Post-Car World: Data collection methods and response behavior in a multi-stage travel survey

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Abstract

The main research question addressed by this study is to what degree individuals would change travel modes, time allocation and activity patterns after experiencing large changes in generalized transportation costs and how they would react regarding their longer-term ownership in mobility tools, assessing suppressed demand effects from an activity-based perspective. The empirical basis is a multi-day travel and online diary that is required to obtain the personalized reference values for the later stated choice and stated adaptation tasks. This paper provides first detailed information of the survey methods, recruitment and fieldwork. An initial investigation of the data and its quality attributes, descriptions of the sampling structure and response behavior are presented.

Participation choice models indicate that a high incentive level leads to a higher participation rate, but the net-effect on completing the survey is zero: Once recruited, higher incentives also lead to a higher drop-out incidence. Certain socioeconomic characteristics are consistently over-represented in the sample: Season ticket ownership, better education and higher income strongly increase participation and completion of the survey. Findings reveal saliency effects, whereby response behavior is influenced by the respondents' interest in the survey topic.

While general fatigue effects can only be detected for the number of reported online activities, better educated and car-less respondents exhibit an increased reporting behavior of trips over time. Importantly, while showing no effects on completion of the survey, higher incentives tend to increase response quality in terms of absolute levels (trips) and stability (online activities).

Keywords: Survey methods, stated preference, response behavior, participation choice, fatigue effects

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1. Introduction and motivation

Policy decisions in many developed countries, especially for urban areas, tend to favor car reducing and pedestrian-friendly environments to reduce urban traffic congestion and improve the overall transportation network efficiency. In fact, a technological and behavioral transformation is already under way towards a world with a reduced role of privately owned and operated cars, which are substituted by various forms of shared mobility. The investigation of temporal rhythms in activity scheduling, the reshaping in time organization and mobility tool ownership plays a key role in understanding travel behavior in a world with restricted car ownership and usage, including carsharing and carpooling as potential mode alternatives (Schmid et al., 2016; Schmid and Axhausen, 2017b).

The main research question addressed by this study[1] is to what degree individuals would be changing travel modes, time allocation and activity patterns after experiencing large changes in generalized transportation costs (e.g. Weis, 2012; Schmid and Axhausen, 2017b) and how they would react regarding their longer-term ownership in mobility tools (e.g. Arentze et al., 2004; Erath and Axhausen, 2010), assessing suppressed demand effects from an activity-based perspective. Two innovative stated adaptation (SA) tools are presented here, collecting data on respondents' mobility adaptations in the short and long-run.

One goal of this study is to combine different established data collection methods, starting with a multi-day reporting period of individual travel behavior and activity scheduling (e.g. Golob and Meurs, 1986; Kitamura and Bovy, 1987; Axhausen et al., 2002; Löchl et al., 2005), including attitudinal and psychometric scales (e.g. Kitamura et al., 1997; Axhausen et al., 2002; Handy et al., 2005; Rieser-Schüssler and Axhausen, 2012; Becker et al., 2017) as well as personalized stated preference (SP) (e.g. Weis et al., 2012; Fröhlich et al., 2012; Axhausen et al., 2014; Weis et al., 2017) and SA experiments (e.g. Arentze et al., 2004; Hanson and Hildebrand, 2011; Le Vine et al., 2011; Weis, 2012). This allows in the later modeling process to e.g. combine the SP data on respondents' preferences for current and emerging modes like carsharing and carpooling with the revealed preference (RP) data from the travel and activity diary (e.g. Train, 2009) and respondents' attitudes, estimating joint models on the acceptance and choice/usage of different modes (e.g. Daziano and Bolduc, 2013).

ICT have experienced a persistent increase in usage over the last decades, allowing for a more flexible spatial and temporal accomplishment of all kinds of activities (Mokhtarian et al., 2006), as e.g. in the case of shopping (e.g. Mokhtarian, 2004; Farag et al., 2006). The inclusion of a non-physical/online activity questionnaire therefore allows to investigate potential interrelations between travel behavior and ICT usage over multiple days for the same respondents, mainly focusing on shopping behavior for which we also included a SP experiment on the choice between in-store and online shopping (Schmid and Axhausen, 2017a).

The detailed collection of travel behavior data implicitly reveals information of respondents' time use patterns, which, in combination with individuals' short- and long-term expenditures for committed and uncommitted goods (see also e.g. Aschauer et al., 2018), allows to develop a microeconomic time use and expenditure allocation choice model (e.g. Jara-Diaz et al., 2008). Then, the value of time as a resource (VOR) can be estimated to calculate all components of the complete Jara-Diaz and Guevara (2003) model formulation, including the value assigned to travel (VTAT). A shift of focus from the value of travel time savings (VTTS) to the two components,

[1] Project website: http://postcarworld.epfl.ch/

i.e. VOR and VTAT, in cost-benefit analyses or the evaluation of shared mobility would help assessing the options under a budget constraint, i.e. investing in average speed or improving the conditions of in-vehicle travel (Jara-Diaz and Astroza, 2013; Schmid et al., 2017).

This paper provides an in-depth overview of the survey methods and fieldwork of this comprehensive study. Data were collected for households living in the Canton of Zurich, Switzerland (see Fig. 1) that cover the relevant range of life cycle positions, mobility tool ownership and household types. Considering the longer reporting period, high response burden and complexity of the survey, the investigation of the data quality, sampling structure and response behavior requires special attention (e.g. Golob and Meurs, 1986; Axhausen et al., 2002, 2007; Groves et al., 2000). Results in this paper cover these issues and analyses of the recruitment and screening process, sampling structure, response and participation likelihood, fatigue and drop-out incidence are conducted. Understanding the respondents' motivation and self-selection to participate in the study play a key role when later analyzing the data and interpreting the results.

The structure of the paper is organized as follows: Section 2 first gives a detailed overview of the recruitment and survey process, describes the methods used in each stage of the survey, discusses potential problems observed when conducting the fieldwork and provides an overview of the experimental designs and assumptions made when conducting the behavioral experiments. Section 3 provides detailed analyses of response behavior, starting with a meta analysis to investigate the relationship between response burden and response rates based on previous studies conducted at the Institute for Transport Planning and Systems (IVT)[2]. Participation choice models are estimated to investigate the effect of different incentive levels and socioeconomic characteristics on participation and drop-out incidence. Descriptive figures of the recruited sample's characteristics are compared with data from the Swiss microcensus, revealing potential sampling biases. Data are tested for the presence of reporting fatigue to evaluate if respondents show a decreasing commitment over the survey period and if incentive levels affect the number of reported trips and activities. Finally, Section 4 provides a discussion of results and gives an outlook for future research.

2. Survey methods

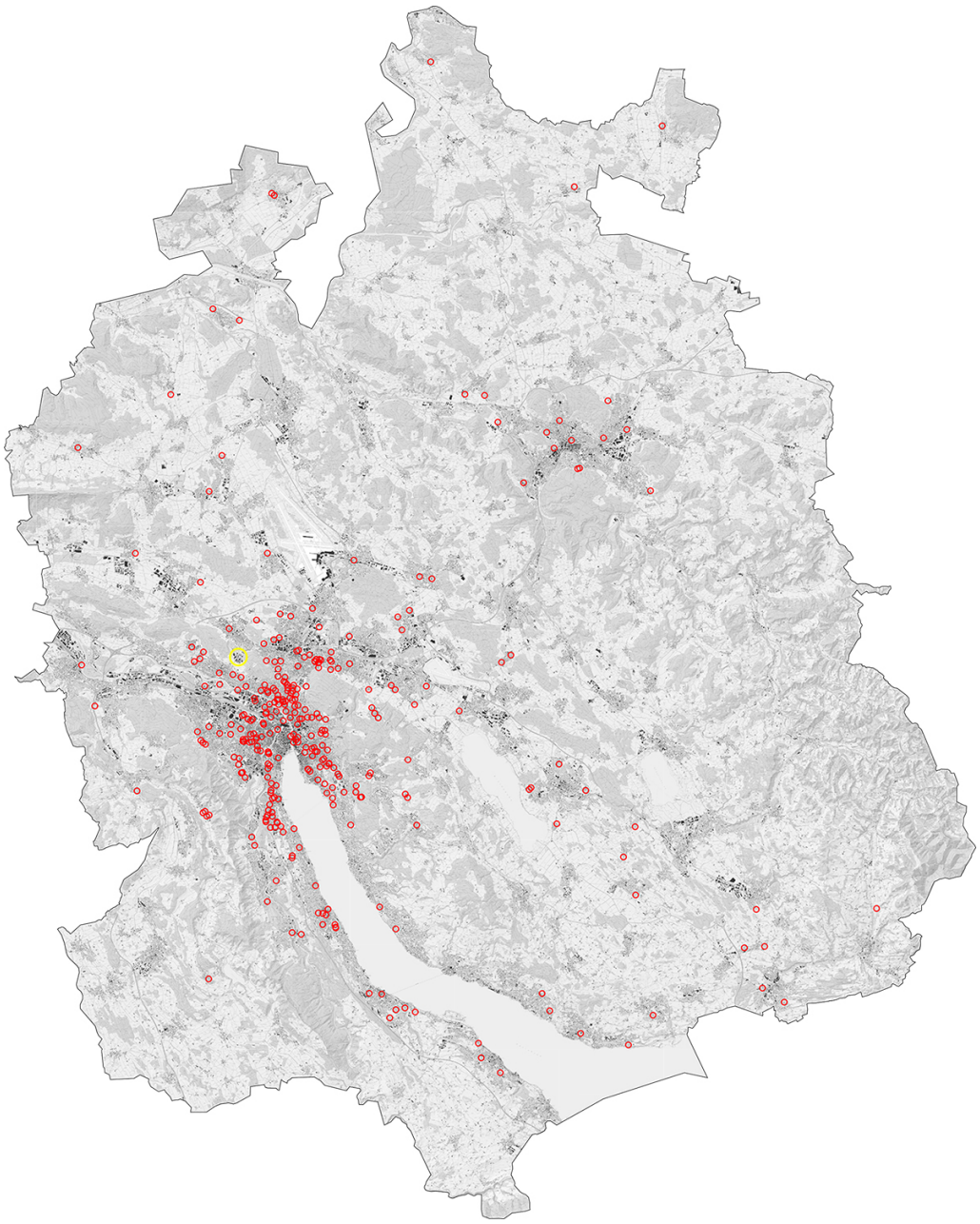
No previous studies are known to serve as an example for this survey as a whole. Apart from a multi-day reporting period to capture respondents' travel, expenditure and online behavior including questionnaires asking for socioeconomic characteristics and attitudes, SP experiments were conducted, including computer-based stated adaptation (SA) interviews for daily activity scheduling and mobility tool ownership.

The general structures were adopted from Axhausen et al. (2002), Weis (2012), Fröhlich et al. (2012) and Erath and Axhausen (2010), and the survey has been designed referring to many suggestions from the literature (e.g. Dillman, 2000; Axhausen et al., 2007; Porter, 2004; Galesic and Bosnjak, 2009), trying to account for potential response rate problems that arise when dealing with long-duration and burdensome studies:

- Medium: Paper-and-pencil surveys have led to higher response rates in studies conducted at the IVT (Axhausen et al., 2015), and a large effort was put into the design and structure of the questionnaires. Internet-based methods were neglected because of the potential

[2]Institute website: http://www.ivt.ethz.ch/en/institute/vpl.html

Figure 1: Residential location of respondent households who completed the survey (red circles) within the study area (Canton of Zurich, Switzerland). Yellow circle: Location of the Institute for Transport Planning and Systems (IVT).



sampling bias in favor of young respondents due to the requirements of respective devices and skills. The exclusive use of telephone interviews was not feasible due to the duration of the weekly travel diary, and because it is assumed that the subjective feeling of confidentiality would be lower compared to a paper-based survey. Only for the more complex and interactive last part of the survey, computer-aided face-to-face interviews were conducted.

- Confidentiality: Due to the high data sensitivity, respondents were reminded several times about the strict confidentiality of their responses.

- Organization and communication: Apart from a sophisticated recruitment process (well-formulated invitation letters with the ETH university logo offering permanent help, followed by the telephonic recruitment), motivation and help calls have been conducted. A personal relationship between the respondents and the survey project manager has been built up during the survey process.

- Incentives: The respondents faced an exceptional effort to complete the survey. Therefore, a monetary incentive for successful completion of the survey was promised during recruitment. Four different incentive levels were tested in the pre-test in order to analyze the effect on the response rate: 50 CHF, 70 CHF, 80 CHF and 100 CHF (1 CHF $\approx$ 1 US$). Based on the findings in the pre-test (Schmid and Axhausen, 2015), the incentive level was fixed at the lowest level of 50 CHF for the main survey waves, which is still higher than just symbolic but substantially lower than a market-based time compensation rate (Doherty and Miller, 2000). These issues are further discussed in Section 3.3.

- Response burden and fatigue effects: Respondents faced a high response burden for completing the whole survey, hence the effort was substantial and not comparable to most previous studies conducted at the IVT, which is further discussed in Section 3.1. A problem that might occur with such long-duration studies is that the number of reported items (trips, activities, etc.) or response quality as a whole might decrease over time as respondents get tired of answering, which is investigated in Section 3.4.

- Leverage-saliency theory (Groves et al., 2000): The motivation to participate in and complete a survey might be influenced by the respondents' interest in the topic. Especially in long-duration surveys, saliency effects might become more substantial regarding initial participation choice, drop-out and fatigue. This paper presents evidence of a participation bias for distinct socioeconomic clusters as discussed in Section 3.2, Section 3.3 and Section 3.4, which can be partly explained by the field of research and the topic of the study.

The survey protocol is depicted in Table 1 and organized in three stages, of which each of them is presented in the following subsections. Data collection took place between January 2015 and April 2016, covering all four seasons. The regular communication and correspondence was conducted in the following steps and order:

- Draw of household addresses and phone numbers from a commercially available address database: In order to limit travel times and expenses for the personal interviews in the last stage of the survey, only households resident in the Canton of Zurich were selected (see also Fig. 1).

Table 1: Survey protocol and household participation, by survey wave.

Stage I survey period:	Pre-Test Jan. 2015	Wave 1 Jul. 2015	Wave 2 Oct. 2015	Wave 3 Apr. 2016
Number of households invited:	800	1600	3500	1600
Invalid addresses:	92	187	449	177
Total response burden scores:	4250	2450	2450	2050
Contacted by phone:	270	676	1110	546
Rejected participation:	203	543	919	428
without screening interview	97	278	619	217
with screening interview	106	265	300	127
Accepted participation:	67	133	191	118
Response burden scores of stage I:	3500	1700	1700	1700
Completion of stage I:	35	73	124	79
Response rate stage I:	52.2%	54.8%	64.9%	66.9%
Response burden scores of stage II:	530	350	350	350
Completion of stage II:	35	73	118	75
Response rate stage II:	52.2%	54.8%	61.7 %	63.6%
Response burden scores of stage III:	270	500	500	–
Completion of stage III:	35	72	115	–
Estimated total response time	360 min.	215 min.	215 min.	170 min.
Final response rate:	52.2%	54.1%	60.2%	63.6%

Note: 12 response burden scores ≈ 1 min. response time.

- Invitation letters with general information and announcement of recruitment call: The participants were informed about the procedure of the survey, estimated effort to complete the survey, the monetary incentive and the confidentiality and support precautions.
- Up to three recruitment calls per household were conducted, including a short screening interview asking for some basic socioeconomic characteristics.
- Stage I questionnaires (empirical basis and travel diary; Section 2.1) were sent to the participants.
- Coding of the responses of stage I questionnaires.
- Stage II questionnaires (stated choice and attitudinal questionnaires; Section 2.2) were sent to the participants.
- Coding of the responses of stage II questionnaires.
- Scheduling of stage III (face-to-face stated adaptation interviews; Section 2.3).
- Face-to-face interviews, debriefing and payment of incentives.

2.1. Stage I: Empirical basis

The empirical basis is an enriched one-week[3] travel diary that is required to explore the individual patterns in daily travel behavior, the planning style and to obtain the reference values

[3]Note that in the pre-test, we asked for a two-week reporting period, which, given the very large administrative effort and response burden, was reduced to a one-week reporting period in the main survey.

Table 2: PCW survey questionnaires and response burden scores in stage I.

Questionnaire	Type	Comments	Avg. score
Household	Socioeconomic characteristics	Type of housing, income, etc.	55
Vehicle	Vehicle characteristics	Type, fuel consumption, etc.	30
Person	Socioeconomic characteristics	Age, education, mobility, etc.	75
Travel diary	Daily travel behavior	Addresses, modes, purpose, etc.	1060[1]
Trip planning	Planning task for 2nd week	Addresses, modes, purpose, etc.	390[2]
Online diary	ICT activities	E-shopping, entertainment, other	290[1]
Short-term expenditures	Daily expenditures	Shopping, food, leisure, etc.	70[1]
Long-term expenditures	Yearly expenditures	Housing, communication, etc.	120
	Stage I questionnaires	Pre-test (two-week reporting period)	Total: 3500
		Main survey (one-week rep. period)	Total: 1700

Note: Examples of stage I questionnaires are included in the Appendix, Fig. A.1-Fig. A.16.
[1]*= Response burden point-score corresponds to a one week reporting period.*
[2]*= Only included in the pre-test.*

for the later SP (stage II) and SA (stage III) tasks.

The design of the travel diary is based on the well-tested *Mobidrive* protocol (Axhausen et al., 2002; Löchl et al., 2005): For each trip conducted, respondents were asked to state the day of the week, starting and arrival times, exact destination addresses, chosen modes, trip purpose, accompanying persons, presence of dogs and out-of-pocket travel costs. Data are organized in a longitudinal panel structure, where each new trip follows its predecessor. It implicitly reveals information about activity durations for nine different activity types/trip purposes: (1) Home activity, (2) accompanying trip, (3) work or education, (4) short and (5) long-run purchase, (6) errand, (7) business trip, (8) leisure and (9) other activity.

