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Choosing carpooling or carsharing as a mode: Swiss stated choice experiments

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ABSTRACT

A recent study aimed to estimate the potential of carpooling in Switzerland. Part of this study was a survey in which the attitude of the public towards this transport option was investigated using both multi-response questions and stated preference (SP) experiments. In order to gain an insight on how innovative modes are perceived in general, the SP part was composed of two different experiments, one of them including carsharing as alternative. In the first experiment respondents were choosing among car, public transport, carpooling as driver and carpooling as passenger. In the second experiment respondents were choosing among car, public transport and carsharing. This paper reports on the multinomial logit choice models, which were estimated based on participants' responses. Both SP experiments were based on a trip reported by participants during a phone interview. For each experiment two specifications, a linear and a nonlinear one were estimated. The nonlinear specification allows investigating the impact of selected socio-demographic variables, in this case income and travel time, on the parameters of the models and on willingness to pay indicators. Such indicators permit to complement the qualitative discussion of the results with quantitative analyses and provide a useful background for policy evaluation and planning.

INTRODUCTION

This paper reports on a recent study aimed to assess carpooling potential in Switzerland. This study has bin commissioned by the Swiss national authority for roads ASTRA and conduced in collaboration with the software firm PTV Swiss, which developed one of the active Swiss carpooling platforms (*1*).

Formal carpooling is defined as two or more persons, not belonging to the same household, sharing a trip, or a part of it, with the passengers contributing to the driver's expenses. Although several web-based carpooling platforms – that is, platforms where potential drivers and passengers can find potential trip-mates – are active in Switzerland, there is a knowledge gap about carpooling customers, actual and potential, regarding their preferences and motivations to participate in carpooling. A specific nationwide statistic of carpooling usage is not available, but for the Zurich region, the largest Swiss metro area, a previous study (*2*) assessed that about 2% above 15 years of age uses carpooling every day, and another 16% uses carpooling 2 to 5 times a week. It is not specified if they carpool with a member of the household or not.

Part of this study was a survey in which the attitude of the public towards this transport option was investigated using both multi-response questions and stated preference (SP) experiments. In order to have a hint on how innovative modes are perceived in general, the SP part included an experiment focused on carsharing. In the first experiment respondents choose among car, public transport, carpooling as driver and carpooling as passenger. In the second experiment respondents choose among car, public transport and carsharing. This paper reports on these two experiments and on the discrete choice models, which were estimated based on responses. Discrete choice modeling is based on random utility theory and models choices made among a finite set of alternatives (*3*). The advantage of this modeling approach, widely used in various fields, is that preferences of persons can be quantitatively inferred based on data describing actual choices (revealed preferences or RP) or fictive choices (stated preference or SP). In transport planning, their most common use is probably the modeling of modal choices. However, studies using this technique for the modeling of choice situations including carpooling are sparse in the literature – some examples are (*4, 5, 6, 7, 8*) – and are mainly focused on the effect of congestion-pricing and HOV lanes on carpooling behavior or on methodological issues. On the carsharing side literature on the subject is even more limited. In (*7*), for example, a discrete choice model is used to understand preferences of potential carsharing users, but no modal choice is involved. None of the previous studies was focused on the Swiss context, which is the one investigated in this paper. The main goal of this paper is to provide an insight on individuals' preferences in a way that might be directly used to estimate the market share of carpooling. The results will be also the basis for further work in the modeling of carpooling and carsharing. Finally, this paper is written also in the hope that other researchers will be encouraged in using discrete choice modeling in the field of innovative modes of transport. A large corpus of research of this type would enhance the discussion among researchers of the field and would be beneficial for a deeper understanding of the potential of such modes in different contexts and countries.

The remainder of this paper is organized in three sections. Section two describes the whole data collection process. It involved the recruitment of participants and the design of the experiments. The section provides also information about the response rate and shows a summary of the most important sample's statistics. Section three is about the formulation and the estimation of the discrete choice models. The results for the two experiments and their discussion are also included in this Section. The fourth and last Section offers a summary of the work, some conclusions and an outlook on future work.

DATA COLLECTION

The participants were recruited among respondents of a year-round continuously going survey commissioned by Swiss Federal Railways, known as KEP (Continuous Survey of Passengers, *9*). This is a computer-assisted phone survey, in which approximately 400 persons per week are interviewed. All trips exceeding 3 km length made by the respondent in the week previous to the interview are recorded with their attributes such as origin, destination, travel and waiting times, etc. Eligible for our study were all interviewees owning a driving license and with at least one reported trip above 10 km length. The minimum length criterion was introduced assuming that persons with a longer trip are more likely to consider carpooling as an option. Those accepting to participate in the study were asked the following additional questions:

- Exact origin and destination addresses of one of the trips longer than 10 km
- If the person carpooled on a regular basis in the last year
- Membership in a carsharing program
- Use of carsharing in the last year
- Original cost of the car (cost as new, if owns a car)
- Fuel consumption of the respondent's car (if any)

This additional information was used together with the information collected in the survey as a basis for the construction of personalized, realistic, mode choice experiments. The recruitment took place in two tranches, between August 23 and October 25 2010 and between January 1 and April 18 2011. More than 2,000 potential participants were recruited, but some of them, for various reasons, were excluded from the sample. The final sample's size of the SP experiment was 1,683 persons.

