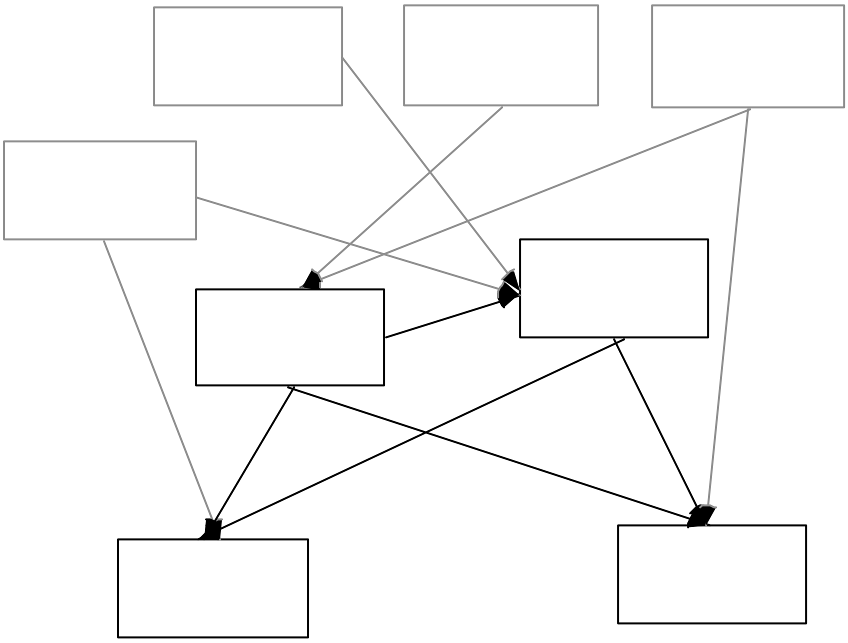

Structures of commitment in mode use: A comparison of Switzerland, Germany and Great Britain

A. Simma und K.W. Axhausen
IVT, ETH Zürich

STRC | 1st Swiss Transport Research Conference
Monte Verità / Ascona, March 1.-3. 2001

Structures of commitment and mode use: A comparison of Switzerland, Germany and Great Britain

A Simma and KW Axhausen
IVT
ETH
CH-8093 Zürich

Telefon: +41-1-633 31 51
Telefax: +41-1-633 10 57
eMail: simma@ivt.baug.ethz.ch

März 2001

Abstract

Travellers commit themselves to particular behaviours through the ownership of cars and season tickets. They trade a large one-off payment for low or zero marginal cost at the point of use. It is assumed that these commitments influence travel behaviour. To the knowledge of the authors there is no literature which addresses this choice between the commitment to the one or the other mode and its impacts on travel behaviour.

The paper presents models using structural equation modelling to test a-priori hypotheses on the paths linking car-availability, season-ticket-ownership and modal usage. Modal usage is operationalised as the number of trips with car respectively public transport or as the distances travelled by car respectively public transport. The models are based on three different surveys (Switzerland, Germany and Great Britain). The results confirm the dominance of car-ownership, which drives the other variables, in particular the usage of car.

Keywords

Car-ownership/availability – Season-ticket-ownership – Mode choice – Interactions – Structural equation modelling

1. Introduction

Travel-behaviour-models concerning car-ownership/availability are abundant in the literature (see for example De Jong, 1998; De Jong, 1996; Bradley, Golob and Polak, 1995; Hensher,1992), models of season-ticket-ownership are rarer (see for example Axhausen, Bader and Köll, 1998; Monheim, 1987), and joint models are nearly – to the knowledge of the authors – non existent (see a previous paper of the authors - Axhausen, Simma and Golob, 2000). For European and other countries with intensively used public transport systems this omission is hard to understand. It is idle to speculate about the reasons for this important omission, but the dominance of US modelling practice, where the issue is nearly non existent, and a habit of not asking about season- ticket-ownership of respondents, even in European travel surveys, are good first guesses.

This paper presents joint models of season-ticket-ownership and car-availability to analyse the effects of these commitments on travel behaviour. It aims to contribute to the growing literature about the influence of long-term decisions of individuals on their daily or short term travel behaviour. This will help to understand whether the current practice of estimating models of long-term choices based on samples of daily behaviour are still appropriate (see for example Ben-Akiva, Bowman and Gopinath, 1996 or Bradley, Bowman and Lawton, 2000). The results will also provide insight into the trade-offs of the travellers behaviour and will support the identification of new policy perspectives.