The amount and usage of ICT interactions are captured in a separate questionnaire, asking for daily E-shopping, entertainment, banking, communication and social network activities, including daily duration and expenditures for each of those categories. In addition, there are detailed household and personal questionnaires, mobility tool and season ticket ownership as well as short- and long-term expenditure questionnaires providing a rich variety of socioeconomic, mobility-related and consumption data. Stage I questionnaires were completed by 476 respondents (311 households; see also Table 1).

Table 2 gives a short overview of the survey questionnaires used, including a point-score for the response burden (see also Axhausen et al. (2015), for a detailed description of the response burden calculation). Note that on average, twelve points roughly correspond to one minute of response time[4], implying a total work effort of about six hours in the pre-test. To reduce response burden in the main survey[5], the trip planning task was excluded, and the reporting period was reduced to one week.

2.2. Stage II: Stated choice and attitudinal questionnaires

After having received the responses for stage I, stage II questionnaires were prepared and sent to the households. To construct the SP questionnaires, a substantial effort was spent on the

[4]Note that point-scores for the travel and planning diary are based on an average of 22 trips per week. Respondents could report a maximum of 40 trips per week.

[5]Many respondents were complaining about the work load, and were facing conceptual problems with the prospective trip planning task for the second reporting week.

Table 3: PCW survey questionnaires and response burden scores in stage II.

Questionnaire	Type	Comments	Avg. score
Mode choice	Stated choice	8 choice sets	90
ICT ordering choice	Stated choice	8 choice sets	70
Route choice	Stated choice	4 choice sets	30[1]
Attitudes	Attitudes and psychometric scales	Pre-test	370
		Main survey	160
	Stage II questionnaires	Pre-test	Total: 530
		Main survey	Total: 350

Note: Examples of stage II questionnaires are included in the Appendix, Fig. A.17-Fig. A.30.
[1] *= Only included in the main survey.*

creation of the experimental designs, selecting the attributes and the coding of the personalized choice set generation based on revealed preference (RP) reference values from stage I of the survey. In this section, the travel time and cost structures are presented, highlighting the pivot design approach to help respondents to better identify themselves with the individually tailored and more realistic choice situations.

A broad range of attitudinal traits were assessed together with the SP experiments. The attitudinal questionnaires are based on the *MOBIDrive* protocol (Axhausen et al., 2002), a set of psychometric scales developed by Rieser-Schüssler and Axhausen (2012) and for shopping related aspects, some selected, modified items from Mokhtarian et al. (2009), trying to reveal the main features of respondents' attitudes towards existing and hypothetical transportation modes as well as personality traits for assessing heterogeneity with respect to their travel, choice and activity behavior (e.g. Hess and Beharry-Borg, 2012; Paulssen et al., 2014; Schmid and Axhausen, 2017a). Table 3 gives a short overview of the questionnaires used, again including a point-score for the response burden. Stage II questionnaires were completed by 466 respondents (301 households; see also Table 1).

The pre-test included a much more detailed attitudinal questionnaire, which was radically shortened based on the feedback of respondents that some questions were too personal. In the main survey, we also included simple route choice experiments for either public transportation or carsharing to which respondents were assigned based on reported travel behavior. Further details about the SP experiments are presented in the following subsections.

2.2.1. Mode choice experiment

Respondents were introduced to the mode choice experiment (see also Schmid et al., 2016) by outlining a future scenario that restricts car availability to a minimum but supports innovative mode sharing systems, including traditional modes such as public transportation (PT), taxi, walk and bike (see Appendix, Fig. A.18 for some example choice situations). In the description of carsharing (CS), decision makers were always assumed to be vehicle drivers, while carpooling (CP) was described as a mode offered to passengers only. This explicit framing of scenarios helps to place respondents in homogeneous choice situations and keeps the number of different modal alternatives manageable.

Reference trips were routed with the agent-based transport simulation software MATSim (Horni et al., 2016) to calculate the shortest path travel times in the congested network (*SPTT*), related (in-vehicle) distances (*IVD*) and other attributes for both the chosen and unchosen alternatives (i.e. walk, bike, car and PT). Most attribute levels are calculated as percentage changes

relative to these individual reference values, using a pivot design approach (Rose et al., 2008). Trip purposes for the mode choice experiment focus on commuting, shopping and leisure trips, where respondents were randomly assigned to one of these categories, given that they conducted at least one trip for a given category. Mode-specific RP travel costs R_{tc} are calculated based on current Swiss market prices.

The following alternatives, attributes and reference values are included:

Alternative 1: Walk or bike (W/B)

- **Travel time** walk and bike: Travel time for walk and bike is calculated based on Dobler (2013), using reference speeds for walk (4.8 km/h) and bike (16.2 km/h) and accounting for individuals' gender, age and steepness of the links.

Alternative 2: Taxi

- **Travel cost**: The RP cost structure for taxi is based on the *UberPop* service for Zurich (*www.uber.com/cities/zurich*), charging about half of the price of current taxis fares:

$$R_{tc,taxi} = 3 \text{ CHF} + IVD * 1.35 \text{ CHF/km} + SPTT * 0.3 \text{ CHF/min} \quad (1)$$

- **Travel time**: *SPTT* for the car route
- **Waiting time**: Percentage of *SPTT* (see Table 5)

Alternative 3: Carpooling passenger (CP)

- **Travel cost**: The RP cost structure for carpooling is based on a cost calculator found on *www.mitfahrgelegenheit.ch*, assuming a mark-up of 20 %, two passengers per car and a minimum cost of 2 CHF per trip (i.e. the minimum amount for which a car driver is willing to catch up a passenger for a small distance trip). In addition, the driver should be considered as unknown to the respondent and the fuel consumption factor and price per liter are set according to the following equation:

$$R_{tc,CP} = \max\left[1.5 * IVD * 0.08 \text{ l/km} * 2 \text{ CHF/l} * \frac{1}{2}, 2 \text{ CHF}\right] \quad (2)$$

- **Travel time**: Travel time for carpooling is calculated based on the assumption that the driver has imperfect geographical knowledge about the respondent's start and destination locations: A detour factor of 20 % is added to *SPTT* for the car route.
- **Access and egress time**: Percentage of *SPTT* (see Table 5)
- **Risk to miss driver**: Probability of missing the driver (see Table 5)

Alternative 4: Free-floating carsharing driver (CS)

- **Travel cost**: The RP cost structure for carsharing is based on the cost calculator on *www.catch-a-car.ch*, a pilot study of free-floating carsharing in the region of Basel, Switzerland, assuming an average reservation time (i.e. access time to the next available car) of 7 minutes. This leads to a fixed cost component of about 2 CHF per trip:

$$R_{tc,CS} = 2 \text{ CHF} + SPTT * 0.37 \text{ CHF/min} \quad (3)$$

- **Travel time**: Travel time for carsharing is calculated based on the assumption that the driver spends some time to find a parking space: A detour factor of 10 % is added to *SPTT* for the car route
- **Access and egress time**: Percentage of *SPTT* (see Table 5)

Alternative 5: Public transportation (PT)

- **Travel cost**: The RP cost structure for PT is based on the routed distances and average km-prices (Allgemeiner Personentarif, Direkter Verkehr Schweiz, 2014): Respondents that reported any kind of regional or national season ticket were assigned to the PT cost category "With season ticket", containing the cost structure for people owning a half fare card (see also Table 4).

Table 4: Travel cost structure for PT alternative.

In-vehicle trip distance	Without season ticket	With season ticket
< 5 km	0.75 CHF/km	0.38 CHF/km
5 - 14 km	0.45 CHF/km	0.23 CHF/km
15 - 48 km	0.38 CHF/km	0.19 CHF/km
49 - 150 km	0.30 CHF/km	0.15 CHF/km
> 150 km	0.28 CHF/km	0.14 CHF/km
Minimum cost per trip	3.00 CHF	2.20 CHF

- **Travel time**: Travel time for PT is based on the routed door-to-door travel time excluding waiting, transfer, access and egress time
- **Access and egress time**: Sum of access and egress time
- **Number of transfers**: According to the route with the lowest generalized costs
- **Headway**: The headway is calculated based on the following four steps:
  (1) Finding connection closest to the departure time
  (2) Searching for alternative connections within $+/-$ 2 hours
  (3) Eliminating alternatives which are more than 30 % slower than (1), or which are "much less direct", i.e. require at least 2 more transfers
  (4) Counting remaining connections $n-1$ and computing the headway by dividing the time difference between the first and last connection by $n-1$

Table 5 highlights the pivot design approach to create the individual choice situations: Most attribute levels are varied relative to some reference values explained above. *D*-efficient designs with 24 choice situations blocked in three parts were calculated using *Ngene* (ChoiceMetrics, 2014), including weak parameter priors and assigning eight choice situations to each respondent. Choice sets with strongly superior travel time relative to travel cost alternatives (and vice versa) were excluded and travel time differences between taxi, CS and CP were held realistic. Based on the pre-test results and to further improve the efficiency, the design for the main survey was updated by modifying the parameter priors and attribute levels.[6]

[6]Note that the taxi alternative was excluded in the main survey as it was only chosen by one respondent in one choice situation.

Table 5: Experimental design for mode choice experiment.

Attributes	W/B	TA	CP	CS	PT	Levels
Travel cost [CHF]		√	√	√	√	−20%, +10%, +40%
Travel time W/B [min]	√					Fix
Travel time MPV [min]		√	√	√		−15%, +5%, +20%
Travel time PT [min]					√	−20%, −5%, +10%
Access and egress time MPV [min]			√	√		15%, 20%, 25%[1]
Access and egress time PT [min]					√	−30%, −10%, +10%
Waiting time [min]		√				10%, 15%, 20%[1]
Risk of missing driver [%]			√			5%, 10%, 20%
Number of transfers [#]					√	$-1, +/-0, +1$[2]
Headway [min]					√	−30%, −10%, +10%[3]

W/B = Walk and bike, TA = taxi, CP = carpooling, CS = carsharing, PT = public transportation. MPV = Motorized public vehicle. [1] *= percentage of in-vehicle travel time.* [2] *= bounded between 0 and 4.* [3] *= ≥ 3 min.* √ *= attribute included.*

Depending on the traveled distances in the reference trips, driving license ownership and chosen modes in the travel diary, respondents were assigned to one out of six mode choice experiments including the choice alternatives PT, taxi, CS, CP and, for short distances, walk or bike. While respondents without a driving license did not receive CS as a choice alternative, trip distances greater than 5 and 15 km excluded walk and bike alternatives, respectively (see Appendix, Table A.1).

2.2.2. Choice between in-store and online shopping

The in-store vs. online shopping choice experiment (see also Schmid and Axhausen, 2017a) requested respondents to trade-off different attributes related to their ICT (online shopping/ordering) and out-of-home (personal procurement) shopping activities for two different shopping purposes:

- Groceries: Daily/weekly shopping (food, drinks, cosmetics, detergent, etc.)
- Standard electronic appliances: Multimedia, HiFi and electronic (household) appliances[7]

The key characteristics of search goods (e.g. standard electronic appliances) can more easily be evaluated from externally provided information, while experience goods (e.g. groceries) need to be physically inspected or tried (e.g. Peterson et al., 1997). Results provide new insights on purchasing channel preferences by allowing attribute sensitivities to differ by product type.

Reference values of shopping time, shopping cost, travel time and travel cost attributes were calculated based on reported shopping trips and average grocery shopping expenditures.[8] A *D*-efficient design with 24 choice situations blocked in three parts was calculated using *Ngene*

[7] This category also exhibits the highest E-shopping market share in Switzerland (Rudolph et al., 2015).

[8] Durable goods expenditures, including standard electronic appliances, were part of a separate questionnaire on an aggregated yearly basis (see also Table 2) and not used for reference value calculation. If a respondent did not report any shopping trip during the multi-day reporting period, a potential shopping location was chosen offering a high variety of goods and high level of accessibility, assigning this respondent to the standard electronic appliances experiment as from a behavioral aspect it might be more problematic to postulate a travel distance to a grocery store. In addition, reference travel time and travel cost to the store were calculated for either carsharing/carpooling or public transportation. To avoid anchoring effects with respect to transportation modes, a specific mode for the in-store alternative was never explicitly mentioned.

(ChoiceMetrics, 2014), including weak parameter priors and assigning eight choice situations to each respondent.

The experiments were introduced to frame the choice environment for the respondents and place them in a coherent choice situation (see Appendix, Fig. A.20 for some example choice situations). Shopping trips are often chained with other activities (e.g. Adler and Ben-Akiva, 1979), which was ruled out by outlining that respondents should imagine a home-based round trip for the in-store alternative. To eliminate social motives and shopping trips as pure leisure activities (Hsiao, 2009), respondents were told that buying the specific goods is the one and only purpose of doing this shopping task. To account for this issue, purchases have been explicitly defined as either daily or weekly grocery or as durable goods shopping. Depending on reported shopping trips, respondents were assigned to one of these two experiments. The attributes presented below and summarized in Table 6 were included in the SP experiment:

Alternative 1: Online shopping

- **Shopping cost**: If assigned to the groceries experiment, respondents were assigned to one out of three reference expenditure categories based on average shopping expenditures for groceries: 40 CHF, 80 CHF and 120 CHF. If assigned to the durable goods experiment, respondents were randomly assigned to one out of three reference expenditure categories: 150 CHF, 300 CHF and 600 CHF.
- **Time spent for in-store/online shopping**: Based on average shopping duration for either groceries or durable goods, respondents were assigned to one out of three reference shopping duration categories (groceries: 15 min, 30 min and 50 min; electronic appliances: 25 min, 40 min and 60 min).
- **Delivery cost** including duty: 0 CHF / 5 CHF / 10 CHF / 15 CHF
- **Delivery time** groceries: Within one day / 1-2 days / more than 2 days; standard electronic appliances: 2-4 days / 4-7 days / more than 1 week

Alternative 2: In-store shopping

- **Shopping cost**: Same as for the online alternative
- **Time spent for in-store/online shopping**: Same as for the online alternative
- **Travel cost** is calculated based on current Swiss market prices for CS, CP and PT (see also Section 2.2.1). They depend on the reported mode in the travel diary and the distance to the store for the reference shopping trip. If the reported mode was ...
  (1) car or motorbike: Average of CP and CS travel costs
  (2) PT: Personalized PT travel costs
- **Travel time** depends on the reported mode in the travel diary and the distance to the store for the reference shopping trip. If the reported mode was ...
  (1) car or motorbike: Car travel time, including an additional detour factor of 10 % assuming that the driver spends some time to find a parking space
  (2) PT: PT door-to-door travel time

In addition, the environmental variable **size/weight of the goods basket** is included in the choice experiments, indicating how convenient it is to do a specific shopping task.

Table 6: Attribute levels of online vs. in-store shopping choice experiment.

Attributes	O	S	Levels
Shopping cost [CHF]	√		−10%, −5%, 0%
Shopping cost [CHF]		√	−5%, 0%, +5%
Time for shop. [min]	√		−20%, −10%, +5%
Time for shop. [min]		√	−10%, 0%, +10%
Del. cost incl. duty [CHF]	√		0, 5, 10, 15 CHF
Travel cost [CHF]		√	−20%, +10%, +40%
Del. time groceries [d]	√		< 1 day, 1-2 days, > 2 days
Del. time electronics [d]	√		2-3 days, 4-7 days, > 1 week
Travel time [min]		√	−30%, 0%, +30%
Size/weight of the good basket [-]	√	√	Low, medium, high (same for both alternatives)

O = online, S = in-store, √ = attribute included.

2.2.3. Route choice experiment

To investigate how different travel related attributes such as travel time and cost are perceived by the respondents for a given mode, simple route choice experiments are conducted.[9] By abstracting from unobserved mode-specific preferences, respondents' choices can be more directly related to the offered trade-offs (see Appendix, Fig. A.22 for some example choice situations).

Depending on driving license ownership, either the CS or the PT route choice experiment was assigned to a respondent, using the same reference trip as for the mode choice experiment (see also Section 2.2.1): If a respondent has a driving license and did not report any PT trips, the CS route choice experiment was assigned. If a respondent has no driving license, the PT route choice experiment was assigned. If both a driving license and PT trips were reported by a respondent, either the CS or PT experiment was randomly assigned.

For both experiments, *D*-efficient designs with twelve choice situations blocked in three parts were calculated using *Ngene* (ChoiceMetrics, 2014), including three choice alternatives, weak parameter priors and assigning four choice situations to each respondent. Choice sets with dominant alternatives were not included (see e.g. Bliemer et al., 2017), as they do not add any trade-off information in an unlabeled choice experiment.

Table 7: Attribute levels of carsharing and public transportation route choice experiments.

Attributes	Levels CS	Levels PT
Travel cost [CHF]	−20%, +10%, +40%	−20%, +10%, +40%
In-vehicle travel time [min]	−15%, +5%, +20%[3]	−15%, +5%, +20%[3]
Congestion time [min]	5%, 10%, 20%[1,4]	
Access + egress time [min]	7.5%, 15%, 22.5%[1,3]	−30%, +/ − 0, +30%
Number of transfers [#]		−1, +/ − 0, +1[2]
Headway [min]		−30%, −10%, +10%

[1] = *percentage of in-vehicle travel time.* [2] = *bounded between 0 and 4.*
[3] = *≥ 3 min.* [4] = *≥ 1 min.*

[9]Note that the route choice experiments were not included in the pre-test.

