UNIT INCOME ELASTICITY OF THE VALUE OF TRAVEL TIME SAVINGS[1]

Mogens Fosgerau
Danish Transport Research Institute
Knuth-Wintherfeldts Allé, Bygning 116 Vest
2800 Kgs. Lyngby
Denmark
mf@dtf.dk

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ABSTRACT

The paper presents an analysis of the income elasticity of the value of travel time savings (VTTS). It expands on previous micro-econometric estimates of the VTTS on binary choice experimental data by accounting for income taxes, for the dependence of trip length on income and for the stochastic distribution of the VTTS using semiparametric methods. Previous empirical estimates of the elasticity are around 0.6 while in practice i.a. Denmark and the UK (until 2004) apply a unit income elasticity for forecasting the future VTTS in economic evaluations of transport projects. This discrepancy may be resolved as shown in the paper.

JEL classification: R22; R41; C14; C25

KEYWORDS: Willingness to pay, value of time, semiparametric, travel, transport

1 INTRODUCTION

1.1 Background

The value of travel time savings (VTTS) is a fundamental concept in transport economics and time savings evaluated by the VTTS often constitute the major part of benefits of a transport investment. Many countries have formalized such evaluations including official sets of values of travel time savings for different components of travel time (e.g., Cowi [4]).

Decisions concerning transport infrastructure are of a long-term nature. Therefore, just as future traffic growth is projected as part of the evaluation, it is also necessary to take into account that the VTTS will grow over time with income as a main driving factor. This requires knowing the income elasticity of the VTTS, which is the topic of this paper. We shall be concerned only with the VTTS for non-working time.

GDP growth can be translated into growth in after-tax personal income. The use of GDP can be divided into personal consumption, public consumption, investment and the balance of trade. Assuming that the shares for these components are roughly constant implies that personal consumption grows at the same rate as GDP. Personal consumption equals total personal after-tax income such that personal after-tax incomes will tend to grow like GDP. Thus empirical results on the relationship between the VTTS and personal after-tax incomes can be applied to the relationship between the VTTS and GDP.

It seems that using a unit elasticity with respect to real GDP is not unusual. Guidelines from the World Bank (Gwilliam, [10]) note that this assumption is made in most countries and further recommends the practice. Denmark employs a unit income elasticity [26] as did the UK until 2004 (Mackie et al. [18]). Mackie et al. [17] discuss and support this practice and find no compelling reason to depart from the assumption of a unit elasticity. However, the

UK recently changed to an elasticity of 0.8 (Department for Transport, [5]). Sweden applies the growth of real GDP to update the VTTS from the year in which the VTTS was established to the base year of application in analysis (SIKA [22]). Curiously, the Swedish practice does not include projection of the VTTS further into the future, so in effect the VTTS is assumed to grow with income with unit elasticity up to the base year of an analysis and then not to grow thereafter. The U.S. Department of Transportation [27] states the VTTS as a share of gross wages and updates VTTS figures using data on gross hourly earnings, which amounts to using a unit income elasticity.

The income elasticity can have a large influence on the results of a cost-benefit exercise. For example a benefit stream from time savings of 1 per year discounted at 6% over 50 years has a net present value of 16.7. Assuming a future economic growth rate of 2% and applying a income unit elasticity leads to a net present value of 22.6, which is 35% higher.

Empirical results seem not to support the practice of applying a unit income elasticity. Most empirical evidence is, however, based on before-tax income. For example, the UK national value of time study (Accent et al. [1]) uses gross household income. The Norwegian study (Ramjerdi et al. [21]) uses gross personal income. Small [24] discusses various empirical results on the relation of the VTTS to the wage rate. Most studies he cites gives the VTTS as a ratio of the gross wage rate. Small concludes that the evidence rejecting a simple proportionality between the VTTS and income is fairly convincing. But he also notes that "income may not be a good proxy for post-tax marginal wage, so the issue is still in some doubt".