The structure of the paper is as follows. The next section presents the surveys on which the analyses are based. The third section describes the basics of the applied modelling approach (*structural equation modelling*), whereas the third core section of this paper covers the behavioural hypotheses, the modelling-process, the estimation results and their interpretation. The concluding section summarises the results and outlines both demand for future work and some policy conclusions.

2. Description of the samples

The research-questions posed in this paper, the interrelationships between commitments and modal usage, is best answered by analysing travel diary data. Three different surveys were considered here due their availability, their quality and their inclusion of season-ticket information. Table 1 gives an overview of the basic features of the surveys used.

- **Switzerland – "*Mikrozensus 1994*"** (see Bundesamt für Statistik, 1995): This is a nation-wide, representative and cross-sectional survey which is conducted by the Swiss National Office for Statistic every five years. Information about the household, the members of the household and the travel behaviour of at most two randomly selected household members is the result of the survey. The travel behaviour of one randomly selected day is covered. Some spatial variables are also available.

- **Germany – "*Deutsches Mobilitätpanel*"** (see Chlond, Lipps and Zumkeller, 1996 and 1998): The German Panel is a representative household-survey. It has been conducted each year since 1994 during autumn. The surveys of 1994, 1995, 1996, 1997 and 1998 are already available. A household is interviewed at most three times to avoid panel fatigue and conditioning. The dataset comprises information about the socio-demographic composition of a household and the weekly travel behaviour of the household members older than 10 years. This dataset is used here as a cross-section.[1]

- **Great Britain – "National Travel Survey" (NTS)** (see Freeth, 1999): The NTS collects data about the household, the household-members and their travel behaviour using two methods – CAPI and seven days of travel diary keeping. It is based on a random sample of private households and is carried out continuously. For this paper the years 1996 to 1998 were used. The dataset was divided for some analysis into two parts – London and the rest of Great Britain.

Table 1 Overview of the three surveys

	Switzerland	Germany	Great Britain
Survey-year(s)	1994	1994-1998	1996-1998
Duration of reporting period	1 day	1 week	1 week
Sample – Persons[1]	13.838	5.174	16.570

[1] Persons were older than 17 and at least mobile for one day.

There are similarities but also differences in the design of the three surveys. Each of them contains information about the most important variables of the analysis (car-availability, season-ticket-ownership and modal usage). They differ mainly in the selection of the socio-

[1] A further paper is planned describing panel based models.

demographic variables and in the coding of the variables. The different variables were harmonised as much as possible. Table 2 shows the descriptive statistics for the most important variables.

Table 2 Descriptive statistics for the most important variables (persons older than 17 years, at least one day mobile) – Switzerland, Germany and Great Britain

Mean/Frequency		Switzerland	Germany	London	Rest of Britain
Socio-demographic variables					
Age	[years]	45,83	47,15	~48[3]	~50[3]
Employed	[%]	65	61	51[2]	50[2]
Male	[%]	47	49	46	47
Number of household-members	[n]	2,46	2,75	2,66	2,69
Commitment variables					
Season-ticket-owner	[%]	22[4]	13	40	19
Car-available	[%]	57	63	46	55
Travel behaviour variables (per week)					
Number of public transport-trips	[n]	2,38[1]	1,17	4,30	1,63
Number of car-trips	[n]	12,39[1]	12,75	10,32	14,72
Distance travelled by public transport	[km]	56,81[1]	26,43	62,81	30,89
Distance travelled by car	[km]	190,19[1]	170,59	155,80	249,58

[1] Survey-results multiplied by seven
[2] At least one work-trip during the reporting period
[3] Only age-groups are available.
[4] Ownership of season-tickets and *Generalabonnements*.

3. Modelling approach - structural equation modelling (SEM)

A precondition for the analysis of the complex questions posed in this paper is a method which can handle relationships between several dependent and independent variables at the same time. SEM meets these requirements (see Maruyama, 1998, Mueller, 1996, Bollen, 1989). SEM is a confirmatory method which should be guided by prior theories about the structures to be modelled.

A SEM-model is a set of simultaneous equations specified by direct links between variables which can be latent. A SEM-model with latent variables has at most three components: a measurement submodel for the endogenous latent variables, a similar measurement submodel for the exogenous latent variables, and a structural submodel. Here we develop only the structural submodel, because travel behaviour is not well suited to be handled by hypothetical constructs (latent variables).