2.3. Stage III: Stated adaptation interviews

The main research question addressed by stage III of the survey is to what degree individuals would change time allocation, mode choice and activity patterns in the short-run (tool I) after experiencing large changes in generalized transportation costs and how they would react regarding their longer-term ownership in mobility tools (tool II), assessing suppressed demand effects from an activity-based perspective. A comparison between the estimated distance elasticities of travel cost for these two similar, but conceptually different approaches help to shed light on the speed of adaptation in a car-reducing society.

The underlying reasoning for these hypothetical future scenarios were outlined to the respondents. The basic assumptions are that future policies, such as road tolls and congestion taxes for motorized individual vehicles (MIV) are introduced and that fuel prices increase up to a possible pain threshold, while motorized public vehicles (MPV; including CS and CP) and PT are subsidized by the government, but prices are still increasing relative to current levels.

Due to the complexity and interactivity of the experiments, they were implemented as a computer-based personal interviews (CASI), consisting of two Java-based stated adaptation (SA) tools (see e.g. Lee-Gosselin, 1996; Arentze et al., 2004; Le Vine et al., 2011; Jäggi et al., 2013). Both experiments start with the preparation and verification of the base scenario, and the experimental setup is explained by the interviewer. Then, the respondent is asked to indicate his/her reaction (tool I) or the reaction of the complete household (tool II) for progressively increasing travel costs in four adaptation scenarios. While the unit of investigation in first tool is at the individual level, the second tool is at the household level.[10] Both experiments are described in Section 2.3.1 and Section 2.3.2.

Personal interviews took around 40 minutes in the main survey, including possible adjustments/corrections of stage I and II responses followed by a debriefing and the payment of the incentive. An overview of the tools and response burden scores for stage III of the survey is presented in Table 8. The interviews were completed by 222 households[11] (see also Table 1).

Table 8: PCW survey tools and response burden scores in stage III.

Tool / task	Type	Comments	Avg. score
Daily scheduling (tool I)	Stated adaptation	4 choice sets	230
Mobility tool ownership (tool II)	Stated adaptation	4 choice sets	230[1]
Adjustments/debriefing	Interview	Payment of incentive	40
	Stage III interviews	Pre-test	Total: 270
		Main survey	Total: 500

[1] = *Only included in the main survey.*

2.3.1. Tool I: Adaptations in daily scheduling

The first SA experiment (see Appendix, Fig. A.31, for one example choice situation) is based on respondents' busiest day reported in the travel diary in which car was preferably chosen at

[10] While asking at least one household member to conduct both interviews, in some cases multiple household members were willing to conduct the first SA experiment.

[11] This number is referring to the conducted interviews (households that were eligible for the payment of the incentive). Note that because of technical problems with the first SA tool, some households had to be excluded from the final data set. The number of valid respondent/household observations are presented for each tool separately in Section 2.3.1 and Section 2.3.2. Also note that tool II (adaptations in mobility tool ownership) was not yet available in the pre-test and that in wave III, no interviews were conducted anymore as the survey budget was exhausted.

least once. For this day, after the explanation and verification of the selected base scenario schedule, the interviewers introduced changes in mode-specific RP travel costs R_{tc} by predefined factors in four adaptation scenarios, using the same reference cost calculation as discussed in Section 2.2.1.

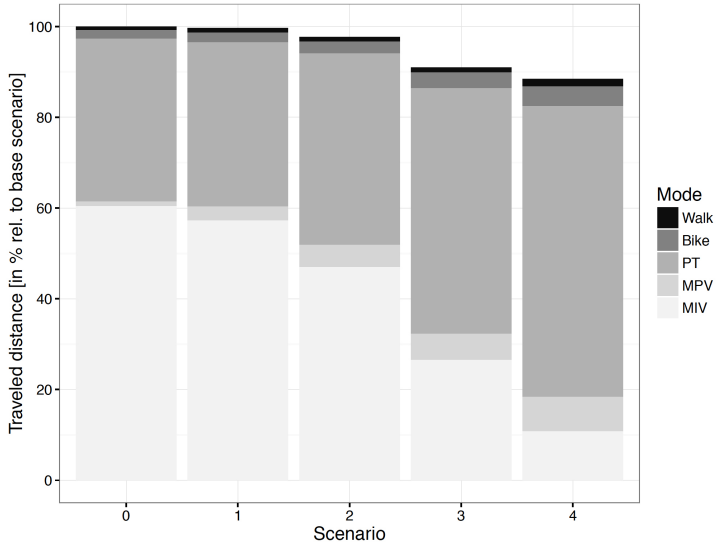
MIV (car and motor-bike) alternatives experience the highest increase, adding a fixed cost amount to each trip and increasing marginal trip costs by factors of 1.5 up to 8, while the increases in PT travel costs range between factors of 1.1 and 1.5 of current prices. MPV modes are integrated as well, with travel costs increasing by the factors defined in Table 9 relative to current prices. In contrast to the work of Weis (2012), travel times were not changed systematically.

Table 9: Experimental design for tool I: Adaptations in daily scheduling.

Mode	Sc. 1 [in CHF]	Sc. 2 [in CHF]	Sc. 3 [in CHF]	Sc. 4 [in CHF]
Car	$R_{tc} * 1.5 + 0.4$	$R_{tc} * 2 + 0.8$	$R_{tc} * 4 + 1.4$	$R_{tc} * 8 + 2$
Motorbike	$R_{tc} * 1.5 + 0.2$	$R_{tc} * 2 + 0.4$	$R_{tc} * 4 + 0.7$	$R_{tc} * 8 + 1$
PT	$R_{tc} * 1.1$	$R_{tc} * 1.2$	$R_{tc} * 1.3$	$R_{tc} * 1.5$
CS	$R_{tc} * 1.1$	$R_{tc} * 1.2$	$R_{tc} * 1.3$	$R_{tc} * 1.5$
CP	$R_{tc} * 1.5$	$R_{tc} * 2$	$R_{tc} * 4$	$R_{tc} * 8$

CP = carpooling, CS = carsharing, PT = public transportation.

Figure 2: Tool I: Traveled distance by mode (in % relative to the base scenario).



The sum of the daily travel costs is automatically calculated and shown at the bottom of the tool. The choice set now contains the whole daily schedule (Lee-Gosselin, 1996; Weis, 2012): Respondents can skip or add certain activities, change the modes and activity durations. When changing activity locations (e.g. to a closer shop or leisure activity), distances, travel times and costs are automatically recalculated by using a google-maps interface. The interviewers make sure that the respondents are aware of all their possibilities to reorganize their day, and if necessary point out behavioral inconsistencies. After the exclusion of seven erroneous interviews,

valid observations were obtained from 237 respondents (215 households).

Fig. 2 gives a first overview of how the increase in mode-specific travel cost affects distance traveled. While in the first two scenarios, the change in demand indicators is relatively small, the decrease in car usage is highest between scenario 2 and 3. Relative to the base scenario, which already exhibits a large mode share of PT typically observed in the metropolitan area of Zurich (e.g. Fröhlich et al., 2012; Weis et al., 2017), the shift from MIV to PT is steady throughout the scenarios. Although less substantial in absolute numbers, the increase in MPV and bike is noticeable as well. The overall distance traveled decreases by roughly 10% in scenario 4.

2.3.2. Tool II: Adaptations in mobility tool ownership

The second SA experiment is based on households' revealed mobility tool ownership and their yearly traveled distances with MIV, MPV and PT, asking them to adapt for increasing mobility costs within a longer-term (yearly) horizon. First, the respondent (a household representative) was asked about the mobile persons in the household (see Appendix, Fig. A.32), the available vehicles in the household (see Appendix, Fig. A.33) and their yearly distance traveled with MIV, MPV and/or PT for weekly, monthly and yearly trips, and the average percentage of PT trips that are within the covered region of the regional season ticket (if available). This information is entered in the SA tool and results in a comprehensive base scenario including mobility tool ownership, mode-specific distance traveled among all household members and the resulting total yearly fixed and variable costs (see Appendix, Fig. A.34).

Cost structures of MIV are based on a *TCS*[12] mobility calculator for nine different car categories including motorbike, which were adapted and implemented in the tool for a real-time calculation of fixed and variable mobility costs. Different cost scaling factors for fixed and variable costs are implemented depending on the vehicle category, fuel type, engine type, fuel consumption and price class of the current vehicle(s). For CS, fixed costs were set to 290 CHF/year (the annual fee of Switzerland's biggest carsharing provider), while for CP the same cost structure was used as discussed in Section 2.2.1. For PT, prices for different kinds of regional and national annual season tickets were collected, while the same variable cost structure was used as discussed in Section 2.2.1.

The fixed and variable household mobility costs were verified by the respondents in the base scenario, after which the hypothetical SA scenarios were introduced with differentiated increases in mobility costs similar to the first SA experiment (see Table 10; note that MIV and CS fixed costs c_{fixed} were not changed systematically between scenarios, only introducing changes in mode-specific variable RP travel costs R_{tc}). Then, all possible adaptation options together with the potential effects on behavior were outlined to the respondents, including the notification that a decrease in yearly distance would also lead to a respective abandonment of utility-generating activities.

Apart from changing the total distance traveled by each mode, the respondents can also change vehicle ownership (affecting both fixed and variable MIV costs), engine type and fuel type, or change PT season ticket ownership. For example, a more expensive regional season ticket typically leads to a decrease in variable PT costs. The interviewers made sure that the adaptations of the respondents were made in a behaviorally consistent manner. Valid observations were obtained from 187 households.

Fig. 3 gives a first overview of how the increase in mode-specific mobility cost affects yearly distance traveled. While in the first three scenarios, the change in demand indicators is relatively

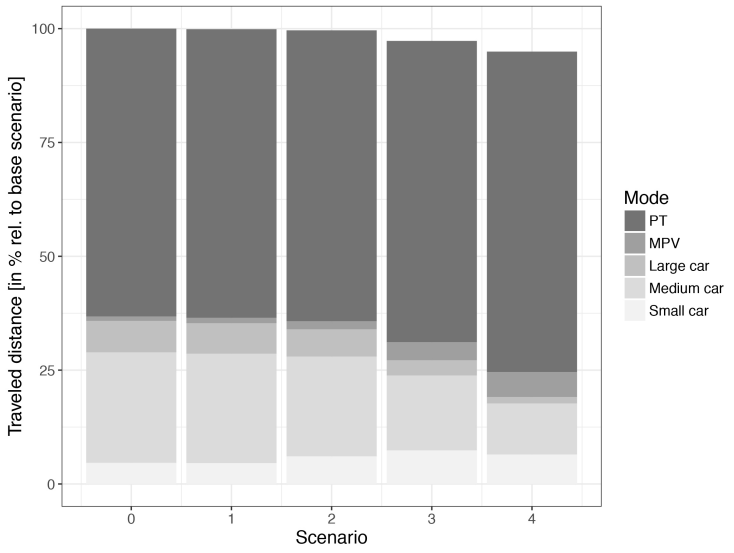
[12]Touring Club Schweiz: https://www.tcs.ch/

Table 10: Experimental design for tool II: Adaptations in mobility tool ownership.

Mode	Sc. 1 [in CHF]	Sc. 2 [in CHF]	Sc. 3 [in CHF]	Sc. 4 [in CHF]
Car	$R_{tc} * 1.5 + c_{fixed}$	$R_{tc} * 2 + c_{fixed}$	$R_{tc} * 4 + c_{fixed}$	$R_{tc} * 8 + c_{fixed}$
Motorbike	$R_{tc} * 1.5 + 1500$	$R_{tc} * 2 + 1500$	$R_{tc} * 4 + 1500$	$R_{tc} * 8 + 1500$
PT	$(R_{tc} + c_{fixed}) * 1.1$	$(R_{tc} + c_{fixed}) * 1.2$	$(R_{tc} + c_{fixed}) * 1.3$	$(R_{tc} + c_{fixed}) * 1.5$
CS	$R_{tc} * 1.1 + 290$	$R_{tc} * 1.2 + 290$	$R_{tc} * 1.3 + 290$	$R_{tc} * 1.5 + 290$
CP	$R_{tc} * 1.5$	$R_{tc} * 2$	$R_{tc} * 4$	$R_{tc} * 8$

CP = carpooling, CS = carsharing, PT = public transportation.

Figure 3: Tool II: Traveled distance by mode (in % relative to the base scenario).



small, the decrease in car usage is now highest between scenario 3 and 4. Also, there is a trend observable from large and medium towards smaller cars, and the share of MPV is increasing at the same time.

3. Response behavior

3.1. Meta analysis on the relationship between response burden and response rates

An initial idea of the required sample size and response rate usually helps to plan the budget and fieldwork of a study. While response behavior, survey quality and response burden have been treated in the literature (see e.g. Dillman (2000), for a broad discussion about different survey techniques, response burden and response rates), an ex-ante assessment of response rates predicted by the burden has not been a widely discussed topic so far. In this section, a meta-analysis based on the assessment of response burden scores - using a predefined scheme for different types of questions and tasks - and response rates (according to the The American Association for Public Opinion Research (2015) definitions) is conducted for past IVT studies (Axhausen et al., 2015).

Observations are fitted by a linear function after applying a Logit transformation[13] to the response rate [%]:

$$\log\left(\frac{response_{i,category}}{100 - response_{i,category}}\right) = \alpha_{category} + \beta_{category}\frac{burden_{i,category}}{1000} + \epsilon_{i,category} \tag{4}$$

Observations are weighted by sampling probabilities of study i, i.e. by putting less weight on observations with fewer potential respondents. Fig. 4 shows the relationship between response burden and response rates for three different categories (all coefficients significant at $p < 0.1$; see Table 11) as well as for a pooled model (same slope coefficient, but different intercepts): On average, no prior incentives and recruitment of the respondents (category 3) exhibits the lowest performance, and personal interaction (category 2) combined with incentives (category 1; including the current *Post-Car World* study) yields much higher response rates. In all categories, a higher response burden leads to lower response rates, flattening out to the right. The decay is strongest for the two "No incentive" categories and becomes much flatter when the study team has put effort in recruiting the respondents and also pays an incentive.

The pooled model shows a slightly lower AICc (for small sample size corrected Akaike Information Criterion) and thus is considered to be more appropriate, but the difference is small. Also, it does not allow to distinguish between category-specific decays, estimating an average slope coefficient ($p < 0.01$) that lies in between the ones for the separate categories. As all observations belong to the same field of research, saliency effects (Groves et al., 2000) across studies are assumed to be minimal.

The current *Post-Car World* survey exhibits response rates[14] much above the predicted ex-ante trend line (before adding the new data points; see Fig. 4), hence speaks in favor of the large recruitment effort and the payment of an incentive. However, the prediction accuracy for such a high response burden is not reliable and out of range, and more observations would help to improve the validity of the survey length versus response trade-off.

[13] This solves the boundedness problem of the original dependent variable (the probability to participate in a survey).

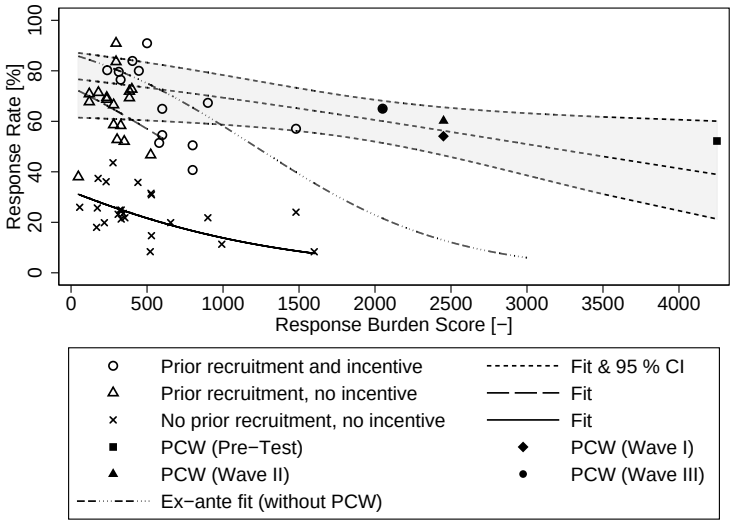
[14] See also Table 1: Given average survey response durations between three (wave III) and six hours (pre-test), the response rate was always above 52%. Note that in the pre-test, many respondents reported a general discontent regarding the high response burden, especially for stage I of the survey: While the socioeconomic questionnaires and the travel diary (although exhibiting a high response burden) worked well, data quality and response behavior of the trip planning and expenditure questionnaires were suffering. While some respondents did not understand the purpose of the trip planning task, others were overwhelmed by calculating their long-run expenditures for the different categories (communication, housing, education, etc.). To reduce the response burden in the main survey, a natural consequence was to skip and simplify some of the questionnaires to achieve a higher data quality of the remaining tasks and to reduce drop-out incidence.

Table 11: Estimation results: Effect of response burden on response rates (including PCW). Observations are weighted by the total number of potential respondents that each survey targeted (= respondents + drop-outs + non-respondents).

	Pooled model	Category 1	Category 2	Category 3
Incentive		√	–	–
Recruitment		√	√	–
Variable	Coef./(SE)	Coef./(SE)	Coef./(SE)	Coef./(SE)
Constant	–	1.206***	1.021***	-0.743***
		(0.29)	(0.21)	(0.24)
Constant category 1	1.395***	–	–	–
	(0.27)			
Constant category 2	0.750***	–	–	–
	(0.12)			
Constant category 3	−0.957***	–	–	–
	(0.13)			
Response burden	−0.599***	−0.389**	−1.480*	−1.087***
	(0.17)	(0.13)	(0.81)	(0.24)
N	57	17	17	23
R^2	0.74	0.20	0.09	0.35
AICc	93.8		94.1	

*Significance levels: *** = 1%, ** = 5% and * = 10%. −: Not included.*

Figure 4: Response burden and response rates: Meta-analysis based on previous IVT studies (Axhausen et al., 2015). Fitted, back-transformed values are based on the category-specific models in Table 11.