Based on British studies Wardman [29] finds that estimates of the income elasticity estimated on cross-sectional data are typically around 0.6 with somewhat higher estimates when personal income is used rather than household income. The income concept was gross household income in 19 out of 20 studies. Fosgerau [9] similarly found an income elasticity of 0.68 (standard deviation of 0.05) on cross-sectional Danish data with respect to personal before-tax income.

Based also on comparisons of cross-sectional studies performed at different times Wardman [28] recommends an elasticity with respect to GDP of 0.5.

In summary, empirical evidence seems to point to an income elasticity of less than unity. It is also clear that most of this evidence is based on gross or before tax income. Furthermore, when income elasticities have been estimated it has been conditional on other variables, which may themselves depend on income.

1.2 Microeconomic background

The micro-economic formulation of the theory of the value of travel time savings was fundamentally formulated by Becker [2], Johnson [15], Oort [19], DeSerpa [6]. Jara-Diaz [13] provides a review. Jiang & Morikawa [14] discuss the relation of the VTTS to travel time, travel cost, wage rate and working hours. It is evident from the micro-economic models that the relevant income concept is after-tax income, since it is after-tax income that can be used for consumption.

From the simplest possible model, one finds that the VTTS is equal to the marginal after-tax hourly wage. Thus an income elasticity of 1 is a natural expectation to have. This seems also to be a common expectation. Train & McFadden [25] formulate a simple model in which the utility of travel and work enters by an adjustment of the amount of leisure into effective leisure. Travel distance is given exogenously. They show that in this case the VTTS is proportional to the wage rate, which is to say that the income elasticity is 1.

The elasticity of after-tax income with respect to before-tax income is less than 1 when the tax system is progressive. Therefore, when some econometric exercise has found an elasticity of the VTTS with respect to before-tax income, the elasticity with respect to after-tax income is higher. The difference between before-tax and after-tax elasticities depend on the tax system. We shall see later that the difference is quite substantial with Danish data.

1.3 **Layout**

The paper is organized as follows. The econometric model is set out in section 2, the dataset is introduced in section 3, estimation results are presented in section 4, while section 5 concludes.

2 **THE ECONOMETRIC MODEL**

The data are from a binary choice experiment where each alternative i is characterized by a travel time and a travel cost. The values for time and cost are based on a recent trip undertaken by the respondent. Travel time is broken down into free flow time and additional time due to congestion. For each respondent, additional congestion time is a constant proportion of total travel time equal to the proportion stated for the actual trip.

Denote the cost of each alternative as c_i and the total travel time as t_i. Let $\alpha_c < 0$ and $\alpha_t < 0$ be the individual marginal utilities of cost and total travel time. The respondent chooses alternative 1 if

$$\alpha_c c_1 + \alpha_t t_1 > \alpha_c c_2 + \alpha_t t_2. \qquad (1)$$

Arrange alternatives 1 and 2 such that alternative 1 is always the cheapest and alternative 2 is always the fastest. Observations where this is not possible are rejected, since one alternative is dominant in this case. Then the cheap alternative 1 is chosen if

$$\alpha_t/\alpha_c < -(c_1-c_2)/(t_1-t_2). \tag{2}$$

The term on the right is the boundary VTTS presented by the experimental design, we denote this by $v = -(c_1-c_2)/(t_1-t_2)$ and note that $v > 0$. The term on the left is the individual VTTS. This is denoted by $w = \alpha_t/\alpha_c$ and parameterised as

$$w = \exp(\beta x)\exp(u), \tag{3}$$

where β is a vector of parameters, x is a vector of independent variables and u has some distribution assumed to be independent of x. This formulation ensures positivity of w, while the ranges of β and u are unrestricted.

Note that (3) is formulated directly in terms of willingness-to-pay. The marginal utilities of travel time and money do not appear separately. Note also that w depends on covariates and need not be constant for the individual. Taking logs allows rewriting (3) as

$$\log(w) = \beta x + u, \tag{4}$$

showing that changing x shifts the location of log(w) while the distribution of u is unaffected due to the assumed independence. This is central to the identification of the model.