The structural submodel captures the relationships between the exogenous and endogenous variables and between the endogenous variables themselves. It is defined by

$$\eta = B\eta + \Gamma x + \xi$$

in which the (m) endogenous variables are a function of each other and of the (q) exogenous variables (denoted by the q-dimensional column vector x). The unexplained portions of the endogenous variables (the errors in equations), have a variance-covariance matrix defined by $Y = E[\xi\, \xi']$.

The modeller specifies which elements of the B, G and Y matrices are free parameters, and these parameters are estimated simultaneously, together with their standard errors. Identification requires, among other conditions, that the matrix (**I** - **B**) must be non-singular. The total effects of various variables on the endogenous variables are given by the so-called reduced-form equations:

$$\eta = (I - B)^{-1}\,\Gamma x$$

Estimation of a SEM-model can be accomplished in several ways. The methods are based on matching model-replicated variance-covariances with the observed variance-covariances. Instead of covariances also correlations can be used. Here we use the ADF-WLS-method in conjunction with a PM-matrix (different types of correlations), because several variables are not normally distributed. SEM has been used more frequently in travel demand modeling recently; see for example Golob and McNally (1997), Lu and Pas (1999) and Golob (1999).

4. Modelling Results

4.1 Hypotheses

The research interest of the study is to understand the interactions between the ownership of season-tickets as well as cars and modal usage. In principle, each variable could influence the others:

- Some simultaneously such as the pairs, car-availability and season-ticket-ownership respectively usage of car and public transport,
- Some hierarchically, such as the commitment variables the usage variables,
- Some lagged, such as the travelled distances by car the car-availability or the public transport usage the season-ticket-ownership.

The last relationship can only be investigated on the basis of a panel-survey due to the uncertainties of modelling this kind of relationship using cross-sectional data. This analysis will be provided in a further paper by the authors in the future.

It is not only necessary to define if a relationship is present, but also the direction of the relationship – especially for testing the hypotheses. On the one hand, complementary effects are conceivable – e.g. in the sense that highly mobile persons have a range of commitments which force them to use the car and public transport more often then less mobile persons who neither possess a car nor a season-ticket (see Axhausen, Simma and Golob, 2000). On the other hand, substitutive effects are conceivable – for example by the fact that travellers only use either public transport or the car. As a commitment and especially the commitment to a car is usually connected with high costs, negative effects between the two different modes are more likely.

The formulation of the Γ matrix was guided by earlier exploratory work using various regression approaches as well as SEMs. For those variables which are available in all surveys the following assumptions are made.

- Employment – which is one of the most important variables in regard to travel behaviour (see Simma, 2000) – is connected with an increase in travelling.
- Women have a significantly higher dependence on public transport compared with men.

- The probability to own a car or season-ticket is higher for younger people than for elderly people.
- People living in a family are less mobile than people living in households without children.

Additionally one spatial variable is defined describing the characteristics of the households' locations (either the number of inhabitants of the residential municipality or a dummy variable for its centrality in the urban system). It is assumed that people living in small villages respectively in rural areas are more car-dependent than people living in towns.

After specifying which parameters are fixed or freed (see Table 3), cross-sectional models were estimated for the three different surveys and for the two different modal usage variables *distances travelled* and *number of trips*. The models were slightly modified because the fits of the first runs were less than satisfying. The modification-process was guided by theoretical considerations.

Additionally a model for different types of season-tickets (Switzerland) and a multiple-sample model (Great Britain) were estimated. For these models the same postulated effects are valid as for the initial models. For the Swiss model it is additionally postulated that the effects of a stronger commitment to public transport on the other endogenous variables are higher than the effects of a lighter commitment to public transport – annual pass for national railway in comparison with a local season or a national discount ticket.

Table 3 Postulated direct exogenous and endogenous effects of the cross-sectional models

From / To	Car-availability	Season-ticket-ownership	Usage of public transport	Usage of car
Car-available		-β	-β	β
Season-ticket-owner			β	-β
Usage of public transport				
Usage of car				
Employed	γ	γ		γ
Male	γ		-γ	
Age	-γ	-γ		
Number of household-members			-γ	-γ
Urban	-γ	γ		

4.2 Estimation results of the common models

The results of the modification-process were models with clearly improved and relatively good fits (see Table 4). The number of iterations could be reduced – indicating stability – and the number of degrees of freedom could be increased in most cases. Additionally the chi²-values of the modified models were smaller than the ones of the postulated models. The high chi²-values and the low probabilities of the Swiss and British models are not an indication for model-misspecification, but they are caused by the huge sample-sizes (chi²-value dependent on sample-size).