Experiments' design

The idea of reproducing realistic situations in SP experiments, based on revealed data, is not new – see for example (*10*) and (*11*) – and, indeed, was the standard approach for other Swiss studies (*12, 13*). For this study, for each participant, information about more than one trip was available, but one reference trip was chosen through the aforementioned additional questions. The attributes of the alternatives presented to this person in the SP experiments were derived from this particular trip. For the mode car the attributes were calculated using the agent-based travel demand and traffic flow simulation MATSim (www.MATSIM.org), which calculates distances on a high definition network and travel time is time-of-day dependent, reflecting congestion. The cost was calculated according to reported consumption of the car or taken as 10 km/liter if no information was available. The cost for parking, which is also accounted for, was taken as the price for two hours in non-central area of the city of Zurich. For the public transport alternative, attributes were calculated using a specifically programmed script which accesses the Swiss Federal Railway Internet timetable. For the other modes more details are later in this section. In an SP experiment each respondent receives multiple situations and chooses from a given set of alternatives. The values of alternatives' attributes in the situations are a variation of the values calculated based on the reference trip. The magnitude of these variations has a given range, which may depend or not on specific assumptions of how some of the alternative attributes could vary in the future. The use of different levels for the attributes in the different situations is necessary capturing respondents trade-offs among alternatives. The design for the experiments – how the attribute values are combined for the alternatives in each choice situation – was determined with the software Ngene (*14*).

Experiment 1: Carpooling

In the first SP experiment four alternatives were considered: car, public transport, carpooling as driver and car pooling as passenger. Each respondent received eight situations and was invited to choose the preferred alternative. The respondent's burden of having to choose among four alternatives in each situation was a concern. For this reason respondents were randomly assigned to one of three groups, each of them corresponding to a combination of three of the four modes listed above. By limiting the burden on the respondents, this strategy keeps the response rate high. The large sample guarantees the statistical significance of the results despite each alternative mode being evaluated in a smaller number of cases. The three combinations proposed were:

- Car – Public Transport – Carpooling as driver
- Car – Public Transport – Carpooling as passenger
- Car – Carpooling as driver – Carpooling as passenger

Some of the assumptions underlying the SP experiment reflect the answers of 30 employees of firms interested in carpooling, interviewed in a sort of pre-survey. For example it was assumed that gasoline cost would be simply split between driver and passenger (50% each), since about 70% of the respondents of that pre-survey indicated the cost of gasoline as the right basis for splitting car costs among carpooling participants. Travel distance was considered the same as for the mode car while travel time was increased by five minutes – perceived by most of the respondents as the maximum acceptable deviation – to take into account waiting times at the meeting point. Parking for the driver was as for the mode car. It was also considered that a few times per year driver and passenger would miss each other and thus need to reorganize the trip. The ranges of attributes for this experiment are shown in Table 1. Ranges need to be large enough to induce behavioral changes. No assumptions on future developments of prices or travel times were made.

Alternative	Attribute	Reference	Variations		
Private Car	Cost (Gasoline)	*	-10%	10%	50%
	Parking	4	-20%	20%	50%
	Travel Time (In Vehicle)	*	-20%	0	20%
	Walking Time	5	-100%	0	100%
Public Transport	Cost (Ticket)	*	-20%	0	50%
	Travel Time (In Vehicle)	*	-20%	0	20%
	Transfers	1	-1	0	+1
	Walking Time	5	-20%	0	20%
	Waiting Time	7	-30%	-10%	20%
Car Pooling as Passenger	Cost (Participation)	½ car cost	-10%	10%	50%
	Travel Time (In Vehicle)	Car + 5 min.	-20%	0	20%
	Walking Time	5	-100%	0	100%
	Type of Passenger	Aquaintance	Unknown	Aquaintance	Colleague
	Risk of missing the lift	1 in 4 Months	-50%	0	50%
Car Pooling as Driver	Cost (Gasoline)	½ car cost	-10%	10%	50%
	Parking	4	-20%	20%	50%
	Travel Time (In Vehicle)	Car + 5 min.	-20%	0	20%
	Walking Time	5	-100%	0	100%
	Type of Passenger	Aquaintance	Unknown	Aquaintance	Colleague
	Risk of missing the passenger	1 in 4 Months	-50%	0	50%

TABLE 1: Variables used for the construction of SP experiments and respective variations. Variables with the sign * in the "reference" column are specifically calculated for each respondent as reported in the text.

