Residence locations and mobility tool ownership during the life course

Results from a retrospective survey in Switzerland

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RESIDENCE LOCATIONS AND MOBILITY TOOL OWNERSHIP DURING THE LIFE COURSE: RESULTS FROM A RETROSPECTIVE SURVEY IN SWITZERLAND

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1. INTRODUCTION

Long-term mobility of people involves on the one hand decisions about their residential locations and the corresponding moves. At the same time the places of education and employment play an important role. On the other hand the ownership of mobility tools, such as cars and different public transport season tickets are complementary elements in this process, which also bind substantial resources. These two aspects of mobility behaviour are closely connected to one another. A longitudinal perspective on these relationships is available from people's life courses, which link different dimensions of life together. Besides the personal and familial history locations of residence, education and employment as well as the ownership of mobility tools can be taken into account. These life course dimensions are usually not independent from one another. Events in one area are frequently connected to changes in other areas. At the same time this longitudinal approach provides the possibility to observe developments over time (Wagner, 1990; Hollingworth and Miller, 1996; Hensher, 1998; Lanzendorf, 2003).

In order to study the dynamics of long-term spatial mobility a longitudinal survey covering the 20 year period from 1985 to 2004 was carried out at the beginning of 2005 in a stratified sample of municipalities in the Zurich region, Switzerland.

The paper describes residential mobility and mobility tool ownership as well as the life course approach. Subsequently the longitudinal data collected in the retrospective survey is described. The paper then concentrates on the analysis of the long-term mobility decisions during the life course. The main focus lies on the dynamics of mobility tool ownership over the last 20 years, at the same time looking at the relationships with residential choices as well as with locations of education and employment. Finally the results are summarised in the conclusions.

2. LONG-TERM SPATIAL MOBILITY

2.1 Residential mobility

Various variables significantly affect residential mobility. In the literature age is most consistently reported showing an inverse relationship to the number of moves. A higher education and employment status is associated with more changes in residence. At the same time residential mobility is less dependent on

absolute income and more dependent on variations in income, which are partially revealed through changes in occupation which lead to a higher number of moves (Hollingworth *et al.*, 1996). The influence of the household structure is rather ambiguous (Vandersmissen, Séguin, Thériault and Claramunt, 2005). Housing characteristics also play an important role, such as type, size, space adequacy and the tenure status. Renters are more likely to move than owners because the transaction costs of owning are substantially higher than those of renting. Accessibility to the places of occupation influences the residential mobility such that with increasing travel distance the probability for moving also rises (Beige, 2006). Furthermore the residential history and the different durations a person stayed in former places of residence are of some importance since prior mobility is strongly correlated to current mobility.

2.2 Mobility tool ownership

Mobility tools include driving licences and available cars as well as different public transport season tickets, such as discount tickets, national and regional tickets for different time periods. The ownership of those mobility tools represents a commitment to the usage of the corresponding modes of transport. Thereby the relationship between the private and the public transport mode is a substitutive one (Simma and Axhausen, 2003). In this context the ownership of cars and the related commitment are widely covered in the literature (De Jong, 1996; De Jong, Fox, Daly, Pieters and Smit, 2004; Hensher, 1998; Bhat and Sen, 2006), whereas the commitment to public transport is seldom considered in studies as they mostly only emphasise its supply. Models taking into account both the ownership of cars and the ownership of different public transport season tickets are very few (Axhausen, Simma and Golob, 2001; Simma *et al.*, 2003; Beige, 2004; Scott and Axhausen, 2006).

Different variables influence the ownership of the various mobility tools (Simma *et al.*, 2003; Beige, 2004). The relationship between age and ownership is nonlinear. Men are more likely to own more driving licences and cars, whereas women show a higher public transport season ticket ownership. Education and employment status as well as income have positive effects on the driving licence and car ownership. A higher income also promotes the ownership of public transport season tickets. The location of the place of residence influences the ownership in such a way that people living in more urban areas tend to have less cars and more public transport season tickets at their disposal as they have better access to public transport in comparison to rural areas.

Through the ownership of those mobility tools people commit themselves to particular travel behaviours as they trade large one-time costs for a low marginal cost at the time of usage. Simma *et al.* (2003) found that the ownership of the different mobility tools influences the usage of the same mode positively and the usage of the other mode negatively. Furthermore it is worthwhile to know how future commitment situations are affected (Simma *et al.*, 2003).