The values of the multiple-correlation-coefficients of the endogenous variable (comparable to the R^2 of a regression analysis) lie between 0,01 and 0,38 (reduced form). There are differences between the models. In the German models the car usage can be explained best, in the Swiss models the car-availability and in the British models the season-ticket-ownership. The usage of public transport is the worst explained variable in all models.

Table 4 Model fit of the postulated and the modified models and the multiple correlation coefficients – separated after surveys and the selected travel behaviour variables

	Switzerland		Germany		Great Britain	
	Trip-model	Distance-model	Trip-model	Distance-model	Trip-model	Distance-model
Fit of postulated model						
Sample size	13.838	13.838	5.175	5.175	15.689	15.689
Number of iterations	45	66	62	334	23	39
Degrees of freedom	11	11	11	11	11	11
Chi²-value	947,42	111,19	31,03	9,39	677,48	433,09
Probability of χ^2-value	0,0	0,0	0,0011	0,59	0,0	0,0
Goodness-of-Fit Index	0,99	1,00	1,00	1,00	1,00	1,00
Critical N	363	3.078	4.123	13.615	574	897
Normed Fit Index	0,98	1,00	1,00	1,00	0,98	0,99
Fit of modified model						
Number of iterations	30	8	37	27	11	24
Degrees of freedom	12	16	13	14	11	12
Chi²-value	153,25	49,63	9,65	11,49	89,80	131,98
Probability of χ^2-value	0,0	0,00	0,72	0,65	0,00	0,0
Goodness-of-Fit Index	1,00	1,00	1,00	1,00	1,00	1,00
Critical N	2.368	8.922	14.843	13.119	4.320	3.117
Normed Fit Index	1,00	1,00	1,00	1,00	1,00	1,00

SEM results provide the fit of a specific model as well as the direct and total effects between the variables. The direct effects are comparable to standardised regression-coefficients. Generally, the results are consistent with the assumptions in regard to the B-matrix. Car-availability influences season-ticket-ownership and both commitment variables influence modal usage in a substitutive way. More modifications had to be made within the Γ-matrix – especially the impacts of age and the number of household-members were different from the expectations. Figure 1 shows a path-diagram with effects which are present in most models, Table 5 and Table 6 show the total effects.

