Mobility Resources in Switzerland in 2015

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Abstract

This paper describes a model for mobility resources in Switzerland. The joint availability of car and public transport season ticket is explained by different factors, such as age, income and region. The model is estimated using the data of the Mobility and Transport Microcensus 2015. Results and cross validation are presented.

Illustration on the title page: AgonPro AG, Dunja Nagel www.agonpro.ch

Keywords

mobility resources, mobility tools, mobility resource ownership, national travel survey, transport and mobility microcensus, discrete choice models, logit model

1 Introduction

Mobility resources[1] are prerequisites that allow to be mobile on a daily basis: having a driving license for cars or a car available, buying cars or public transport tickets, having bicycles or motorbikes, being a member of a car sharing network, installing an App for ride sharing, having a parking space or being fit enough to walk. In this paper, we consider only the ownership of public transport tickets and the availability of cars.

We develop a logit model where the alternatives are a combination of car availability and ownership of three different public transport seasonal tickets. The 10 possible combinations of mobility resources defining the choice set are presented in Section 3. We present the attributes used to explain this choice of a combination of mobility resources in Section 4 and the general structure of the model in Section 5. The model is estimated on Swiss data (see Section 2) and the results are presented in Section 6 and validated in Section 7. We conclude with future works and possible applications of such a model (Section 8).

The main differences in comparison with the results in Kowald *et al.* (2016) are:

1. the usage of the new data from the Swiss national travel survey, the Mobility and Transport Microcensus (MTMC) 2015 (OFS/ARE, 2017) and
2. the addition of one more public transport ticket, the regional travelcard ("Verbundabonnement" in German, "abonnement de communauté tarifaire" in French).

Our main motivation for developing this model is the generation of a synthetic population with mobility resources as a characteristic.

2 Data: Mobility and Transport Microcensus

The data come from the Swiss national travel survey, the Mobility and Transport Microcensus (MTMC). This is a statistical survey of the travel behavior of the Swiss population starting with age 6. It is conducted every five years by the Swiss Federal Statistical Office (FSO) and the Swiss Federal Office for Spatial Development (ARE). Computer-assisted telephone interviewing (CATI) is used to collect the data. The most recent data were collected in 2015 (9th edition). We

[1] Similarly to Kowald *et al.* (2016), we don't use the word "mobility tools" here, since we also consider car availability in our model, which is not a tool *per se*.

use these latest data in this paper. The dataset contains:

- the socioeconomic characteristics of households and individuals
- mobility tools
- daily mobility (trips on a given reference day)
- occasional journeys (day trips and trips with overnight stays)
- attitudes towards transport policy in Switzerland

The sample contains more than 57'000 individuals. The MTMC data are available to researchers in anonymized form once they have signed a non-disclosure agreement. Please contact `mobilita2015@bfs.admin.ch` if you want to access the data.

A report on results can be found on `http://www.mzmv.bfs.admin.ch` and `http://www.are.admin.ch/mtmc` in German and French. A summary is available in English. A methodological report in French, the questionnaire in French and German and the main results with confidence intervals as spreadsheet can be found on the FSO website. Further analysis, e.g. about regional differences or mobility for leisure, can be found on the ARE website.

2.1 Descriptive results about car availability

76% of people with a driving license always have a car available and 18% of them have a car available on demand. The meaning of "on demand" is defined by the interviewee. Only 53% of young people (18 to 24 years old), always have a car available, and 40% of them have it on demand. For more results, see OFS/ARE (2017), Ch. 2.1.3, and the spreadsheets on the FSO website.

2.2 Descriptive results about public transport season tickets

57% of the Swiss resident population aged 16 or more own a public transport season ticket. The half fare travel ticket is the most common (36%), followed by the regional travelcard (15%) and the general abonnement travel ticket (GA) (10%). More results are available in OFS/ARE (2017), Ch. 2.2, and in the spreadsheets on the FSO website.

3 Definitions of mobility resources

We consider ten combinations of mobility resources in our model:

1. Car available
2. Car available and general abonnement travel ticket (GA)
3. Car available and half fare travel ticket
4. Car available, half fare travel ticket and regional travelcard
5. Car available and regional travelcard
6. No mobility resource (no car available and no public transport ticket)
7. General abonnement travel ticket (GA)
8. Half fare travel ticket
9. Half fare travel ticket and regional travelcard
10. Regional travelcard

The mobility resources are described in the following sections: Car availability in Section 3.1, GA in Section 3.2, half fare travel ticket in Section 3.3 and regional travelcard in Section 3.4.

3.1 Car availability

In our model, we use the definition from the Mobility and Transport Microcensus (MTMC). The question was "Please tell us for the following transport means if they are always, on demand or not at all available to you, including when you or your household do not own them, but when you can borrow them". The list of transport means included the car as option number 5.

The variable in the raw data (available on demand for researchers) is coded `f42100e` in the table "person" ("Zielperson" in German). It takes the following values:

1 Always available
2 Available on demand
3 Not available
-99 The person has no driving license
-98 No answer
-97 Don't know

Individuals who answered 1, 2, 3 and -99 have been used in the estimation of our model. The

other observations have not been considered. The answers "available on demand" (2) and "the person has no driving license" have been considered as "not available". This classification is motivated by our focus on daily mobility. "Available on demand" is not considered as a long term solution to have a car available.

Previous studies used another definition. Axhausen *et al.* (2006) and Kowald *et al.* (2016) define car availability as:

- having a driving license, and
- the ratio of cars per persons having a driving license in the household is higher than 0.5: $\frac{\text{nb cars}}{\text{nb driving license}} \geqslant 0.5$

3.2 General abonnement travel ticket (GA)

The general abonnement travel ticket (GA) allow free and unlimited use of most of the public transport network in Switzerland.

The question in the MTMC was "do you own one or more of these public transport season tickets?" and the GA was the first public transport season ticket to be mentioned in the interview. The possible answers were:

1 Yes
2 No
-99 The question was not asked
-98 No answer
-97 Don't know

Only individuals with valid values (1 and 2) have been used in the estimation of our model. The variable is coded `f41610a` in the table "persons" in the dataset. Another variable, `f41651`, provides the information about the class, 1st or 2nd. This information was not used in our model.

3.3 Half fare travel ticket

The half fare travel ticket offer a price reduction of 50% for most of the public transport in Switzerland.

The question in the MTMC was the same as for the GA. The half fare travel ticket was the second public transport season ticket mentioned in the interview. The possible answers were:

1 Yes
2 No
-99 Younger than 16 years old
-98 No answer
-97 Don't know

Values 1, 2 and -99 have been used in the estimation of our model. The answer "younger than 16 years old" is considered like "not available". The variable is coded `f41610b` in the table "persons" in the dataset.

3.4 Regional travelcard

The regional travelcards ("Verbundabonnement" in German, "abonnement communautaire" or "abonnement de communauté tarifaire" in French) allow to travel for free in an area. They are available in most regions in Switzerland.

The question in the MTMC was the same as for the GA and the half fare travel ticket. The regional travelcard was the third public transport season ticket mentioned in the interview. The possible answers were:

1 Yes
2 No
-99 The question was not asked
-98 No answer
-97 Don't know

Only individuals with valid values (1 and 2) have been used in the estimation of our model. The variable is coded `f41610c` in the table "persons" in the dataset.

4 Attributes explaining the choice of mobility resources

4.1 Age

Age is available in the data (table "persons", variable `alter` in the database). It has been included in the model using a piecewise linear specification.