3.2. Descriptive statistics

Descriptive figures of respondents' characteristics (PCW sample: 301 households, 466 respondents; after completion of stage II) are compared with data from the Swiss microcensus for mobility and travel behavior (MZ2010, Swiss Federal Statistical Office ARE, 2010), a weighted, representative sample of the Swiss[15] population (see Table 12). While the residential area, the number of vehicles as well as gender of the household members are well represented by the PCW sample, older and larger households with kids, high income and education[16] levels as well as season ticket owners are overrepresented. Although the PCW sample size is small, it indicates the usual sample selection problems with many studies conducted at the IVT (e.g. Rieser-Schüssler and Axhausen, 2012; Weis et al., 2012): An overrepresented share of higher-income, well-educated, PT affine and middled-aged respondents[17].

3.3. Participation choice

Research has no conclusive suggestions regarding the implementation of incentives (e.g. Dillman, 2000; Porter, 2004). A high incentive is generally assumed to positively influence both participation rate and response quality, but the effects are not always that clear. E.g. Groves et al. (2000) shows that higher incentives lead to lower response rates for respondents with high community involvement. Hence, for the main survey, it was of special interest for the budgeting and ex-ante assessment of response behavior how the "optimal" incentive should look like. Therefore, the incentive levels in the pre-test were varied randomly between four different levels - 50, 70, 80 and 100 CHF.[18] Note that *each* respondent within a household would receive the same and prior (in the invitation letter) specified amount of money when completing the survey.

Participation choice models are estimated based on the screening interviews with non-recruited (N = 624) and recruited (N = 457) households[19], of whom 301 households completed the survey, to measure the effects of the different incentive levels and socioeconomic characteristics on the willingness to (1) participate in the survey and (2) complete the survey.

Participation and completion choice is modeled using a Heckman (1976) type sample selection Probit model (Van de Ven and Van Praag, 1981), where the same factors are affecting the selection (i.e. participation) and outcome (i.e. completion) equation.[20] A likelihood ratio test indicates that the two equations are not independent ($p < 0.05$), and not accounting for the error term correlation would lead to biased estimates.

Results are reported in Table 13. The differences in respondents' characteristics compared to the MZ2010 discussed in Section 3.2 mostly coincide with the probability of participation

[15] To compare with the PCW sample, only a subsample of the MZ2010 is considered, limited to the Canton of Zurich.

[16] Low education: No education, obligatory school, lower commercial school or apprenticeship. Medium education: Grammar school, higher education entrance qualification, proficient diploma or professional school. High education: Higher technical academy, college or university.

[17] A major problem involved the recruitment of all eligible (older than 18 years) household members, simultaneously affecting the age distribution in the PCW sample: Although larger households are overrepresented, mostly fractions (e.g. parents or the addressed household heads) of all eligible household members actually participated in the survey.

[18] Note that for model estimation, the medium incentive categories (70 CHF and 80 CHF) were pooled together, as their effects were not significantly different from each other.

[19] Note that these numbers are smaller than the ones reported in Table 1, as the model in Table 13 only includes households who also reported their income.

[20] Arguing that the Heckman estimator in such a case is problematic, Sartori (2003) derives an estimator under the assumption that the error terms in both equations are identical, which, in the traditional Heckman approach, is estimated from the data. In the current application, however, both approaches yield exactly the same results.

Table 12: Descriptive statistics: MZ2010 versus PCW sample.

Variable	Value	MZ2010 (%)	PCW (%)
Household size	1	31.6	17.9
	2	37.4	29.5
	3	12.4	20.2
	≥ 4	18.6	32.5
Household income	Not reported	24.1	5.3
	< 4'000 CHF	14.9	3.6
	4'000 - 6'000 CHF	17.5	5.0
	8'000 - 10'000 CHF	14.5	12.9
	10'000 - 12'000 CHF	10.6	12.9
	> 12'000 CHF	18.4	60.3
Household type	Single-person household	31.6	17.9
	Couple without kids	33.0	23.8
	Couple with kids	26.6	49.7
	Single-parent household	5.8	5.0
	Living community	3.1	3.6
Residential location area	City centre	38.9	41.4
	Agglomeration	54.8	42.1
	Rural	6.3	16.6
Number of cars	0	24.5	24.5
	1	49.1	52.3
	2	21.7	18.9
	≥ 3	4.6	4.3
Number of bikes	0	30.1	10.6
	1	21.3	15.6
	2	22.2	17.9
	≥ 3	26.4	56.0
Sex	Female	54.3	51.0
	Male	45.7	49.0
Age	18 - 35 years	20.7	12.9
	36 - 50 years	29.4	38.6
	51 - 65 years	27.4	44.6
	66 - 80 years	22.5	3.9
Education	Low	21.0	18.0
	Medium	54.9	24.4
	High	24.1	57.6
Season tickets	Half-fare card	51.8	39.4
	National or regional season ticket	17.4	47.8
	None of above	30.8	15.6
Car availability	Always	74.6	60.6
	Sometimes	18.0	24.2
	Never	7.3	15.2

(column 1) and completion (column 3): Better education, higher share of season tickets (= # season tickets / household member) and higher income show significant and positive effects ($p < 0.05$) on the probability of both participation and completion.

The substantial effect of season ticket ownership on participation and completion is most probably because frequent users of PT are more interested in the topic of future (urban) transportation systems, and this effect might be even reinforced by the higher education level. This finding is supported by the leverage-saliency theory (Groves et al., 2000): The motivation to participate in a survey is influenced by the respondents' interest in the topic. Especially in long-duration surveys, saliency effects might become much more substantial regarding initial participation choice, drop-out and fatigue.

Results also indicate that wave III exhibits an increased response rate of 18 percentage points ($p < 0.05$; relative to the pre-test), which can be attributed to the lower response burden without personal interviews. Older households living in rural areas exhibit a lower probability to participate ($p < 0.1$), but the net effect on completion is not significantly different from zero.

The incentive level, only varied in the pre-test, shows an ambiguous effect: While offering 100 CHF per household member increases the initial participation probability by 28.1 percentage points on average ($p < 0.05$; relative to the base category 50 CHF), it facilitates a later drop-out as shown by the negative effect on completion conditional on participation (column 2; -33.2 percentage points; $p \approx 0.2$). One explanation is that when realizing the high response burden, the survey was perceived as work effort rather than a social contribution, and the inhibition threshold to drop-out was lower for such high incentives.[21] The net effect is not significantly different from zero, and there is little point of paying an incentive higher than 50 CHF to keep respondents on board. Therefore, for the three main survey waves, the incentive was fixed at 50 CHF (Schmid and Axhausen, 2015).

3.4. Reported travel behavior and fatigue

A key feature of testing the validity of the longitudinal data structure is to investigate travel and activity behavior over time, checking for possible inconsistencies, decreasing number of trips or other exogenous influences (e.g. Axhausen et al., 2002, 2007). A first investigation of the *Post-Car World* data therefore focuses on descriptive analyses for investigating the representativeness of travel behavior and the number of trips and online activities over the reporting period, detecting a possible prevalence of reporting fatigue. The analyzed sample comprises 466 respondents who completed stage II of the survey.[22]

Key mobility figures are found to be comparable to the MZ2010 (see Table 14), and regarding the average number of trips (mobile days and all days) no substantial decreasing commitment has been detected for the second reporting week (pre-test only). There is a higher share of mobile person days in the PCW sample, which is even slightly increasing in the second week (pre-test only). The average number of trips per day are very similar as in the MZ2010, and findings indicate no manifestations of reporting fatigue.

Although the length of the seven days reporting period in the main survey and 14 days in the pre-test is moderate compared to the six weeks in *MobiDrive* (Axhausen et al., 2002; Löchl et al., 2005), it is still exceeding most of the Swiss transportation studies. There is, for example,

[21] A slightly different interpretation is that high incentives might convince people who are actually not interested in the survey topic to participate, but when realizing the enormous response burden, they decide to drop-out.

[22] Note that four respondents are excluded for analyzing the number of online activities. They were classified as complete, but did not fill in the online diary.

Table 13: Participation choice: Sample selection Probit model of (1) initial participation and (2) completion of the survey.

Variable	(1) *dy/dx*/(SE)	(2) | (1) *dy/dx*/(SE)	(2) *dy/dx*/(SE)
50 CHF	Base	Base	Base
70 CHF or 80 CHF	0.067	-0.176	-0.030
	(0.11)	(0.18)	(0.10)
100 CHF	0.281**	-0.332	0.045
	(0.12)	(0.21)	(0.11)
Pre-test	Base	Base	Base
Wave 1	0.026	-0.154	-0.048
	(0.09)	(0.14)	(0.09)
Wave 2	0.012	-0.100	-0.034
	(0.09)	(0.14)	(0.09)
Wave 3	0.236**	0.063	0.180**
	(0.09)	(0.15)	(0.09)
Low education	Base	Base	Base
Medium education	0.091*	0.147*	0.121**
	(0.05)	(0.09)	(0.05)
High education	0.118***	0.042	0.095**
	(0.04)	(0.07)	(0.04)
Age/100	-0.486***	0.378	-0.159
	(0.16)	(0.31)	(0.15)
City center	0.079*	0.032	0.065
	(0.04)	(0.07)	(0.04)
Share of season tickets	0.151***	0.056	0.122***
	(0.03)	(0.05)	(0.03)
Share of vehicles	0.048	-0.052	0.010
	(0.03)	(0.06)	(0.03)
Share of workers	-0.088	0.235**	0.041
	(0.05)	(0.10)	(0.05)
Income < 6'000 CHF	Base	Base	Base
Income 6'000 - 9'000 CHF	0.117**	0.025	0.087*
	(0.05)	(0.08)	(0.05)
Income 9'000 - 12'000 CHF	0.131***	0.040	0.102**
	(0.05)	(0.08)	(0.05)
Income > 12'000 CHF	0.182***	0.068	0.147***
	(0.05)	(0.08)	(0.05)
N (# censored/# uncensored)		1081 (624/457)	
ρ^2		0.36	
Prob. $> \chi^2$: Indep. equations		0.05	
Prob. $> \chi^2$: Model		0.00	

*Significance levels: *** = 1%, ** = 5% and * = 10%.*

Table 14: MZ2010 and PCW key mobility figures, chosen main mode and trip purpose distributions.

		MZ2010	PCW Week 1[1]	PCW Week 2[2]
Mobility figures	Share of mobile person days	88.5	93.6	95.1
	Average # of trips (all person days)	3.3	3.4	3.3
	Average # of trips (mobile days)	3.8	3.8	3.5
Main mode	Walk	31.1	18.4	20.4
	Bike	5.9	14.0	5.9
	Car or motorbike (MIV)	43.3	38.0	39.4
	Public transportation (PT)	18.7	28.4	34.0
	Other	1.0	1.4	0.3
Trip purpose	Return home	36.7	37.2	38.9
	Accompanying trips	3.4	4.3	3.3
	Work / eductation	15.7	19.8	15.5
	Shopping	12.2	9.5	10.7
	Errands	4.1	4.4	4.3
	Business	1.9	3.0	2.5
	Leisure	24.9	21.3	17.8
	Other purpose	1.0	0.5	7.1

[1]*: All waves (incl. pre-test).* [2]*: Week 2 only available in the pre-test.*

a higher share of walking trips in the MZ2010, which may be due to the fact that it asks for respondents' one day travel behavior, eventually leading to a higher trip resolution by detecting more short-distance trips. Regarding the chosen main modes in the MZ2010 and PCW sample, as expected there is a clear tendency of choosing PT instead of MIV, while for the other modes, the PCW sample is comparable. Also, the observed trip purpose distribution in the PCW sample is very similar to the MZ2010.

Fig. 5 presents the average (only mobile days) number of trips and the average number of *different* online activities in the pre-test and different survey waves. For the number of trips, a clear daily pattern is observable, exhibiting significantly fewer trips on Sundays (day 7 and 14), which is similar to the number of different online activities, though much more pronounced. At first glance, fatigue effects are not present and seem to be dominated by learning effects, whereby the number of reported trips even slightly increased in the second week (pre-test only). Also, on a daily basis, the 95% confidence bands in Fig. 5 indicate that behavior is not significantly different between the four survey waves. However, the number of reported online activities exhibit a negative trend which is consistent between all waves, but then jumping up again on Monday in the second week (pre-test only).

Random-effects Poisson regressions (Hausman et al., 1984) are conducted to account for the panel structure, the discreteness and non-negativity of the dependent variables, to empirically investigate if there is a significant deviation from a steady number of reported trips and online activities, additionally controlling/testing for the survey wave, weekend effects, incentive levels, sex, age, car availability, education, income and season ticket ownership. Interaction terms of the day of reporting period with these characteristics are tested, investigating if e.g. higher incentives prevents respondents from fatigue. Results are reported in Table 15, excluding all variables with a t-value smaller than one.

Regarding the number of trips per day, there is no clear global trend observable over the reporting period. Results are comparable to Axhausen et al. (2007), where positive learning rather than negative fatigue effects are present, and the number of trips in the second week (pre-

Figure 5: Average number of reported trips and different online activities per day.

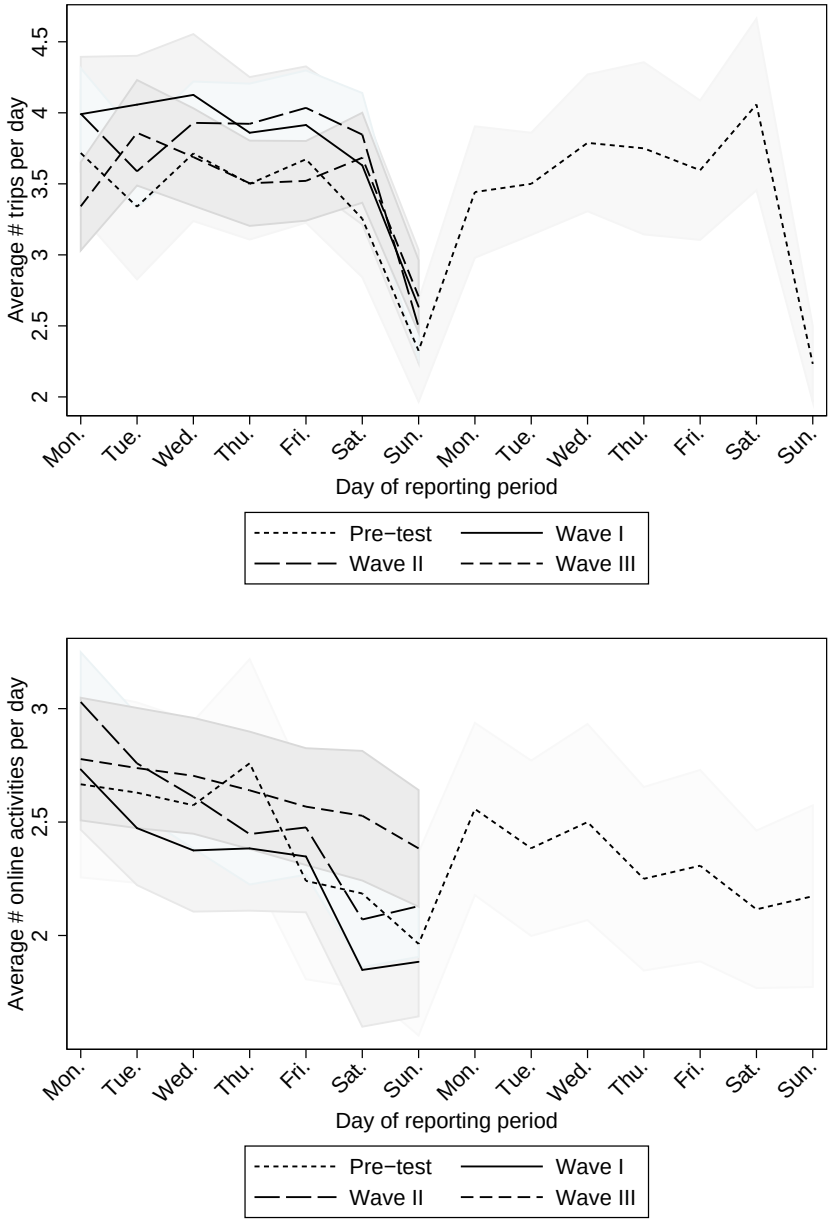


Table 15: Random-effects Poisson regressions: Number of reported trips and online activities per day.