2.3 Long-term spatial mobility during the life course

The life course perspective allows the inclusion of the temporal dimension into the analysis of long-term spatial mobility. Decisions concerning residential mobility as well as mobility tool ownership have long-term effects since corresponding changes involve certain amounts of resources (costs, time, etc.).

Furthermore it is possible with this approach to link different dimensions of life together as they are usually not independent from one another. Events in one area are frequently connected to changes in other areas. Analysing people's life course can contribute to the understanding of their reactions to changes occurring in their personal and familial life, within their household as well as in the spatial structures (Simma *et al.*, 2003). For instance, one can analyse how a move affects mobility tool ownership and therefore travel behaviour. At the same time developments over time can be observed, including time dependent aspects of decisions concerning long-term spatial mobility (Hollingworth *et al.*, 1996; Hensher, 1998).

3. METHODS FOR THE ANALYSIS OF LIFE COURSE DYNAMICS

Life course dynamics can be described with the concepts of trajectory and transition. In this context the life course is seen as a sequence of events. Thereby it is worthwhile to understand an event and the history leading up to the event's occurrence (Box-Steffensmeier and Jones, 2004). By means of event history modelling differences in timing, duration, rates of change and probabilities for the occurrence of certain events within a period of time as well as explanatory variables can be determined. In this context the dependent variable measures the duration until an event occurs.

An essential advantage of the duration modelling approach over traditional linear regression models is its ability to account for problems with censoring. Censoring occurs when information about durations is incomplete. This is the case when subsequent events are unobserved, i.e., no transition from one state to another is made within the surveyed time. The basic problem is that if uncensored and censored cases are treated equally, parameter estimates from a model with the duration as dependent variable might then be under- or overestimated. Furthermore time-varying covariates, i.e., explanatory variables with values changing over time, can easily be included in event history modelling (Yamaguchi, 1991; Box-Steffensmeier *et al.*, 2004).

In the context of event history analysis there exist different approaches. In parametric models the underlying hazard rate or transition rate, i.e., the rate at which events occur, is parameterised in terms of the probability distribution, e.g., Weibull, Gompertz, exponential, gamma, log-logistic and log-normal distributions (Allison, 1995). A semi-parametric alternative is the Cox proportional hazard model (Cox, 1972; Cox, 1975). Thereby it is not necessary to make assumptions

about the particular distributional form of the duration times which makes it preferable over its parametric alternatives (Box-Steffensmeier *et al.*, 2004). In the Cox model the hazard rate for the *i*th individual is

$$h_i(t) = h_0(t)\exp(\beta' x_i),$$

where $h_0(t)$ is the baseline hazard function and $\beta' x_i$ are the parameters and covariates. The hazard rate for the Cox model is proportional as the hazard ratio of the two hazards for two individuals *i* and *j* can be written as

$$\frac{h_i(t)}{h_j(t)} = \exp(\beta'(x_i - x_j)),$$

which demonstrates that this ratio is constant over time (Box-Steffensmeier *et al.*, 2004). The estimation method in the Cox model is the maximum partial likelihood method and allows to estimate the parameters β' without having to specify the baseline hazard function $h_0(t)$. This method is based on the assumption that the intervals between successive duration times contribute no information regarding the relationship between the hazard rate and the covariates, but rather the ordered duration times (Box-Steffensmeier *et al.*, 2004).

Event histories can consist of single events. On the other hand they can include multiple events of the same type or multiple events of different types. Cases where different kinds of events occur are often referred to as competing risks situations. There are many variants of competing risks models proposed in the literature (Kalbfleisch and Prentice, 1980; Han and Hausman, 1990; Box-Steffensmeier *et al.*, 2004). A commonly applied approach is the latent duration time approach. It assumes that there are *K* (*k=1, 2, 3, …, r*) specific events and that there exists a potential or a latent duration time associated with each event. The implementation of this model simply requires that *K* models with type specific hazards are estimated where all events other than *k* are treated as randomly censored (Box-Steffensmeier *et al.*, 2004). Thereby the assumption is made that the *K* risks are conditionally independent. The latent variables approach has been extended to both parametric and semi-parametric settings.