Figure 1 Path-diagram of the models with commonly observed effects

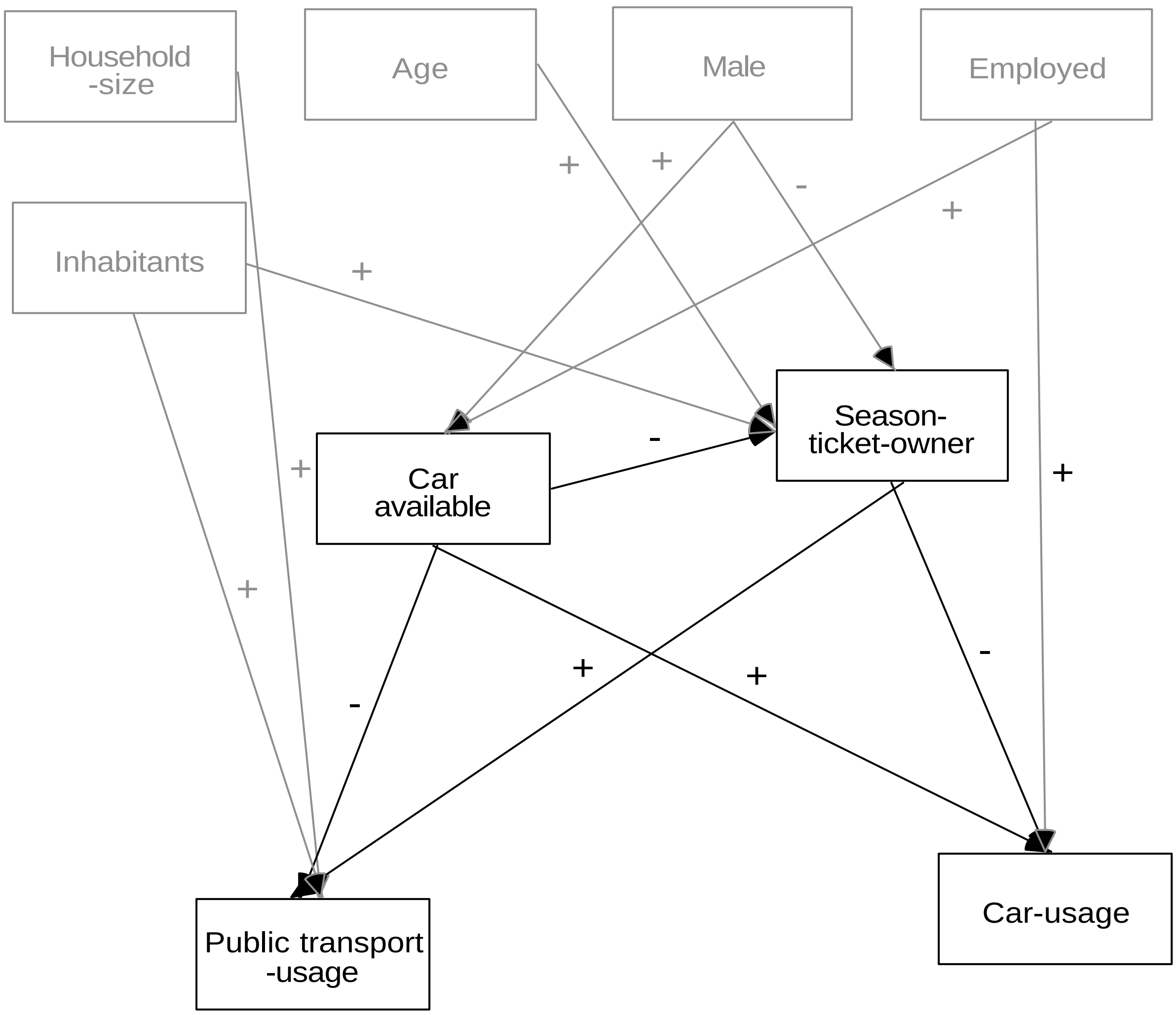

Table 5 Total effects of the three different cross-sectional trip-models (Swiss, German, British) – all effects significant at the 0,001 level

From	**To** Car-availability			Season-ticket-ownership			Public transport-trips			Car-trips		
	CH	D	GB	CH	D	GB	CH	D	GB	CH	D	GB
Car-availability				-0,44	-0,52	-0,31	-0,33	-0,36	-0,34	0,38	0,65	0,13
Season-ticket-ownership							0,33	0,57	1,09	-0,05	-0,34	-0,42
Public transport-trips										-0,15		
Car-trips												
Employed	0,22	0,36	0,27	-0,10	0,41	*	-0,07	0,21	*	0,25	*	0,28
Male	0,33	0,18	0,25	-0,04	-0,09	-0,08	-0,07	-0,06	-0,09	0,12	0,12	0,03
Age		0,19	-0,08	-0,20	0,31	0,38	-0,21	0,16	-0,10	0,03	-0,38	-0,16
Household-size			0,06			-0,21			-0,23			0,09
Urban	-0,10		-0,09	0,11	0,40	0,25	0,05	0,23	0,27	-0,04	-0,14	-0,10
Reduced form R^2	0,23	0,13	0,21	0,06	0,15	0,31	0,05	0,05	0,13	0,10	0,17	0,14

* Estimated, but not significantly different from zero

Table 6 Total effects of the three different cross-sectional distance-models (Swiss, German, British) – all effects significant at the 0,001 level

From	**To** Car-availability			Season-ticket-ownership			PT-distances			Car-distances		
	CH	D	GB	CH	D	GB	CH	D	GB	CH	D	GB
Car-availability					-0,51	-0,29		-0,17	0,08	0,28	0,32	0,68
Season-ticket-ownership	-0,35						0,39	0,32	0,51	-0,10		-0,26
PT distances												
Car distances												
Employment	0,33	0,36	0,31		0,43	-0,09		0,14	0,02	0,16	0,12	0,21
Male	0,31	0,18	0,24	-0,05	-0,09	-0,07	-0,02	-0,04	0,02	0,09	0,18	0,16
Age	0,12	0,19	-0,18		0,31	0,38		0,10	0,15	0,03	0,06	-0,21
Household-size	0,03			-0,08		-0,18	-0,03		0,39	0,01	0,57	0,05
Urban	-0,06		-0,11	0,17	0,40	0,24	0,06	0,13	0,10	-0,02		-0,13
Reduced form R^2	0,27	0,14	0,23	0,04	0,15	0,30	0,01	0,02	0,12	0,04	0,38	0,15

The following differences between the models can be observed.