Dep. Var.	# trips per day		# online activities	
Variable	Coef./(SE)	Coef./(SE)	Coef./(SE)	Coef./(SE)
Constant	1.104***	1.101***	1.479***	1.469***
	(0.05)	(0.06)	(0.15)	(0.16)
Day/100	0.440	0.519	-3.558***	-3.284**
	(0.58)	(0.98)	(0.58)	(1.61)
Saturday	-0.027	-0.028	-0.078***	-0.078***
	(0.03)	(0.03)	(0.03)	(0.03)
Sunday	-0.418***	-0.418***	-0.054*	-0.055*
	(0.04)	(0.04)	(0.03)	(0.03)
Pre-test	Base	Base	Base	Base
Wave I	0.184***	0.183***	0.065	0.065
	(0.05)	(0.05)	(0.14)	(0.14)
Wave II	0.167***	0.166***	0.122	0.122
	(0.05)	(0.05)	(0.14)	(0.14)
Wave III	0.111**	0.111**	0.119	0.119
	(0.05)	(0.05)	(0.14)	(0.14)
Week 2 (pre-test only)	0.027	0.028	-0.059*	-0.059*
	(0.03)	(0.03)	(0.03)	(0.03)
Incentive: 50 CHF	Base	Base	Base	Base
70 or 80 CHF	0.146**	0.133*	0.150	0.195
	(0.06)	(0.08)	(0.15)	(0.14)
100 CHF	0.028	0.064	0.202	0.024
	(0.08)	(0.09)	(0.18)	(0.19)
Car always avail.	0.066**	0.130***		
	(0.03)	(0.05)		
High education	0.042	-0.025		
	(0.03)	(0.05)		
Male			0.170***	0.170***
			(0.04)	(0.05)
Age/100			-1.311***	-1.281***
			(0.19)	(0.21)
70 or 80 CHF x day/100		0.339		-1.203
		(1.63)		(1.50)
100 CHF x day/100		-0.977		4.563***
		(1.08)		(1.77)
Car x day/100		-1.682*		
		(0.92)		
Educ. x day/100		1.773*		
		(0.92)		
Male x day/100				-0.004
				(0.87)
Age/100 x day/100				-0.802
				(3.32)
N (# respondents)	3391 (466)	3391 (466)	3593 (462)	3593 (462)
Pseudo R^2	0.06	0.06	0.12	0.12
AICc	12989	12992	11753	11758
Prob. $> \chi^2$: Model	0.00	0.00	0.00	0.00
Prob. $> \chi^2$: RE (H_A) vs. pooled (H_0)	0.00	0.00	0.00	0.00

*Significance levels: *** = 1%, ** = 5% and * = 10%. –: Not included. RE: Random effects.*

test only) even slightly increased. There are some significant level effects for the survey waves, indicating that in the pre-test, respondents reported less trips on average, which can be attributed to the season (i.e. less trips in Winter).

Incentive levels, only varied in the pre-test, and its interactions with the day of reporting period are non-significant, showing that higher incentives have no effect either on the absolute number of reported trips nor on fatigue, except for the medium incentive level (70 or 80 CHF) which exhibits a positive level effect ($p < 0.05$; about 0.4 trips more).[23]

Interestingly, the number of trips for respondents having a car always available are on a higher level ($p < 0.01$), but response behavior of this group slightly decreases over the reporting period ($p < 0.1$; about 0.3 trips less after seven days), while for season ticket owners, no significant effects have been detected. Also, while education exhibits no significant level effect, the interaction with the day of reporting period indicates that highly educated respondents report slightly more trips over time ($p < 0.1$; about 0.4 trips more after seven days).

For the number of online activities, a significant and negative global trend has been detected ($p < 0.01$; about one activity less after seven days), and in addition, this number decreased in the second week ($p < 0.1$; pre-test only), indicating some sort of decreasing commitment over time. While younger and male respondents perform significantly more online activities ($p < 0.01$), incentive levels show no significant level effect, and the differences between the survey waves are also not significant.

Given the pattern in Fig. 5 that is consistent between all waves and the erratic increase in the beginning of the second week (pre-test only), it may also be plausible to argue that respondents actually conduct less different online activities during the course of a week which is unrelated to fatigue. However, results indicate that offering the highest incentive level leads to an increasing number of reported activities ($p < 0.01$), exactly offsetting the negative global trend. Note, however, that due to the relatively low number of observations for which the incentive levels were varied (56 respondents), results have to be treated with caution.

4. Conclusions and outlook

Long-duration, multi-stage and/or just very burdensome studies face different problems when recruiting and motivating respondents, but they may add a substantial value to the empirical basis for transportation related planning and policy decisions. Combined with respondents' SP choices and attitudes, this data might help to get a better understanding of individuals' daily scheduling, mobility tool ownership and travel behavior in given socioeconomic and travel-related contexts.

Based on the findings in the pre-test (Schmid and Axhausen, 2015), several adaptations were proposed to improve the work flow, efficiency and response behavior, and the "optimal" incentive level was fixed at 50 CHF given the results obtained from participation choice models. Apart from changes in the survey and recruitment process, questionnaires were shortened, improved or skipped and respondents were better instructed and accompanied during the initial recruitment interviews and reporting period to reduce drop-out incidence and improve response quality in the main survey. An initial idea of the respondents' motivation for participating in the survey was found to play an important role when improving the recruitment and survey process.

Survey methods, descriptive figures and results in this paper also include the three main survey waves, showing similar evidence for different socioeconomic characteristics having an

[23] Due to the relatively low number of (independent) observations for which the incentive levels were varied (56 respondents), results have to be treated with caution.

effect on participation, completion and response behavior as in the pre-test. A high incentive level leads to a significantly higher initial participation rate, but the net-effect on completion is zero. One explanation might be that when realizing the high response burden, high incentives might convince people who are actually not interested in the survey topic to participate, but when realizing the enormous response burden, they may decide to drop-out.

Findings indicate a general sampling problem observed in many transportation studies. Certain socioeconomic characteristics are consistently overrepresented: Better educated and higher income households seem to be more interested in the topic and tend to participate more frequently, but they also exhibit a higher probability to complete the survey. Similarly, the share of PT season tickets in the households strongly affects both participation and completion of the survey. Minimizing saliency effects, e.g. by better addressing and involving the group assumed to be less interested in the topic (in the current case, the car users), should therefore receive highest priority in subsequent surveys independent of the research field.

Response behavior seems to be influenced by respondents' interest in the survey, supporting the leverage-saliency theory with regard to the current topic investigating travel behavior in a world with restricted car ownership and usage. This is further confirmed when investigating fatigue effects, whereby the number of reported trips over the reporting period are positively affected by education and negatively affected by car availability. Importantly, while higher incentive levels did not affect completion of the survey, results indicate an increased response quality in terms of more reported trips and a stabler reporting behavior of online activities over time. However, more data, especially in the longitudinal dimension, would be necessary to confirm these findings. Also, it is not fully clear if the above mentioned respondent characteristics indeed are related to response quality, or if these groups just behave in different ways with respect to their weekly activity patterns.

Acknowledgments

The authors gratefully thank to the SNSF (Swiss National Science Foundation) for funding the *Post-Car World* project (grant number 2-77894-13). We also give thanks to Simon Schmutz, former research assistant at the IVT, for his outstanding contributions to the project.

Glossary

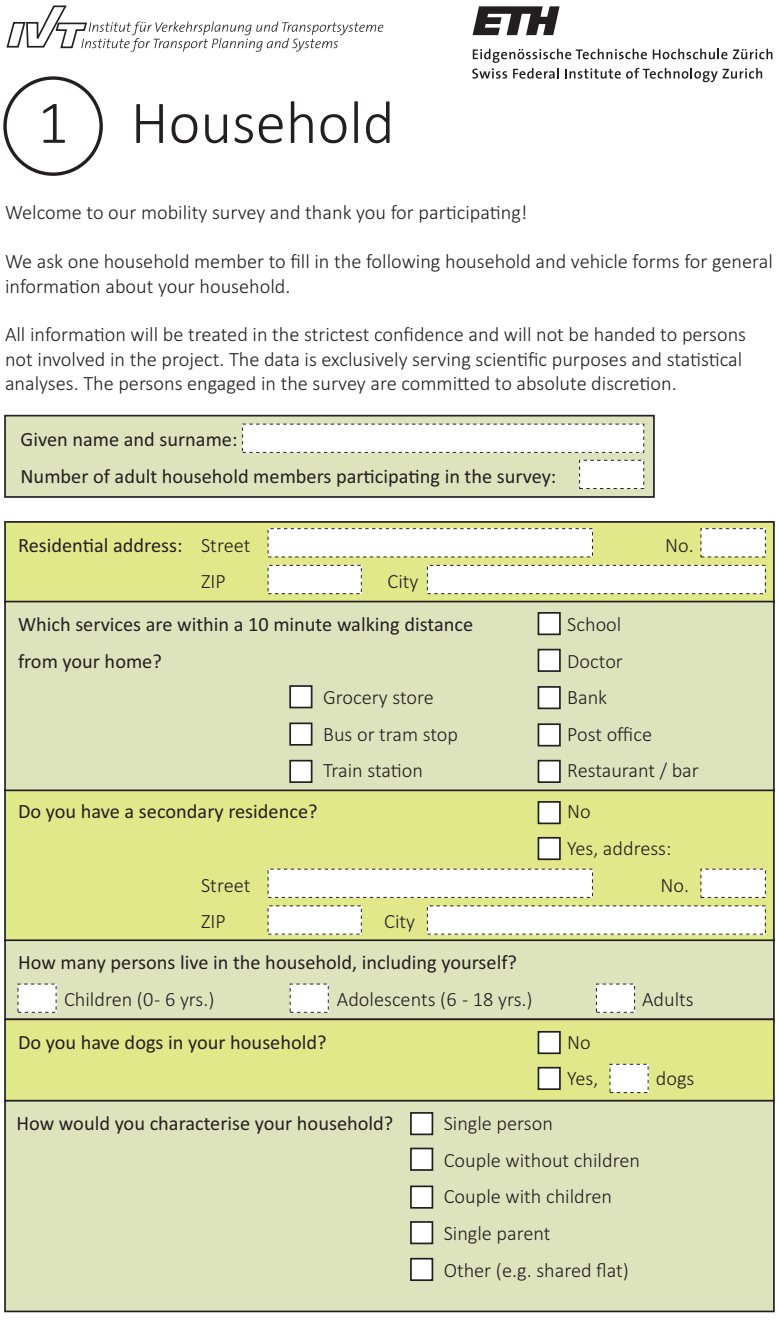
AICc: For finite sample size corrected Akaike Information Criterion
CHF: Swiss Francs (1 CHF $\approx$ 1 US$)
CP: Carpooling
CS: Carsharing
IVT: Institute for Transport Planning and Systems at ETH Zurich, Switzerland
MIV: Motorized individual vehicles (car, motorbike)
MPV: Motorized public vehicles (carsharing, carpooling, taxi)
MZ2010: Data from the (representative) Swiss microcensus for mobility and travel behavior
PCW: Post-Car World (name of the project)
PT: Public transportation (train, bus)
RP: Revealed preference
SA: Stated adaptation
SP: Stated preference

Conflict of interests

On behalf of all authors, the corresponding author states that there is no conflict of interest.

Appendix

Figure A.1: Household questionnaire I.



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1 Household

Welcome to our mobility survey and thank you for participating!

We ask one household member to fill in the following household and vehicle forms for general information about your household.

All information will be treated in the strictest confidence and will not be handed to persons not involved in the project. The data is exclusively serving scientific purposes and statistical analyses. The persons engaged in the survey are committed to absolute discretion.

Given name and surname:

Number of adult household members participating in the survey:

Residential address: Street No.

ZIP City

Which services are within a 10 minute walking distance from your home?

- School
- Doctor
- Grocery store
- Bank
- Bus or tram stop
- Post office
- Train station
- Restaurant / bar

Do you have a secondary residence?

- No
- Yes, address:

Street No.

ZIP City

How many persons live in the household, including yourself?

Children (0- 6 yrs.) Adolescents (6 - 18 yrs.) Adults

Do you have dogs in your household?

- No
- Yes, dogs

How would you characterise your household?

- Single person
- Couple without children
- Couple with children
- Single parent
- Other (e.g. shared flat)

1

Figure A.2: Household questionnaire II.

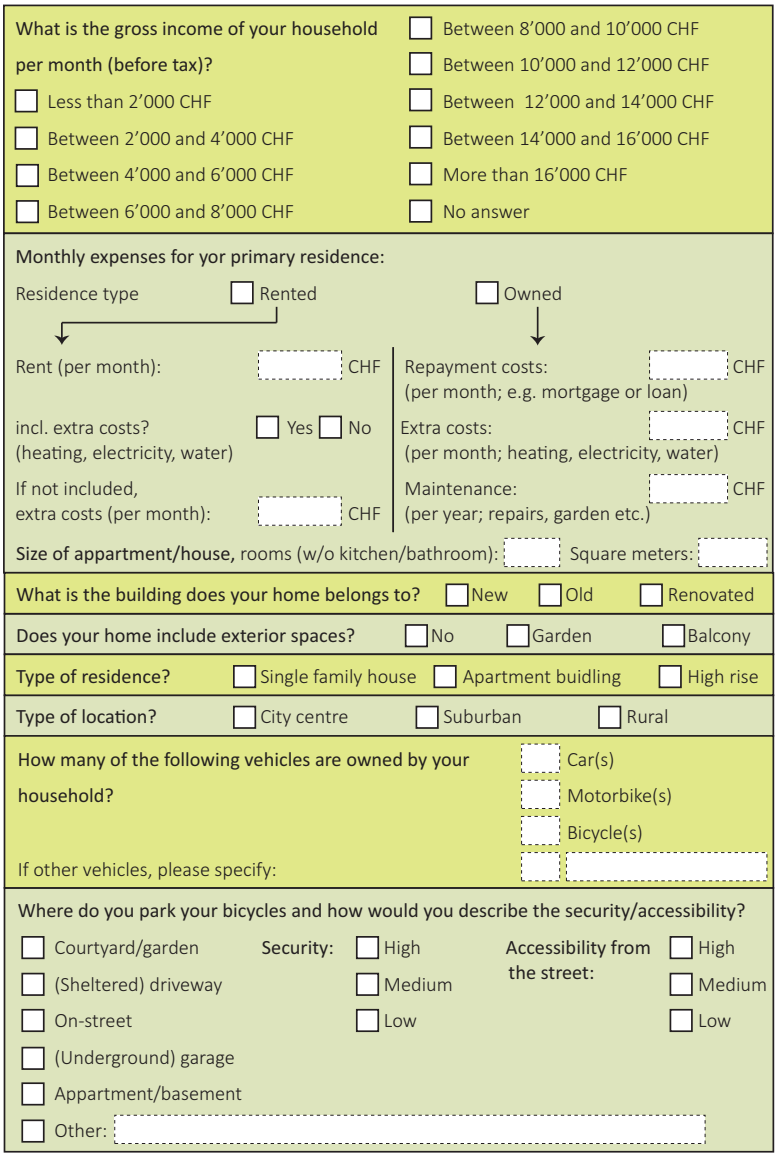

Figure A.3: Vehicle questionnaire I.

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2 Motorized vehicles

We ask you now to give detailed information about all motorized vehicles in your household. If your household does not possess motorized vehicles, please skip this form and continue with the next questionnaire.

Please fill in the required information about motorized vehicles available in your household (Car, van, motorbike, SUV, jeep, truck, etc.).

	Vehicle 1	Vehicle 2	Vehicle 3
Make			
Model			
Displacement (ccm)			
Year of manufacture			
Year of purchase			
Effective price (CHF)			
Company car	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Fuel type	Gasoline ☐ Diesel ☐ Hybrid ☐ Other ☐	Gasoline ☐ Diesel ☐ Hybrid ☐ Other ☐	Gasoline ☐ Diesel ☐ Hybrid ☐ Other ☐
Fuel consumption	l/100km	l/100km	l/100km
Mileage per year (estimate)			
Motorway toll sticker	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Available parking	Courtyard ☐ Driveway ☐ On-street ☐ Garage ☐ Other ☐	Courtyard ☐ Driveway ☐ On-street ☐ Garage ☐ Other ☐	Courtyard ☐ Driveway ☐ On-street ☐ Garage ☐ Other ☐
Monthly cost	CHF	CHF	CHF
Distance from home (estimate)	m	m	m
Used vehicle	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Motorbike	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No

Figure A.4: Vehicle questionnaire II.

Please fill in the required information about motorized vehicles available to your household (Car, van, motorbike, SUV, jeep, truck, etc.).

	Vehicle 1	Vehicle 2	Vehicle 3
Brand			
Make			
Displacement (ccm)			
Year of manufacture			
Year of purchase			
Effective price (CHF)			
Company car	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Fuel type	Gasoline ☐ Diesel ☐ Hybrid ☐ Other ☐	Gasoline ☐ Diesel ☐ Hybrid ☐ Other ☐	Gasoline ☐ Diesel ☐ Hybrid ☐ Other ☐
Fuel consumption	l/100km	l/100km	l/100km
Mileage per year (estimate)			
Motorway toll sticker	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Available parking	Courtyard ☐ Driveway ☐ On-street ☐ Garage ☐ Other ☐	Courtyard ☐ Driveway ☐ On-street ☐ Garage ☐ Other ☐	Courtyard ☐ Driveway ☐ On-street ☐ Garage ☐ Other ☐
Monthly cost	CHF	CHF	CHF
Distance from home (estimate)	m	m	m
Used vehicle	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
Motorbike	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No

Thank you for your information.

Figure A.5: Person questionnaire I.

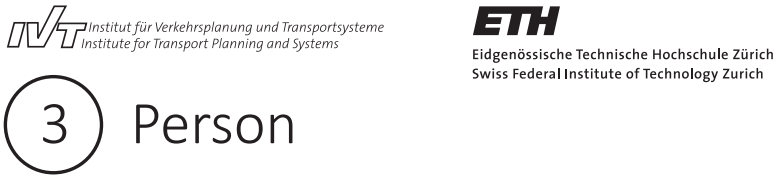


Figure A.6: Person questionnaire II.