Experiment 2: Carsharing

In the second SP experiment the alternatives were car, public transport and carsharing. All respondents received six choice situations. The cost of carsharing travel was an issue. The norm in SP experiments if car and public transport are among the modal options is to consider, respectively, the cost of the ticket and the cost of the gasoline. The parking cost can be eventually added. In the case of carsharing the usage fee covers other costs which are not usually taken into account in such experiments, nor generally by the driver a of a private car as cost of a particular trip; car insurance and amortization costs are the most important. For that reason, in the second SP experiment total kilometer costs were used; calculated using appropriate tables available on the web page of a Swiss automobile club (*15*). In order to have personalized costs, twelve different categories were considered according to the type of car (using price as proxy, with four levels) and to the yearly mileage (with three levels). Consumption, as in the previous exercise, was the one declared by the respondent. The cost for carsharing was calculated using the current prices of the Swiss operator Mobility (*16*). The carsharing car was, as far as possible, of a similar category as the respondent's own car. Another issue was how to take into account the time related part of the carsharing fee.

Carsharing users, in general, pay a fee, which is the sum of a distance dependent fee and a time dependent fee. The latter broadly depend on the duration of the round-trip tour; at least in the case of carsharing systems like Mobility not allowing one-way rentals. Ideally, one would compare tours and not trips; however, since it was not possible to have the precise information needed for the whole tour, the experiment is made at the trip level. Resulting trade offs will be more favorable to carsharing than they would be otherwise, and the resulting models might tend to overestimate carsharing usage. The ranges for the second experiment are reported in Table 2.

Alternative	Attribute	Reference	Variations		
Private Car	Cost (Gasoline)	*	-10%	10%	50%
	Parking	4	-20%	20%	50%
	Travel Time (In Vehicle)	*	-20%	0	20%
	Walking Time	5	-100%	0	100%
Public Transport	Cost (Ticket)	*	-20%	0	50%
	Travel Time (In Vehicle)	*	-20%	0	20%
	Transfers	1	-1	0	+1
	Walking Time	5	-20%	0	20%
	Waiting Time	7	-30%	-10%	20%
Car Sharing	Cost	*	-20%	10%	30%
	Parking	4	-20%	20%	50%
	Travel Time (In Vehicle)	*	-20%	0	20%
	Walking Time	5	-100%	0	100%
	PT time	3	-100%	0	100%

TABLE 2: Variables used for the construction of the second SP experiments and respective variations. Variables with the sign * in the "reference" column are specifically calculated for each respondent as reported in the text.

Response Rate

Despite being the questionnaire long and complex – the total length was 27 pages, the SP experiments accounted for 15 pages, the multi-response questions, on which this paper does not report, accounted for the rest – the overall response rate was 51% (876 respondents), higher than the expected rate given the a-priori assessed response burden calculated as described in Axhausen and Weis (*17*).

Non-traders

Non-traders are a problem of SP surveys. Non-traders are those respondents, who always pick the same alternative ignoring the different attributes' levels among the sketched situations. A possible interpretation is that some respondents, not particularly motivated but committed to complete the questionnaire, pick one alternative in the first situation and choose the same in all the others. According to this, non-traders' answers should be removed from the sample. In some cases, however, a non-trading behavior might simply reflect reallife situations. For example, one might want to use the car, disregarding an apparently more convenient option, because one must bring the children to school; the other might prefer public transport because has already bought an annual season ticket, and so on. In such cases non-traders behavior reflects a decision on the strategic level and must be taken into account. Therefore, all cases have been used for the analysis and the mode chosen in the reference case has been used as an inertia indicator.

Sample Summary Statistics

A comparison among the respondents, the recruited participants and the population in the 2005 Swiss National Travel Diary Survey (SNTDS, *18*) on some key socio-demographic variables (Table 3), allows for a qualitative evaluation of the representativeness of the sample.

		Respondents	Recruited	SNTD 2005 With driving licence
Gender	Male	55.0	56.4	50.0
	Female	45.0	43.6	50.0
Age	18-35	15.9	19.6	25.3
	35-50	39.9	38.4	32.4
	51-65	30.2	29.8	26.7
	> 65	14.0	12.2	15.9
Education	Compulsory Education or less	5.6	7.0	11.2
	Professional School	48.6	48.6	61.7
	College/University	44.5	44.5	27.1
Cars in the Household	0	4.0	4.5	9.1
	1	47.4	47.3	55.3
	2	39.7	38.5	28.9
	>2	8.9	9.7	6.7
Persons in the Household	1	10.6	10.8	27.7
	2	41.0	37.6	36.0
	3	15.4	17.0	11.7
	4	23.4	24.9	17.6
	> 4	9.6	9.7	7.0
PT Season Ticket	None	44.6	46.5	56.4
	Half Fare	40.9	39.8	30.3
	GA	10.8	9.9	5.8
	Other Discount Card	3.7	3.7	7.4
Income	< 2,000	3.6		2.7
	2,001 – 4,000	7.5		15.7
	4,001-6,000	22.1		27.6
	6,001 – 8,000	21.3		22.2
	8,001 – 10,000	16.1		14.3
	10,001 – 12,000	12.7		7.8
	12,001 – 14,000	5.3		4.1
	14,001 – 16,000	3.7		2.2
	> 16,000	7.6		3.3

TABLE 3: Summary of some key statistics. All values are expressed as percent.