4. DATA

In order to estimate dynamic models for long-term spatial mobility longitudinal data is required. Essentially, there are two ways of collecting such data. The most obvious and well-recognized method is to conduct a panel survey. Data collected this way are very reliable since events are observed as they happen. However, panel surveys are difficult and expensive to carry out as well as rather effort and time consuming. The second method approximating a panel survey is to use a retrospective approach that relies on individual's recall capacity and therefore is subject to the limitations of the human memory. With increasing time elapsed since an event the amount of information retained decreases in a

logarithmic relationship (Hollingworth *et al.*, 1996). People tend to remember major events such as residential moves or personal and familial events better. Therefore those can be used as support for the memory by further linking different dimensions of life together and in doing so placing single events into a larger context (Brückner, 1990). Experiences from Hollingworth *et al.* (1996) showed that a retrospective survey proved to be a favourable alternative to a panel survey. They tested the retrospective approach as a tool for collecting longitudinal data on residential mobility and found that people's ability to recall prior residential mobility decisions and housing details is generally good.

In the context of analysing long-term spatial mobility decisions a longitudinal survey covering the 20 year period from 1985 to 2004 was carried out at the beginning of the year 2005 in a stratified sample of municipalities in the Zurich region, Switzerland, taking into account different spatial and transport-related types of municipalities (Beige und Axhausen, 2005). The survey was conducted as a written self-completion questionnaire consisting of two parts, a household form and a person form. The household form asked for the current address, a short description of all persons living in the household and the household income. In the person form socio-demographic and socio-economic characteristics of the respondents were collected. The essential part of this form was a multidimensional life course calendar for the years from 1985 to 2004. For this 20 year period retrospective information about the personal and familial history, the household size as well as data on moves and corresponding places of residence was collected. In addition, the respondents were asked to indicate their changing ownership of cars and different public transport season tickets. Furthermore data on the places of education and employment, on the main mode of transport for the commuting trip as well as on the personal income was collected for the last 20 years. The household form and the person form are shown in Beige (2006). The questionnaire, together with a self-addressed envelope was sent per post to 3600 households. Overall the response rate amounts to 23.1%, which seems rather low but which is primarily due to the relative complexity and length of the questionnaire. 780 household forms and 1166 person forms are available for further statistical analyses.

5. RESULTS

5.1 Mobility tool ownership

The mobility tools considered in the retrospective survey are cars and different public transport season tickets, including national annual tickets (Nat T), regional annual and monthly tickets (Reg T) as well as half-fare discount tickets (HF T). In Figure 1 and Figure 2 the ownership of mobility tools is shown for the observed time period from 1985 to 2004 and for the age of the respondents, respectively.

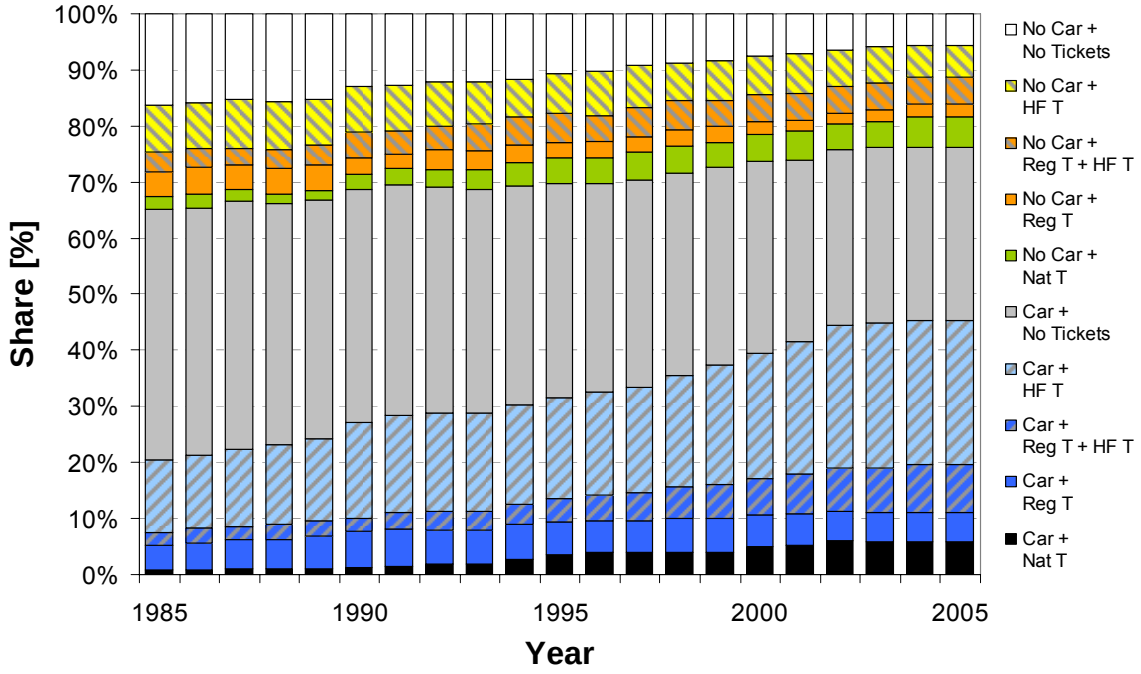

Figure 1 Mobility tool ownership in regard to time (persons aged 18 years and older)