Independence of x and u further implies that $E(w \mid x) = \exp(\beta x) * E(u)$. Thus the derivative of w with respect to x can be found without estimating E(u). In fact,

$$\frac{d\log E(w \mid x)}{dx} = \beta . \tag{5}$$

This further means that if an element of x is the log of some variable, say $x_k = \log(z)$, then β_k is the elasticity of the VTTS conditional on x with respect to z. This conditionality is important. If $x_k = \log(z)$ is the log of income then the corresponding β_k is the direct income elasticity *conditional on x*. But the other elements of x may depend on income and should not be regarded as fixed when assessing the income elasticity of the VTTS. This must be taken into account in order to arrive at an unconditional elasticity. We shall return to this subject in section 4.3.

Now w is not observed. Instead it is observed whether $w < v$. Define $y = 1$ if alternative 1 is chosen and 0 otherwise. After transformation to logs we have the model

$$y = 1\{u < \log(v) - \beta x\}. \tag{6}$$

Serial correlation arising from repeated observation of the same individual is ignored. Various models such as probit or logit can be obtained from this formulation, depending on the assumptions employed for the distribution of u. Generally, misspecification may bias the estimation of β. Hensher [12] has shown the extreme sensitivity of VTTS estimates to the specification of errors. Here we shall not assume any particular distribution for u. Estimation of β is still possible using the Klein & Spady [16] semiparametric estimator. The logic of that is that we can express

$$P(y = 1) = P(u < \log(v) - \beta x) = F_u(\log(v) - \beta x) \tag{7}$$

and

$$y = F_u(\log(v) - \beta x) + \eta,\ E(\eta) = 0. \tag{8}$$

Given an estimate of β, (8) shows that the cumulative distribution function F_u can be estimated by a nonparametric regression of y on $\log(v) - \beta x$ invoking only weak smoothness assumptions on F_u. The regression estimate is expressible in closed form. Then the nonparametric regression function estimating F_u is substituted into the loglikelihood function arising from (7) in order to perform maximum likelihood estimation of β.

F_u is estimated nonparametrically with the Nadaraya-Watson estimator using a normal density kernel (Pagan & Ullah [20]) with bandwidth $0.15N^{-1/6}$ (Klein & Spady [16]), where N is the number of observations and where log(v) - βx has been scaled to the unit interval.

Models are estimated by maximum likelihood in Ox (Doornik [7] using the average outer product of the score to estimate the covariance matrix. The Ox code is available from the author on request.

3 DATA

The data originate from the Danish value of time study with data collection undertaken in 2004 (Burge et al. [3]). A dataset has been extracted consisting of car drivers comprising 17020 observations from 2553 individuals making repeated choices. Personal income is coded into twelve categories. The first ten categories indicate before-tax income in 100,000 DKK intervals ranging from 0 to 1 million DKK.[2] There is a further category for income in excess of 1 million DKK and also a category for missing income information. Before-tax income has been set at interval midpoints and then transformed to after-tax income using the tax rates that prevailed in 2004. Observations with missing income information have been discarded. So have observations from the highest income class, since the interval midpoint is not defined. The observations from the lowest income class are also discarded since the interval midpoint is expected to be a less good indicator of the average income when incomes are bounded by zero and also since persons with very low income often rely on the income of a spouse, personal wealth or other that makes income a less relevant determinant of the VTTS. This leaves 14,072 observations. A further 156 observations are discarded corresponding to 23 individuals who are pensioners or otherwise unemployed and who

[2] The currency is Danish kroner, 1 Euro = 7.45 DKK.

indicated work as their trip purpose. The sample used for analysis thus comprises 13,918 observations.

Descriptive statistics for the variables employed in the analysis are given in Table 1. Here, y is the dependent variable, which is 1 if the respondent declines to pay the stated bid v. The model is formulated in logs and hence log(v) appears in the table. By experimental design, v varies between 1 and 201 DKK/hour.