4.2 Gender

Gender is available in the data (table "persons", variable "gesl" in the dataset). The possible values are:

1 Man
2 Woman

4.3 Income of the household

The income of the household is available in the data (table "household", "Haushalte" in German, variable `F20601`). The possible answers are:

1 Below CHF 2000 (the 3.4% of people with the lowest income in the MTMC)
2 Between CHF 2000 and 4000 (3.4% to 22.4% of the income distribution in the MTMC)
3 Between CHF 4001 and 6000 (22.4% to 45.1% of the income distribution in the MTMC)
4 Between CHF 6001 and 8000 (45.1% to 63.7% of the income distribution in the MTMC)
5 Between CHF 8001 and 10'000 (63.7% to 76.7% of the income distribution in the MTMC)
6 Between CHF 10'001 and 12'000 (76.7% to 85.7% of the income distribution in the MTMC)
7 Between CHF 12'001 and 14'000 (85.7% to 90.4% of the income distribution in the MTMC)
8 Between CHF 14'001 and 16'000 (90.4% to 94.3% of the income distribution in the MTMC)
9 More than CHF 16'000 (94.3% to 100% of the income distribution in the MTMC)
-98 No answer
-97 Don't know

For the estimation of the model, the answer -98 and -97 have been merged as "not available

(NA)" and three groups have been used for people with valid information:

- Below CHF 4000 (0% to 22.4% of the income distribution in the MTMC, as reference)
- Between CHF 4001 and 10'000 (22.4% to 76.7%)
- More than CHF 10'000 (76.7% to 100%)

4.4 Region of the place of living

Seven different regions have been included in the model (variable `W_REGION` in table "household"):

1 Lake Geneva region
2 Espace Mittelland
3 Northwestern Switzerland
4 Zurich region
5 Eastern Switzerland
6 Central Switzerland
7 Ticino/Tessin
-97 No information / missing geoinformation

4.5 Category of household

The variable `hhtyp` in the table "household" defines the following categories:

100 Household with one person
210 Couples without children in the household
220 Couples with children in the household
230 Household with one parent and children in the household
240 Adults with elderly care
300 Not-family household
-98 No answer
-97 Don't know

The values -98 and -97 have been merged in the model.

4.6 Labour status

The variable ERWERB in table "persons" provides different labour status:

1 Working full-time
2 Working part-time
3 Studying
4 Not active
9 Active, but unknown if full-time or part-time
-98 No answer
-97 Don't know

4.7 Highest level of education completed

The level of education exists in two levels of details in the MTMC: one variable, HAUSB3, defines three levels of education as aggregates of the answers of the respondents:

1 Mandatory school finished
2 Secondary education
3 Tertiary education
-99 Age of the person is lower than 15 years old
-98 No answer
-97 Don't know

A more detailed variable, HAUSB, is the raw data from the telephone interview and contains 19 different levels of education (sometimes difficult to translate in English):

1 No school attended
2 Mandatory school not finished
3 Mandatory school finished
4 One-year extra education after mandatory school
5,6 Two-year vocational training ("berufliche Grundbildung" in German)
7 2-3-year vocational training
8, 9 3-4-year vocational training
10 School to become teacher
11 High school (with the goal to access university)

12 High school (specialized or professional)
13, 14 Higher vocational education
15 Technical high school
16 Higher technical college
17 Universities of applied science
18 Teacher training college
19 Universities
-99 Age of the person is lower than 15 years old
-98 No answer
-97 Don't know

None of these definitions corresponds with the needs for generating a synthetic population. In our mobility resources model, we use the following 4 levels of education:

1 No post mandatory school education ([HAUSB] = 1, 2, 3, 4)
2 Secondary education ([HAUSB] = 5, 6, 7, 8, 9, 10, 11, 12)
3 Tertiary Education ([HAUSB] = 13, 14, 15, 16)
4 University ([HAUSB] = 17, 18, 19)

4.8 Population of the commune

In our model, we use the population in the commune of the place of residence on January 1st, 2015.

5 The model

Ten alternatives are available at most. Some mobility resources are limited by the age: cars are only available from 18 and the half fare travel ticket is only useful from 16 (before 16, the public transport tickets are anyway half fare in Switzerland).

Code	Combinations of mobility resources	Availability
1	Car available + GA (with or without half fare travel ticket)	18+
2	Car available + half fare travel ticket	18+
3	Car available only	18+
20	Car available + half fare travel ticket + regional travel card	18+
30	Car available + regional travel card	18+
4	GA	All
5	Half fare travel ticket	16+
6	No mobility resources (among the 4 considered here)	All
50	Half fare travel ticket + regional travel card	16+
60	Regional travel card	All

Table 1: Choice set and availability of the model

6 Results

The logit model contains 247 parameters. 56'915 observations/individuals with valid informations about mobility resources are used for the estimation (out of a total of 57'090 observations/individuals in the MTMC). The results are decomposed in different tables for readability. In the tables, "HT" stands for half fare travel ticket ("Halbtax" in German) and "Verbund" stands for regional travel card ("Verbundabonnement" in German).

Summary statistics

$$\begin{aligned} \mathcal{L}(0) &= -121699.317 \\ \mathcal{L}(\hat{\beta}) &= -87890.622 \\ -2[\mathcal{L}(0) - \mathcal{L}(\hat{\beta})] &= 67617.390 \\ \rho^2 &= 0.278 \\ \bar{\rho}^2 &= 0.276 \end{aligned}$$

Table 2: Summary statistics

The ownership of a general abonnement travel ticket (GA) presents two peaks, between 18 and 20 years old, and after 65 (Table 3). The first peak might be explained by a higher mobility rate. Indeed, the age group 18-24 is the most mobile with 48 km per day on average, e.g. in comparison with an average of 36.8 km among the whole population (see OFS/ARE (2017), figure G 3.2.1.1 & 3.2.1.3). The first peak might also be explained by the discounts that are available for students and for households owning several general abonnement travel ticket. The second peak is most probably due to retirement and a larger time budget for leisure. The

Description	Coeff. estimate	Robust Asympt. std. error	*t*-stat	*p*-value
B_age_6_16_GA	0.643	0.0382	16.82	0.00
B_age_6_16_Verbund	0.451	0.0160	28.21	0.00
B_age_16_18_GA	0.465	0.0792	5.86	0.00
B_age_16_18_HT	0.402	0.0796	5.05	0.00
B_age_16_18_HT_Verbund	0.356	0.0873	4.07	0.00
B_age_16_18_Verbund	0.352	0.0659	5.35	0.00
B_age_18_20_CarAvail_GA	0.210	0.127	1.65	0.10
B_age_18_20_CarAvail_HT	-0.263	0.111	-2.36	0.02
B_age_18_20_GA	-0.0716	0.0686	-1.05	0.30
B_age_18_20_HT	-0.508	0.0756	-6.73	0.00
B_age_18_20_HT_Verbund	-0.458	0.0848	-5.40	0.00
B_age_18_20_Verbund	-0.452	0.0737	-6.13	0.00
B_age_18_25_CarAvail	0.138	0.0157	8.81	0.00
B_age_18_25_CarAvail_HT_Verbund	0.00286	0.0397	0.07	0.94
B_age_18_25_CarAvail_Verbund	-0.0850	0.0276	-3.09	0.00
B_age_20_25_CarAvail_GA	-0.0649	0.0335	-1.94	0.05
B_age_20_25_CarAvail_HT	0.164	0.0274	5.99	0.00
B_age_20_25_HT	-0.00613	0.0252	-0.24	0.81
B_age_20_25_HT_Verbund	-0.121	0.0306	-3.94	0.00
B_age_20_25_Verbund	-0.150	0.0283	-5.30	0.00
B_age_20_45_GA	-0.0540	0.00433	-12.49	0.00
B_age_25_45_HT_Verbund	-0.00573	0.00607	-0.94	0.35
B_age_25_45_Verbund	-0.0123	0.00579	-2.12	0.03
B_age_25_65_CarAvail	0.0123	0.00187	6.56	0.00
B_age_25_65_CarAvail_GA	0.0433	0.00313	13.82	0.00
B_age_25_65_CarAvail_HT	0.0371	0.00209	17.77	0.00
B_age_25_65_CarAvail_HT_Verbund	0.0285	0.00390	7.30	0.00
B_age_25_65_CarAvail_Verbund	0.00329	0.00378	0.87	0.38
B_age_25_65_HT	0.0136	0.00242	5.62	0.00
B_age_45_65_GA	0.0265	0.00552	4.80	0.00
B_age_45_65_HT_Verbund	0.0140	0.00624	2.24	0.02
B_age_45_65_Verbund	-0.0107	0.00625	-1.72	0.09
B_age_65_and_more_CarAvail	-0.0683	0.00395	-17.29	0.00
B_age_65_and_more_CarAvail_GA	-0.0580	0.00790	-7.34	0.00
B_age_65_and_more_CarAvail_HT	-0.0584	0.00411	-14.22	0.00
B_age_65_and_more_CarAvail_HT_Verbund	-0.0385	0.00867	-4.44	0.00
B_age_65_and_more_CarAvail_Verbund	-0.0430	0.00966	-4.45	0.00
B_age_65_and_more_GA	-9.46e-05	0.00592	-0.02	0.99
B_age_65_and_more_HT	-0.0251	0.00462	-5.43	0.00
B_age_65_and_more_HT_Verbund	-8.42e-05	0.00678	-0.01	0.99
B_age_65_and_more_Verbund	-0.0143	0.00749	-1.90	0.06

Table 3: Results related to age

age group 65-79 shows the largest increase in the average daily travel distance since 1994 in Switzerland among all age groups (see OFS/ARE (2017), Chapter 3.2.1). Car availability increases with age between 18 and 65. Then it starts decreasing.