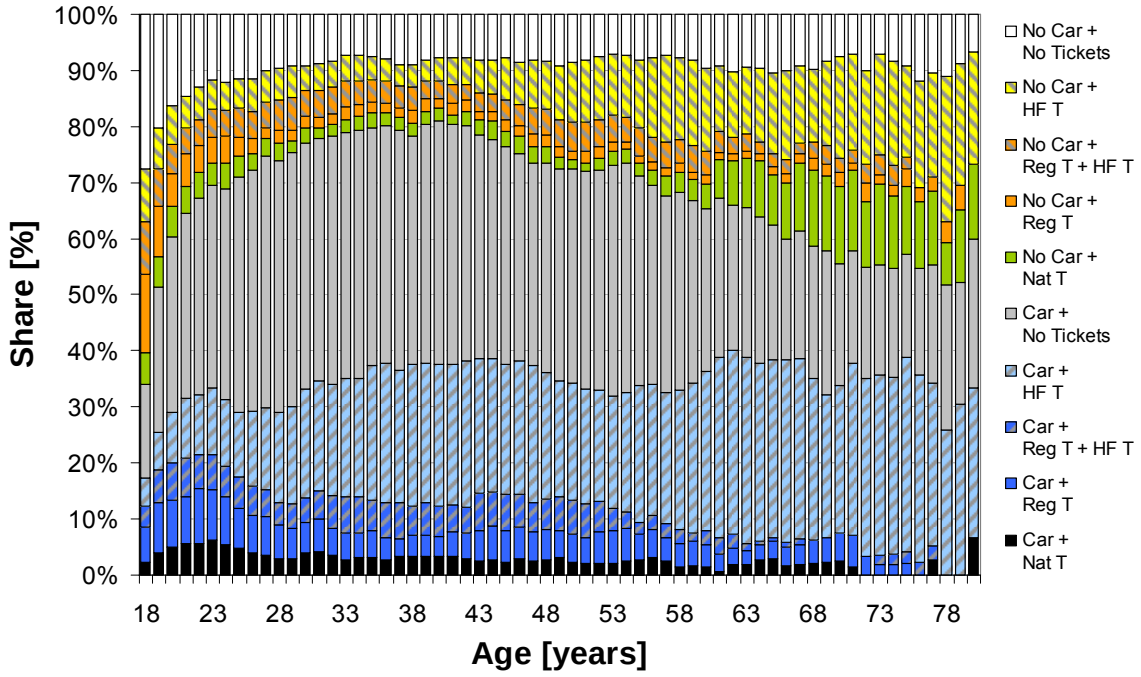

Figure 2 Mobility tool ownership in regard to age (persons aged 18 years and older)

During the 20 year period an increase in the ownership of all mobility tools is observed. The availability of only a car declines over time, whereas the share of car and public transport season ticket owners increases from 20% to 45%. At the same time respondents without any mobility tools diminish during these 20 years. In regard to the age of the respondents there is a strong increase in car ownership after reaching the age of 18 years. Persons aged from 25 to 45 years show the highest share with about 75%. Then a slow decrease is visible. The ownership of national annual tickets increases over the life course, whereas the share of regional annual and monthly tickets decreases at the same time. The half-fare discount tickets have a growing share. About one third of the respondents own a car and public transport season tickets at the same time. The share of national annual, regional annual and monthly tickets decreases with increasing age. Overall the ownership of mobility tools increases at the beginning and then remains relatively stable over the life course with only approximately 10% of persons not having any mobility tool at their disposal.