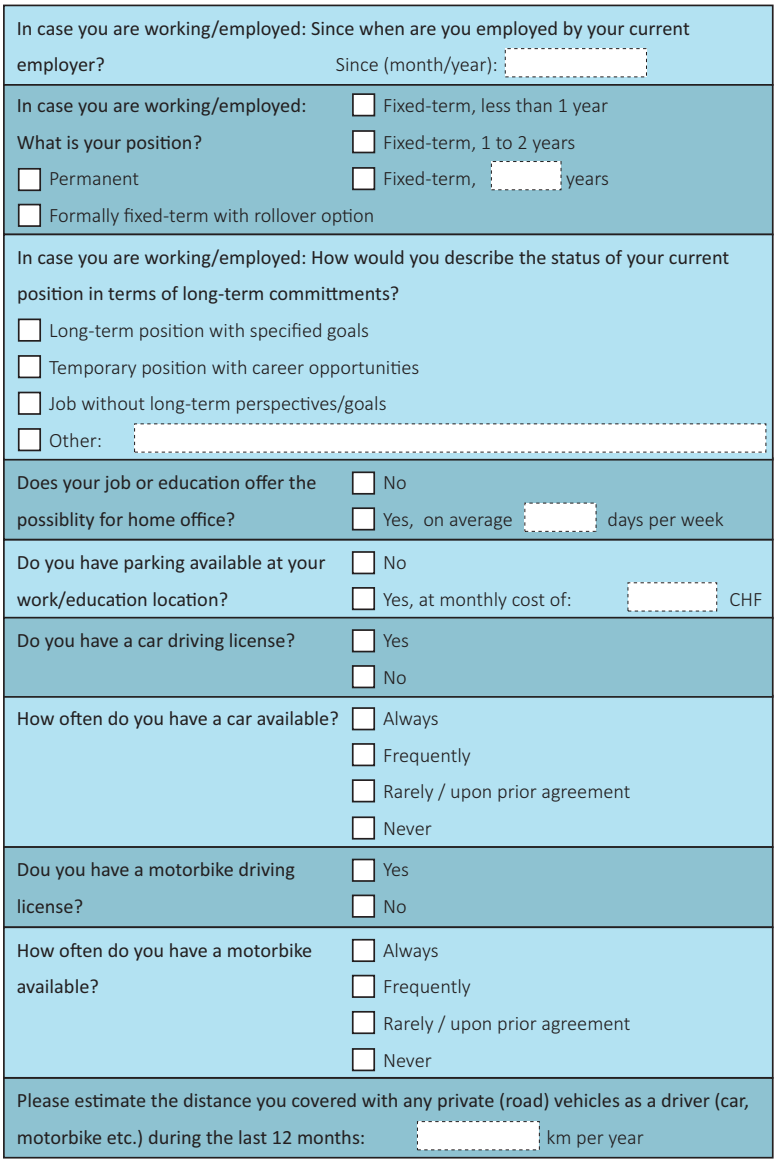


Figure A.7: Person questionnaire III.

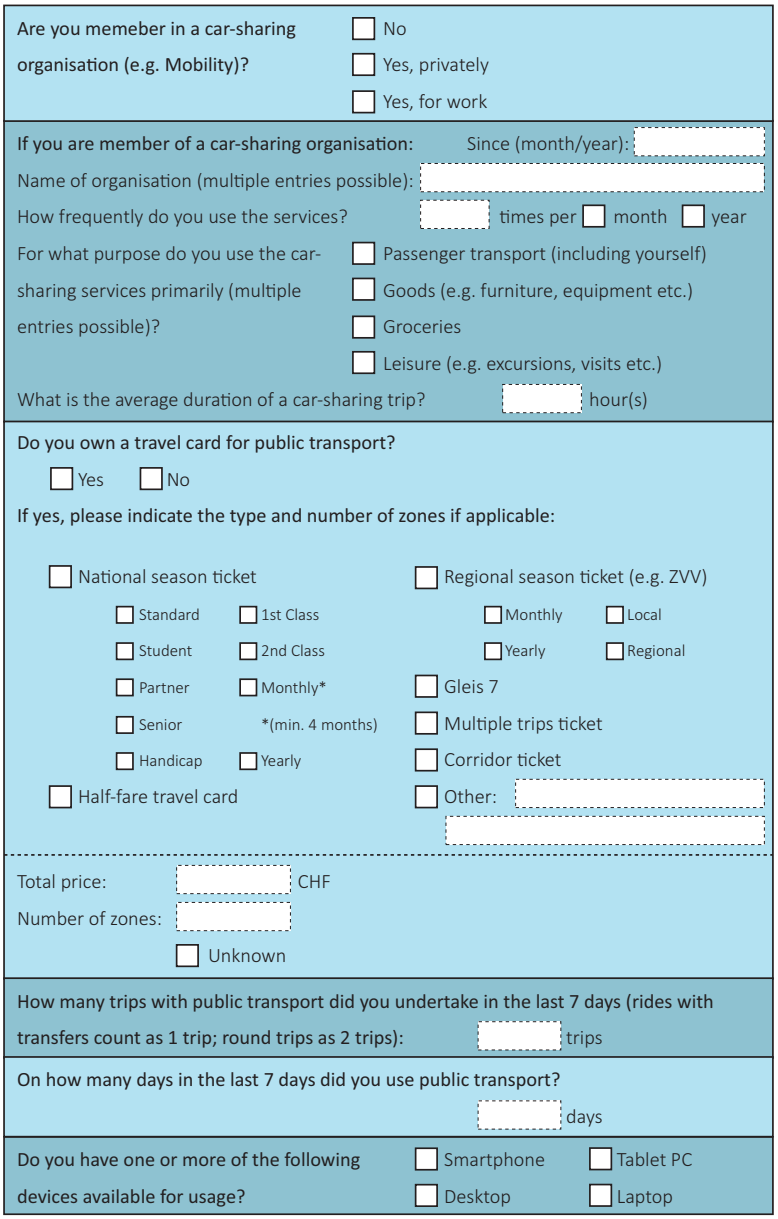
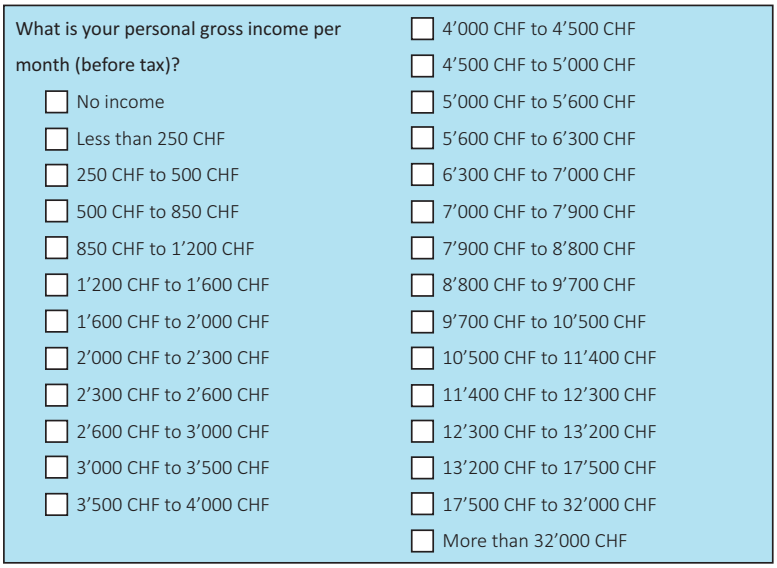


Figure A.8: Person questionnaire IIII.



Thank you for your information.

Figure A.9: Travel diary I.

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4.1 Travel diary

Thank you for participating in our survey!

In this part, we ask you to report all trips you undertake during the reporting week indicated in the cover letter.

Each trip represents exactly one change in location in order to undertake one activity at this location. Please indicate the day of the week that the trips on each page refer to.

All information will be treated in the strictest confidence and will not be handed to persons not involved in the project. The data is exclusively serving scientific purposes and statistical analyses. The persons engaged in the survey are committed to absolute discretion.

Given name: Year of birth: 19

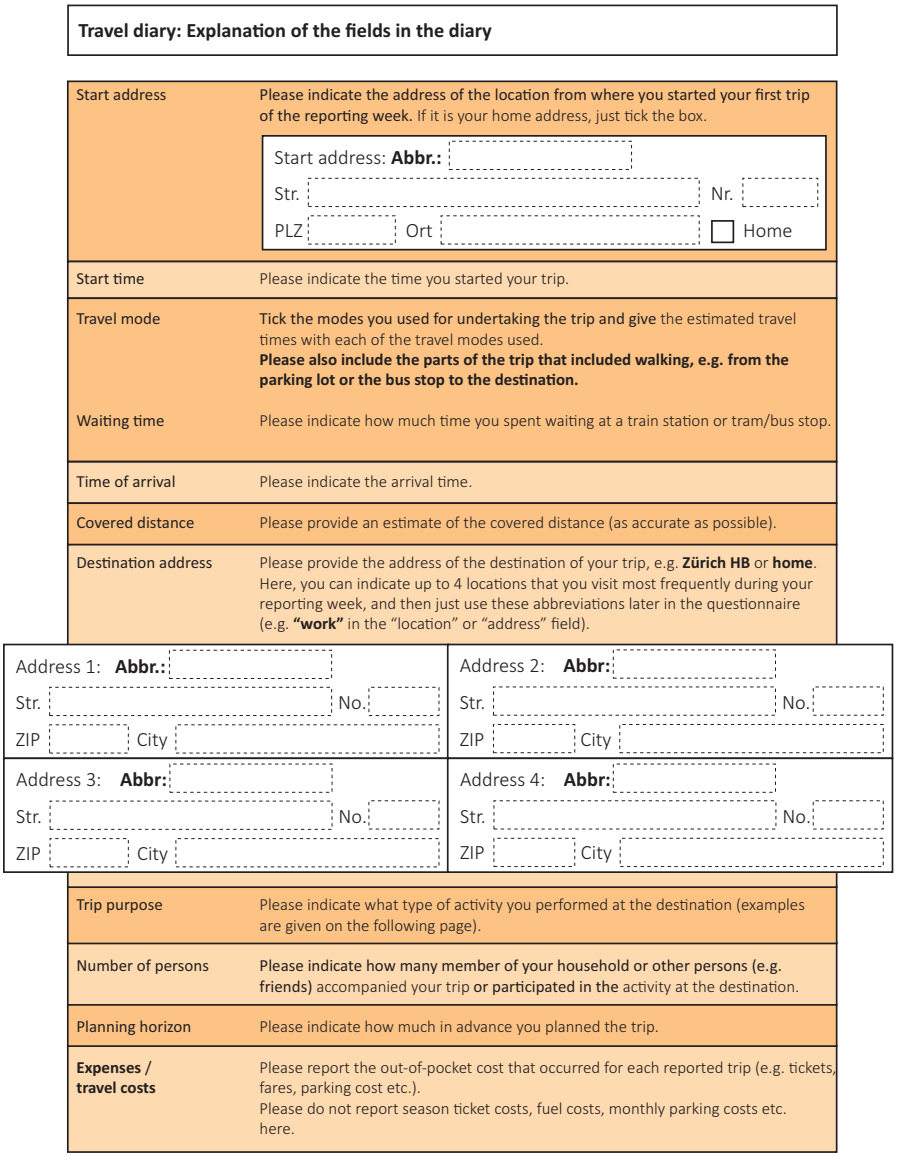
Did you **not** leave your home for one of the following days during the reporting week?

If you did not leave your home for one day during the reporting week, please indicate this in the following list, and add the reason.

- ☐ Monday — Reason:
- ☐ Tuesday — Reason:
- ☐ Wednesday — Reason:
- ☐ Thursday — Reason:
- ☐ Friday — Reason:
- ☐ Saturday — Reason:
- ☐ Sunday — Reason:

Please fill in this part of the questionnaire at the end of the reporting week.

Figure A.10: Travel diary II.



Travel diary: Explanation of the fields in the diary

Start address	Please indicate the address of the location from where you started your first trip of the reporting week. If it is your home address, just tick the box. Start address: **Abbr.:** ____ Str. ____ Nr. ____ PLZ ____ Ort ____ ☐ Home
Start time	Please indicate the time you started your trip.
Travel mode	Tick the modes you used for undertaking the trip and give the estimated travel times with each of the travel modes used. **Please also include the parts of the trip that included walking, e.g. from the parking lot or the bus stop to the destination.**
Waiting time	Please indicate how much time you spent waiting at a train station or tram/bus stop.
Time of arrival	Please indicate the arrival time.
Covered distance	Please provide an estimate of the covered distance (as accurate as possible).
Destination address	Please provide the address of the destination of your trip, e.g. **Zürich HB** or **home**. Here, you can indicate up to 4 locations that you visit most frequently during your reporting week, and then just use these abbreviations later in the questionnaire (e.g. **"work"** in the "location" or "address" field).

Address 1: **Abbr.:** ____ Str. ____ No. ____ ZIP ____ City ____	Address 2: **Abbr:** ____ Str. ____ No. ____ ZIP ____ City ____
Address 3: **Abbr:** ____ Str. ____ No. ____ ZIP ____ City ____	Address 4: **Abbr:** ____ Str. ____ No. ____ ZIP ____ City ____

Trip purpose	Please indicate what type of activity you performed at the destination (examples are given on the following page).
Number of persons	Please indicate how many member of your household or other persons (e.g. friends) accompanied your trip or participated in the activity at the destination.
Planning horizon	Please indicate how much in advance you planned the trip.
Expenses / travel costs	Please report the out-of-pocket cost that occurred for each reported trip (e.g. tickets, fares, parking cost etc.). Please do not report season ticket costs, fuel costs, monthly parking costs etc. here.

Figure A.11: Travel diary III.

Examples of trip purposes

For each conducted trip you are asked to indicate exactly one purpose.
The following examples should help you to assign your trip purpose to one of the categories. If you cannot find an appropriate category, please tick "Other" and specify.

Return home: → From outside Bring/pick up someone: → Train station, airport → Kindergarden, school → Doctor, hospital → etc. Work / education → Work location → Study location	Errands → Administration, bank → Post office → Hairdresser, nail studio → Doctor, hospital → Optician → Repair service → Tailor, laundry service → Police station → Gas station → Travel office → Fotographer → etc.
Shopping (daily needs): → Food, drinks → Sanitary articles → Cleaning products → Tobacco, cigarettes → Newspapers, magazines → Medicine → etc. Shopping (long term needs): → Clothing, shoes → Devices → Furniture, decoration → Sports equipment, bikes → Construction, gardening → Tableware → CD's, books, stationery → etc.	Leisure: → Private meetings or visits → Cinema, theater, concert, museum → Restaurant, cafe, bar, club → Personal sports exercise → Public swimming pool → Sports event → Walk, promenade → Botanical garden → Park, zoo, recreational area → Excursions, bike tours → Markets, exhibitions → Religion/church → Hospital visits → etc.

Important notes:
- One trip describes the travel to one single location, where a single activity is conducted. Don't forget: Going home (i.e. "Return home") is a separate trip and should be indicated accordingly.
- If the expenses occur in foreign currencies (e.g. Euro), please indicate the currency.
- Please write clearly and in block letters.

Thank you!

Figure A.12: Travel diary IIII.

Travel diary (day of week): ☐ Mon ☐ Tue ☐ Wed ☐ Thu ☐ Fri ☐ Sat ☐ Sun

Trip number	1	2
Start time	hh:mm	hh:mm
Travel mode	☐ Walk min. ☐ Bicycle min. ☐ Motorbike min. ☐ Car (as driver) min. ☐ Car (as passenger) min. ☐ Tram / bus min. ☐ Train min. ☐ Other min. Wating time: min.	☐ Walk min. ☐ Bicycle min. ☐ Motorbike min. ☐ Car (as driver) min. ☐ Car (as passenger min. ☐ Tram / bus min. ☐ Train min. ☐ Other min. Wating time: min.
Arrival time	hh:mm	hh:mm
Total distance	km (estimated)	km (estimated)
Destination (address or location)	Str. No. ZIP City Location	Str. No. ZIP City Location
Trip purpose: Please choose **only 1 activity**!	☐ Return home ☐ Drop off / pick up someone ☐ Work / education ☐ Shopping (daily needs) ☐ Shopping (long term needs) ☐ Errands ☐ Business ☐ Leisure, specify: ☐ Other, specify:	☐ Return home ☐ Drop off / pick up someone ☐ Work / education ☐ Shopping (daily needs) ☐ Shopping (long term needs) ☐ Errands ☐ Business ☐ Leisure, specify: ☐ Other, specify:
Number of involvevd persons / dogs	Trip (**Please do not include yourself**) Activity Household memebers Other persons dogs	Trip (**Please do not include yourself**) Activity Household memebers Other persons dogs
Planning horizon	☐ Routine activity / return home trip ☐ One or several days in advance ☐ During the same day ☐ Spontaneous	☐ Routine activity / return home trip ☐ One or several days in advance ☐ During the same day ☐ Spontaneous
Expenses / Travel cost	☐ PT fare CHF ☐ Parking fees CHF ☐ Taxi fees CHF ☐ Rental costs (e.g. for car, bike etc.) CHF ☐ No travel expenses for this trip	☐ PT fare CHF ☐ Parking fees CHF ☐ Taxi fees CHF ☐ Rental costs (e.g. for car, bike etc.) CHF ☐ No travel expenses for this trip

Figure A.13: Online diary I.

Figure A.14: Online diary II.

Online and telecommunication diary: **Monday**

	Duration	Amount spent
(Online-)Shopping: Purchase / bookings of (please also indicate *phone* orders) ...		
☐ Tickets for events, flights, train tickets, hotel bookings (e.g. starticket.ch, ebookers.com, SBB.ch, etc.)	min.	CHF
☐ Clothes or sports equipment (e.g. zalando.ch, sportxx.ch, etc.)	min.	CHF
☐ Electronic appliances (e.g. digitec.ch, hshop.ch, melectronics.ch, distrelec.ch, exlibris.ch, etc.)	min.	CHF
☐ Furniture and accessoires (e.g. möbel-online.home24.ch, micasa.ch, etc.)	min.	CHF
☐ Books and magazines (e.g. amazon.de, etc.)	min.	CHF
☐ Groceries (e.g. leshop.ch, nespresso.ch, coopathome.ch, muesli.ch, etc.)	min.	CHF
☐ Other:	min.	CHF
(Online-)Entertainment: Download / stream / watch / play ...		
☐ Music	min.	CHF
☐ TV / movies / TV shows / youtube	min.	CHF
☐ Computer games	min.	CHF
☐ Other:	min.	CHF
☐ E-Banking / bank transactions	min.	
☐ Social networks (e.g. facebook.com, twitter.com, etc.)	min.	
☐ Non-work communication (e.g. phone calls, SMS, Email, WhatsApp, online-chatting; with friends, acquaintances, etc.)	min.	
☐ Inquiries and education (e.g. google, online-news, vacation planning, restaurants, hotels, online-tutorials, blogs, price comparison, etc.)	min.	
☐ Online dating (e.g. parship.ch, c-date.ch, etc.)	min.	
☐ Other:	min.	CHF
	min.	CHF
☐ No online- and/or telecommunication activities on this day		

Figure A.15: Short-term expenditures.