Description	Coeff. estimate	Robust Asympt. std. error	*t*-stat	*p*-value
B_MALE_CarAvail	-0.257	0.0824	-3.12	0.00
B_MALE_CarAvail_GA	0.530	0.0624	8.49	0.00
B_MALE_CarAvail_HT	-0.502	0.101	-4.98	0.00
B_MALE_CarAvail_HT_Verbund	-0.494	0.201	-2.46	0.01
B_MALE_CarAvail_Verbund	-0.664	0.174	-3.82	0.00
B_MALE_GA	-0.462	0.0885	-5.22	0.00
B_MALE_HT	-0.112	0.0984	-1.14	0.26
B_MALE_HT_Verbund	-0.416	0.119	-3.50	0.00
B_MALE_Verbund	-0.297	0.0764	-3.89	0.00

Table 4: Results related to gender

Description	Coeff. estimate	Robust Asympt. std. error	*t*-stat	*p*-value
B_AGE_TIME_MALE_CarAvail	0.158	0.0153	10.36	0.00
B_AGE_TIME_MALE_CarAvail_HT	0.133	0.0178	7.45	0.00
B_AGE_TIME_MALE_CarAvail_HT_Verbund	0.123	0.0374	3.28	0.00
B_AGE_TIME_MALE_CarAvail_Verbund	0.184	0.0358	5.14	0.00
B_AGE_TIME_MALE_GA	0.107	0.0190	5.62	0.00
B_AGE_TIME_MALE_HT	-0.0173	0.0185	-0.93	0.35
B_AGE_TIME_MALE_HT_Verbund	-0.00334	0.0249	-0.13	0.89
B_AGE_TIME_MALE_Verbund	0.0285	0.0203	1.41	0.16

Table 5: Results related to gender and age

People living in the households with the highest incomes tend to have more mobility resources in comparison with the people living in the households with the lowest incomes (Table 6). This is true for all mobility resources, but for the regional travelcard where there is no difference. The exact same effect is observed for people living in households with middle incomes: they own more mobility resources than the people living in households with the lowest incomes. However, the coefficient estimates for people living in households with middle incomes are lower for all mobility resources in comparison with people living in the richest households, which is coherent.

People living in Ticino/Tessin have more often a car available than in other regions (Table 7). Then also have less general abonnement travel ticket (GA) and less half fare travel ticket (HT)

Description	Coeff. estimate	Robust Asympt. std. error	*t*-stat	*p*-value
B_HH_INCOME_4001_to_10000_CarAvail	0.422	0.0480	8.79	0.00
B_HH_INCOME_4001_to_10000_CarAvail_GA	1.39	0.127	10.96	0.00
B_HH_INCOME_4001_to_10000_CarAvail_HT	1.11	0.0569	19.52	0.00
B_HH_INCOME_4001_to_10000_CarAvail_HT_Verbund	1.24	0.144	8.62	0.00
B_HH_INCOME_4001_to_10000_CarAvail_Verbund	0.682	0.125	5.45	0.00
B_HH_INCOME_4001_to_10000_GA	0.610	0.0778	7.84	0.00
B_HH_INCOME_4001_to_10000_HT	0.340	0.0600	5.67	0.00
B_HH_INCOME_4001_to_10000_HT_Verbund	0.286	0.0831	3.44	0.00
B_HH_INCOME_4001_to_10000_Verbund	-0.137	0.0785	-1.75	0.08
B_HH_INCOME_MORE_THAN_10000_CarAvail	0.787	0.0654	12.04	0.00
B_HH_INCOME_MORE_THAN_10000_CarAvail_GA	2.53	0.138	18.37	0.00
B_HH_INCOME_MORE_THAN_10000_CarAvail_HT	2.13	0.0727	29.30	0.00
B_HH_INCOME_MORE_THAN_10000_CarAvail_HT_Verbund	2.40	0.156	15.40	0.00
B_HH_INCOME_MORE_THAN_10000_CarAvail_Verbund	1.27	0.141	9.02	0.00
B_HH_INCOME_MORE_THAN_10000_GA	1.49	0.0939	15.82	0.00
B_HH_INCOME_MORE_THAN_10000_HT	0.905	0.0796	11.36	0.00
B_HH_INCOME_MORE_THAN_10000_HT_Verbund	0.967	0.102	9.44	0.00
B_HH_INCOME_MORE_THAN_10000_Verbund	-0.0599	0.104	-0.57	0.57
B_HH_INCOME_NA_CarAvail	0.286	0.0558	5.12	0.00
B_HH_INCOME_NA_CarAvail_GA	1.19	0.137	8.67	0.00
B_HH_INCOME_NA_CarAvail_HT	0.913	0.0647	14.11	0.00
B_HH_INCOME_NA_CarAvail_HT_Verbund	1.07	0.156	6.89	0.00
B_HH_INCOME_NA_CarAvail_Verbund	0.459	0.141	3.26	0.00
B_HH_INCOME_NA_GA	0.510	0.0860	5.92	0.00
B_HH_INCOME_NA_HT	0.196	0.0694	2.82	0.00
B_HH_INCOME_NA_HT_Verbund	0.0744	0.0957	0.78	0.44
B_HH_INCOME_NA_Verbund	-0.0644	0.0890	-0.72	0.47

Table 6: Results related to income

alone (without a car associated). These results are coherent with the descriptive statistics in OFS/ARE (2017), Table T2.2.1. We don't observe such a clear distinction for the regional travelcard, both in the descriptive statistics and in our model of mobility resources.

People living alone in their household tend to have more mobility resources than other categories of households (Table 8). They have more general abonnement travel ticket (GA), which was already observed with the data of 2010 (Kowald *et al.,* 2016). Surprisingly, they also have a higher accessibility to a car, which is not intuitive and contradicts the results in Kowald *et al.* (2016).