In Table 1 the results of binary logit models for the ownership of cars and the different public transport season tickets during the observed time period from 1985 to 2004 are presented, including observations for every half year for each respondent. Therefore each respondent appears several times in the data set. In this context panel effects are taken into account in the models. Besides the estimated constants all shown variables are significant. The variable measuring the years elapsed since the beginning of the observed time period has a positive influence for the ownership of all mobility tools, thereby indicating an increase over time. With increasing age the ownership of cars and half-fare discount tickets also increases, whereas the ownership of national and regional tickets for public transport is reduced. Men tend to own more cars but less public transport season tickets than women. A college or university degree leads to a higher ownership of mobility tools. Car ownership is decreased by the simultaneous ownership of public transport season tickets and vice versa. The household size affects car ownership and national annual ticket ownership in a negative way, whereas the size of the accommodation increases the ownership of cars. Respondents living abroad stated a lower ownership of regional annual and monthly tickets as well as of half-fare discount tickets. Persons in education tend to own cars less frequently, whereas persons in employment tend to own cars more frequently. Both groups indicate higher shares of regional ticket and half-fare discount ticket ownership. The distance between the place of residence and the place of employment only plays a role for the ownership of regional annual and monthly tickets. The monthly income influences the mobility tool ownership overall positively with the exception of the ownership of national annual tickets. Population, population density and the degree of urbanisation have different effects for the different mobility tools. Regions of residence with higher numbers of inhabitants show a lower car ownership and national annual ticket ownership. In comparison with urban regions the ownership of cars is higher in more rural regions, whereas the ownership of regional and half-fare discount tickets is lower.

Table 1 Binary logit models for car and public transport season ticket ownership

Explanatory variable	Car ownership	National annual ticket ownership	Regional annual / monthly ticket ownership	Half-fare discount ticket ownership
Year since 1985	+ 0.126	+ 0.104	+ 0.066	+ 0.079
Age in years	+ 0.162	– 0.083		+ 0.083
Age in years * age in years	– 0.002	+ 0.001	– 0.000	– 0.001
Gender: male	– 0.158			– 0.530
Age in years * gender: male	+ 0.025		– 0.009	+ 0.004
College or university degree	+ 0.068		+ 0.283	+ 0.511
Nationality: Swiss	+ 0.098		– 0.116	+ 1.043
Driving licence ownership			– 0.235	+ 0.263
Car ownership			– 0.578	– 0.891
National annual ticket ownership	– 0.559			
Regional annual / monthly ticket ownership	– 0.544			+ 0.594
Half-fare discount ticket ownership	– 0.586		+ 0.599	
Number of persons in the household	– 0.129	– 0.127		
Place of residence abroad			– 0.335	– 0.504
Number of rooms	+ 0.114		– 0.074	
In education	– 0.187		+ 0.497	+ 0.284
Change of education				+ 0.170
In employment	+ 0.329		+ 0.224	+ 0.199
Change of employment			+ 0.196	+ 0.149
Distance between place of residence and place of employment in 1000 km			– 0.003	
Monthly income in 1000 CHF	+ 0.160		+ 0.023	+ 0.093
Monthly income (logarithmic)	– 0.094	– 0.138		– 0.289
Population in residential region in 1000 inhabitants	– 0.000	– 0.001	+ 0.001	– 0.000
Population density in residential region in 1000 inhabitants per km^2			– 0.171	+ 0.177
Degree of urbanisation:				
Urban (referential category)				
Urban to rural	+ 0.471		– 0.412	– 0.098
Rural	+ 0.209		– 0.619	– 0.150
Purchasing power index in residential region	– 0.033		– 0.015	– 0.018
Constant	– 0.056	– 0.026	– 0.086	– 0.297
N = 31695 observations	$\rho^2 = 0.349$	$\rho^2 = 0.633$	$\rho^2 = 0.346$	$\rho^2 = 0.127$

The index of purchasing power measures the changes in consumer prices in a country in euro, making an adjustment for changes in exchange rates (Ascoli, 2000). The purchasing power index in the region of residence has a negative influence for the ownership of all mobility tools. These results are in general consistent with other analyses of mobility tool ownership (Simma *et al.*, 2003; Beige, 2004).

5.2 Duration analysis for mobility tool ownership

In the following the method of event history modelling is applied to the retrospective data for the ownership of the different mobility tools. Figure 3 shows the observed durations of car availability and public transport season ticket ownership.