The figures for respondents and recruited individuals are compared with all respondents of the Swiss mobility census owning a driving license, since one precondition for the recruitment was driving license ownership. Comparing between recruited (those to who the questionnaires were sent) and respondents (those who returned the questionnaire at least partly filled) shows if the response rate depended on some particular socio-demographic attribute. This was not the case, since the figures are fairly similar for almost all the variables considered. The comparison with the SNTDS shows if the sample used is representative for the part of the Swiss population (adults with a driving license) which the study targeted. Moreover, it gives an idea which categories of individuals were more motivated to participate (and respond) to the study. Observing the table some noticeable facts are:

- Male were more likely to participate
- Younger individuals (18-35) were less likely to participate
- Wealthier people were more likely to participate
- Participants belong to comparatively large families
- Participants live in households with comparatively many cars
- Participants are above-average public transport discount cards owners

The higher share of male participants is typical of Swiss SP surveys. Wealthier and better educated individuals and public transport users are usually keener to participate in such studies. Apparently, such categories of people are more interested in, but also have a higher awareness of, transport related subjects. Finally, non-traders were 27% of the respondents for the carpooling experiment and about 30% for the carsharing one, fairly low numbers compared to those of similar studies.

ESTIMATION OF DISCRETE CHOICE MODELS

Estimation of the models

The models were estimated using the software Biogeme (*20, 21*), which estimates the parameters of various discrete choice models, including logit models, that were the modeling form chosen in this study. Logit models have the advantage of being relatively simple and easy to implement; a possible risk is to have biased parameters if not all relevant variables are included in the model. Starting the estimation process with very simple models and adding new variables one by one allows to better understand their impact on the overall model fit. As a guideline, variables were retained in the model if the correspondent parameter estimate had the expected sign, even if not highly significant; and were discarded, if the sign was not as expected and the parameter estimate was not significant. The critical case, in which the sign is different from expectation and the parameter estimate is significant, did not occur. The fact that, from a given point on, parameters were stable, suggests the all most relevant variables are in the model. An attempt was also made to estimate separate models for different purposes; a strategy used in some previous studies (*13, 22*) that sometimes increases the fit of the model and the reliability of the estimates. However the purpose specific sub-models did not give, in any respect, better results than the global models. Similarly, an attempt to use nested logit instead of multinomial logit didn't provide any significant improvement.

Continuous Interactions

The present work employs continuous interactions between tastes and socio-demographic attributes, namely trip distance and income. This formulation, originally introduced by (*23*) and already previously used in Swiss studies (*12, 21, 24*), is alternative to the use of arbitrary segmentations into different income and distance classes. The interactions are formulated as follows:

$$(1)\quad f(y,x) = \beta_x (y/y^*)^{\lambda(y,x)}\, x,$$

where y is the observed value for a given socio-demographic variable, and y* is a reference value, usually the mean value across a sample population. The sensitivity to an attribute x is composed by the parameter β_x and a multiplier, which varies with y. The estimate of $\lambda_{y,x}$ represents the elasticity of the sensitivity to x with respect to changes in y. If $\lambda_{y,x}$ has a negative value, the (absolute) sensitivity decreases with increases in y, with the opposite applying in the case of positive values for $\lambda_{y,x}$. Finally, the rate of the interaction is determined by the absolute value of $\lambda_{y,x}$, where a value of 0 indicates a lack of interaction.

Estimation Results

For each SP experiment two different specifications of the models are presented, the linear and the nonlinear, and the estimates of the parameters are shown and discussed. Also some willingness to pay (WTP) indicators are presented and commented. Finally, the impact of nonlinear terms on WTP indicators is discussed with the help of the relevant plots.

Carpooling Experiment

In the first experiment the alternatives are: car, public transport, carpooling (driver) and carpooling (passenger). The majority of estimated parameters are mode-specific, with a few exceptions for some attributes, common to both carpooling modes that have a single estimate. The estimation for the final models, linear and nonlinear, are summarized in Table 4.