Description	Coeff. estimate	Robust Asympt. std. error	*t*-stat	*p*-value
B_REGION_CENTRAL_SWITZERLAND_CarAvail	-0.323	0.0788	-4.10	0.00
B_REGION_CENTRAL_SWITZERLAND_CarAvail_GA	0.994	0.206	4.81	0.00
B_REGION_CENTRAL_SWITZERLAND_CarAvail_HT	1.38	0.104	13.24	0.00
B_REGION_CENTRAL_SWITZERLAND_CarAvail_HT_Verbund	1.17	0.268	4.36	0.00
B_REGION_CENTRAL_SWITZERLAND_CarAvail_Verbund	-0.727	0.196	-3.71	0.00
B_REGION_CENTRAL_SWITZERLAND_GA	1.66	0.199	8.31	0.00
B_REGION_CENTRAL_SWITZERLAND_HT	1.44	0.138	10.48	0.00
B_REGION_CENTRAL_SWITZERLAND_HT_Verbund	1.34	0.203	6.59	0.00
B_REGION_CENTRAL_SWITZERLAND_Verbund	-0.675	0.110	-6.12	0.00
B_REGION_EASTERN_SWITZERLAND_CarAvail	-0.315	0.0738	-4.27	0.00
B_REGION_EASTERN_SWITZERLAND_CarAvail_GA	0.722	0.204	3.55	0.00
B_REGION_EASTERN_SWITZERLAND_CarAvail_HT	1.07	0.101	10.61	0.00
B_REGION_EASTERN_SWITZERLAND_CarAvail_HT_Verbund	0.788	0.266	2.96	0.00
B_REGION_EASTERN_SWITZERLAND_CarAvail_Verbund	-0.837	0.185	-4.52	0.00
B_REGION_EASTERN_SWITZERLAND_GA	1.44	0.196	7.32	0.00
B_REGION_EASTERN_SWITZERLAND_HT	1.31	0.134	9.77	0.00
B_REGION_EASTERN_SWITZERLAND_HT_Verbund	0.864	0.202	4.27	0.00
B_REGION_EASTERN_SWITZERLAND_Verbund	-0.995	0.108	-9.22	0.00
B_REGION_ESPACE_MITTELLAND_CarAvail	-0.274	0.0710	-3.85	0.00
B_REGION_ESPACE_MITTELLAND_CarAvail_GA	1.28	0.196	6.54	0.00
B_REGION_ESPACE_MITTELLAND_CarAvail_HT	0.963	0.0986	9.76	0.00
B_REGION_ESPACE_MITTELLAND_CarAvail_HT_Verbund	0.873	0.261	3.34	0.00
B_REGION_ESPACE_MITTELLAND_CarAvail_Verbund	-0.419	0.168	-2.49	0.01
B_REGION_ESPACE_MITTELLAND_GA	1.83	0.193	9.49	0.00
B_REGION_ESPACE_MITTELLAND_HT	1.21	0.132	9.20	0.00
B_REGION_ESPACE_MITTELLAND_HT_Verbund	1.03	0.197	5.21	0.00
B_REGION_ESPACE_MITTELLAND_Verbund	-0.440	0.0962	-4.58	0.00
B_REGION_LAKE_GENEVA_CarAvail	-0.205	0.0715	-2.86	0.00
B_REGION_LAKE_GENEVA_CarAvail_GA	0.780	0.199	3.92	0.00
B_REGION_LAKE_GENEVA_CarAvail_HT	0.636	0.100	6.36	0.00
B_REGION_LAKE_GENEVA_CarAvail_HT_Verbund	0.549	0.263	2.09	0.04
B_REGION_LAKE_GENEVA_CarAvail_Verbund	0.382	0.158	2.42	0.02
B_REGION_LAKE_GENEVA_GA	1.16	0.195	5.96	0.00
B_REGION_LAKE_GENEVA_HT	0.754	0.134	5.62	0.00
B_REGION_LAKE_GENEVA_HT_Verbund	0.709	0.198	3.58	0.00
B_REGION_LAKE_GENEVA_Verbund	-0.142	0.0938	-1.52	0.13
B_REGION_NORTHERN_SWITZERLAND_CarAvail	-0.381	0.0758	-5.02	0.00
B_REGION_NORTHERN_SWITZERLAND_CarAvail_GA	1.15	0.202	5.71	0.00
B_REGION_NORTHERN_SWITZERLAND_CarAvail_HT	0.909	0.103	8.85	0.00
B_REGION_NORTHERN_SWITZERLAND_CarAvail_HT_Verbund	1.46	0.261	5.59	0.00
B_REGION_NORTHERN_SWITZERLAND_CarAvail_Verbund	0.224	0.167	1.34	0.18
B_REGION_NORTHERN_SWITZERLAND_GA	1.75	0.197	8.90	0.00
B_REGION_NORTHERN_SWITZERLAND_HT	1.33	0.136	9.78	0.00
B_REGION_NORTHERN_SWITZERLAND_HT_Verbund	1.52	0.199	7.65	0.00
B_REGION_NORTHERN_SWITZERLAND_Verbund	-0.0788	0.101	-0.78	0.44
B_REGION_ZURICH_CarAvail	-0.383	0.0819	-4.67	0.00
B_REGION_ZURICH_CarAvail_GA	1.04	0.209	4.99	0.00
B_REGION_ZURICH_CarAvail_HT	1.34	0.106	12.66	0.00
B_REGION_ZURICH_CarAvail_HT_Verbund	1.68	0.264	6.38	0.00
B_REGION_ZURICH_CarAvail_Verbund	0.198	0.175	1.13	0.26
B_REGION_ZURICH_GA	1.82	0.200	9.11	0.00
B_REGION_ZURICH_HT	1.54	0.139	11.03	0.00
B_REGION_ZURICH_HT_Verbund	1.61	0.203	7.91	0.00
B_REGION_ZURICH_Verbund	-0.363	0.111	-3.28	0.00

Table 7: Results related to the region of the place of living

Description	Coeff. estimate	Robust Asympt. std. error	*t*-stat	*p*-value
B_couple_with_children_CarAvail	-0.162	0.0507	-3.20	0.00
B_couple_with_children_CarAvail_GA	-0.666	0.0847	-7.86	0.00
B_couple_with_children_CarAvail_HT	-0.605	0.0551	-10.98	0.00
B_couple_with_children_CarAvail_HT_Verbund	-0.901	0.0975	-9.24	0.00
B_couple_with_children_CarAvail_Verbund	-0.128	0.101	-1.26	0.21
B_couple_with_children_GA	-1.04	0.0709	-14.63	0.00
B_couple_with_children_HT	-0.700	0.0647	-10.82	0.00
B_couple_with_children_HT_Verbund	-1.10	0.0821	-13.45	0.00
B_couple_with_children_Verbund	-0.373	0.0788	-4.74	0.00
B_couple_without_children_CarAvail	-0.0155	0.0471	-0.33	0.74
B_couple_without_children_CarAvail_GA	-0.255	0.0810	-3.15	0.00
B_couple_without_children_CarAvail_HT	-0.120	0.0501	-2.40	0.02
B_couple_without_children_CarAvail_HT_Verbund	-0.309	0.0913	-3.39	0.00
B_couple_without_children_CarAvail_Verbund	0.0514	0.103	0.50	0.62
B_couple_without_children_GA	-0.531	0.0682	-7.80	0.00
B_couple_without_children_HT	-0.239	0.0565	-4.23	0.00
B_couple_without_children_HT_Verbund	-0.488	0.0751	-6.49	0.00
B_couple_without_children_Verbund	-0.364	0.0824	-4.42	0.00
B_single_parent_with_children_CarAvail	-0.129	0.0706	-1.82	0.07
B_single_parent_with_children_CarAvail_GA	-0.396	0.131	-3.02	0.00
B_single_parent_with_children_CarAvail_HT	-0.493	0.0822	-6.00	0.00
B_single_parent_with_children_CarAvail_HT_Verbund	-0.501	0.155	-3.24	0.00
B_single_parent_with_children_CarAvail_Verbund	-0.00426	0.142	-0.03	0.98
B_single_parent_with_children_GA	-0.777	0.0955	-8.14	0.00
B_single_parent_with_children_HT	-0.548	0.0894	-6.13	0.00
B_single_parent_with_children_HT_Verbund	-0.574	0.107	-5.37	0.00
B_single_parent_with_children_Verbund	-0.264	0.0938	-2.82	0.00

Table 8: Results related to the category of household

Full-time employed people are more likely to have a car available (Table 9), which was already observed in 2010 Kowald *et al.* (2016). Inactive people generally have less mobility resources in comparison with full-time employees, except for the half fair travel ticket (HT). It seems coherent, since the half fair travel ticket is not expensive, popular and quickly worth buying. Students are more likely than full-time worker to own a general abonnement travel ticket (GA). It is most probably due to special discounts for students (about -30% compared to the full price).

People without post mandatory school education are less likely to have a car available or a half fare travel ticket (Table 10). The chances of having a car available are increasing when having a tertiary education in comparison with a secondary education, but do not increase further

Description	Coeff. estimate	Robust Asympt. std. error	*t*-stat	*p*-value
B_inactive_CarAvail	-0.872	0.0513	-17.00	0.00
B_inactive_CarAvail_GA	-1.10	0.0921	-11.99	0.00
B_inactive_CarAvail_HT	-0.676	0.0560	-12.08	0.00
B_inactive_CarAvail_HT_Verbund	-1.02	0.105	-9.74	0.00
B_inactive_CarAvail_Verbund	-1.20	0.108	-11.05	0.00
B_inactive_GA	-0.435	0.0829	-5.25	0.00
B_inactive_HT	-0.0564	0.0667	-0.85	0.40
B_inactive_HT_Verbund	-0.762	0.0939	-8.11	0.00
B_inactive_Verbund	-0.393	0.0836	-4.70	0.00
B_part_time_work_CarAvail	-0.193	0.0518	-3.72	0.00
B_part_time_work_CarAvail_GA	-0.137	0.0850	-1.62	0.11
B_part_time_work_CarAvail_HT	0.115	0.0557	2.06	0.04
B_part_time_work_CarAvail_HT_Verbund	0.0152	0.0948	0.16	0.87
B_part_time_work_CarAvail_Verbund	-0.257	0.0963	-2.67	0.01
B_part_time_work_GA	0.333	0.0782	4.26	0.00
B_part_time_work_HT	0.443	0.0660	6.70	0.00
B_part_time_work_HT_Verbund	0.0854	0.0852	1.00	0.32
B_part_time_work_Verbund	0.190	0.0824	2.31	0.02
B_studying_CarAvail	-0.758	0.0933	-8.13	0.00
B_studying_CarAvail_GA	0.962	0.146	6.58	0.00
B_studying_CarAvail_HT	-0.0634	0.119	-0.53	0.59
B_studying_CarAvail_HT_Verbund	0.846	0.197	4.29	0.00
B_studying_CarAvail_Verbund	0.292	0.147	1.99	0.05
B_studying_GA	1.14	0.102	11.26	0.00
B_studying_HT	0.728	0.102	7.13	0.00
B_studying_HT_Verbund	0.801	0.118	6.80	0.00
B_studying_Verbund	0.341	0.0996	3.42	0.00

Table 9: Results related to the labour status

with a university education. People with a university degree have significantly more general abonnement travel ticket (GA).