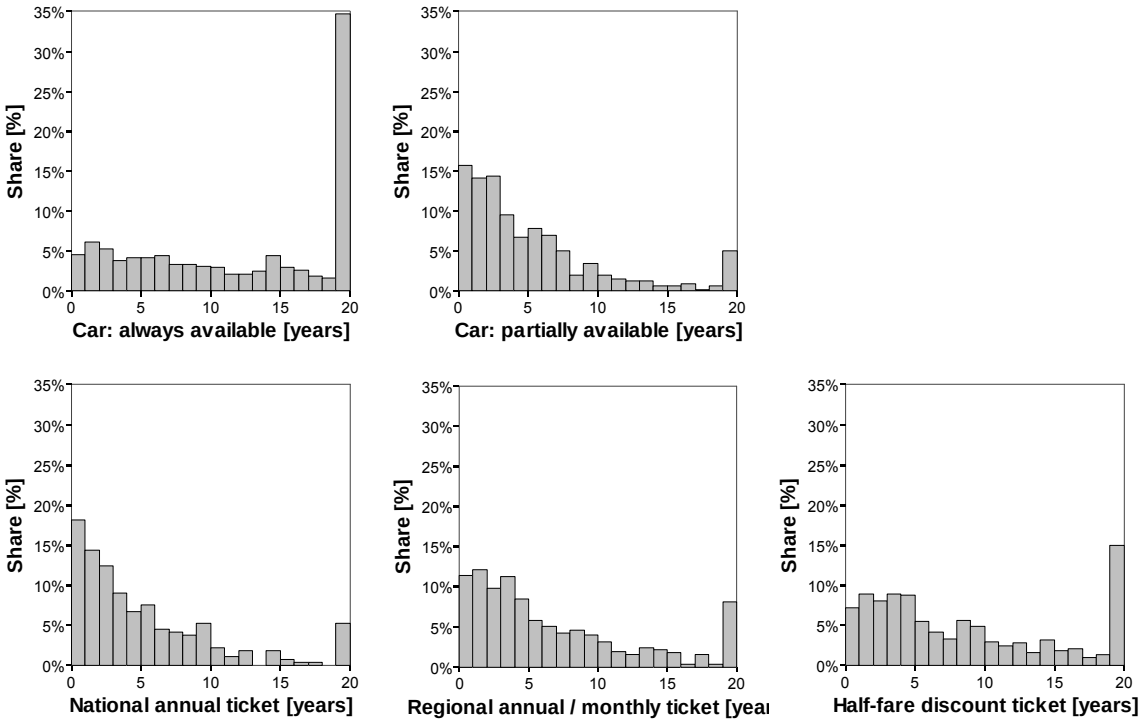

Figure 3 Distribution of the car availability and public transport season ticket ownership durations

For about one third of these durations cars are always available over the whole period from 1985 to 2004. In this context the other duration lengths are relatively evenly distributed. Partial car availability is more often indicated for shorter periods of time with over 50% being less than five years long and over 80% being less than ten years long. Concerning the public transport season tickets the ownership of national annual, regional annual and monthly tickets is left-skewed distributed showing the highest shares for durations shorter than five years. To a lesser extent this also applies for the half-fare discount ticket ownership. Overall the ownership of the different mobility tools is relatively stable

over time, especially the availability of cars. The reason for the slightly more variable ownership of public transport season tickets during the last 20 years is a weaker commitment to public transport as well as to the observed increase in ownership. So a person without a public transport season ticket at the beginning might later own one continuously until the end of the surveyed period. This stability in mobility tool ownership over longer periods of time was also found in other studies (Axhausen and Beige, 2003; Axhausen and Beige, 2004; Simma *et al.*, 2003).

In order to compare the different types of durations competing risks models for the car availability and public transport season ticket ownership durations are estimated. For each type of duration models are estimated treating the others in this context as right censored (Allison, 1995; Box-Steffensmeier *et al.*, 2004).

Figure 4 shows the corresponding hazard rates for the car availability and public transport season ticket ownership durations. The hazard rate represents the probability or intensity of events occurring per time unit. The curves for the different mobility tool durations are relatively flat with the hazard rate not rising above a 0.02-level. There are no clear tendencies noticeable. The hazard rates strongly vary over time.

