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TRAVEL COST AND TIME MEASUREMENT IN TRAVEL COST MODELS[1]

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ABSTRACT

In this paper we use the results of a recent on-site recreation survey to know whether it matters to use perceived rather than calculated travel costs. The calculated travel costs (time and money) are derived from detailed GIS computations. The perceived travel times and costs are taken directly from the survey responses.

We first find that there is a high non-response rate for the perceived cost question. For those who respond we find that the perceived costs are close to the sum of the calculated time and fuel costs. The relative difference between perceived and calculated costs is negatively related to distance and visit frequency.

We explain perceived costs by simple factors such as distance, time, group size, social class, education level, length of stay and general satisfaction with their visit.

To examine the effect of the specification of the travel cost and time variables, we estimate several individual trip demand equations for three functional forms of the dependent variable: semi-log, negative binomial and truncated negative binomial. Based on the log-likelihood values of the estimation of the different trip demand equations we show that there are no significant differences in model performance as far as cost specifications are concerned. Comparing cost coefficients and consequently consumer surplus estimates shows that only for the negative binomial functional form there is a statistically significant difference between the specification with perceived costs and the model with total calculated cost measures.

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1. INTRODUCTION

The definition of the travel cost variable is a key issue in travel cost models. Most studies prefer objective but often also rather simple/crude data on distance, costs per kilometre and time over visitors' own stated costs and time. However, since visitors have no knowledge of these objectively measured time and cost aspects (Englin and Shonkwiler, 1995b), their decision whether or not to visit a natural park is based on their own, ex ante perception of travel time and costs.

In this paper we use the results of a recent on-site recreation survey to know whether it matters to use perceived rather than calculated travel costs. The calculated travel costs (time and money) are derived from detailed GIS computations[2]. The perceived travel times and costs are taken directly from the survey responses.

In section 2 we discuss the data sources. What questions were used to estimate the perceived travel times and costs? We also show in detail how the calculated travel times and costs were computed. This forms the basis for a comparison of perceived and four concepts of calculated travel costs and times in section 3. In section 4 we try to explain the structure of perceived travel costs by simple factors such as distance, time, group size, social class, education level, length of stay and general satisfaction with their visit. The ultimate purpose of travel cost models is to estimate consumer surpluses and travel cost elasticities. To examine the effect of the specification of the travel cost and time variables, we estimate several individual trip demand equations for three functional forms of the dependent variable: semi-log, negative binomial and truncated negative binomial. This is done in section 5. Section 6 concludes.

2. DATA DESCRIPTION

The data used in this analysis come from two sources: an on-site survey of visitors in Heverleebos-Meerdaalwoud and GIS-computations. The survey was used to obtain the origin and frequency of the visits as well as the visitors' perceived costs. The GIS-information was used to compute travel distances and travel times to obtain calculated travel costs.

The forest recreation site under study is located fairly close to the major population centres of Brussels and Leuven (75% of visitors come from within 15 km).

The survey

From August 1998 through April 1999 a survey of visitors of Heverleebos-Meerdaalwoud (the second largest public forest complex in Flanders) was administered.

The questionnaire consisted of four parts. The first part contained questions about the respondents' current visit: the number of persons in their group, mode of transportation, the respondents' own estimate of travel time and travel costs, their visit frequency, the primary and secondary reasons for

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[2] This approach is similar to Bateman et al. (1996)

their visit, how long they were planning to stay and whether the forest was the only destination on their trip. The second part asked about the respondents' general recreation behaviour (e.g. whether or not they visited other forests or outdoor recreation areas during the past twelve months). The third part asked about the respondents' attitudes towards several social and environmental issues. The final part informed about some important socio-economic characteristics including age, gender, family composition, marital status, education and profession. Questions about their wage rate and non-labour income were excluded since the pre-test showed a non-response rate of approximately 90% on this particular question. In total 530 visitors completed the questionnaire.

Calculated travel distances, costs and time

GIS software was used to calculate travel distances and times down to the street level.

Travel time was calculated according to the following formula:

$$Travel\,Time = \sum_{i=1}^{8} \frac{distance(i)}{average\,speed(i)} \tag{1}$$

A distinction was made between eight different road types, each with a different typical speed[3].

We make a distinction between two calculated variable car cost concepts. The first is the pure fuel cost. The second is the total car usage cost that includes expected maintenance costs, replacement cost of the car, part of the insurance, etc. We make this distinction because it is sometimes argued that people only perceive fuel costs as the cost of a trip.

Fuel costs were calculated by multiplying travel distance (two-way) by the fuel cost (EURO per car-km) and dividing by the number of passengers in the car:

$$Fuel\,Costs = \frac{fuel\,cost(EURO/car\ per\,km) * distance(km)}{number\,of\ passengers} \tag{2}$$

Total car usage costs were calculated according to the same formula by replacing the 'fuel cost' in the numerator by 'the total car usage cost':

$$Total\,car\,usage\,costs = \frac{total\,car\,usage\,cost(EURO/car\ per\,km) * distance(km)}{number\,of\ passengers} \tag{3}$$

A distinction is made between four types of cars: small gasoline, big gasoline, small diesel and big diesel cars. More detailed information about fuel costs and total car usage costs is given in table 1.