7 Validation

We estimate the model on 80% of the observations contained in the dataset. The selection of the 80% of the data is random. The results of the estimation are then used for simulating the market shares of the remaining 20% of the observations. Finally, we compare the forecasted market

Description	Coeff. estimate	Robust Asympt. std. error	*t*-stat	*p*-value
B_secundary_education_CarAvail	0.564	0.0355	15.88	0.00
B_secundary_education_CarAvail_GA	0.175	0.0632	2.76	0.01
B_secundary_education_CarAvail_HT	0.328	0.0389	8.43	0.00
B_secundary_education_CarAvail_HT_Verbund	0.117	0.0756	1.55	0.12
B_secundary_education_CarAvail_Verbund	0.526	0.0742	7.09	0.00
B_secundary_education_GA	0.0326	0.0537	0.61	0.54
B_secundary_education_HT	0.162	0.0451	3.59	0.00
B_secundary_education_HT_Verbund	0.164	0.0611	2.69	0.01
B_secundary_education_Verbund	0.105	0.0586	1.78	0.07
B_tertiary_education_CarAvail	0.834	0.0677	12.33	0.00
B_tertiary_education_CarAvail_GA	0.606	0.102	5.91	0.00
B_tertiary_education_CarAvail_HT	1.06	0.0702	15.10	0.00
B_tertiary_education_CarAvail_HT_Verbund	0.858	0.114	7.55	0.00
B_tertiary_education_CarAvail_Verbund	0.875	0.123	7.13	0.00
B_tertiary_education_GA	0.119	0.109	1.10	0.27
B_tertiary_education_HT	0.523	0.0849	6.16	0.00
B_tertiary_education_HT_Verbund	0.545	0.113	4.83	0.00
B_tertiary_education_Verbund	0.112	0.127	0.88	0.38
B_university_CarAvail	0.707	0.106	6.68	0.00
B_university_CarAvail_GA	1.18	0.134	8.83	0.00
B_university_CarAvail_HT	1.30	0.106	12.30	0.00
B_university_CarAvail_HT_Verbund	1.31	0.146	8.93	0.00
B_university_CarAvail_Verbund	0.812	0.174	4.66	0.00
B_university_GA	1.15	0.127	9.08	0.00
B_university_HT	1.08	0.118	9.17	0.00
B_university_HT_Verbund	0.991	0.144	6.88	0.00
B_university_Verbund	0.364	0.168	2.17	0.03

Table 10: Results related to the highest level of education

shares of the model with the real market shares among these 20%.

The result in Figure 1 show that the predicted market shares are close to the real market shares.

The results by age, for age groups 6-16, 16-18, 18-20, 20-25, 25-45, 45-65 and 65+, show that the model perform well also for subgroups (Figures 2, 3, 4, 5, 6, 7 and 8). Note that the age groups include the limit age of the age group (age group 16-18 includes people with age 16, 17 and 18) and thus overlap. The age group 6-16 does not have access to cars, and only 16-year-old people have half fare travel tickets (HT) (Figure 2). The model overestimates the market share of people without any mobility resource in the age group 16-18 (Figure 3). This age group contains

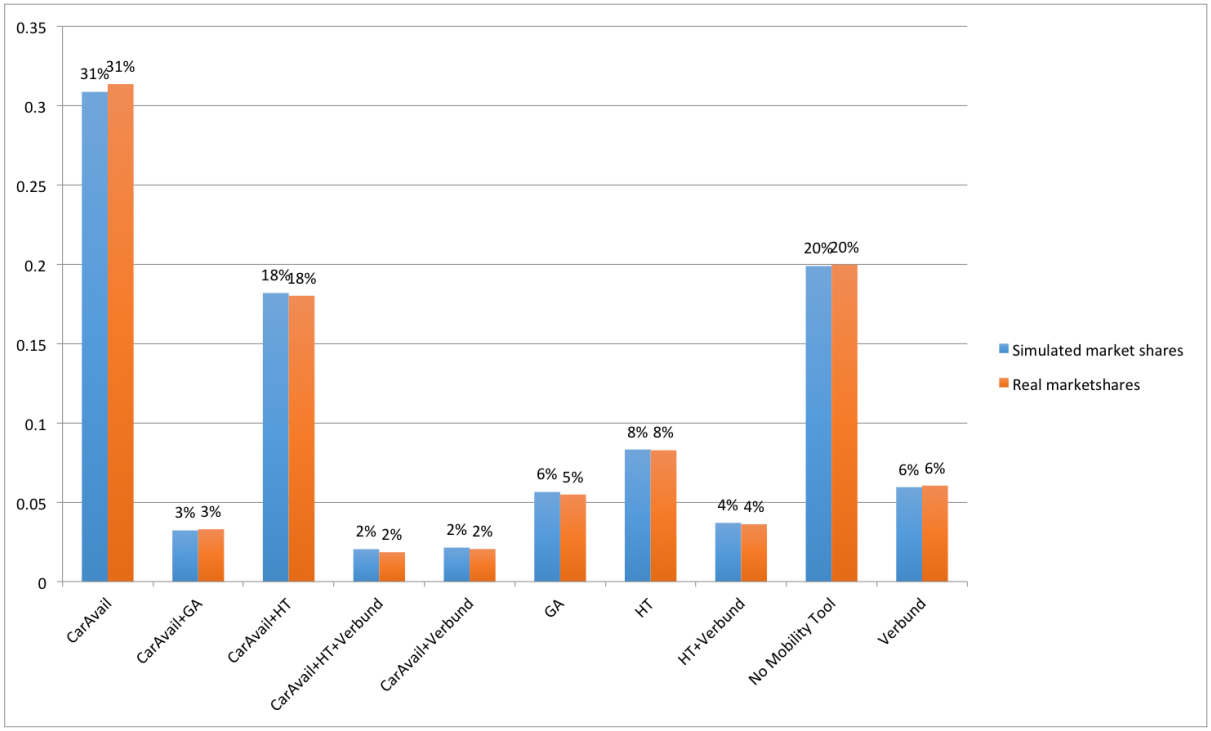

Figure 1: Comparison of the real market shares and the predicted market shares for 20% of the population

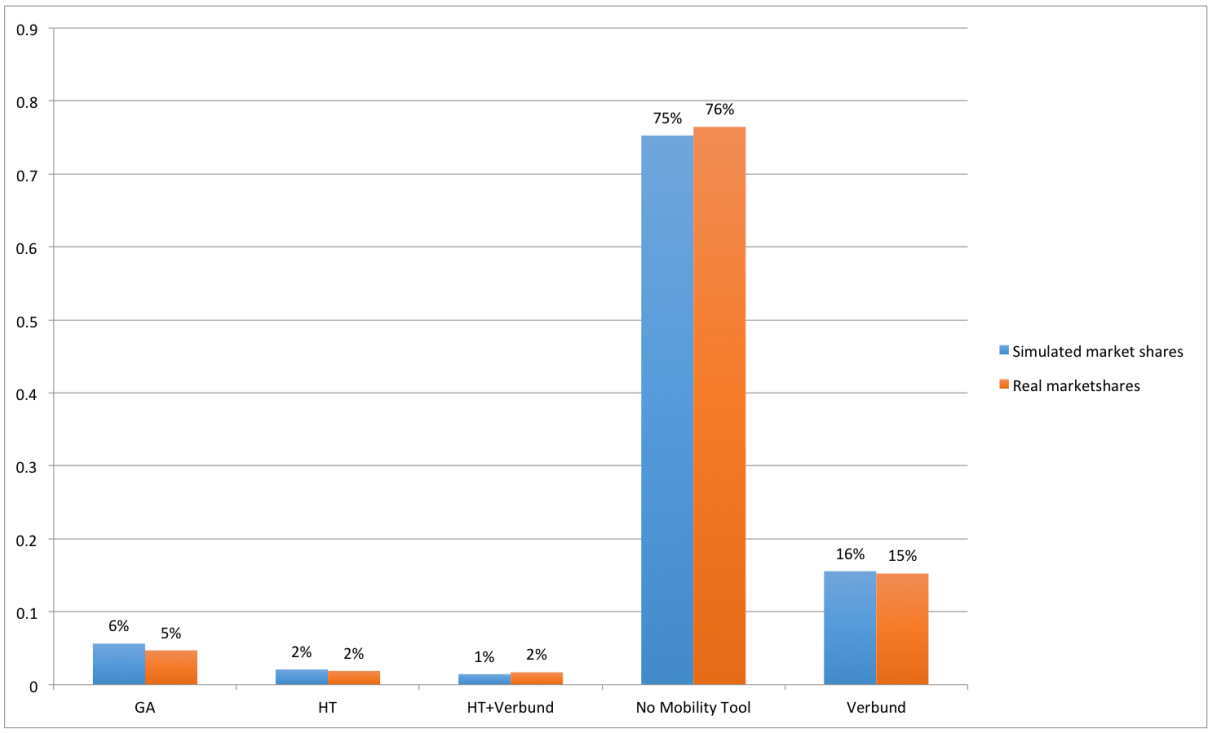

Figure 2: Comparison of the real market shares and the predicted market shares for people between 6 and 16 years old (20% of the population)