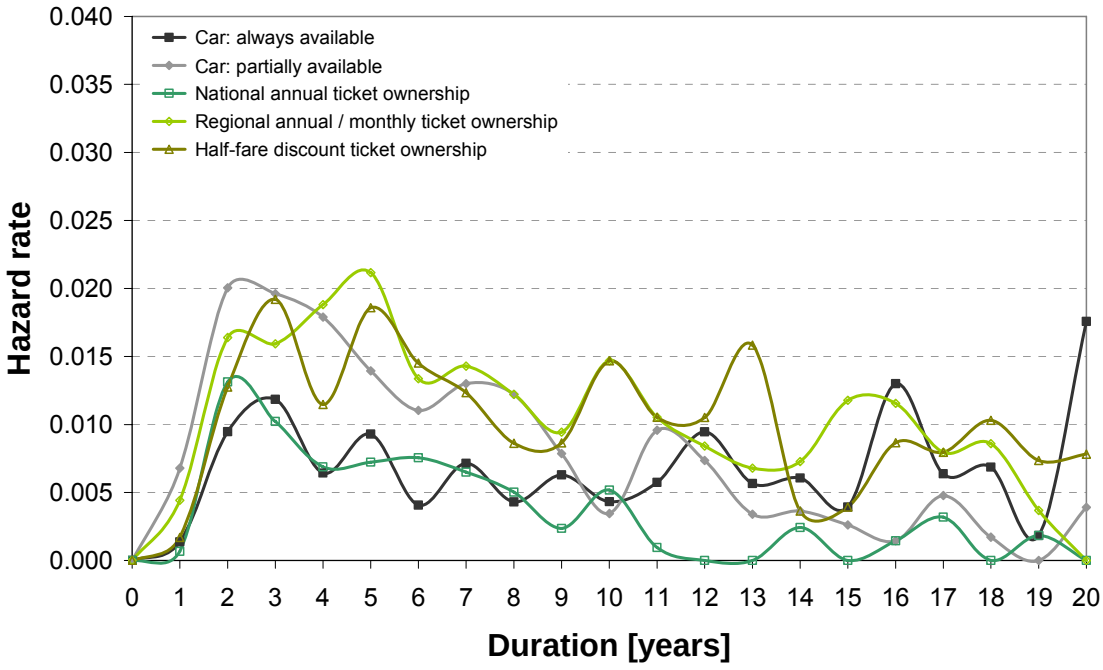

Figure 4 Hazard rate of the car availability and public transport season ticket ownership durations

Table 2 shows the results of the different competing risks models for the mobility tool ownership durations are shown. The observations for these five types are

grouped together. At the same time the multiple appearances of persons in the data set are taken into account using the fixed-effects partial likelihood (FEPL) method which allows correcting for unobserved heterogeneity (Allison, 1995; Box-Steffensmeier *et al.*, 2004). In this context the identification of the respondents is included as strata variable. So each stratum has its own baseline hazard rate while the parameters are restricted to be the same across strata. One disadvantage of the FEPL method is that it can only estimate parameters for those covariates that vary over time. On the other hand this method controls for all constant covariates, such as gender, education, nationality, etc. For all three models the same explanatory variables are used to make a comparison of the results possible. In the table the hazard ratio and the level of significance are given. The hazard ratio is equivalent to the exponential parameter (Allison, 1995). For continuous variables it indicates the percentage change of the hazard rate, whereas for dichotomous variables it equals the proportion of the two corresponding hazard rates. As a measure of how good the different models are and how well the corresponding durations can be predicted with the set of covariates, respectively, generalised R^2's are given at the bottom of the table (Allison, 1995). R^2 is calculated, as proposed by Cox and Snell,

$$R^2 = 1 - \exp\left(-\frac{2(L(\max) - L(0))}{N}\right),$$

where *L(0)* and *L(max)* represent the initial and the final log-likelihoods, respectively, and *N* is the sample size. The variable for the occurrence of left censoring is significant and has, concurrent with the expectations, a positive influence on the duration. Car availability and national annual ticket ownership are positively influenced by the squared age of the respondents. The ownership of national and regional tickets increases the hazard rate for the availability of cars. The same applies for the effect of car availability on public transport season ticket ownership, especially on half-fare discount ticket ownership. The household size and particularly the number of births reduce the probability of variations in mobility tool ownership. When a simultaneous change of residence, education and employment occurs the ownership durations tend to be much shorter. Moves during the observed period lead to lower risks of variations. The duration for always available cars is increased for respondents living abroad, but decreases for persons in bigger accommodations. Education only plays primarily a role for the ownership of partially available cars. Changes in employment have a positive influence on the ownership of all mobility tools. For an increasing purchasing power index in the region of residence the hazard rates also increase, being most important for cars and national tickets since these two mobility tools are the most costly ones.