- **Switzerland**: The Swiss distance-model is the only model in which season-ticket-ownership negatively influences car-availability. Additionally, the effects of season-ticket ownership on the car usage are not strong. Interestingly, the effects of employment on season-ticket-ownership and public transport-usage are negative within the trip-model.

- **Germany**: One characteristic of the German distance-model is the direct effect of season-ticket-ownership on the car usage. Another difference between the trip and the distance model is that women more often possess a season-ticket and make more trips with public transport than men, but the distances travelled by public transport are bigger for men than for women. Reasons for the positive effects of age on car-availability and season-ticket-ownership are the confounding with the employment variable.

- **Britain**: One effect within the B-matrix of the distance-model is not consistent with the expectations, namely the positive effect of car-availability on the distances travelled by public transport (see also the multi-sample model). An interesting result is also that age has a positive effect on season-ticket-ownership and distances travelled by bus, but a negative effect on the number of trips made by public transport. The quality of the relationships between sex and the endogenous variables is similar to that in the German case.

The influence of bicycle-ownership on modal usage was also estimated. The bicycle-ownership only has an effect on the usage of the bike, the usage of the bike is mainly influenced by the bicycle-ownership. There are nearly no relationships between the three modes.

4.3 Impacts of different ticket-types – Estimation results of the Swiss survey

Different kinds of season-tickets are available in Switzerland:

- The *Generalabonnement* (GA) gives access to the whole Swiss public transport system, free at the point of use. At a prize of 2800 sFr (second class) or 4400 sFr (first class) per person and year in 2000; the costs are equivalent to those of running a mid-sized car.
- Local annual or monthly season tickets

- The Swiss *Halbtaxabo* is a rail discount ticket, reducing all fares by 50% for an advance payment of 150 sFr per year (222 sFr for two years).

A model was estimated based on the same hypotheses as the models above with the exception of the season-ticket-ownership variable, which was divided into three categories. The aim of this model was to investigate if different ticket-types are connected with different modal usage.

The model obtained after a theory based modification-process had a satisfactory model fit. The total effects are shown in table 7. Persons possessing a GA do not own a season-ticket or a Halbtaxabo. There are complementary effects between local season-ticket-ownership and Halbtaxabo-ownership. The relationship between car-availability and the different ticket-types is a substitutive one. This findings are consistent with the expectations. But with regards to the hierarchical effects some unexpected results could be found. Season-ticket- and Halbtaxabo-ownership have positive total effects on the distances travelled by public transport as well as by car, the ownership of a GA has positive total effects on the trips made by public transport and by car.

Table 7 Total effects of the two models (trips and distances (in italic)) with different ticket-types (Switzerland) – all effects significant at the 0,001 level

From	**To** Car-availa-bility	GA-owner-ship	Season-ticket-ownership	Halbtax-owner-ship	Public transport-usage	Car-usage
Car-availability	-0,02	-0,31	0,06	-0,15	-0,25	0,73
	0,02	*-0,31*	*-0,06*	*-0,07*	*-0,03*	*0,45*
GA-ownership	0,06	-0,02	-0,20	-0,21	0,12	0,04
	0,06	*-0,02*	*-0,20*	*-0,21*	*-0,10*	*-0,09*
Season-ticket-ownership	-0,30	0,09	-0,02	0,12	0,38	-0,22
	-0,06	*0,02*	*-0,46*	*-0,49*	*0,26*	*0,29*
Halbtaxabo-ownership					0,05	
	-0,16	*0,05*	*0,51*	*-0,45*	*0,25*	*0,23*
Public transport usage						
Car usage					-0,14	
Employment	0,40	-0,13	0,03	-0,06	-0,10	0,30
	0,22	*-0,07*	*0,03*	*-0,05*	*0,01*	*0,12*
Male	0,25	0,09	-0,08	-0,07	-0,05	0,09
	0,32	*0,05*	*-0,05*	*-0,05*	*-0,02*	*0,12*
Age	0,12	-0,04	0,01	-0,02	-0,23	0,09
Household-size	0,02	-0,02	-0,07	-0,10	-0,03	0,02
	0,03	*-0,02*	*-0,08*	*-0,09*	*-0,04*	*-0,04*
Urban	-0,05	0,03	0,16	0,06	0,07	-0,04
	-0,09	*0,04*	*0,16*	*0,07*	*0,08*	*0,05*
Reduced form R^2	0,27	0,01	0,04	0,03	0,05	0,10
	0,23	*0,01*	*0,04*	*0,02*	*0,01*	*0,05*

Within the Γ-matrix the influence of sex and employment on the endogenous variables is of greater interest. Men more often have a car and a GA at their disposal then women, but women use public transport more often and for longer distances. Employment is connected with an increase of season-ticket-ownership and car-availability and with a decrease of the level of GA- and halbtaxabo-ownership.

