normal distribution. In this model some controls are added, namely dummies for employed persons, employees with flexible working hours, log age.

4 ESTIMATION RESULTS

Model specification A

Table 4 shows the parameter estimates of specification A. The pooled model is rejected against yearly models at a significance level of 2 percent in a χ^2-test. However, the income elasticity increases with income in all models. For drivers with income lower than the median, the income elasticity is not significantly different from zero. For drivers with income above the median, the elasticity is significantly positive with the t-statistics being around 5. In all cases the income elasticity is between 1.1-2.4 in the two higher income segments. The differences in the income elasticity between the median and the .75 income quantile intervals are not significant.

As found in several previous studies (Hultkrantz & Mortazavi, 2001; Fosgerau, 2006) the VTT increases with the size of the time difference presented in the choice. We find an implied elasticity on the VTT of 0.6-0.7. We find also that the VTT increases with travel distance and decreases with travel time, which would be a selection effect. That is, a high VTT for a particular trip tends to increase the speed of this trip.

The parameter WTP indicates the well documented gap between and willingness-to-accept *WTA*) and willingness to pay (*WTP*). In this study we find that the difference is a factor of about 2.5 in all models.

The VTT is calculated at the sample mean of all controls.

Table 4: Parameter estimates, specification A

	1994 data		*2007 data*		*Pooled data*	
# parameters:	9		9		9	
# observations:	3947		3301		7248	
# individuals:	3947		3301		7248	
Final LL:	-2188.2		-1824.0		-4022.0	
Rho^2:	0.200		0.203		0.199	
Rho^2:	0.197		0.199		0.198	
	Value	t-test	Value	t-test	Value	t-test
constant (δ)	-0.32	-0.43	-1.61	-1.27	-0.35	-0.55
log Δt						
	0.62	5.58	0.66	5.12	0.62	7.44
log distance	0.63	5.61	0.30	2.59	0.50	6.32
log time	-0.69	-4.62	-0.36	-2.20	-0.56	-5.11
WTP	-0.95	-11.55	-0.94	-9.60	-0.93	-15.05

Income (β_I)	0.11	0.69	0.31	1.16	0.09	0.69
Income$_{50}$ (β_{I50})	1.13	2.31	2.38	5.22	1.69	5.47
Income$_{75}$ (β_{I75})	2.23	3.04	1.69	4.33	1.73	5.29
Scale	0.99	-0.16	0.91	-1.83	0.96	-1.11
VTT at mean (SEK/h)	38		43		40	

Model specification B

In the second set of models a number of socioeconomic variables are included as controls, but the model specification is otherwise the same as specification A. Specification A is rejected by specification B in all cases, signifying that the added controls are jointly significant. Pooling of the years in the joint model is rejected.

The parameter names are in most cases self-explanatory and we will not go deeper in discussing them. The point of interest here is the income elasticity estimates obtained. The general pattern obtained with specification A seems to be robust with respect to the addition of socio-economic controls, even though some of these are correlated with income. In particular, we still find that the income elasticity is not significantly different from zero for incomes below the median. It is significantly positive for incomes above the median, with all estimates being around unity or more. It is not clear whether the income elasticity is increasing above the median.

Table 5: Parameter estimates, specification B

	1994 data		*2007 data*		*Pooled data*	
# parameters:	21		21		21	
# observations:	3947		3301		7248	
# individuals:	3947		3301		7248	
Final LL:	-2129.7		-1775.7		-3929.1	
Rho^2:	0.222		0.224		0.218	
Rho^2:	0.214		0.215		0.214	
	Value	t-test	Value	t-test	Value	t-test
constant (δ)	0.60	0.63	2.86	1.91	2.09	2.71
log Δt						
	0.59	5.50	0.69	5.34	0.62	7.56
log distance	0.56	5.01	0.13	1.09	0.37	4.64
log time	-0.59	-4.00	-0.11	-0.69	-0.37	-3.41
WTP	-0.94	-11.78	-0.95	-9.79	-0.94	-15.28
income (β_I)	0.09	0.51	0.32	1.13	0.06	0.43

income$_{50}$ (β_{I50})	0.95	1.93	1.87	3.98	1.39	4.50
income$_{75}$ (β_{I75})	2.54	3.50	1.58	3.98	1.76	5.36
Employed	-0.33	-0.56	-0.65	-0.65	-0.54	-1.05
# employed persons in household	0.38	5.56	0.29	2.86	0.34	6.01
flexible hours	0.33	3.37	0.42	3.81	0.37	5.17
# working hours	0.07	0.44	0.03	0.12	0.08	0.58
Woman	0.12	1.48	-0.11	-1.07	0.04	0.66
log age	-0.32	-2.48	-1.06	-5.45	-0.61	-5.70
Need to be punctual	0.14	1.46	-0.04	-0.38	0.06	0.92
trip leg to main purpose	-0.09	-1.12	-0.12	-1.19	-0.11	-1.73
Commute	-0.45	-3.35	-0.14	-0.82	-0.35	-3.39
Recreation	-0.09	-0.67	-0.45	-2.98	-0.26	-2.73
School	0.15	0.56	-0.36	-0.60	-0.01	-0.06
Service	-0.07	-0.52	-0.31	-2.01	-0.22	-2.17
Scale	1.03	0.66	0.93	-1.34	0.98	-0.46
VTT at mean (SEK/h)	38		43		40	

Model specification C

The next set of models allows the constant to be an individual specific random parameter and excludes the socio-economic controls of specification B. The random constant performs much of the same function as socio-economic controls.

The model fit improves considerably relative to the MNL models, indicating the significance of an individual specific effect. The pooling of models across years is no longer rejected. We accept the pooling with the significance level of 82 percent. The main thing to note is that the general pattern of the income elasticities is unaffected.