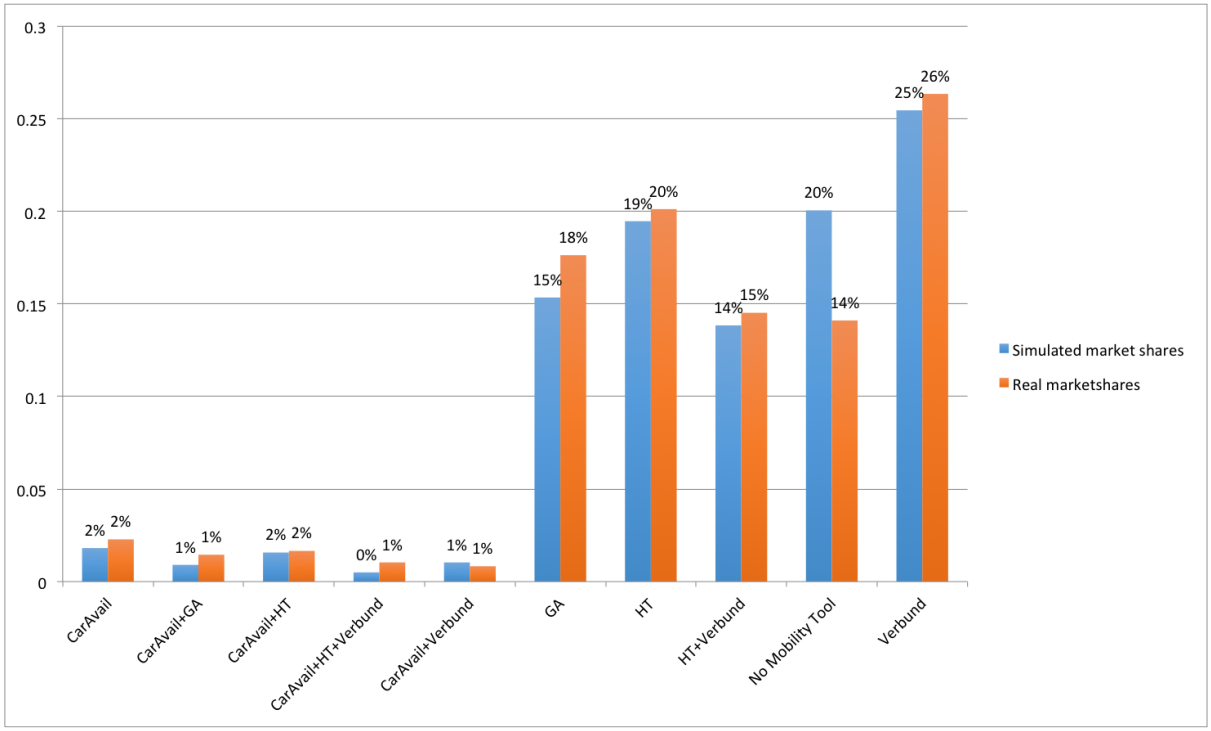

Figure 3: Comparison of the real market shares and the predicted market shares for people between 16 and 18 years old (among 20% of the population)

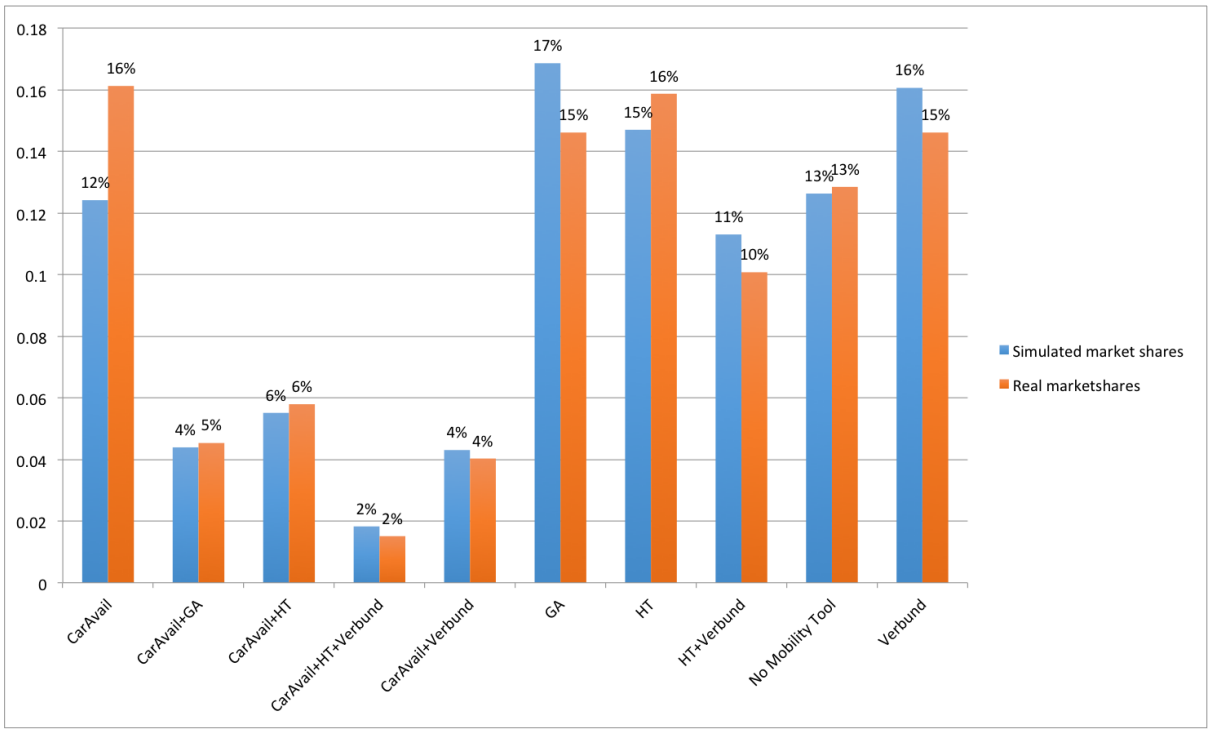

Figure 4: Comparison of the real market shares and the predicted market shares for people between 18 and 20 years old (among 20% of the population)