[3] Data on typical speeds were obtained from the transport economics research group at the Centre for Economic Studies, KULeuven.

Table 1: Calculated travel costs: fuel costs and total car usage costs

Car type	Small gasoline	Big gasoline	Small diesel	Big diesel
Cylinder capacity (in cm³)	*< 1600*	*≥ 1600*	*< 2000*	*≥ 2000*
Fuel consumption (litre/km)	0.0716	0.0771	0.0534	0.0758
Price of fuel (EURO/litre)	0.89	0.89	0.61	0.61
Fuel cost (EURO/km)	0.064	0.068	0.033	0.046
Total car-usage cost (EURO/km)	0.33	0.52	0.25	0.38

Source: Courcelle, C. (1997), Trenen-II interregional database, Antwerpen, SESO, 25 pp.

Finally, we need a measure for the value of travel time to calculate time costs. Values of travel timesavings were based on a study by the Hague Consulting Group[4]. Their value of time measure is based on both revealed and stated preference data.

On the one hand, respondents of the stated preference survey were asked twelve time-cost trade off questions, which were appropriate for the respondents' transport mode and journey distance (Gunn et al., 1997). On the other hand, the Hague Consulting Group used information on actual travel choices (car-train) from a large travel demand survey in order to validate the results of the stated preference analysis. For the estimation of the value of time, money and time budget constraints were taken into account as well as the characteristics of the journey itself (e.g. purpose of the journey). The value of timesavings for leisure journey trips in 1998 is 4.43 EURO per hour. As this value of time has been derived from specific surveys to derive values of transport time we prefer this estimate to the ad-hoc assumptions based on a proportional relation with the wage rate.

By summing up fuel costs and the monetary value of travel time, we get the total calculated cost measure:

$$\text{Total calculated costs(a)} = \text{fuel costs} + \text{travel time} * 4.43 \quad (4)$$

We can derive a similar cost measure by summing up total car usage costs and the monetary value of time:

$$\text{Total calculated costs(b)} = \text{total car usage costs} + \text{travel time} * 4.43 \quad (5)$$

Perceived travel costs and time

The survey form contained questions asking the respondent about his/her own idea of travel time and travel costs of a one-way trip to the forest.

The exact wording of the questions is as follows:

I.8 "How long did it take you to get to the forest (minutes, one-way)?"

I.9 "Do you have any idea of how much it costs you to get to the forest (BEF, one-way)?"

1 = yes ⇒ go to the next question

2 = no

[4] Source: Gunn, H., J.G. Tuinega, Y.H.F. Cheung and H.J. Kleijn (1997), Value of Dutch Travel Time Savings in 1997, Den Haag, Hague Consulting Group.

I.9a "How much do you think it costs you?"

Only half of the sample of respondents (50.5%) had an idea about the costs related to the trip to the forest. About 12% of the respondents included in our final sample said it did not cost them anything.

The questions about the visitors' perception of the cost of the trip are rather general. No questions were asked about which costs the visitors included when stating their costs.

Sample used in this paper

For reasons of comparability we use only those observations of respondents who came by car and who have an idea about the costs related to the trip to the forest. About 54.4% of all respondents came by car. For those respondents that drove to the forest, about 50.5% did have an idea about their costs. After excluding all respondents for whom the forest complex was not the only destination on their trip and after excluding the observations for which data were missing on crucial variables, 77 observations were left.

Table 2: Composition of the sample

	Absolute numbers	%
Total sample size[5]	408	100
Respondents coming by car	222	54.4
Those coming by car and answering they had an idea about their costs	112	27.5
Those coming by car, answering they had an idea about their costs and whose only destination on this trip is the forest	97	23.8
Final sample size, after excluding missings for relevant variables	77	18.9

3. DIFFERENCE BETWEEN PERCEIVED AND CALCULATED TRAVEL TIMES AND COSTS

Table 3 presents the descriptive statistics for different travel time and cost measures. The average one-way trip duration is 15 minutes according to the GIS calculations and 20 minutes according to the visitors' own perceptions. The difference is to a great extent due to rounding errors.

The relative difference between perceived and calculated time is calculated as follows:

$$Time\ difference = \frac{perceived\ time - calculated\ time}{calculated\ time} \quad (6)$$

Table 4 presents the significance tests of these differences. According to the non-parametric Mann-Whitney and Kruskall-Wallis tests, the difference between calculated and perceived time is indeed significant[6].

[5] Horseback riders were excluded from the sample since most of them have their horses in stables close the forest complex. Therefore, not all of their trip costs should be attributed to their visit the forest. Since it is not the goal of this paper to examine this specific aspect, horseback riders are excluded from the sample.
[6] Significance is given between brackets. A value of less than 0.05 implies that the distributions of the two variables/measures are significantly different.