Female is a dummy indicator; Log of total time is the total travel time computed as the log of the average travel time in the two alternatives presented. This variable is intended to capture an effect of travel distance. In order to capture an effect whereby small time savings are valued less than large time savings (in the choice experiment) the log of the difference between travel times is included. These variables allow the VTTS to depend on choice characteristics such that also the marginal utilities of time and cost depend on the trade-off presented. The variable Cngshare expresses the share of total travel time that is additional over free flow time due to congestion. This share is fixed for each respondent. During the experiment, free flow time and additional time due to congestion were indicated separately such that respondents would make choices on the basis that the congestion share is fixed. Applying a first-order Taylor approximation shows that the parameter for Cngshare can be interpreted as a markup for additional congestion time on the VTTS for free-flow time.

Both age and age squared enter to allow for a nonlinear relationship with age. Similarly a second-order term appears for income. The variable logInc is the log of after-tax income, shown here in actual level. It is centered on the mean before it is used in the models. Working is a dummy for whether the respondent is employed, self-employed or an apprentice. Only workers can commute by construction of the sample. Leisure, Maintenance and Education are dummies for the current trip purpose. Maintenance includes shopping, errand and transport of persons or things. Leisure comprises visits, holiday trips, cottage visits, meetings, sport, leisure, café and other activities. Finally, the table contains after-tax income in actual level. This income in levels and the education dummy do not enter the models to be estimated. The variables from Female to Maintenance correspond to the vector x in the model formulation.

4 RESULTS

4.1 Accounting for taxes

The Danish income tax is fairly complicated but consists essentially of a flat rate tax and three tax rates applied to different income intervals. Only the flat rate tax is paid on incomes below a certain amount. The selected sample is above this threshold. A marginal tax rate of 42% applies to the lowest two income groups selected, while the highest marginal tax rate of 63% applies to the remainder. The third marginal rate between 42% and 63% applies only over a short range between the second and third income groups.

When income has been set at interval midpoints, about half of the selected sample, 53%, pays 42% in marginal tax and the remainder pays 63%. The average tax rate ranges from 33% for the lowest income group to 54% for the highest. This shows the extent to which after-tax income as a function of before-tax income deviates from a linear relationship. The deviation from linearity implies an error in the estimated income elasticity when using before-tax rather than after-tax income.

The elasticity of after-tax income with respect to before-tax income is calculated as a weighted average over the sample yielding a figure of 0.79. From the discussion in section 1.2 it follows that the income elasticity of the VTTS using after-tax income will be $1/0.79 \approx 1.26$ times higher than the income elasticity estimated using before-tax income. This is a considerable effect. Of course the size of the effect depends on the particulars of the tax system and the Danish is quite progressive with a top marginal tax rate of 63%.

Only after-tax income will be used for the models to be estimated in the following. When models have been estimated (not shown) with both before-tax and after-tax income, a ratio between income elasticities very close to 1.26 has been found.

4.2 **Model estimation**

Nine models have been estimated with results shown in tables 2 and 3. The models in Table 2 will be discussed first.

Model 1 disposes of the trips for education. Average income elasticities are computed as $\beta_{logInc} + 2 * \beta_{logInc^2} * E(logInc)$ with standard deviations computed using the estimated covariance of the parameter estimates. Note that the log income has been demeaned before input to the estimation procedure. The estimated direct income elasticity for the education segment is fairly low but significantly different from zero and also from 1.

Model 2 comprises all other trips with dummies for leisure and maintenance trips and a dummy for working status; the latter is always 1 for commuting trips. These reveal that the average VTTS is about 14% = 1 - exp(-15%) lower for leisure trips and 23% = 1 - exp(26%) lower for maintenance trips than for commuting trips. Women have a lower VTTS than men, the VTTS increases with total travel time and with the size of the time saving offered. There is a markup of 72% = exp(54%) - 1 for additional travel time due to congestion. The VTTS decreases with age. The first-order term for income is highly significant and close to 1, while the second-order term that allows the income elasticity to vary by income is not significant. The average direct income elasticity is 0.86 (0.07).[3]

Models 3-5 split the sample for model 2 by the travel purposes leisure, maintenance and commuting. A number of observations can be made: The VTTS is much lower for women for maintenance trips while the gender difference is small and not significant for commuting trips. The sensitivity to the total travel time is small for leisure purposes and high for maintenance and commuting, where the time schedule might be tighter. The markup for congested time is not significantly different across purposes but is only significant for leisure.