4.4 Multi-sample model for different urban structures – Estimation results from the British NTS

The last models have shown that the dummy-variable describing the location of a household (urban/rural) has an great impact on the commitment-variables as well as on the modal usage variables. A dummy-variable can not only be treated as exogenous variable, but it can also be used as a variable for segmenting samples. Comparing models across samples provides information that allows researchers to talk about comparability of causal processes in different populations. This feature is interesting with regards to the question if people in towns act different to people in rural areas.

It was assumed that the comparison of London and the rest of Great Britain was most interesting because of the dimensions of London. Therefore an additional model was estimated using the British survey. The postulated effects are the same as in the other models – with the one exception that the sampled is divided by location (London and rest of Great Britain). The result of the modification-process was a model with a satisfying model-fit. The total effects within the B-matrix are shown in Table 8.

Some results in the distance-model for the London-sample are not consistent with the expectations: the pre-emptive effect of season-ticket ownership on car availability in London and the positive effect of the car-availability on the distances travelled by public transport. Additionally men travel larger distances with the public transport than women.

Table 8 Total effects of the multi-sample (London – rest of Great Britatin) trip-model and the multi-sample distance-model (in italic) – all effects significant at the 0,001 level (Exogenous variables are not presented in this table)

From	**To** Car-availability		Season-ticket-ownership		PT-usage		Car usage	
	London	Rest	London	Rest	London	Rest	London	Rest
Car-availability			-0,29	-0,26	-0,49	-0,40	0,59	0,53
				-0,25	*0,24*	*-0,08*	*0,77*	*0,65*
Season-ticket-ownership	*-0,34*				*0,57*	*0,31*	*-0,34*	*-0,27*
PT usage							-0,49	-0,34
Car usage								
Reduced form R^2	0,14	0,20	0,22	0,33	0,06	0,02	0,08	0,20
	0,13	*0,20*	*0,22*	*0,32*	*0,16*	*0,01*	*0,09*	*0,14*

4.5 Interpretation of results

The main result of all models is the fact that there are close interrelationships between the endogenous variables and that similar effects can be observed in the different models. Car-availability influences season-ticket-ownership negatively. That means that the probability to possess a season-ticket decreases if a person has access to a car. In contrast, season-ticket-ownership has no significant effects on car-ownership – with three exceptions: the Swiss distance-model, the Swiss models with different ticket-types and the distance-model for the London-sample. The reasons for the exceptions are probably the high standard of public transport system in Switzerland and in London as well as problems concerning car-usage in London.

As expected, the commitments influence the modal usage. Car-ownership increases the usage of car, season-ticket-ownership increases the usage of public transport and vice versa. The only exception is the British distance-model. Here, the effect of car-ownership to distances travelled by public transport is positive. This exception can be explained among other reasons by the spatial location of the households and the in general higher incomes of suburban London residents. The influence of a commitment on the corresponding mode is mostly higher than the influence of this commitment on the opposite mode.

5. Conclusions and outlook

The models have shown that their are strong relationships between commitments and modal usage. The commitment to a specific mode promotes the usage of this mode and reduces the usage of the other mode. The relationship between using the car and using the public transport system is rather substitutive than complementary. These consistent findings stress the importance of including all pre-commitments into any modelling structure used to describe travel behaviour. Modelling car ownership is not enough.

But there are some findings which show that the relationships are more complicated then generally assumed, e.g..

- **GA and its impacts**: One would expect that the decision for a GA is really a substitutive decision to a car because of the high costs of a GA and that it would induce the use of public transport. Owners of a GA are less likely to own a car than owners of season-tickets. But the ownership of a season-ticket increases the usage of public transport on a daily basis more than the ownership of a GA, which has a strong long-distance element.
- **Car-availability and its impacts in London**: Car-availability in London induces an increase of distances travelled by public transport and by car and a decrease of trips made by public transport. This result can only be understood against the background of the structure of London and the high distances between the city and the suburbs.