As for travel costs, we compare the perceived costs and calculated costs (table 3). As it is sometimes argued that visitors perceive fuel costs as the only variable car costs of their trip, we make two comparisons. First we compare perceived costs to calculated fuel costs (as defined in table 1), next we compare perceived costs to total car usage costs (as defined in table 1).

Table 3: Descriptive statistics for some important variables

	Mean	**S.e. mean**	**Min.**	**Median**	**Max.**
Perceived time[1]	20.21	1.80	1.00	15.00	70.00
Calculated time[1]	15.39	1.55	0.95	12.17	59.28
Perceived costs[2]	4.08	0.40	0.00	3.12	9.92
Fuel costs[2]	0.61	0.08	0.01	0.40	3.93
Total car usage costs[2]	4.38	0.54	0.09	2.89	26.17
Total calculated costs: Fuel costs + time costs[2]	2.89	0.28	0.23	2.25	10.55
Total calculated costs: total car usage costs + time costs[2]	6.65	0.72	0.37	4.53	31.69
Fuel cost difference	11.96	2.69	-1.00	6.00	186.78
Total car usage cost difference	0.83	0.35	-1.00	0.05	23.22
Total calculated cost (a) difference	1.27	0.34	-1.00	0.36	17.72
Total calculated cost (b) difference	0.03	0.17	-1.00	-0.39	10.79
Time difference	1.40	0.30	-0.97	0.30	11.59

[1]one way, in minutes
[2]two way, in EURO

Average perceived costs are 4 EURO whereas average fuel costs and total calculated costs (a) are much lower (resp. 0.61 EURO and 2.89 EURO). Comparison of the medians and maxima tells the same story. Perceived costs seem to be closer to total calculated costs than to just fuel costs. This is confirmed by the results of the non-parametric tests presented in table 4. Perceived costs are significantly different from fuel costs but not form total calculated costs (a), i.e. the sum of fuel costs and time costs. The relative difference between the perceived costs on the one hand and the fuel costs or total calculated costs (a) on the other hand are rather large The relative difference is larger for fuel costs than for total calculated costs (table 3). Relative differences are calculated as follows:

$$Fuel\,cost\,difference = \frac{perceived\,costs - fuel\,costs}{fuel\,costs} \tag{7}$$

$$Total\,calculated\,cost\,difference(a) = \frac{perceived\,costs - total\,calculated\,costs(a)}{total\,calculated\,costs(a)} \tag{8}$$

When we compare the perceived costs to the total car usage costs and the total calculated costs (b), we see that the average total car usage costs are slightly higher and average total calculated costs (b) are much higher than average perceived costs. Non-parametric testing (table 4) shows that the distributions of perceived costs and total car usage costs are not significantly different. However, the difference between the distributions of perceived costs and total calculated costs (b) is statistically significant.

Relative differences are calculated as follows:

$$Total\ car\ usage\ cost\ difference = \frac{perceived\ costs - total\ car\ usage\ costs}{total\ car\ usage\ costs} \tag{9}$$

$$Total\ calculated\ cost\ difference(b) = \frac{perceived\ costs - total\ calculated\ costs(b)}{total\ calculated\ costs(b)} \tag{10}$$

The average relative difference is smaller for total car usage costs than for total calculated costs (b). Both these relative differences are smaller than those for fuel costs and total calculated costs (a).

Table 4: Non-parametric tests

	Calculated time	Fuel costs	Total car usage costs	Total calculated costs (a)	Total calculated costs (b)
Perceived time	-2.354[1] (0.019) 5.539[2] (0.019)				
Perceived costs		-7.269[1] (0.000) 52.836[2] (0.000)	-0.045[1] (0.964) 0.002[2] (0.964)	-1.711[1] (0.087) 2.927[2] (0.087)	-2.851[1] (0.004) 8.131[2] (0.087)

[1] Mann-Whitney U-test
[2] Kruskall-Wallis test
Significance between brackets[7]

So far we have shown that there are significant differences between perceived and calculated time, and between perceived costs on the one hand and fuel costs or total calculated costs on the other hand. But we would also like to get an explanation for this difference. The relative difference between perceived time and calculated time decreases with distance, which was to be expected since the effect of rounding becomes smaller when the distance and therefore the time travelled is larger. Moreover, the relative difference decreases with higher visit frequencies. Education level or social class did not have a statistically significant effect on the relative difference.

The relative difference between the perceived costs on the one hand and the fuel costs or total calculated costs (a) on the other hand are a decreasing function of distance. Moreover, the fuel cost difference is negatively related to visit frequency. Education level or social class did not seem to have a statistically significant effect on the relative difference.

The relative differences are a decreasing function of distance and visit frequency. Social class nor education levels had a significant effect on the relative differences. The regression results are presented in appendix I.