The means of the VTT distributions are calculated at the sample mean of the controls. Table 6 shows first the mean VTT for each model, assuming an unbounded log-normal distribution of the VTT. Now, using the estimated distributions to compute the mean VTT requires a choice regarding the assumption about the continuation of the distribution above the maximum bids. We will not do this here. Just to state one example, however, the means of the truncated VTT distributions are shown in the table. The choice of truncation point, 1500 SEK/h, was guided by responses to the CV question asked in the more recent Swedish value of time survey.

As compared to the previous model specifications VTT, not only the VTT increases in all models, but also the difference between the VTT of the yearly models.

Table 6: Parameter estimates, specification C

	1994 data		2007 data		Pooled data	
# parameters:	10		10		10	
# observations:	3947		3301		7248	
# individuals:	483		400		883	
Final LL:	-1965.9		-1607.9		-3580.7	
Rho^2:	0.281		0.297		0.287	
Rho^2:	0.278		0.293		0.285	
	Value	t-test	Value	t-test	Value	t-test
mean constant (δ)	-0.32	-0.27	-2.25	-1.05	-0.45	-0.43
Stddv constant (δ)	-1.10	-16.81	-1.31	-15.03	-1.19	-22.59
	0.46	4.62	0.69	5.41	0.55	7.0
log Δt						
log distance	0.61	3.46	0.30	1.52	0.48	3.78
log time	-0.56	-2.71	-0.38	-1.54	-0.49	-3.15
WTP	-0.90	-13.14	-0.95	-11.10	-0.92	-17.20
Income (β_I)	0.10	0.41	0.44	0.97	0.11	0.50
Income$_{50}$ (β_{I50})	1.14	1.49	2.34	3.16	1.64	3.33
Income$_{75}$ (β_{I75})	2.15	2.03	1.68	2.72	1.70	3.38
Scale	1.42	6.24	1.29	4.15	1.36	7.51
VTT at mean (SEK/h)	71		99		81	
VTT at mean, truncated 1500 SEK/h	71		96		80	

Model specification D

The last set of models relaxes the assumption of normality of the random constant. It is possible to accept the pooled model against yearly models. And, importantly, the general pattern of income elasticities remains robust.

Table 7: Parameter estimates, specification D

	1994 data	2007 data	Pooled data
# parameters:	16	16	16
# observations:	3947	3301	7248
# individuals:	483	400	883
Final LL:	-1954.4	-1588.0	-3554.4
Rho^2:	0.281	0.297	0.287
Rho^2:	0.278	0.293	0.285

	Value	t-test	Value	t-test	Value	t-test
“mean” constant (δ)	2.19	1.56	3.31	1.42	2.36	2.02
“Stddv” constant (δ)	-1.14	-7.08	1.19	8.78	-1.25	-10.90
	0.46	4.60	0.70	5.46	0.55	7.04
log Δt						
log distance	0.56	3.27	0.10	0.55	0.38	3.01
log time	-0.47	-2.29	-0.07	-0.28	-0.33	-2.13
WTP	-0.90	-13.14	-0.96	-11.09	-0.92	-17.20
Income (β_I)	-0.10	-0.37	0.26	0.57	0.05	0.23
Income$_{50}$ (β_{I50})	1.10	1.44	2.09	3.06	1.43	2.95
Income$_{75}$ (β_{I75})	2.11	1.98	2.11	3.30	1.82	3.65
log age	-0.459	-2.33	-1.17	-4.07	-0.74	-4.43
Employed	0.23	1.44	-0.24	-1.09	0.10	0.80
Flexible hours	0.35	2.23	0.37	2.33	0.34	3.01
γ_1	0.01	0.09	0.47	4.21	-0.10	-1.17
γ_2	-0.05	-0.58	-0.52	-6.07	-0.05	-0.78
γ_3	0.03	0.44	0.55	3.34	0.03	0.64
Scale	1.42	6.22	1.28	4.07	1.36	7.42

5 CONCLUSION

This paper has used data collected in 1994 and in a repeated survey in 2007, where much care was taken to collect data in the same way as in 1994. A range of models has been estimated, focusing on the income elasticity of the value of travel time. All the models estimated indicate an income elasticity of the value of travel time that is not significantly different from zero for incomes below the median. For incomes above the median, most income elasticity estimates were significantly different from zero, attaining values of around 1 or more.

It therefore appears to be a robust finding that the income elasticity of the value of travel time is not constant but increases with income. In other words, the value of travel time seems not to be log-linear in income. From this, it follows that changes in the income distribution and the average income also will affect the average income elasticity of the value of travel time. In particular, the income elasticity of the value of time has increased between the two survey years since the income level has increased.

For the specifications that allow for an individual specific random constant, the constancy of parameters across years was not rejected. This lends support to the idea that it is not so much the relationship between income and the value of travel time that has changed over time as it is the level and distribution of income in the samples that has changed. The present results thus allow one to accept that the income elasticity of the value of time has remained constant at each real income level.

The present results may turn out to be helpful in interpreting the differences that exist between studies of the value of travel time carried out at various times and places in various countries (Wardman 2001a, Wardman 2001b, Gunn et al. 1999; Shires and de Jong, 2006). As an example, it would be consistent with the present result to expect high income elasticity for travel time by car in Denmark, as was indeed found in Fosgerau (2005), since cars are expensive in Denmark and car drivers therefore tend to have higher incomes. The present result also suggest also that the average income elasticity on the value of time would be higher in more recently collected data as compared to data collected ten or twenty years ago, which is also consistent with the relatively high income elasticity found in Fosgerau (2005) as compared to studies using older data. It seems reasonable to seek to qualify the commonly applied approach of projecting the average value of travel time into the future assuming constant income elasticity.

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