		Linear Model			Elasticity Model	
	Observations: 5885	**Adj. ρ^2:** 0.221			**Adj. ρ^2:** 0.222	
Alternative	**Utility parameters Name**	**Value**	**p-value**		**Value**	**p-value**
All	**Travel cost**	-0.0569	0		-0.0502	0
	Elasticity Distance	-	-		-0.179	0
	Elasticity Income	-	-		*-0.162	0.27
	Walking time	-0.0438	0		-0.044	0
PT	**Constant**	-6.54	0		-6.7	0
	Travel time	-0.00774	0		-0.0111	0
	Transfers Time	-0.0799	0		-0.0674	0
	Transfers (n)	-0.104	0.03		-0.0961	0.04
	Season Ticket	0.987	0		0.975	0
	Log(Age)	1.36	0		1.35	0
	Inertia	2.07	0		2.1	0
Car	**Constant**	*-0.335	0.23		*-0.423	0.14
	Travel time	-0.03	0		-0.0343	0
	Parking cost	-0.065	0.04		-0.0654	0.04
	Male	0.652	0		0.654	0
	Car always available	0.401	0		0.41	0
	Inertia	0.767	0		0.746	0
CPD	**Constant**	*0.23	0.3		*0.217	0.35
	Travel time	-0.0348	0		-0.0394	0
	Parking cost	-0.154	0		-0.163	0
CPP	**Travel time**	-0.0379	0		-0.0446	0
CP	**Previous Experience CP**	*0.104	0.24		*0.102	0.25
	Female	-0.639	0		-0.638	0
	German Speaking	0.167	0.02		0.163	0.03
	Household Dimension	0.089	0		0.0881	0
	Work trip	*0.0553	0.42		*0.0691	0.32
	Positive opinion on CP	0.981	0		0.978	0
	Higher education	*0.101	0.13		*0.101	0.13
	Trip mate Acquaintance	0.268	0		0.275	0
	Trip mate Colleague	0.296	0		0.288	0
	No show risk	-0.0487	0		-0.048	0.01
	Ready to participate	0.371	0		0.376	0

TABLE 4: Parameters' estimates for Experiment 1. Abbreviations are as follow: Public Transport = PT; Carpooling as driver = CPD, Carpooling as passenger = CPP, Carpooling = CP (parameters which are both for CPD and CPP). The first column of each model reports the estimates while the second is an indicator of the significance of the estimate. Statistically less significant estimates come with an asterisk.

All parameters are of the expected sign and, aside from a few parameters, highly significant. The fit of the model is increased introducing the interaction terms, although not substantially. Indeed, most of the parameters used in both specifications are fairly stable across the models. The parameters of travel time and travel cost are, as expected, an exception, because the new model has the interaction terms. Almost all those estimates are highly significant. A few, including the income elasticity term, are statistically less reliable, but none of them is strongly insignificant. Some of the most important points raised by these results are:

- A dummy variable for female users in the carpooling modes is significantly negative. This confirms that female individuals are less attracted to carpooling, maybe for security concerns.
- Previous carpooling experience, positive orientation toward carpooling and readiness to carpool have a strong positive impact on the choice to carpool.
- It is commonly acknowledged that the German speaking population of Switzerland has more open attitude towards innovative transport solutions. This is confirmed by the positive and significant parameter for the dummy variable “German speaking” in carpooling alternatives.
- In general, persons with a higher education level (college and higher) and members of larger households are more likely to choose carpooling. The degree to which a potential trip mate is already known before to carpool is also an important choice factor (variables “Acquaintance” and “Colleague”).
- The purpose of the trip also plays a role, i.e. carpooling is more likely to happen for work trips.
- The inertia variables for “Car” and “Public Transport” modes are positive and significant. This shows the commitment that some individuals have to a given mode whatever the alternatives.

The most important WTP indicators are shown in Table 5.

		Linear	Nonlinear
Indicator	Unit	Value	Value
VTTS CPD	CHF/h	36.7	47.1
VTTS CPP	CHF/h	40.0	53.4
VTTS Car	CHF/h	31.7	41.0
VTTS PT	CHF/h	8.2	13.2
WTP PT Transfers (#)	CHF/Transfer	1.8	1.9
WTP PT Transfer Time	CHF/h	84.3	80.6
WTP Walking Time	CHF/h	46.2	52.6
Average Income = 8,300 CHF/Month			
Average Trip Distance = 38.1 Km			

TABLE 5: Willingness-to-pay (WTP) indicators for Experiment 1. In the non linear case the value is calculated using income and travel time sample's averages for income and travel time, as reported in the table. Abbreviations are as follow: VTTS = Value of Travel Time Saving, CPD = carpooling driver, CPP = carpooling passenger, PT = public transport