Table 2 Hazard ratios of the competing risks models for the car availability and public transport season ticket ownership durations

Explanatory variable *(Average values for the observed period)*	Car: always available	Car: partially available	National annual ticket ownership	Regional annual / monthly ticket ownership	Half-fare discount ticket ownership
Left censoring of the duration	0.008 ***	0.072 ***	0.035 *	0.363	0.323 **
Age in years	1.735	0.755	1.178	0.686	0.787
Age in years * age in years	0.969 ***	0.987 ***	0.981 ***	0.995	1.000
Driving licence ownership			2.400	0.983	2.377
Car: always available			0.010 ***	0.331	0.101 ***
Car: partially available			0.099	0.655	0.115 ***
National annual ticket ownership	0.102 *	0.900			
Regional annual / monthly ticket ownership	0.059 *	0.221 ***			0.243 ***
Half-fare discount ticket ownership	0.270	1.126		0.813	
Number of persons in the household	0.509 **	1.064	0.643	1.097	1.247
Number of births in the household	0.213 **	0.306 ***	0.093 **	0.235	0.301 *
Moving out of parents' house	0.335	0.375 **	1.450	0.308	0.680
Simultaneous change of residence and education / employment	3.402	5.658 ***	13.026 ***	12.177 ***	3.075 **
Duration of residence at the beginning of the period in years	0.833 **	1.026	0.955	1.118 **	1.027
Changes of residence during the period	0.183 ***	0.303 ***	0.335 ***	0.219 ***	0.451 ***
Place of residence abroad	0.002 **	0.244	0.112	0.070	0.335
Number of rooms	3.290 ***	0.863	1.272	0.670 *	0.874
Share in education during the period	0.126	0.129 **	2.709	3.626	1.656
Duration of education at the beginning of the period in years	0.804	1.366 ***	1.047	0.845 *	1.155
Changes of education during the period	1.091	0.343 ***	0.785	0.523 **	0.667
Distance between place of residence and place of education in 1000 km	$>10^9$	0.000	4628.3	$>10^9$ *	0.684
Share in employment during the period	4.126	0.283	3.710	7.142 **	1.192
Duration of employment at the beginning of the period in years	1.019	1.301 **	0.865	0.895	1.076
Changes of employment during the period	0.386 *	0.565 **	0.101 ***	0.489 ***	0.501 ***
Distance between place of residence and place of employment in 1000 km	0.000	13.771 *	$>10^9$ ***	7.251	0.069
Monthly income in 1000 CHF	0.107 **	0.773	1.419	1.784 **	0.888
Monthly income (logarithmic)	714.74 **	1.410	3.548	0.210 *	6.671 **
Population in residential region in 1000 inhabitants	1.000	0.999	1.001	1.001	0.999
Population density in residential region in 1000 inhabitants per km^2	1.673	4.650 **	1.157	1.460	0.692

Continuation of the table …

Explanatory variable *(Average values for the observed period)*	Car: always available	Car: partially available	National annual ticket ownership	Regional annual / monthly ticket ownership	Half-fare discount ticket ownership
Purchasing power index in residential region	1.326 **	1.293 ***	1.356 ***	1.148 **	1.007
N = 2689 durations	R^2 = 0.057	R^2 = 0.113	R^2 = 0.062	R^2 = 0.120	R^2 = 0.072
	Level of significance:	* = 0.10		** = 0.05	*** = 0.01

6. CONCLUSIONS

The analyses concerning the ownership of the different mobility tools show that it is relatively stable over longer periods of time, especially the availability of cars.

In order to compare the different types of durations competing risks models for the car availability and public transport season ticket ownership durations are analysed. The ownership of national and regional tickets increases the hazard rate for the availability of cars. The same applies for the effect of car availability on public transport season ticket ownership, especially on half-fare discount ticket ownership. The household size and particularly the number of births reduce the probability of variations in mobility tool ownership. When a simultaneous change of residence, education and employment occurs the ownership durations tend to be much shorter. Moves as well as changes in education and employment during the observed period lead to lower risks of variations in the ownership of all mobility tools. For an increasing purchasing power index in the region of residence the hazard rates also increase, being most important for cars and national tickets since these two mobility tools are the most costly ones. The distances to the places of occupation have no distinct influence.

Further developments in duration modelling include the estimation of more flexible hazard models with the form of discrete choice models that allow for inter-individual and intra-individual variability of people (Bhat, 2003; Bhat, Srinivasan and Axhausen, 2003). In a next step these analyses will be applied for the residential mobility as well as for the ownership of mobility tools. In addition the points in time when events occur in the different life course dimensions and the delays between these events are of interest (Rouwendal and Vlist, 2005). Further analysis in this context will concentrate on duration models for the delays between events in the different life course dimensions, as for instance applied by Vandersmissen et al. (2005) to the propensity to move after a change in work and/or work place.

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