Based on the result that the respondents' own cost estimates are significantly different from the fuel costs and the total calculated costs (b), we expect that recreation benefit estimates based on perceived costs or on fuel costs or total calculated costs (b) are significantly different. There might not be a

[7] A value of less than 0.05 implies that the distributions of the two variables/measures are significantly different.

significant difference in consumer surplus measures based on perceived costs or total car usage costs or total calculated costs (a). However, one should keep in mind that only about 50% of all respondents have an idea about trip costs. In our analysis, no correction is made for the other 50% that have no idea about their costs[8].

4. WHAT DETERMINES PERCEIVED COSTS?

Total calculated costs are the sum of fuel costs or total car usage costs, i.e. the product of distance travelled and a cost per kilometre, and time costs, i.e. the product of time travelled and the value of time. Since the non-parametric tests showed that perceived costs are not significantly different form total car usage costs or total calculated costs (a), it is interesting to find out how the perceived costs are composed. Since the questionnaire did not include questions asking for the composition of perceived costs, we need to find out what costs respondents include when stating their perceived costs in order to compare the perceived costs with the corresponding calculated cost measure. We can assume that the most important factor is distance. The average distance travelled is rather low (11.6 km) and about 90% of the visitors live less than 30 km away from the forest. Table 5 gives the results of some simple linear regressions that were performed in order to explain perceived travel costs. The results in column 2 shows that distance is a significant factor in explaining travel costs but it only explains 14.7% of the perceived costs. According to this first regression, the cost per kilometre is about 0.0612 EURO, which is not significantly different from the calculated fuel cost per km (0.0524 EURO) but which is significantly lower than the total car usage cost per km (0.366 EURO)[9]. We find that fixed costs are an important component of the perceived travel costs.

Apart from costs related to distance, respondents' may also take into account the time travelled. Column 3 in table 5 gives the results for the OLS-regression of perceived costs including distance and perceived travel time. Both distance and perceived time have a positive significant effect on perceived costs. These two variables together explain 43.2% of perceived costs. Comparing the results in columns 3 and 4 shows that the regression of perceived costs including distance and GIS-calculated time performs much worse. The time and distance variables are not even significant and explain only 14.3% of the variance in perceived costs.

Finally, as this is also taken into account in the calculated costs, we include the number of persons in the group as an explanatory variable. The results are presented in column 5 of table 5. Together, distance, perceived time and the number persons in the group explain 53% of the variation in perceived costs. An extra kilometre increases costs by 0.03579 EURO; an extra minute increases costs by 0.07317 EURO (i.e. a value of time of approximately 4.4 EURO per hour) and each extra person in the party decreases costs by almost 0.67 EURO. These costs per kilometre and per minute are not

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[8] We are still trying to correct our estimation process of the trip demand equation by using the Heckman sample selection model. So far, we have not found a good specification of the selection equation. We will continue working on this problem.

[9] Significance was tested using 95% confidence intervals around the coefficient estimates.

significantly different from the fuel costs per km and the value of time measures that were used in the calculated cost measures (resp. 0.0612 EURO per km and 4.43 EURO per hour).

Although distance, perceived time and group size explain 53% of variation in perceived costs, we were unable to detect any other variables that contribute significantly to the explanation of the composition of perceived costs. Nor social class, education level, length of stay or general satisfaction with their visit had a significant effect on perceived costs.

Table 5: OLS-regression results for perceived costs (EURO)

	Perceived costs	**Perceived costs**	**Perceived costs**	**Perceived costs**
Cte	2.638[3]	0.719	2.492[3]	1.815[3]
	(4.948)	(1.347)	(4.414)	(3.267)
Distance	0.06123[3]	0.03505[2]	0.01960	0.03579[3]
	(3.749)	(2.508)	(0.362)	(2.815)
Perceived time		0.06274[3]		0.07317[3]
		(6.215)		(7.699)
Calculated time			0.03661	
			(0.807)	
# persons in the party				-0.670[3]
				(-4.052)
R^2adj.	0.147	0.432	0.143	0.530
N	77	77	77	77

[1] significant at 10% level
[2] significant at 5% level
[3] significant at 1% level
T-statistics between brackets

Based on the results of these simple regressions, we can conclude that people include both time and distance and also take into account the number of persons in their group when giving their own estimate of the costs of the trip. The cost per kilometre is much closer to our calculated fuel cost per km than to the total car usage cost per km. Moreover the implicit value of time in the perceived costs is close to estimates derived from Value of Time studies. Finally, according to the respondents, there is a significant fixed cost associated with their visit to the forest[10].

This result, together with the fact that perceived costs and total calculated costs (a) are not significantly different (see table 4), favours the use of just one combined travel cost variable instead of two separate variables for distance-related costs and travel time, a result that also follows from Becker (1965). Moreover, this approach was also recommended by Cesario (1976)[11] and Cesario and Knetsch (1976), because of the high correlation between costs and time.

[10] The relatively high constant in the regression is not only due to a high fixed cost involved in a forest visit but also to the fact that only 53% of the variation in perceived costs is explained by the variables included in the regression. If it would be possible to increase the explanatory power of the regression by including more relevant variables, the value of the constant might become smaller.

[11] Cesario (1976) adopts the “wage rate” approach to the evaluation of travel time.