The investigation of the impacts of the socio-demographic variables have confirmed most of our posed hypotheses – e.g. that employment is connected with an increase of car-ownership and usage, that women are more dependent on public transport than men and that public transport is used especially in towns.

The wish to present comparable models restricted the set of variables included into the models. Obviously important variables, such as income, household division of labour, working hours, presence of small children, a detailed description of the home and work location, would add to the results. In addition, the current results have ignored the temporal dimension, but a further paper will address this gap. It is hoped that future work will address these issues, but in particular it is hoped, that future studies will include, as a matter of course, both car-ownership/availability and season-ticket-ownership as endogenous elements in their model systems.

6. Acknowledgements

The authors wish to thank the the Swiss National Office for Statistic and the Institut für Verkehrswesen, Karlsruhe for making the surveys available to us.

7. Literature

Axhausen, K.W., 1991. Licence holding and car ownership: A review of available evidence, Working Paper, 623, Transport Studies Unit, University of Oxford, Oxford.

Axhausen, K.W., Bader, M., Köll, H., 1998. Public transport usage intensity of season tickets holders in the city of Innsbruck, Report to the Innsbrucker Verkehrsbetriebe GsmbH, Innsbruck.

Axhausen, K.W., Simma, A., Golob, T.F., 2000. Pre-commitment and usage: season-tickets cars and travel, Working Paper, 24, Institut für Verkehrsplanung, Transporttechnik, Strassen- und Eisenbahnbau, ETH Zürich, Zürich.

Ben-Akiva, M.E., Bowman, J.L., Gopinath, D., 1996. Travel demand model system for the information era, Transportation, 23 (3) 241-266.

Bollen, K.A,. 1989. Structural Equations with Latent Variables, Wiley, New York.

Bradley, M., Bowman, J.L., Lawton, K., 2000. Application of microsimulation techniques in activity based transportation modelling, paper presented at the 79th Annual Meeting of the Transportation Research Board, Washington, D.C.

Bradley, M.,. Golob, T.F, Polak, J.W., 1995. Travel and activity participation as influenced by car availability and use, Working Paper, 286, Institute for Transport Studies, University of California, Berkeley.

Bundesamt für Statistik, 1995. Mikrozensus Verkehrsverhalten 1994: Beschreibung der Daten, Abteilung Raumwirtschaft, Neuchâtel.

Chlond, B., Lipps, O., Zumkeller D., 1998. Haushaltspanel 1997/1998 – Auswertung, Schlussbericht, Institut für Verkehrswesen, Universität Karlsruhe, Karlsruhe.

Chlond, B., Lipps, O., Zumkeller D., 1996. Auswertung der Paneluntersuchung zum Verkehrsverhalten, Schlussbericht, Institut für Verkehrswesen, Universität Karlsruhe, Karlsruhe.

De Jong, G., 1998. Forecasting car occupancy: Literature review and model development, in D. Hensher, S. Jara-Diaz, J de Dios Ortuzar (eds.) Travel Behaviour Research: Updating the State of Play, 507-525, Elsevier, Oxford.

De Jong, G, 1996. A disaggregate model system of vehicle holding duration, type choice and use, Transportation Research, 30B (4) 263-276.

Freeth, S., 1999. National Travel Survey – Technical Report 1998, Office for National Statistics, London.

Golob, T.F., 1999. A simultaneous model of household activity participation and trip chain generation, Transportation Research, 34B (5) 355-376.

Golob, T.F., McNally, M.G., 1997. A model of activity participation and travel interactions between household heads, Transportation Research, 31B (3) 177-491.

Hensher, D.A., 1992. Dimensions of Automobile Demand: A Longitudinal Study of Household Automobile Ownership and Use, Elsevier, New York.

Maruyama, G.M., 1998. Basics of Structural Equation Modelling, Sage Publications, Thousand Oaks.

Monheim, R., 1987. Verkehrsmittelwahl und Zeitkartenbesitz im Ausbildungsverkehr: Eine Fallstudie bei Schülern und Studenten in Bayreuth, Verkehr und Technik, 40 (1) 3-9.

Mueller, R.O., 1996. Basic Principles of Structural Equation Modeling - An Introduction to LISREL and EQS, Springer, Heidelberg.

Lu, X., Pas, E.I., 1999. Socio-demographics, activity participation and travel behaviour. Transportation Research, 33A (1) 1-18.

Simma, A, 2000. Verkehrsverhalten als eine Funktion sozio-demografischer und räumlicher Faktoren, Dissertation, Universität Innsbruck, Innsbruck.