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4.3 Short- and long-term expenses

In this part, we ask you to keep track on your short-term daily expenses (e.g. groceries, restaurant, clothes etc.). Please specify the expenses separately for each day of the week.

On the last page, we ask you to specify your longer-term and/or regularly occurring expenses. Please do not try too hard to get a perfect estimate and provide the numbers as accurately as possible.

All information will be treated in the strictest confidence and will not be handed to persons not involved in the project. The data is exclusively serving scientific purposes and statistical analyses. The persons engaged in the survey are committed to absolute discretion.

Given name: Year of birth: 19

Expenses form: **Monday**

	Amount spent
Short-term cost of living: Expenses for ...	
☐ **Groceries** (z.B. Drinks, food, tobacco etc.)	CHF
☐ **Leisure and entertainment** (e.g. movie theatre, club, concert, sports, swimming pool entrance, etc.)	CHF
☐ **Food and accomodation** (e.g. cafe, restaurant, hotel, etc.)	CHF
☐ **Newspapers and magazines**	CHF
☐ **Clothing, shoes, accessoires**	CHF
☐ **Other:**	CHF
	CHF
☐ No expenses on this day	

Figure A.16: Long-term expenditures.

Expenses form for longer-term and/or regularly occurring expenses and savings

Please enter estimates of your **average longer-term and/or regularly occurring expenses for the given categories for the last** 12 months. You can give the amount per year or month, whatever is more convenient for you.
Here is an example for the category "Communication":

- Mobile phone subscription of **75 CHF per month**
- Land-line phone, TV- and internet subscription costs incl. concession (Billag) of **100 CHF per month**
- Homepage-fees of **60 CHF per year**

→ 75 CHF + 100 CHF + 60 CHF / 12 = **200 CHF per month**

You can use a different temporal basis for each category!
Don't think too long and just give a rough estimate!
In case the expenses apply to the household (and not only to you as a person), please only indicate the amount once!

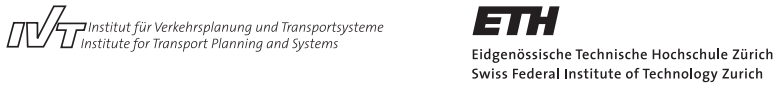
Longer-term and/or regularly occurring expenses: Summarised expenses for ...	Amount spent	per
☐ Eletronic devices and appliances (e.g. computer, tablet, laptop, HiFi set, smartphone, CD's, DVD's, household appliances, camera, spare parts, etc.)	CHF	
☐ Clothing, accessoires, apparel, sports equipment (e.g. shoes, jeans, skis, rollerblades, tennis racket, snowboard, etc.)	CHF	
☐ Communication (e.g. mobile phone or combined subscription (Phone, internet, TV), Fees, etc.)	CHF	
☐ Services (e.g. hairdresser, technician, custaodian, pedicure, etc.)	CHF	
☐ Vacation (e.g. flight, hotel, etc.)	CHF	
☐ Appartement decoration (e.g. furniture, lamps, etc.)	CHF	
☐ Education (e.g. university fees, advanced training, books, private lessons, etc.)	CHF	
☐ Health (e.g. dentist, therapy, medication, etc.)	CHF	
☐ Health insurance (e.g. base insurance plus special policies)	CHF	
☐ Other insurance (e.g. car, liability, accident, retirement arrangements, etc.)	CHF	
☐ Newspaper and magazine supscriptions (e.g. Tagesanzeiger, NZZ, Annabelle, Weltwoche, etc.)	CHF	
☐ Sports and leisure subscriptions (e.g. fitness card, yearly subscriptions for football games, etc.)	CHF	
☐ Association fees, alimony and other payments to third parties (e.g. Rega, church, sports club, professional organisation, etc.)	CHF	
☐ Private vehicle leasing (e.g. car, motorbike, bike, etc.)	CHF	
☐ Other:	CHF	
	CHF	

Savings: How much do you have left at the end of a month on average?
The number can be negative, which means that your savings decrease.

CHF ☐ positive balance ☐ negative balance

4

Figure A.17: Mode choice SP introduction.



1 Mode choice

This questionnaire addresses the following person in your household. We ask this person to fill in the forms on the following pages:

Given name: **Andreas**	Year of birth: **1967**

In this part, we ask you about your choice of travel modes under different conditions. Imagine you live in the near future. The weather is friendly with a outdoor temperature of about 15 °C. You plan to make a trip for the purpose of:

Shopping

The distance relates to one of the trips you reported in the first part of the study. Assume you have the following modes available:

- **Walk**
- **Carpooling** as passenger (a carpooling member located nearby is driving in the same direction as your destination. You register online. Assume that you have never met the driver before.
- **Carsharing** (flexible use of vehicles parked nearby that can be parked at any location after use)
- **Public transportation (PT)**

On the following two pages you find eight choice situations. In each situation, the available alternatives are described with the following attributes:

- **Travel cost:** Share of expenses for carpooling, cost for carsharing (based on duration and distance travelled) or ticket cost for public transportation usage (2nd class)
- **Travel or walking time**
- **Access and egress time:** Time you spend walking to the mode or from the mode to your destination
- **Risk of missing carpooling driver:** The driver may not show up, despite the appointment
- **Number of transfers in PT**
- **Headway:** Regularity of PT service

Attribute levels of the available modes differ from situation to situation. Please imagine yourself in these situations and try to **make your choices solely based on the values and characteristics shown**. Carefully trade-off the attributes against each other and for each situation, choose one mode that you consider best.

Figure A.18: Example choice situation: Mode choice SP.

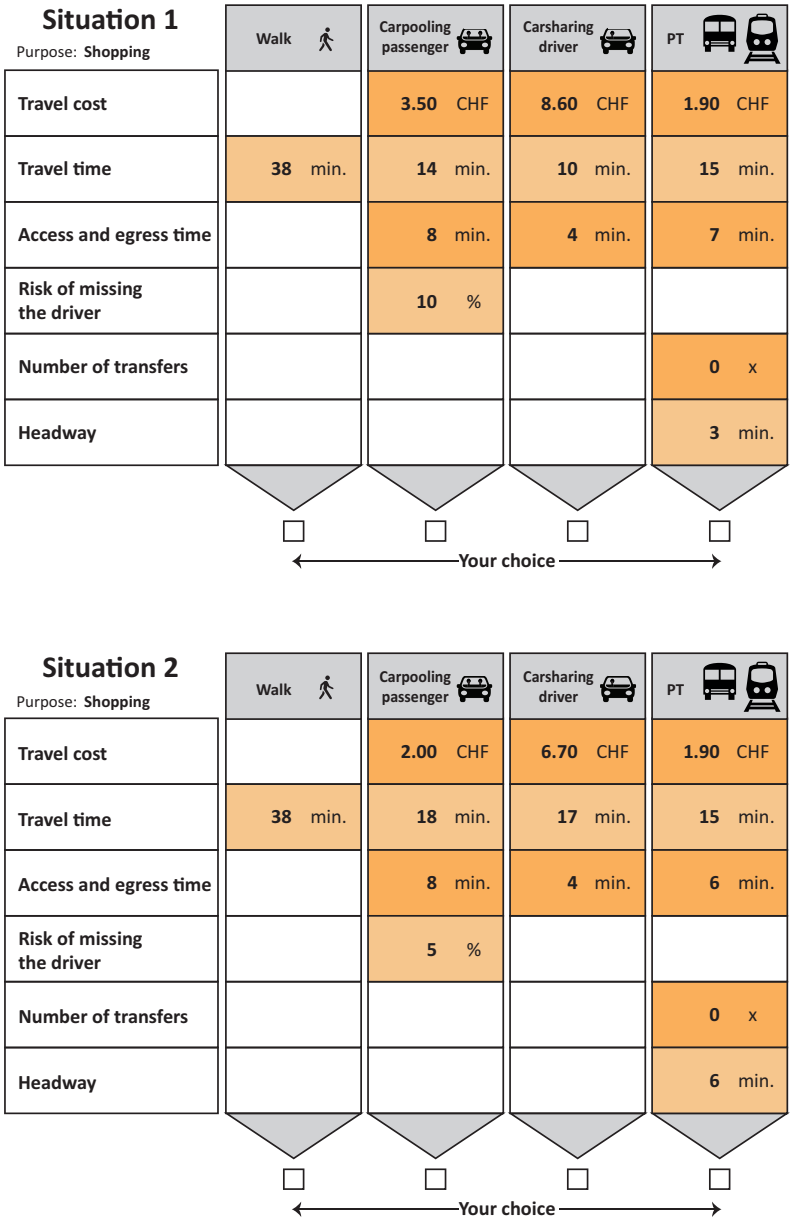


Figure A.19: In-store vs. online shopping SP introduction.

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2 In-store or online shopping

This questionnaire addresses the following person in your household. We ask this person to fill in the forms on the following pages.

Given name: **Jonathan**	Year of birth: **1960**

Imagine you live in the near future and decide about doing your purchases either by **ordering online** or by **traveling to a store nearby** that you can only access by means of public transportation, carsharing or carpooling. Hence, you experience either delivery cost or travel cost.

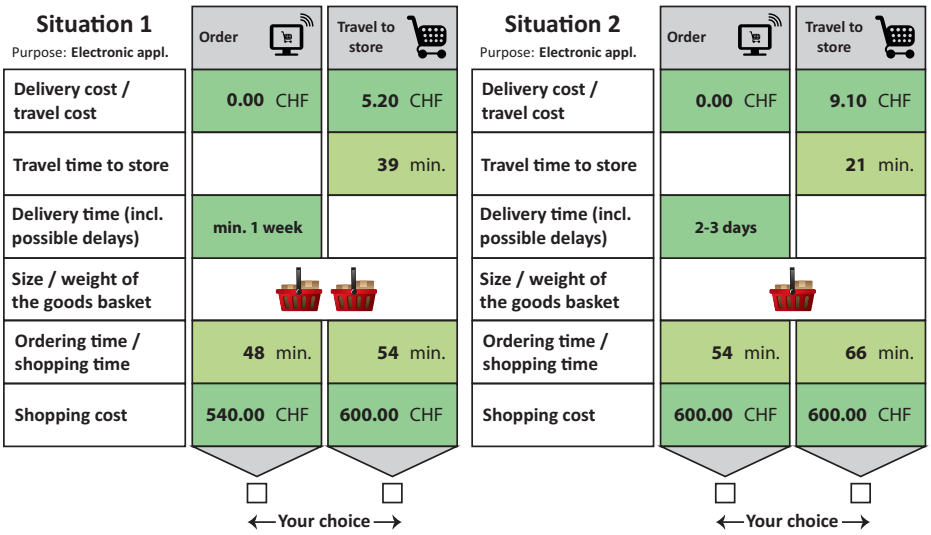
Please note that you do not have a private car available and that shopping is for one single purpose: Buying **standard electronic devices for entertainment** or **household appliances**.

Assume that the products are identical, regardless of whether you order or buy them in the shop (same brand, quality, etc.). On the following two pages you find eight choice situations. In each situation, the available alternatives are described with the following attributes:

- **Delivery cost** (incl. possible custom fees) or **travel cost** for the trip to the store
- **Travel time** to the store
- **Delivery time** (incl. possble delays)
- Approximate **Size / Weight** of the purchases
  - : Easy to carry
    (e.g. water kettle, smartphone, hairdryer, etc.)
  - : Heavy / inconvenient to carry
    (e.g. computer, TV set, coffee machine, etc.)
  - : Very heavy or inconvenient to transport
    (e.g. large Hifi set, lawn mower, fridge, etc.)
- **Time** for **ordering** or for **purchase** in the shop (incl. waiting time at the cashier)
- **Cost** of purchase

Please consider that the attribute values shown in the choice situations only partly relate to the information you declared in the first part of the study and can therefore be different to situations of your personal experience. Please try to **make your choices solely based on the values and characteristics shown**. Carefully trade-off the attributes against each other and choose the one alternative you consider best, i.e. ordering online or travel to the store.

Figure A.20: Example choice situations: In-store vs. online shopping SP.



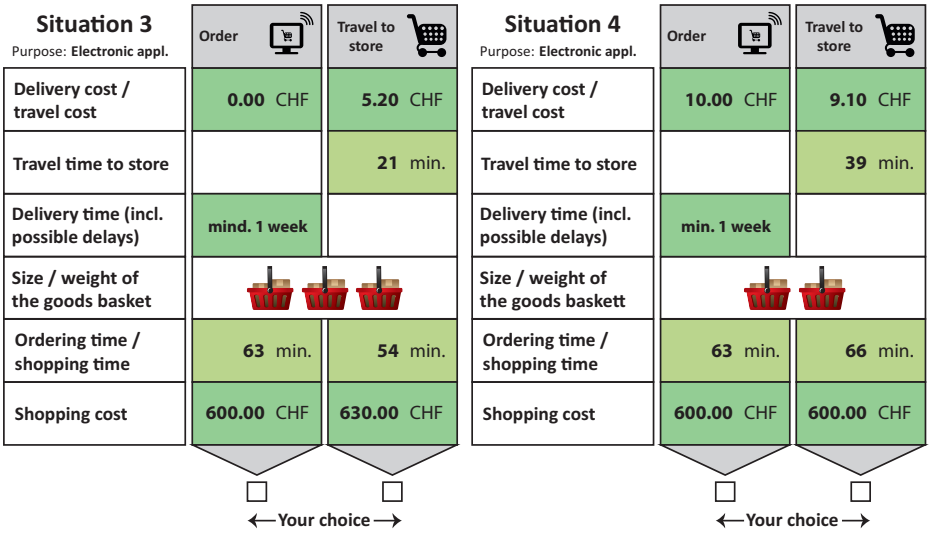


Figure A.21: Route choice SP introduction.

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3 Route choice

This questionnaire addresses the following person in your household. We ask this person to fill in the forms on the following pages:

Given name: **Barbara**	Year of birth: **1967**

In this part, we ask you about your choice of different route alternatives. Imagine you live in the near future. The weather is friendly with an outdoor temperature of about 15 °C. You think about undertaking a public transportation trip for the purpose of

Leisure

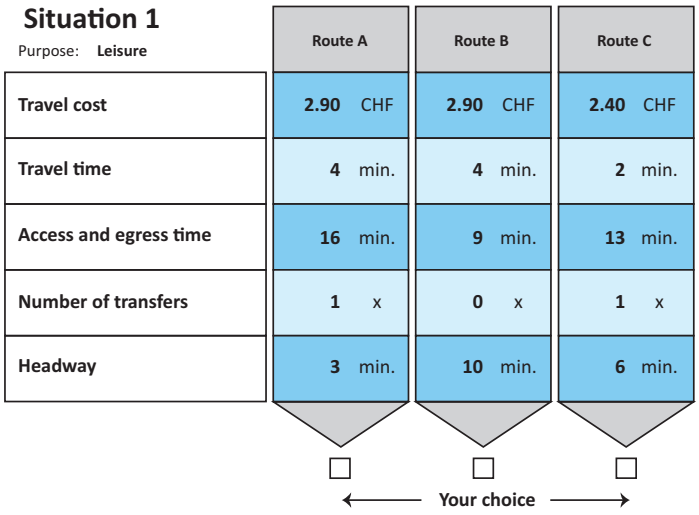
The distance is related to one of the trips you specified in the first part of the study.

On the following pages you find four choice situations. In each situation, the available route alternatives are described with the following attributes:

- **Travel cost**
- **Travel time**: Time spent in the vehicle
- **Access and egress time:** Time you spend walking to the mode or from the mode to your destination
- **Number of transfers**
- **Headway:** Regularity of PT service

Attribute levels of the available routes differ from situation to situation. Please imagine yourself in these situations and try to **make your choices solely based on the values and characteristics shown**. Carefully trade-off the attributes against each other and for each situation, choose one route that you consider best.

Figure A.22: Example choice situations: In-store vs. online shopping SP.



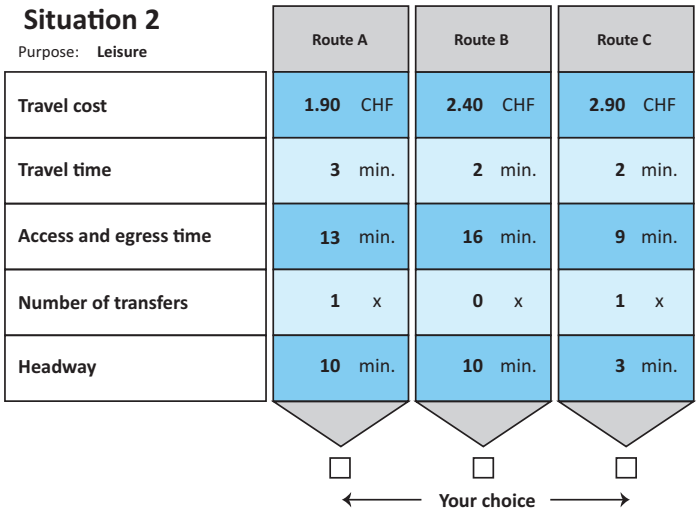
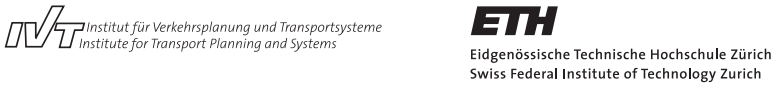


Figure A.23: Attitudinal questionnaire I.