5. ESTIMATION OF THE TRAVEL COST MODEL

Specification of the recreation demand function

One of the most important elements in a travel cost model is the specification of the recreation demand function which explains the visit frequency (for a given period of time, e.g. a year) of the visitors as a function of travel costs (monetary and time costs) and other explanatory variables such as site characteristics, prices of substitute sites and some socio-demographic variables (Freeman, 1993; Loomis and Walsh, 1997).

Our interest lies in the sensitivity of the consumer surplus and price elasticity of the demand for forest visits with respect to the specification of the travel cost variable. The analysis in section 3 has examined the differences between calculated and perceived costs. Therefore, five different recreation demand functions will be estimated: two including calculated monetary costs (either fuel costs or total car usage costs) and travel time as two separate variables, two including total calculated costs (i.e. the sum of monetary costs (either fuel costs or total car usage costs) and the monetary valuation of travel time) and a fifth demand function including the own perception of costs by the visitors. All other explanatory variables are the same for the three specifications:

HBMW	= a dummy indicating the part of the forest the respondent was interviewed at (1 = Heverleebos; 2 = Meerdaalwoud)[12]
SUBSTITUTE	= the two-way distance between the respondents' home address and Zoniënwoud[13] (as a measure of the implicit price of a trip to Zoniënwoud)
AGE	= the age of the respondent at the time he/she was interviewed.

Including a substitute price variable either yields a more elastic or a more inelastic demand curve, depending on the correlation between the travel costs related to a trip to the site in question and the travel costs to the substitute site. The sign of the correlation depends upon the spatial distribution of the population relative to the two sites (Freeman, 1993). As for the age-variable, former travel cost studies (e.g. Englin and Shonkwiler, 1995a) have found a positive relationship between age and visits to hiking trails.

An income variable was excluded due to the large non-response rate on the income question. One can expect that the omission of an income variable does not change the results significantly since several studies (Englin and Shonkwiler, 1995a; Desvousges, Smith and McGivney, 1983; et al.) have found a positive but insignificant income coefficient. Other variables that were rejected because they proved insignificant are gender, a variable describing the relief of the forest at the interview location,

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[12] The two parts of the forest complex differ in size, relief, characteristics of the paths, division coniferous-deciduous trees, etc.
[13] Zoniënwoud is the largest public forest in Flanders and was mentioned by the vast majority of the respondents as one of other forests that were most often visited.

dummies for the different professions of the respondents and dummies that indicate the different activities that the respondents were practising during their current forest visit.

We can expect a great similarity between the five recreation demand specifications since the only difference is the way the travel cost variable is measured.

Estimation technique

Due to the special nature of the dependent variable (number of visits in the past 12 months is a nonnegative integer variable), the recreation demand function is estimated using the negative binomial count data model. These count data models are estimated via maximum likelihood techniques (Hellerstein, 1992). The advantage of the negative binomial specification as compared to the linear specification is that it corrects for the nonnegative integer character of the dependent variable.

The maximum likelihood estimator of the negative binomial model is based on the negative binomial probability distribution (Grogger and Carson, 1991):

$$\Pr[y_i = j] = F_{nb} = \frac{\Gamma\left(j + \frac{1}{\alpha}\right)}{\Gamma(j+1)\Gamma\frac{1}{\alpha}} (\alpha\lambda_i)^j [1 - \alpha\lambda_i]^{-\left(j + \frac{1}{\alpha}\right)} \tag{11}$$

where $\alpha > 0$ is the overdispersion[14] parameter estimated together with the vector of unknown parameters and λ_i is the expected value of the dependent variable (y_i) given the value of the independent variables.

Since data were collected by surveying visitors of Heverleebos-Meerdaalwoud on-site, no observations were made for individuals making zero trips. This implies that the dependent variable in the travel cost model is truncated at zero, taking on only positive values. Not correcting for truncation leads to biased estimates of the parameters of the demand curve (Hellerstein, 1992).

The model for truncated counts based on the negative binomial probability distribution is specified as follows (Cameron and Trivedi, 1998):

$$\Pr[y_i = j | y_i > 0] = \frac{\Gamma\left(j + \frac{1}{\alpha}\right)}{\Gamma(j+1)\Gamma\frac{1}{\alpha}} (\alpha\lambda_i)^j [1 - \alpha\lambda_i]^{-\left(j + \frac{1}{\alpha}\right)} [1 - F_{nb}(0)]^{-1} \tag{12}$$

Due to the rather large average number of yearly visits of the respondents in the sample (60.45), a simple OLS model will give good results too. Hellerstein (1992) shows that, when the mean of a

[14] Overdispersion is a form of heteroskedasticity. There is overdispersion when the conditional variance is greater than the conditional mean, which is true for many datasets. The negative binomial count data model corrects for overdispersion. If the Poisson model would be used in the presence of overdispersion, the mean would still be consistently estimated but the standard errors of the estimated coefficients would be biased downwards (Cameron and Trivedi, 1998)

variable is larger than 10, the distribution of this variable shows great similarity with a normal distribution. Consequently, using count data models does not significantly improve regression results.