In both models, linear and nonlinear, the CPP alternative has the highest value of travel time saving (VTTS). CPD is lower than CPP but higher than Car and PT has the lowest VTTS, which is consistent with previous research. The relatively large difference between the two carpooling alternatives is somewhat surprising. Given the characteristics of those modes – not as fast as car travel but faster than public transport, not as cheap as public transport but cheaper than car travel – one would expect similar VTTS for the two modes. An individual is ready to pay more to reduce the travel time of an unpleasant mode, than for more pleasant modes. This, keeping in mind that "pleasant" and "unpleasant" are subjective and merely depend on tastes. However, it is commonly accepted that the less pleasant modes usually turn out in surveys to have lower values of travel time savings (*25*). This would be because more affluent people, who generally have higher values of time, prevalently use such pleasant modes. From this perspective, one can try to understand the reason of that difference. The hypothesis is that passenger and driver are splitting gasoline costs and CPP does not involve substantial longer travel time than the CPD or the car alternative. The driver needs to pay the parking, as a normal car driver, which makes CPD slightly more expensive than CPP. Under these circumstances, CPP may be seen like a cheap taxi ride while CPD only offers a small reduction in travel expenses conditional to drive somebody. This may explain why CPP is seen as a better option. In general it seems that carpooling has a good unexploited potential, as hypothesized earlier, in Switzerland. Apparently, existing platforms are not yet effective enough exploiting potential. Other significant points arising from an inspection of Table 5 are:

- PT: The WTP for waiting time reduction may appear very high, but is reasonable considering that it includes actual transfer time.
- CPP: The WTP for walking time is also high, but reasonable in comparison with the WTP for in-vehicle time. It was not possible to estimate a specific sensitivity for carpooling but this means that for any transportation mode a convenient access is very important. It suggests that potential carpooling passengers are willing to carpool only if they can be conveniently picked up and dropped.

The changes in the value of travel time savings (VTTS) according to variation in income and travel distance are shown in Figure 1 for both carpooling modes.

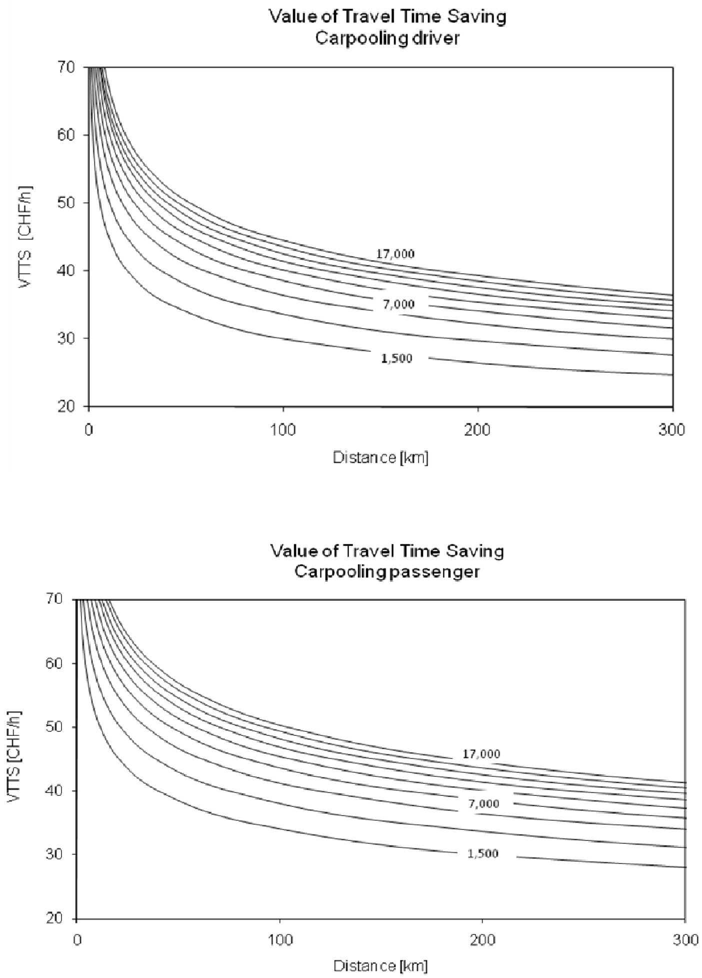

FIGURE 1: Value of Travel Time Savings (VTTS) according to Travel Distance variation for Carpooling Driver (CPD) and Carpooling Passenger (CPP). Different lines represent different levels of Income (CHF/Month)

The two plots in Figure 1, share the following characteristics:

- VTTS is generally higher for persons with higher income.
- VTTS is lower for persons traveling longer.
- The effects of income and travel time on the value of travel time savings are similarly strong.

The two plots are a way to see what the elasticity parameters actually mean. Persons with a higher income tend to have higher VTTS for any mode since their value of time is generally higher. In fact, the value that anybody gives to his own time is supposed to be proportional to the person's wage. Regarding distance, it is intuitive that the marginal (negative) value of an additional minute of travel is higher for a short trip than for a long trip. The income effect is also documented in the official Swiss values of travel time savings for Cost-Benefit analysis (*26*). Therefore, the model estimated is in accord with both these general principles.

Carsharing Experiment

In the second experiment the alternatives are: car, public transport and carsharing. In this case, all the estimated parameters are mode-specific. The estimation results for the final models, linear and nonlinear, are presented in Table 6.