The estimated average income elasticities for leisure and maintenance are very close at 0.96 (0.09) and 0.94 (0.15), while it is lower, 0.54 (0.13) for commuting. Only commuting is significantly different from unity.

The models 3 and 4 for leisure and maintenance have been split further into models for workers and nonworkers. This is shown in models 6-9 in Table 3. It is notable that the total travel time is much higher for workers' maintenance and indistinguishable from zero for nonworkers' maintenance. This reinforces the conjecture made above that the variable reflects on the tightness of the daily schedule. Similarly, the markup for congestion is high for workers while it is not significant for nonworkers' maintenance and just significant for nonworkers' leisure. The estimated average direct income elasticities are similar and again close to 1.

4.3 **The total income elasticity of travel time**

The direct income elasticity of the VTTS has been estimated when controlling for a number of covariates. This means that the direct income elasticity applies when holding the covariates

[3] Standard deviations in parentheses throughout.

constant. When asking what the income elasticity of the VTTS is, it must also be asked whether the covariates depend on income. It seems reasonable to fix the sex and age distribution to the sample. Also the distribution on travel purposes can be regarded as fixed since this is controlled in the traffic forecast to which the VTTS figures are to be applied. The same argument also applies to the share of travel time due to congestion. The time saving is set by design and is not affected by income.

This leaves the total travel time, proxying travel distance, which itself depends on income. It is reasonable to expect this to grow with increasing incomes. Since the VTTS generally increases with total travel time, this represents a further contribution to the unconditional income elasticity that is additional to the conditional direct income elasticity estimated in the previous section.

A series of regression models have been estimated using one observation per individual from the dataset with one regression corresponding to each of the 9 models estimated for the VTTS. The regressions have the log of total travel time as a function of the same covariates as above including the log of income. The parameter to the log of income in each regression is the estimate of the income elasticity of total travel time with respect to income.

Table 4 shows in the first column the direct income elasticities estimated above. The second column contains the estimated parameters for the total travel time. The third column shows the income elasticities of the total travel time computed in the auxiliary regressions. Combining these columns leads to the estimates in the last column. Calculation of standard deviations for these estimates is not readily feasible: the estimated standard deviations of the direct income elasticities are used for rough evaluation of significance as the standard deviation of the total income elasticities are likely to be at least as big.

The hypothesis that the income elasticity of the VTTS is unity is remarkably well supported. Except for education trips, all estimated income elasticities seem not to be significantly different from 1. When computing the weighted average of the estimates from the most detailed set of models, from models 1 and 5 to 9, the resulting average total income elasticity is 0.90. The weighted average direct income elasticity is 0.79 (0.15) such that the effect of income on total travel time accounts for the difference up to 0.90. Excluding education trips leads to a weighted average direct income elasticity of 0.84 (0.15) and a weighted average total income elasticity of 0.96.

4.4 **Semiparametric estimation vs. logit**

To complete the story it remains to see the effect of using a semiparametric model rather than the traditional logit model to account for the distribution of the value of time. Recall the semiparametric model formulation where $y = 1\{u < \log(v) - \beta x\}$ and u has an unknown distribution. We finish by also estimating a logit model with specification chosen to include the index used above. Specify the indirect utility difference as $(\Delta t \exp(\beta x) + \Delta c)\eta + \Delta\varepsilon$, where η is a scale parameter, ε are the errors of the logit model and where x now includes a constant. The constant is included since the error terms are now specified to have zero means.

This logit model is not nested within the semiparametric model. Nevertheless, it is instructive to compare the loglikelihoods obtained from the two models shown in Table 5: the differences are large, indicating a clear preference for the semiparametric model.