Statistical tests indicated that the natural log of visits fits the data best. Moreover, the negative binomial models imply a functional form with a semi-log of the dependent variable. Therefore, we also estimate a semi-log demand function.

Regression results

The estimation results are presented in tables 6a, 6b and 6c. For each of the five different specifications of the travel cost variable, we estimate the semi-log, negative binomial and truncated negative binomial models.

Based on the log-likelihood values, the semi-log fits best followed by the truncated negative binomial and the negative binomial models. This result confirms the result found by Hellerstein (1992). The overdispersion parameter is significant in all but one case (truncated negative binomial model, total calculated costs (b)), which implies that the negative binomial count data models are more appropriate than the Poisson count data models (the latter are not estimated here). The good performance of the semi-log can be explained by the large average number of yearly visits of the respondents in the sample. Truncation does not seem to be too important since the log-likelihood value of the truncated model is only slightly smaller than that of the standard negative binomial model.

Before giving a detailed explanation and interpretation of the effect of the different travel cost variable specifications, we start with a discussion of the other explanatory variables.

The age of the visitor has no significant influence on trip demand. However, we decided to include this socio-demographic variable as it performed slightly better than other socio-demographic variables such as education level, gender and social class.

The distance from the respondent's home address to Zoniënwoud has a significantly negative effect on trip demand for Heverleebos-Meerdaalwoud (except when perceived costs are included as cost variable). Normally, one would expect a positive sign for the coefficient of the substitute variable since one expects that people make more trips to Heverleebos-Meerdaalwoud when they live further away from Zoniënwoud, the substitute site. A negative sign suggests that the two forests (Heverleebos-Meerdaalwoud on the one hand, Zoniënwoud on the other hand) are complements rather than substitutes. Besides, the correlation between the two-way distance to Heverleebos-Meerdaalwoud and the two-way distance to Zoniënwoud is positive which implies that the population is arrayed along a line that is perpendicular to the line connecting the two sites (Freeman, 1993). The further away people live from Zoniënwoud, the further away they also live from Heverleebos-Meerdaalwoud and the smaller the number of yearly visits to Heverleebos-Meerdaalwoud.

The variable indicating the part of the forest where the respondent was interviewed is significant and negative in all cases. Meerdaalwoud seems to be the less popular part of the forest.

Table 6a: Regression results of the trip demand equation (semi-log functional form)

	Perceived costs	Fuel costs	Total car usage costs	Total calculated costs (a)[15]	Total calculated costs (b)[16]
Cte	4.310736530[3]	4.889535124[3]	4.883092639[3]	4.81836[3]	4.687129433[3]
	(4.448)	(4.588)	(4.582)	(4.55848)	(4.419)
Monetary cost		0.1133448462	0.01221610097		
		(0.297)	(0.226)		
Time		-0.0161846897[1]	-0.01576759207		
		(-1.707)	(-1.644)		
Total cost	-0.2123577496[3]			-0.147076[1]	-0.04698134579
	(-4.047)			(-1.93938)	(-1.555)
HBMW	-0.8368371965[2]	-0.8937019742[2]	-0.8903526027[2]	-0.877134[2]	-0.8907404838[2]
	(-2.330)	(-2.283)	(-2.276)	(-2.25321)	(-2.266)
Substitute	-0.00828792182	-0.0144513615[2]	-0.0144876119[2]	-0.0150914[2]	-0.0159136807[2]
	(-1.363)	(-2.276)	(-2.276)	(-2.4106)	(-2.524)
Age	0.02693393384	0.01354904482	0.01371741920	0.0155563	0.01777075711
	(1.854)	(0.856)	(0.866)	1.0036	(1.138)
Log-L	-138.2343	-143.9039	-143.9241	-144.1654	-144.8543
N	77	77	77	77	77

[1] significant at 10% level
[2] significant at 5% level
[3] significant at 1% level
T-statistics between brackets

Table 6b: Regression results for the trip demand equation (Negative binomial functional form)

	Perceived costs	Fuel costs	Total car usage costs	Total calculated costs (a)	Total calculated costs (b)
Cte	6.137342800[3]	6.488391624[3]	6.491784056[3]	6.506377994[3]	6.482365946[3]
	(6.872)	(8.091)	(8.108)	(8.195)	(7.576)
Monetary cost		-0.00643598298	-0.00324230699		
		(-0.013)	(-0.47)		
Time		-0.0202751681[1]	-0.0200175429[1]		
		(-1.787)	(-1.741)		
Total cost	-0.2091124088[3]			-0.2190049494[2]	-0.0682636766[2]
	(-3.084)			(-2.558)	(-1.959)
HBMW	-1.186316387[3]	-1.106206870[3]	-1.107413748[3]	-1.116646351[3]	-1.185210770[3]
	(4.228)	(-3.406)	(-3.399)	(-3.457)	(-3.677)
Substitute	-0.01105046891	-0.0167829039[1]	-0.0168103425[1]	-0.0173635076[1]	-0.0191873083[2]
	(-1.796)	(-1.887)	(-1.891)	(-1.932)	(-2.097)
Age	0.01935457822	0.01275318125	0.01281350566	0.01379552351	0.0159965979
	(1.296)	(0.841)	(0.844)	(0.903)	(1.031)
α	1.371584018[3]	1.474798231[3]	1.474827829[3]	1.481536017[3]	1.523212664[3]
	(5.163)	4.710)	(4.689)	(4.746)	(4.634)
Log-L	-354.1088	-357.7662	-357.7644	-357.9551	-359.3162
N	77	77	77	77	77