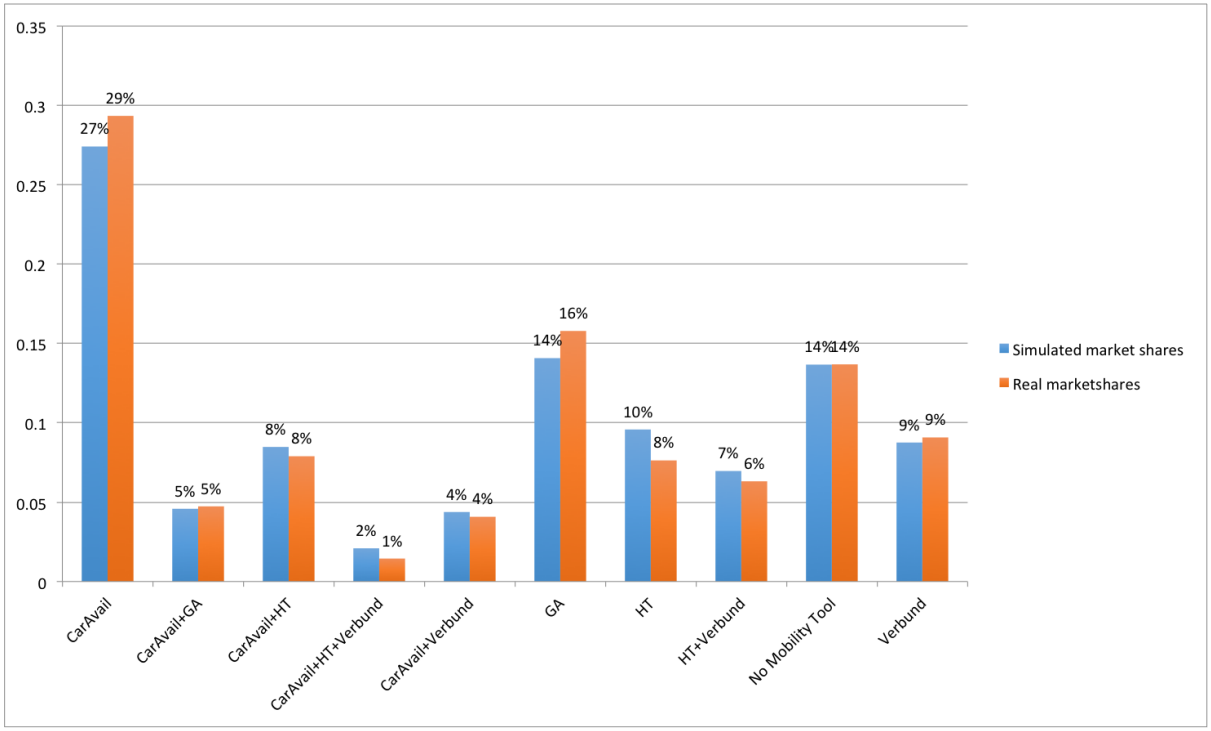

Figure 5: Comparison of the real market shares and the predicted market shares for people between 20 and 25 years old (among 20% of the population)

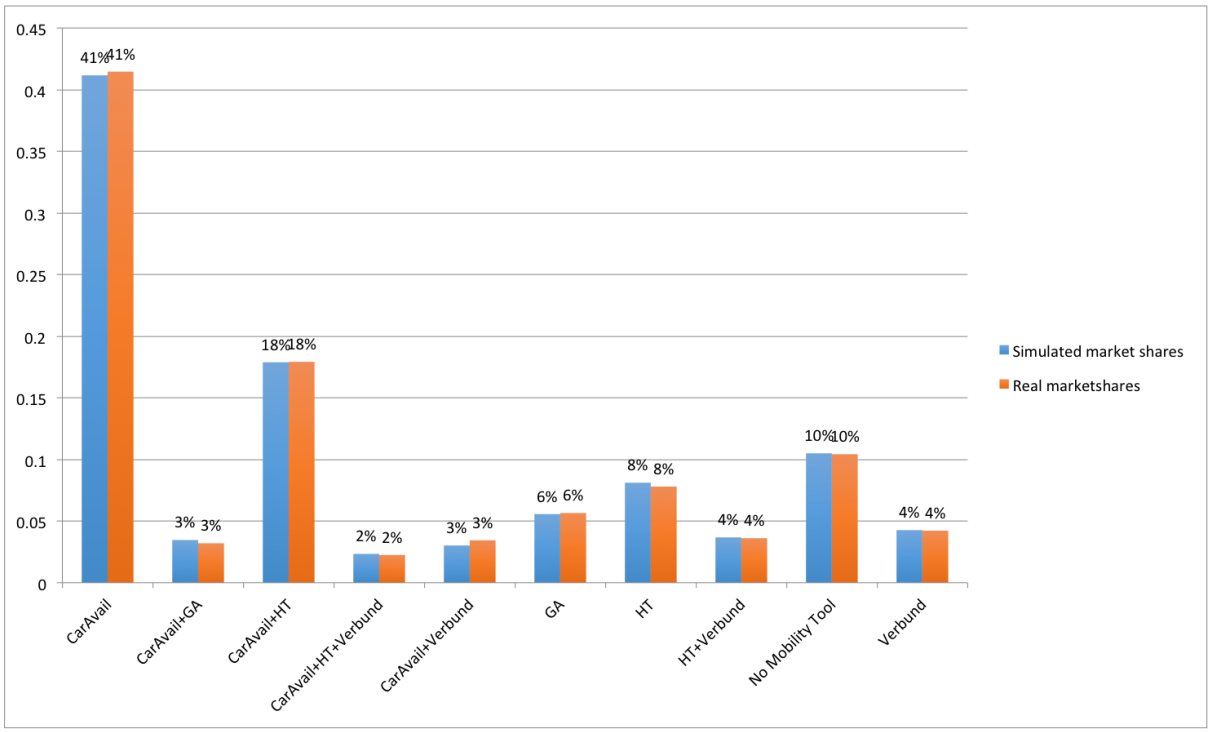

Figure 6: Comparison of the real market shares and the predicted market shares for people between 25 and 45 years old (among 20% of the population)

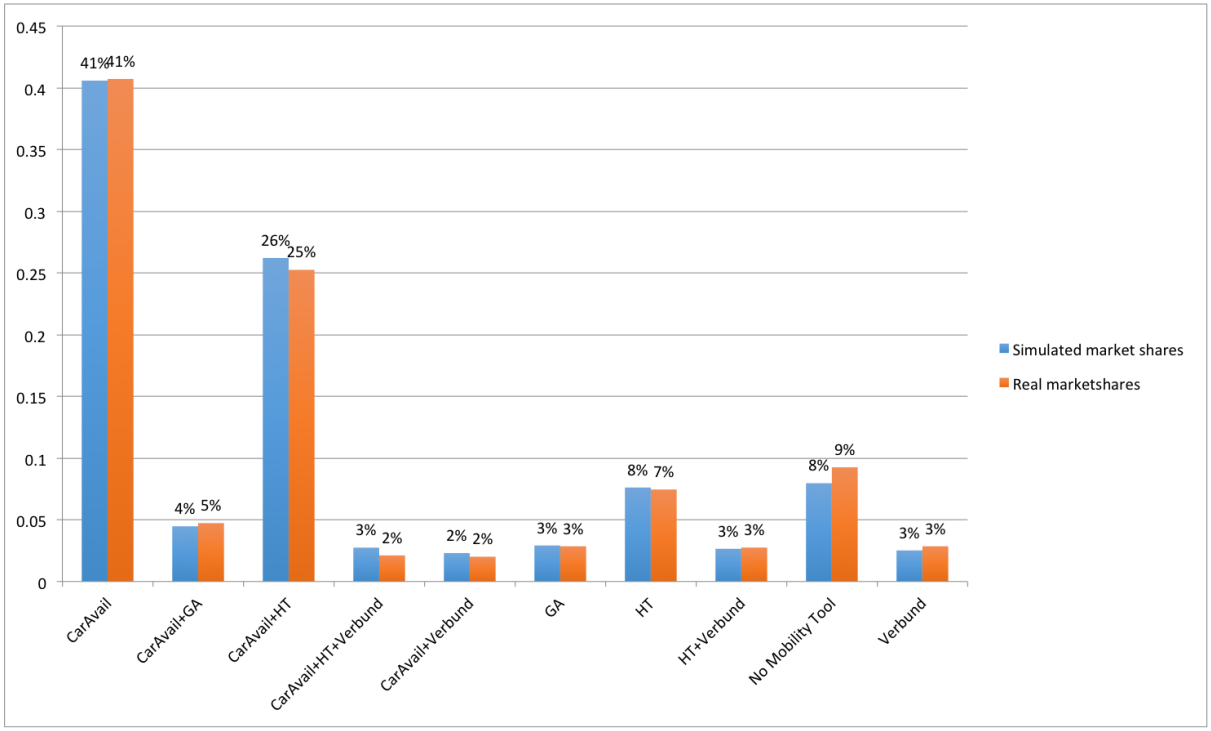

Figure 7: Comparison of the real market shares and the predicted market shares for people between 45 and 65 years old (among 20% of the population)