A formal test of the logit models against the nonparametric alternative has been carried out using Zheng [30] and the same bandwidth as above. It should be noted that the nonparametric alternative for the logit model is not the same as the semiparametric model above, since the logit model is conditional on $\Delta t (\exp(\beta x) - v) \eta$ and not on the $v * \exp(-\beta x)$ that occur in the semiparametric model above. The Zheng test statistics in Table 5 should be evaluated in a N(0,1) distribution such that values larger than 1.96 indicate rejection of logit at the 95% confidence level. The logit model is clearly rejected in all cases. This means that income elasticities estimated from the semiparametric model should be preferred.

5 CONCLUDING REMARKS

A set of semiparametric models has been applied in combination with a set of linear regressions in order to account for the income elasticity of the value of travel time savings. An average total income elasticity of 0.90 has been found for the sample, which is considerably larger than previous estimates and not significantly different from unity.

Two causes for the previous underestimation of this elasticity have been identified that would also apply to other similar datasets. The first is the use of before-tax rather than after-tax income. With the sample and the Danish tax system this accounts for a factor of 1.26 on the direct income elasticity keeping total travel time constant. The direct income elasticity has been estimated to 0.79 using after-tax income. Had before-tax income been used instead, a direct income elasticity around 0.79/1.26 = 0.63 would have been found. This is in the range of previous estimates referenced in the introduction.

The second cause is the recognition that travel distance and hence travel time cannot be expected to be constant when income grows. The common findings that the value of travel time savings depends on the total travel time and further that the total travel time depends on income are repeated. Including this effect leads to an estimate of the total income elasticity, which is statistically indistinguishable from 1. Thus, the practice of projecting the value of travel time savings into the future with unit income elasticity is supported.

A third cause for the previous underestimation might be the use of an inappropriate model. The previous value of time studies referenced have generally used the logit model. This model has here been clearly rejected.

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Table 1. Descriptive statistics

	Mean	Min	Max
y	0.58536	0	1
log(v)	3.5354	1.0986	5.3033
Female	0.39661	0	1
Log of total time	3.4832	1.5041	6.2344
Log of time difference	1.8823	1.0986	4.0943
Cngshare	0.091721	0	0.68
Age	49.581	16	84
Age^2/1000	2.6507	0.256	7.056
logInc	12.070	11.517	12.977
logInc^2	145.83	132.64	168.42
Working	0.69636	0	1
Leisure	0.47909	0	1
Maintenance	0.22891	0	1
Education	0.065886	0	1
Income, DKK	187260	100412	432570

Table 2. Estimation results

	1 Education	2 Leisure, maintenance and commuting	3 Leisure	4 Maintenance	5 Commuting
Female	-0.18 (0.08)*	-0.22 (0.04)*	-0.21 (0.06)*	-0.37 (0.09)*	-0.07 (0.08)
Log of total time	0.23 (0.08)*	0.20 (0.03)*	0.12 (0.04)*	0.23 (0.08)*	0.44 (0.07)*
Log of time difference	0.45 (0.09)*	0.37 (0.03)*	0.38 (0.04)*	0.21 (0.09)*	0.31 (0.07)*
Cngshare	0.30 (0.27)	0.54 (0.15)*	0.74 (0.23)*	0.29 (0.32)	0.37 (0.22)
Age	-0.07 (0.02)*	-0.01 (0.01)	0.00 (0.01)	0.02 (0.02)	-0.10 (0.02)*
Age^2/1000	0.73 (0.27)*	-0.20 (0.11)	-0.24 (0.15)	-0.52 (0.22)*	0.86 (0.27)*
logInc	0.20 (0.12)	0.88 (0.07)*	1.01 (0.09)*	0.76 (0.16)*	0.52 (0.13)*
logInc^2	0.51 (0.28)	0.20 (0.13)	0.39 (0.16)*	-0.56 (0.31)	0.27 (0.26)
Working		-0.02 (0.06)	0.05 (0.08)	-0.31 (0.11)*	
Leisure		-0.15 (0.06)*			
Maintenance		-0.26 (0.06)*			
N	917	13001	6668	3186	3147
Loglikelihood	-558.1	-7707.8	-3957.0	-1819.0	-1880.7
Bandwidth	0.034	0.022	0.025	0.028	0.028
Direct income elasticity	0.07 (0.11)*	0.86 (0.07)*	0.96 (0.09)	0.94 (0.15)	0.54 (0.13)*
Avg. income, DKK	178785	187858	188959	170148	203453

Significance at 5% marked by *. Significance is measured relative to unity for the direct income elasticity.