[1] significant at 10% level
[2] significant at 5% level
[3] significant at 1% level
T-statistics between brackets

[15] Total calculated costs (a) are defined as the sum of fuel costs and the monetary value of travel time.
[16] Total calculated costs (b) are defined as the sum of total car usage costs and the monetary value of travel time.

Table 6c: Regression results for the trip demand equation (truncated negative binomial functional form)

	Perceived costs	Fuel costs	Total car usage costs	Total calculated costs (a)	Total calculated costs (b)
Cte	6.732676295[3] (5.008)	6.687108440[3] (5.890)	6.689770568[3] (5.944)	6.721095437[3] (6.072)	6.908659921[3] (5.752)
Monetary cost		-0.1552160518 (-0.232)	-0.01927977239 (-0.208)		
Time		-0.0249048524[1] (-1.853)	-0.0251180546[1] (-1.906)		
Total cost	-0.2593436512[3] (-2.594)			-0.3028925124[3] (-2.732)	-0.1017493828[1] (-1.853)
HBMW	-1.334869659[3] (-3.015)	-1.104141919[2] (-2.141)	-1.109738284[2] (-2.144)	-1.108800044[2] (-2.153)	-1.230562738[2] (-2.333)
Substitute	-0.0246862456[3] (-2.594)	-0.0313110775[3] (-2.556)	-0.0312498709[3] (-2.562)	-0.0319098977[3] (-2.642)	-0.0365175978[3] (-2.587)
Age	0.02302162779 (0.961)	0.021627870 (0.865)	0.0215722484 (0.853)	0.02204039283 (0.880)	0.02287138903 (0.875)
α	3.731503211[2] (2.008)	4.329640109[1] (1.646)	4.326431148[1] (1.634)	4.413275275[1] (1.658)	5.126419147 (1.442)
Log-L	-326.7241	-328.7111	-328.7191	-328.7454	-329.6977
N	77	77	77	77	77

[1] significant at 10% level
[2] significant at 5% level
[3] significant at 1% level
T-statistics between brackets

The variables we are most interested in are the different travel cost variables. These are discussed in the following paragraphs.

Case 1: Visitors' perceived cost variable

Although the calculated costs based on GIS calculation of distance and costs are more accurate since they are not subject to rounding errors, it is interesting to also estimate the recreation demand function using visitors' own perception of their trip costs. After all, when deciding whether or not to visit the forest, people have no information on the objectively calculated costs associated with the trip to the forest. They base their decision on their own ex-ante perception of costs.

The perceived cost variable is for the three econometric models negative and highly significant (columns 2 of tables 6a, b and c). Apart from the dummy variable HBMW it is the only variable that has a significant effect on recreation demand in all estimated models.

Case 2: Fuel costs and travel time as two separate variables

Results are presented in columns 3 of tables 6a, b and c. The sign of the fuel cost variable is negative only for the truncated negative binomial model. However, this monetary cost variable has no significant effect on trip demand. The second cost-related variable is travel time. This variable has the expected negative sign for all three functional forms and is significant for all functional forms. Due to the relative short travel distance (75% of the respondents in the sample live less than 15 km away from the forest), it could be expected that time was a more important factor in determining the visit frequency than just fuel costs.

Case 3: Total car usage costs and travel time as two separate variables

As shown in columns 4 of tables 6a, b and c, the monetary part of travel costs (total car usage costs) has no significant influence on trip demand. Travel time is negative and significant in both negative binomial models. The explanation of these results is similar to that given for case 1.

Case 4: Total calculated costs (a) as one single variable

The insignificance of the key variable in the travel cost model with two separate travel cost variables and the composition of the perceived cost variable favours the use of one single travel cost variable combining both fuel costs and the monetary valuation of travel time. Columns 5 of tables 6a, b and c present the regression results for the different econometric specifications of the recreation demand function with calculated costs (a) specified as one single variable.

The total calculated cost (a) variable is negative and significant for all three functional forms.

Case 5: Total calculated costs (b) as one single variable

Results are presented in columns 6 of tables 6a, b and c and are similar to the results for case 3. The total calculated cost variable defined as the sum of total car usage costs and time costs, have a negative and significant effect on trip demand for both negative binomial models.