		Linear Model		Elasticity Model	
	Observations: 4350 **Adj. ρ²:**	0.275		0.279	
Alternative	**Utility parameters Name**	**Value**	**p-value**	**Value**	**p-value**
PT	**Constant**	1.35	*0.18	-1.58	0
	Travel cost	-0.0324	0	-0.0308	0
	Travel time	-0.0206	0	-0.0261	0
	Elasticity Distance	-	-	-0.304	0
	Elasticity Income	-	-	0.0922	*0.69
	Walking time	-0.0358	0	-0.0398	0
	Waiting time	-0.0364	0	-0.0312	0
	Connections	-0.137	0	-0.132	0
	Season Ticket	0.813	0	0.78	0
	Log(AGE)	0.499	0	0.552	0
	Log (INCOME)	-0.393	0	-	-
	German speaking	0.0836	*0.37	0.106	*0.26
	Inertia	1.09	0	1.03	0
Car	**Constant**	0.0235	*0.98	0.507	*0.08
	Travel cost	-0.0131	0	-0.0122	0
	Travel time	-0.0332	0	-0.0334	0
	Elasticity Distance	-	-	-0.183	0
	Elasticity Income	-	-	-0.497	0
	Walking time	-0.0194	0.03	-0.0215	0.02
	Parking cost	-0.0586	*0.06	-0.062	0.05
	Car always available	0.306	0	0.294	0.01
	Male	0.0629	*0.38	0.0938	*0.19
	Inertia	0.486	0	0.494	0
CS	**Travel cost**	-0.02	0	-0.0177	0
	Travel time	-0.0229	0	-0.0231	0
	Elasticity Distance	-	-	-0.22	0.04
	Elasticity Income	-	-	-0.247	0.04
	Walking time	-0.107	0	-0.106	0
	PT to reach station	-0.13	0	-0.128	0
	Parking cost	-0.0306	0	-0.0287	0
	Leisure Trip	0.0946	*0.3	0.104	*0.25
	Higher education	0.134	*0.15	0.156	*0.09
	Household Dimension	0.0394	*0.27	0.0415	*0.25
	Log (INCOME)	-0.0407	*0.66	-	-

TABLE 6: Parameters' estimates for Experiment 2. Abbreviations are as follow: Public Transport = PT; Carsharing = CS. The first column of each model reports the estimates while the second is an indicator of the significance of the estimate. Statistically not significant estimates come with an asterisk.

As in the previous SP exercise, all the estimated parameters are of the expected sign and, aside from a few parameters, are highly significant. The fit of the model is increased by the introduction of the interaction terms, but again, not substantially. Parameters used in both models show stable values. Some additional observations on the parameters are:

- Some socio-demographic variables – German speaking, higher education, household size –compared to the carpooling model are either less significant or not significant.
- Leisure trips, the bulk of carsharing use in reality, are only marginally more likely to be carsharing trips in the responses.
- Experience or membership does not count in the choice; an attempt to introduce them in the model failed because they were insignificant.
- Income has a negative impact; more affluent individuals are more likely to drive their own car than to use carsharing.

A more accurate evaluation on the behavior of individuals toward carsharing can be gained with the most important WTP indicators. They are shown in Table 7.

	Linear		**Nonlinear**
Indicator	Unit	Value	Value
VTTS Car	CHF/h	151.59	163.70
VTTS CS	CHF/h	68.59	78.39
VTTS PT	CHF/h	38.16	50.76
WTP PT Transfer Time	CHF/h	67.42	60.59
WTP PT Transfers (#)	CHF /Transfer	4.22	4.28
WTP Walk Car	CHF /h	88.1	105.6
WTP Walk PT	CHF /h	66	77.4
WTP Walk CS	CHF /min	321	360
WTP PT Time to Station CS	CHF /min	390	433.7
Average Income = 8300 CHF/Month			
Average Trip Distance = 38.1 Km			

TABLE 7: Willingness-to-pay (WTP) indicators and Trade-offs for Experiment 2. In the non linear case the value is calculated using income and travel time sample's averages for income and travel time, as reported in the table. Abbreviations are as follow: VTTS = Value of Travel Time Saving, CS = carsharing, PT = public transport

In this case values are generally higher, which is related with the use of full-costs for car. Some observations derived from Table 7 are:

- VTTS is more consistent with the traditional interpretation as the pleasantness of a mode; the car alternative has the highest and public transport the lowest VTTS, carsharing lies in between.
- The walking time to reach a carsharing station has a really high value compared to corresponding car and PT walking time values. It confirms that convenient access to car sharing is a key for its success.

- The time spent on public transport to reach the carsharing station is valued even higher (worse); apparently potential users are not willing to use public transport to reach the stations. Again, an access to carsharing within short walking distance is a fundamental factor of success.

The changes in the value of travel time savings for the carsharing mode, according to variation in income and travel time can be observed in Figure 2.