Table 3. Estimation results, leisure and maintenance by working status

	6 Leisure, workers	7 Leisure, nonworkers	8 Maintenance, workers	9 Maintenance, nonworkers
Female	-0.16 (0.07)*	-0.32 (0.09)*	-0.31 (0.12)*	-0.13 (0.11)
Log of total time	0.14 (0.05)*	0.12 (0.06)*	0.51 (0.11)*	-0.01 (0.09)
Log of time difference	0.40 (0.05)*	0.34 (0.06)*	0.32 (0.10)*	-0.06 (0.11)
Cngshare	0.68 (0.25)*	0.60 (0.30)*	0.83 (0.46)	-0.32 (0.34)
Age	0.02 (0.02)	0.02 (0.02)	0.12 (0.04)*	-0.04 (0.03)
Age^2/1000	-0.40 (0.22)	-0.32 (0.19)	-1.64 (0.41)*	0.12 (0.24)
logInc	0.87 (0.11)*	0.46 (0.13)*	0.59 (0.21)*	1.19 (0.25)*
logInc^2	0.62 (0.20)*	-0.82 (0.25)*	-1.26 (0.42)*	-0.01 (0.48)
N	4188	2480	1852	1334
Loglikelihood	-2557.4	-1379.04	-1089.79	-700.234
Bandwidth	0.0265	0.0290	0.0304	0.0321
Direct income elasticity	0.96 (0.11)	0.96 (0.14)	0.66 (0.21)	1.20 (0.23)
Avg. income, DKK	212664	148929	191566	140413

Significance at 5% marked by *. Significance is measured relative to unity for the direct income elasticity.

Table 4. Total income elasticities

Model	Direct income elasticity 1	Total travel time parameter 2	Total travel time income elasticity 3	Total income elasticity 1 + 2*3
1. Education	0.07 (0.11)*	0.23 (0.08)*	0.14 (0.16)	0.11
2. Leisure, maintenance and commuting	0.86 (0.07)*	0.20 (0.03)*	0.48 (0.06)*	0.96
3. Leisure	0.96 (0.09)	0.12 (0.04)*	0.54 (0.08)*	1.02
4. Maintenance	0.94 (0.15)	0.23 (0.08)*	0.39 (0.11)*	1.03
5. Commuting	0.54 (0.13)*	0.44 (0.07)*	0.46 (0.12)*	0.75
6. Leisure, workers	0.96 (0.11)	0.14 (0.05)*	0.45 (0.10)*	1.02
7. Leisure, nonworkers	0.96 (0.14)	0.12 (0.06)*	0.69 (0.12)*	1.04
8. Maintenance, workers	0.66 (0.21)	0.51 (0.11)*	0.51 (0.15)*	0.92
9. Maintenance, nonworkers	1.20 (0.23)	-0.01 (0.09)	0.24 (0.15)	1.20

Significance at 5% marked by *. Significance is measured relative to unity for the direct income elasticity.

Table 5. Comparison of semiparametric and logit models

Model	Loglikelihood Semiparametric	Loglikelihood Logit	Zheng statistic N(0,1)
1. Education	-558.1	-577.9	3.6
2. Leisure, maintenance and commuting	-7707.8	-8402.3	119.5
3. Leisure	-3957.0	-4332.8	69.2
4. Maintenance	-1819.0	-1952.3	21.7
5. Commuting	-1880.7	-1996.2	11.6
6. Leisure, workers	-2557.4	-2748.4	34.4
7. Leisure, nonworkers	-1379.0	-1550.0	30.9
8. Maintenance, workers	-1089.8	-1159.2	7.3
9. Maintenance, nonworkers	-700.2	-764.3	13.6