Conclusion

Comparing the log-likelihood values of the five trip demand equations with the different cost specifications for each of the functional forms using the simple likelihood ratio test (Greene, 1993) shows no significant difference in overall performance of the five trip demand equations with the different cost specifications. Using 95% confidence intervals, only the coefficient on 'total cost' in the trip demand equation using the total calculated costs (a) is not significantly different from the coefficient on total cost in the trip demand equation using perceived costs. This is true for the three functional forms.

6. SENSITIVITY ANALYSIS OF COEFFICIENTS, ELASTICITIES AND CONSUMER SURPLUS ESTIMATES

Table 7 gives the consumer surplus per person per trip and the travel cost elasticity estimates based on the recreation demand models with total calculated costs (a and b) and perceived costs. Since the fuel cost and total car usage cost variables when included separately are statistically insignificant and since therefore the resulting demand curve is perfectly inelastic, the consumer surplus cannot be computed.

Consumer surplus estimates for trip demand specification (negative binomial functional form) using perceived and total calculated costs (b) are statistically different, but this is not true for the semi-log and truncated negative binomial functional forms[17]. This result also holds for the travel cost elasticity of recreation demand.

Table 7: Consumer surplus and elasticity estimates

	Consumer Surplus (EURO)			Elasticity		
	Perceived costs	Total calc. costs (a)	Total calc. costs (b)	Perceived costs	Total calc. costs (a)	Total calc. costs (b)
Semi-log	4.709	6.799	/	-0.130	-0.425	0.000
Negative Binomial	4.782	4.566	14.649	-0.128	-0.632	-0.454
Truncated Negative Binomial	3.856	3.302	9.828	-0.159	-0.875	-0.677

These results were to be expected as the analysis in sections 3 and 4 showed the similarity between perceived costs and total calculated costs (a).

6. CONCLUSION

In this paper we have used results of an on-site survey for visits to a public forest in Belgium to compare calculated and perceived travel costs and times. Although all respondents were able to state their trip duration, only 50% of the respondents in our sample had an idea about trip costs. Of those respondents who had an idea of the costs of the trip to the forest, about 12% said the trip was costless. Non-parametric testing showed a significant difference between perceived and calculated time measures. Concerning monetary travel costs, perceived costs were significantly different from fuel costs. Comparison of perceived costs with the sum of monetary and time costs showed a significant difference between perceived costs and the sum of total car usage costs and time costs.

The relative difference between perceived and calculated time and cost measures is negatively related to distance and in most cases to visit frequency as well. Furthermore, we have shown that perceived costs are best explained by distance, time and group size and that there seems to be a rather large fixed cost associated with a trip to the forest. Perceived costs per kilometre and value of time are close to resp. fuel costs per kilometre and value of time used in our calculated cost measures.

Based on the log-likelihood values of the estimation of the different trip demand equations we can conclude that there are no significant differences in model performance as far as cost specifications are concerned. Comparing cost coefficients and consequently consumer surplus estimates showed that only for the negative binomial functional form there is a statistically significant difference between perceived costs on the one hand and total calculated cost (b) on the other hand.

This is a first attempt to understand better the difference between perceived and computed travel costs. For trips of short distance such as found in our data set, it appears that either perceived or calculated

[17] We use 95% confidence intervals. See also appendix II.

travel costs yield approximately similar estimates of recreation benefits. However, the robustness of this result will need to be verified using other data sets where the recreation site is at greater distances more typical of TCM recreation demand analysis before our results can be generalised. Other important issues to be explored further are the high non-response rate and the zero cost responses on the perceived cost question.

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APPENDIX I: EXPLANATION OF THE RELATIVE DIFFERENCES BETWEEN PERCEIVED AND CALCULATED TIME AND COST MEASURES

	Time difference	Fuel cost difference	Total car usage cost difference	Total calculated cost (a) difference	Total calculated cost (b) difference
Cte	3.288[3]	22.488[3]	2.294[3]	2.670[3]	0.758[2]
	(7.286)	(4.954)	(3.860)	(4.756)	(2.607)
Distance	-0.05895[3]	-0.300[2]	-0.04194[3]	-0.04722[3]	-0.02231[3]
	(-4.988)	(-2.523)	(-2.695)	(-3.212)	(-2.931)
Visits	-0.008206[3]	-0.0567[1]	-0.007778[2]	-0.004646	-0.003315[2]
	(-2.768)	(-1.902)	(-1.993)	(-1.260)	(-1.736)
R^2adj.	0.248	0.073	0.084	0.101	0.091
N	77	77	77	77	77

[1] significant at 10% level
[2] significant at 5% level
[3] significant at 1% level
T-statistics between brackets

APPENDIX II: 95%-CONFIDENCE INTERVALS FOR THE ESTIMATED CONSUMER SURPLUS

	Perceived costs		Total calculated costs (a)		Total calculated costs (b)	
	Lower bound	Upper bound	Lower bound	Upper bound	Lower bound	Upper bound
Semi-log	3.173	9.131	3.378	530.786	/	/
Negative Binomial	2.924	13.118	2.585	19.540	7.276	1105.758
Negative Binomial	2.196	15.772	1.922	11.680	4.776	170.379

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