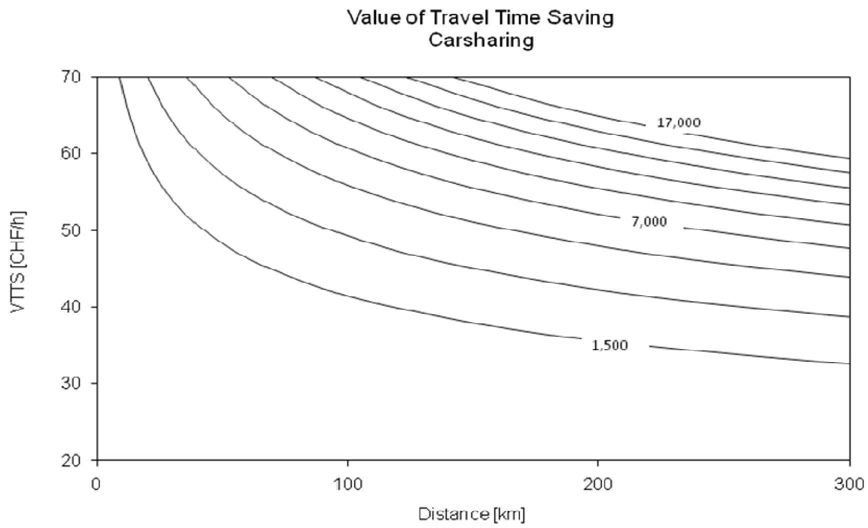

FIGURE 2: Value of Travel Time Savings (VTTS) according to travel distance variation for Carsharing (Cs) Different lines represent different levels of Income (CHF/Month)

Observing the plot the following characteristics can be seen:

- VTTS is higher for higher level of income and for shorter distances.
- Income and distance have a similar impact on sensitivities (elasticity values are close).
- Sensitivities are smaller for longer distances.

The plot confirms that the usage of carsharing follows a “traditional” pattern and more affluent people have a higher VTTS for it, while longer distances reduce it.

Use of WTP indicators

The WTP indicators allow policy-makers and planners to provide a monetary evaluation of a given policy or investment using a cost-benefit approach. Transport policies and projects are usually justified with the amount of time that travellers will save. WTP indicators are used to quantify the economic benefit and compare it to the cost. For example a subsidy policy in favour of carpooling might increase the share of this mode. As a consequence, the number of cars on the road would be reduced, reducing also travel times. Using the model estimated for this study, coupled with a transportation model, it is possible to evaluate the reduction of travel time corresponding to a given level of subsidies. WTP indicators are used to evaluate the gain in monetary terms and compare it to the cost of the policy. Similar evaluations are possible for policies regarding carsharing.

CONCLUSIONS AND OUTLOOK

Formal carpooling programs do exist in Switzerland but, as in many other countries, they are all very small and their use is not even close to be mainstream. This might be reflected in the way people confront the simulated choice situation, making choices a bit less consistent. The lower fit of the carpooling model, compared to that of carsharing, a more established concept in Switzerland, despite the higher number of observations, seems to confirm that. Nonetheless, the fit of the model is satisfactory and a useful insight was obtained. The Value of Travel Time Savings (VTTS) is influenced by income and travel distance for both carpooling options. Persons with higher income and shorter trips tend to have a higher VTTS which is the expected behavior. More interestingly, the two carpooling alternatives have a higher VTTS than car, suggesting that they are preferred to the other available modes. This might mean that the choice to carpool is not only of economic nature, but other motivations – environmental, social, etc. – that are not captured by the model, play also an important role. Finally, potential carpoolers seem to prefer to be passenger rather than drivers, which suggests that carpooling as passenger is a more attractive option, being comfortable and comparatively cheap. Also in the case of carsharing the pattern of VTTS is perfectly consistent with previous literature and with expectations. The different WTP indicators appear reliable and might be used for the quantitative evaluation of policies or for planning purposes. Their values also confirm the eminent importance of access convenience in the choice of carsharing. Unlike the case of carpooling, the choice of carsharing seems exclusively economically driven and not related to some particular ideological inclination. This is a logical output if one considers that carsharing in Switzerland is not a new product but rather well known and, in relative terms, a widely used alternative to private car usage.

The work presented improves the understanding of the public's attitude towards carpooling, in Switzerland. Overall, the results suggest the existence of a good unexploited potential for carpooling in Switzerland and the development of new platforms might be crucial for its future expansion. The analysis of the multiple-response part of the questionnaire will guide the further refinement of the models in the future. It is possible to implement and run the models on the whole Swiss population to estimate the potential modal share for carpooling in Switzerland. Key for this estimate is the availability of the relevant data – the variables of the models – for the whole population. The result would be a sort of upper bound, since the problem of pooling people together wouldn't be taken into account. If data on the time distribution of trips is also available – i.e. commuting trips – it is possible to solve the problem of creating compatible cliques, obtaining a more realistic estimation of carpooling potential. The already mentioned agent-based simulation MATSim allows this type of implementation of the model being all the necessary data for a Swiss scenario available in the modeling tool. The next task that this research team will tackle in the near future is the integration of the models in MATSim.

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