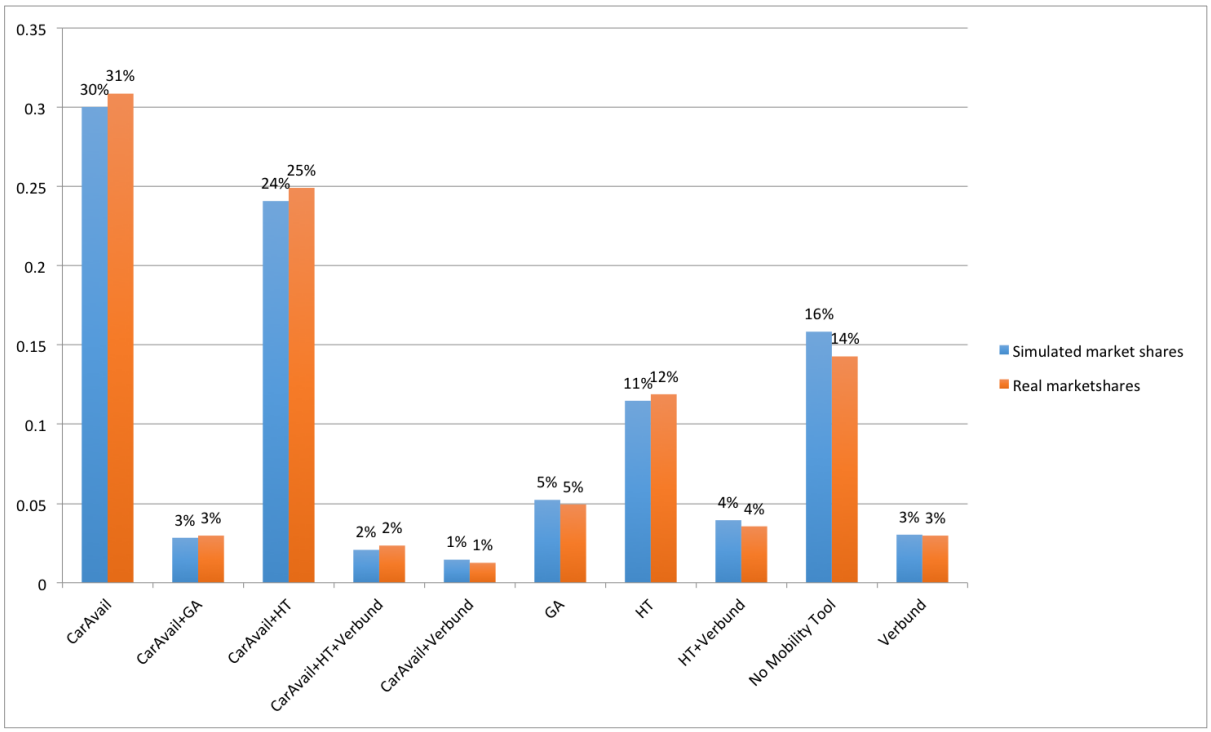

Figure 8: Comparison of the real market shares and the predicted market shares for people 65 years old and older (among 20% of the population)

Description	Coeff. estimate	Robust Asympt. std. error	*t*-stat	*p*-value
B_INHABITANTS_CarAvail	0.346	0.382	0.91	0.36
B_INHABITANTS_CarAvail_GA	-0.118	0.641	-0.18	0.85
B_INHABITANTS_CarAvail_HT	0.0532	0.398	0.13	0.89
B_INHABITANTS_CarAvail_HT_Verbund	1.73	0.585	2.95	0.00
B_INHABITANTS_CarAvail_Verbund	0.829	0.638	1.30	0.19
B_INHABITANTS_GA	2.05	0.447	4.59	0.00
B_INHABITANTS_HT	0.606	0.425	1.43	0.15
B_INHABITANTS_HT_Verbund	1.98	0.482	4.11	0.00
B_INHABITANTS_Verbund	2.11	0.440	4.79	0.00
B_LOG_INHABITANTS_CarAvail	-0.253	0.0164	-15.40	0.00
B_LOG_INHABITANTS_CarAvail_GA	-0.0503	0.0286	-1.76	0.08
B_LOG_INHABITANTS_CarAvail_HT	-0.196	0.0178	-11.01	0.00
B_LOG_INHABITANTS_CarAvail_HT_Verbund	0.0267	0.0362	0.74	0.46
B_LOG_INHABITANTS_CarAvail_Verbund	0.116	0.0346	3.37	0.00
B_LOG_INHABITANTS_GA	0.0597	0.0233	2.57	0.01
B_LOG_INHABITANTS_HT	0.00683	0.0207	0.33	0.74
B_LOG_INHABITANTS_HT_Verbund	0.205	0.0290	7.06	0.00
B_LOG_INHABITANTS_Verbund	0.166	0.0232	7.16	0.00

Table 11: Results related to the population in the commune of residence

Description	Coeff. estimate	Robust Asympt. std. error	*t*-stat	*p*-value
ASC_CarAvail	-0.343	0.409	-0.84	0.40
ASC_CarAvail_GA	-3.78	0.415	-9.10	0.00
ASC_CarAvail_HT	-0.592	0.269	-2.20	0.03
ASC_CarAvail_HT_Verbund	-4.36	1.07	-4.08	0.00
ASC_CarAvail_Verbund	-1.15	0.740	-1.56	0.12
ASC_GA	-13.4	0.637	-21.10	0.00
ASC_HT	-8.11	1.38	-5.88	0.00
ASC_HT_Verbund	-8.83	1.54	-5.73	0.00
ASC_Verbund	-8.07	0.354	-22.79	0.00

Table 12: Alternative specific constants

only 482 observations. The model underestimates the people with a car available among very young adults (18-20) (Figure 4). This group contains only 397 observations. Starting with 20 years old, the car is the main mobility resource (Figure 5). This large market share of the car remains till 65 years old (Figure 6 and 7). The simulated and real market shares are very similar when the number of observation increases.

8 Future work

8.1 Modeling car availability "on demand"

In this paper, we assume that having a car available only "on demand" is similar to not having a car available on a daily basis. This assumption might need to be modified. Are persons answering this because they could borrow the car of a friend or a family member? Or do they mean that they could possibly rent a car from a car sharing system like *Mobility Car Sharing*, *Sharoo* or *Catch-a-Car* or use a ride-hailing service like *Uber*, *Taxito* or *Publiride* in Switzerland? One solution to this problem might be to explicitly model car sharing as a mobility resource. The data about car sharing membership are available in the MTMC 2015. Another possibility would be to model car availability with the three different levels (available, available on demand, not available) and see what are the factors explaining availability "on demand". Finally, a third solution is not available in the data from the MTMC 2015 but might be available in the MTMC 2020: Explicitly modeling the readiness to use ridesharing services.

8.2 Modeling car-sharing membership and bike and e-bike ownership

The data of the MTMC provide information about car-sharing membership and bike and e-bike ownership. It would be particularly relevant for e-bikes. Between 2010 and 2015, the proportion of households owning an e-bike has been multiplied by 3 (7% in 2015). Detailed results show that e-bikes are mostly owned is less densely inhabited areas in Switzerland (Bubenhofer *et al.,* 2018).

8.3 Forecasting 2015 with data of 2010

To test the robustness of our model, developing a model for 2010 and comparing its forecast with the data of 2015 would help identify weaknesses in the model.

8.4 Modeling driving license rates with the data of 2015

Modeling driving license rates is particularly important, since the trend toward less driving license possession among young adults has stopped (see OFS/ARE (2017), figure G 2.1.1.1). Between 1994 and 2010, the rate of driving licenses among young adults (18 to 24 years old) has continuously decreased from 71% to 59%. In 2015, we observe a stabilization (61%).

9 Data availability

The data of the Mobility and Transport Microcensus are available for researchers (see Chapter 2).

The model presented in this paper has been estimated using Biogeme (Bierlaire, 2003). The model specification file (`.mod`) for Biogeme and a python script to transform the data of the Mobility and Transport Microcensus in a valid format for Biogeme are available by contacting the first author.

10 References

Axhausen, K. W., S. Beige and M. Bernard (2006) Prognose über Besitz und Nutzenintensität von Mobilitätswerkzeugen im Personenverekehr, Grundlagenbericht für die Perspektiven des Schweizerischen Personenverkehrs bis 2030, *Technical Report*, Bundesamt für Raumentwicklung ARE.

Bierlaire, M. (2003) BIOGEME: A free package for the estimation of discrete choice models, paper presented at the *Proceedings of the 3rd Swiss Transportation Research Conference*, Monte Verità, Ascona, Switzerland.

Bubenhofer, J., A. Hool, C. Naef and J. Heß (2018) Dichte und Mobilitätsverhalten, *Technical Report*, Bundesamt für Raumentwicklung ARE.

Kowald, M., B. Kieser, N. Mathys and A. Justen (2016) Determinants of mobility resource ownership in Switzerland: Changes between 2000 and 2010, *Transportation*, ISSN 0049-4488, 1572-9435.

OFS/ARE (2017) Comportement de la population en matière de transports. Résultats du microrecensement mobilité et transports 2015, *Technical Report*, Office fédéral de la statistique / Office fédéral du développement territorial, Neuchâtel et Berne.