4 Attitudinal questionnaire

In this questionnaire we present different statements about several topics related to your attitudes towards mobility, your shopping behavior and other personal traits. Each statement is followed by four boxes forming a scale from “completely agree” to “completely disagree”. Please give your opinion to each of these statements.

Please do not think too long about your opinion - there is no correct or wrong answer. Please note that there will be no political or other kind of judgement of your opinion.

All information will be treated in the strictest confidence and will not be handed to persons not involved in the project. The data is exclusively serving scientific purposes and statistical analyses. The persons engaged in the survey are committed to absolute discretion.

Given name: Year of birth: 19

Figure A.24: Attitudinal questionnaire II.

Attitudes towards car usage

		completely disagree			completely agree
1.	One is less worth without owning a car in today's society.	☐	☐	☐	☐
2.	In my opinion it is a status symbol to own a car.	☐	☐	☐	☐
3.	To reduce emissions, as a first step the whole road traffic should be slowed down.	☐	☐	☐	☐
4.	I support the idea of radically increasing fuel prices in order to improve the public transportation infra-structure.	☐	☐	☐	☐
5.	My car should stand out from the big crowd and should be something special.	☐	☐	☐	☐
6.	I would not be able to organize my daily life without a car.	☐	☐	☐	☐
7.	Car driving is a criminal offence against the environment.	☐	☐	☐	☐

Figure A.25: Attitudinal questionnaire III.

Attitudes towards public transportation

		completely disagree			completely agree
1.	I think it is right that public transportation gets prioritized accross the whole city.	☐	☐	☐	☐
2.	It bothers me that when using public transportation, one often is confronted with unpleasant people.	☐	☐	☐	☐
3.	The public transportation infrastructure in Zurich is amazing.	☐	☐	☐	☐
4.	I am a very outgoing person.	☐	☐	☐	☐
5.	The complicated timetables discourage me from using public transportation.	☐	☐	☐	☐
6.	I often prefer to be by myself.	☐	☐	☐	☐
7.	Public transportation is not flexible enough.	☐	☐	☐	☐

Attitudes towards walk and bike

		completely disagree			completely agree
1.	I walk as often as possible because it is healthy.	☐	☐	☐	☐
2.	There are plenty of places in Zurich where it is life-threatening to walk.	☐	☐	☐	☐
3.	The noise and smell of the road traffic make life of pedestrians hard.	☐	☐	☐	☐
4.	When driving a bike I feel independent and free.	☐	☐	☐	☐
5.	Driving a bike is the best means of transportation for me.	☐	☐	☐	☐

Figure A.26: Attitudinal questionnaire IIII.

Attitudes towards emerging modes

		completely disagree			completely agree
1.	I like the humming of a gasoline engine.	☐	☐	☐	☐
2.	I could totally imagine to completely go without a car.	☐	☐	☐	☐
3.	Car-sharing schemes (such as e.g. Mobility) should be increasingly provided and promoted.	☐	☐	☐	☐
4.	I would be happy to share my car with others, if all users would equally share the costs.	☐	☐	☐	☐
5.	It should be more invested into the development of self-driving cars (which are equipped with a high number of sensors and cameras and thus are able to detect their surroundings) with an environmentally friendly engine.	☐	☐	☐	☐
6.	Autonomous cars that could be ordered online to a desired location would be a good alternative to a privately owned vehicle.	☐	☐	☐	☐
7.	Preferably everything should stay as it is.	☐	☐	☐	☐
8.	Moving pathways (as e.g. at the airport) are worth investigating to be the main means of transportation within a city.	☐	☐	☐	☐
9.	The most obvious instrument to decrease urban traffic in the future is a strict reduction of the immigration quota.	☐	☐	☐	☐
10.	I would like to become a member of a car-sharing scheme that allows the free usage of available cars, and, after usage, the vehicle can be placed at any free parking space within the city.	☐	☐	☐	☐
11.	A city like Zurich without any cars is inconceivable.	☐	☐	☐	☐
12.	I dream of a calm life without any nasty surprises.	☐	☐	☐	☐
13.	Self-driving cars are scary.	☐	☐	☐	☐

Figure A.27: Attitudinal questionnaire V.

Attitudes towards online and in-store shopping

		completely disagree			completely agree
1.	I often order products on the Internet.	☐	☐	☐	☐
2.	Online shopping is associated with risks.	☐	☐	☐	☐
3.	Credit card fraud is one of the reasons why I don't like online shopping.	☐	☐	☐	☐
4.	The internet has more cons than pros.	☐	☐	☐	☐
5.	A disadvantage of online shopping is that I cannot physically examine the products.	☐	☐	☐	☐
6.	Online shopping facilitates the comparison of prices and products.	☐	☐	☐	☐
7.	The risk of receiving a wrong product is one of the main reasons why I don't like online shopping.	☐	☐	☐	☐
8.	I like to visit shops, even if I don't want to buy something, just for looking around.	☐	☐	☐	☐
9.	Shopping is exhausting and does not make fun.	☐	☐	☐	☐
10.	Shopping usually is an annoying duty.	☐	☐	☐	☐
11.	I like to follow the new developments in the tech industry.	☐	☐	☐	☐
12.	All what I need, I find in the shops.	☐	☐	☐	☐

Figure A.28: Attitudinal questionnaire VI.

Risk-taking behavior

		completely disagree			completely agree
1.	I admit if my taste differs from that of my friends.	☐	☐	☐	☐
2.	I would openly disagree with my boss in front of my co-workers.	☐	☐	☐	☐
3.	I also speak my mind about unpopular issues at social events.	☐	☐	☐	☐
4.	I often cheat in my daily life.	☐	☐	☐	☐
5.	I would drive home even if I was feeling a little tipsy.	☐	☐	☐	☐
6.	I have shoplifted a small item (e.g. a lipstick or a pen) once.	☐	☐	☐	☐
7.	I would accept a job that is paid solely based on commission.	☐	☐	☐	☐
8.	I start my trip earlier if I have to drive an unfamiliar route.	☐	☐	☐	☐
9.	I always try to be at the airport at the latest possible time.	☐	☐	☐	☐
10.	I would gamble in casinos with an amount worth my daily income.	☐	☐	☐	☐
11.	Risky sports such as parachuting or bungee jumping are too dangerous for me.	☐	☐	☐	☐
12.	I prefer public transportation connections with short transfer times.	☐	☐	☐	☐

Figure A.29: Attitudinal questionnaire VII.

Environmental sensitivity

		completely disagree			completely agree
1.	Too much attention is paid to environmental problems.	☐	☐	☐	☐
2.	The ongoing discussions about the greenhouse effect are totally exaggerated.	☐	☐	☐	☐
3.	Environmental pollution affects health.	☐	☐	☐	☐
4.	Environmental pollution is a threat to the future of our children.	☐	☐	☐	☐
5.	Saving threatened species is an unnecessary luxury.	☐	☐	☐	☐
6.	We should care for our environment because we depend on it.	☐	☐	☐	☐
7.	Behavorial change requires a good example by the government.	☐	☐	☐	☐
8.	Environmental protection is too costly.	☐	☐	☐	☐
9.	Stricter vehicle exhaust gases control should be enforced.	☐	☐	☐	☐
10.	The price of gasoline should be increased to reduce pollution.	☐	☐	☐	☐
11.	Behavorial change requires more environmentally friendly products.	☐	☐	☐	☐
12.	The one who causes environmental damage should also pay to repair it.	☐	☐	☐	☐

Figure A.30: Attitudinal questionnaire VIII.

Love of variety

		completely disagree			completely agree
1.	I like to experience novelty and change in my daily life.	☐	☐	☐	☐
2.	I like to have lots of activity around me.	☐	☐	☐	☐
3.	I prefer a clearly structured, repetitive daily schedule.	☐	☐	☐	☐
4.	I do not like surprises.	☐	☐	☐	☐
5.	When eating outside I like to try the most unusual things.	☐	☐	☐	☐
6.	Cultures completely different from my own fascinate me.	☐	☐	☐	☐
7.	I always keep an open door for surprise visitors.	☐	☐	☐	☐
8.	I like to explore new places.	☐	☐	☐	☐
9.	I like to choose new routes to known destinations.	☐	☐	☐	☐
10.	I like to drive around just for the fun of it.	☐	☐	☐	☐
11.	I like to meet new people while traveling by public transportation.	☐	☐	☐	☐
12.	I travel a lot in order to experience new cultures.	☐	☐	☐	☐

Table A.1: Assignment of the different mode choice SP questionnaire types.

Driving lic.	Bike avail.	Distance	Chosen mode	Choice alternatives	SP type
Yes	Yes / No	< 5 km	Walk	Walk / Taxi / CP / CS / PT	1
	Yes	< 15 km	Bike	Bike / Taxi / CP / CS / PT	2
	No	< 5 km	MIV / PT	Walk / Taxi / CP / CS / PT	1
	Yes	< 5 km	MIV / PT	Bike / Taxi / CP / CS / PT	2
	Yes	5 ≤ ... < 15 km	MIV / PT	Bike / Taxi / CP / CS / PT	2
	No	5 ≤ ... < 15 km	MIV / PT	Taxi / CP / CS / PT	3
	Yes / No	≥ 15 km	MIV / PT	Taxi / CP / CS / PT	3
No	Yes / No	< 5 km	Walk	Walk / Taxi / CP / PT	4
	Yes	< 15 km	Bike	Bike / Taxi / CP / PT	5
	No	< 5 km	MIV / PT	Walk / Taxi / CP / PT	4
	Yes	< 5 km	MIV / PT	Bike / Taxi / CP / PT	5
	Yes	5 ≤ ... < 15 km	MIV / PT	Bike / Taxi / CP / PT	5
	No	5 ≤ ... < 15 km	MIV / PT	Taxi / CP / PT	6
	Yes / No	≥ 15 km	MIV / PT	Taxi / CP / PT	6

CP = carpooling, CS = carsharing, PT = public transportation.

Figure A.31: Example choice situation: Adaptations in daily scheduling (tool I).

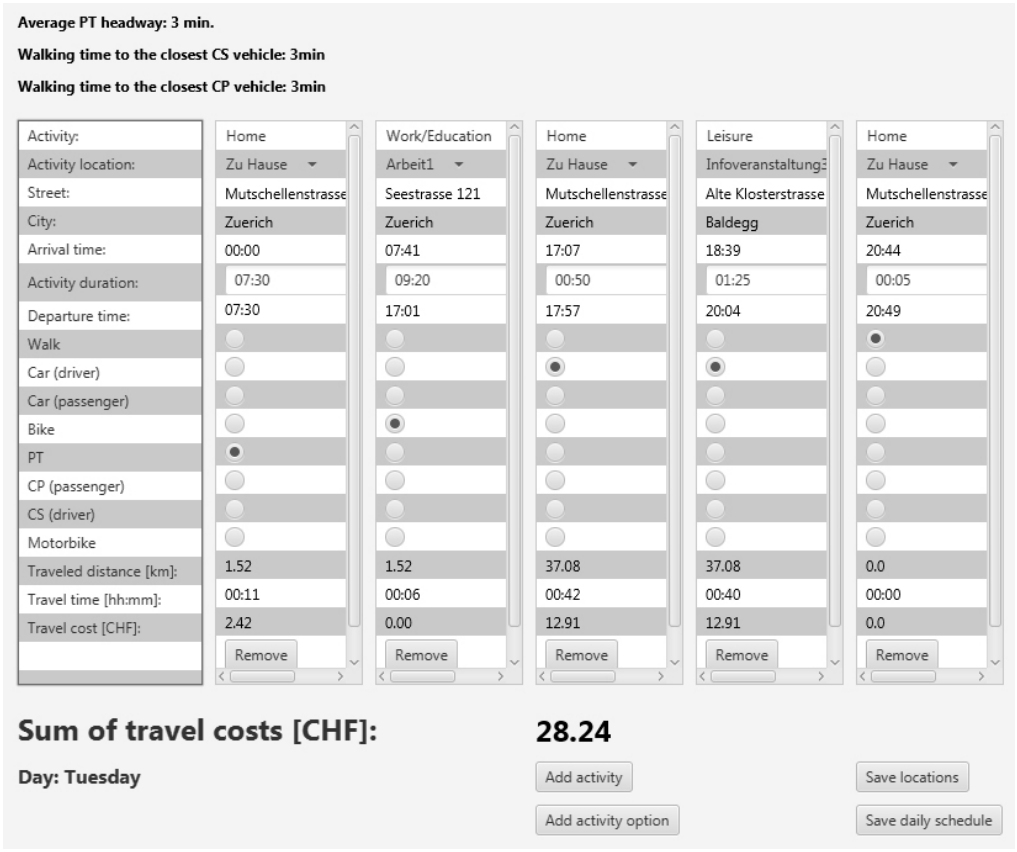


Figure A.32: Mobile persons in household: Adaptations in mobility tool ownership (tool II).

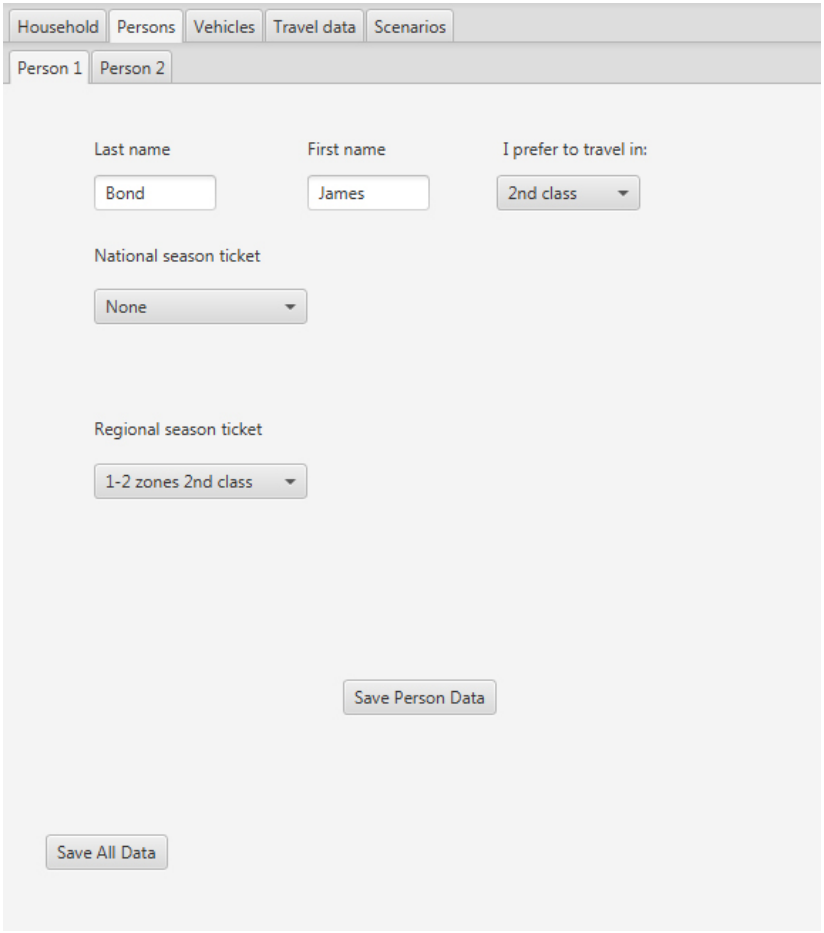


Figure A.33: Vehicle information: Adaptations in mobility tool ownership (tool II).

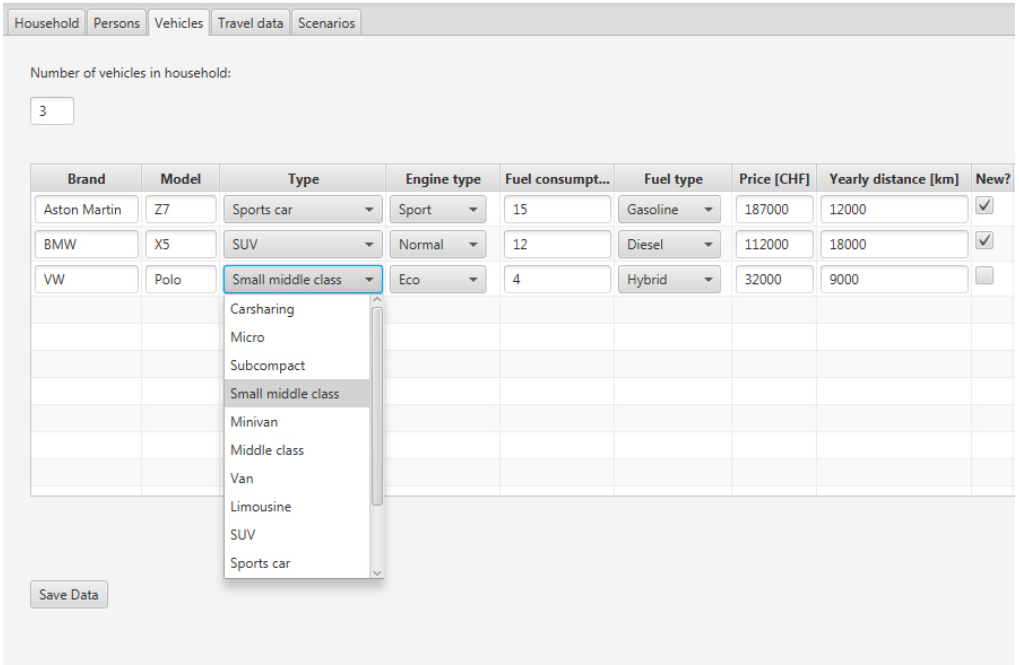
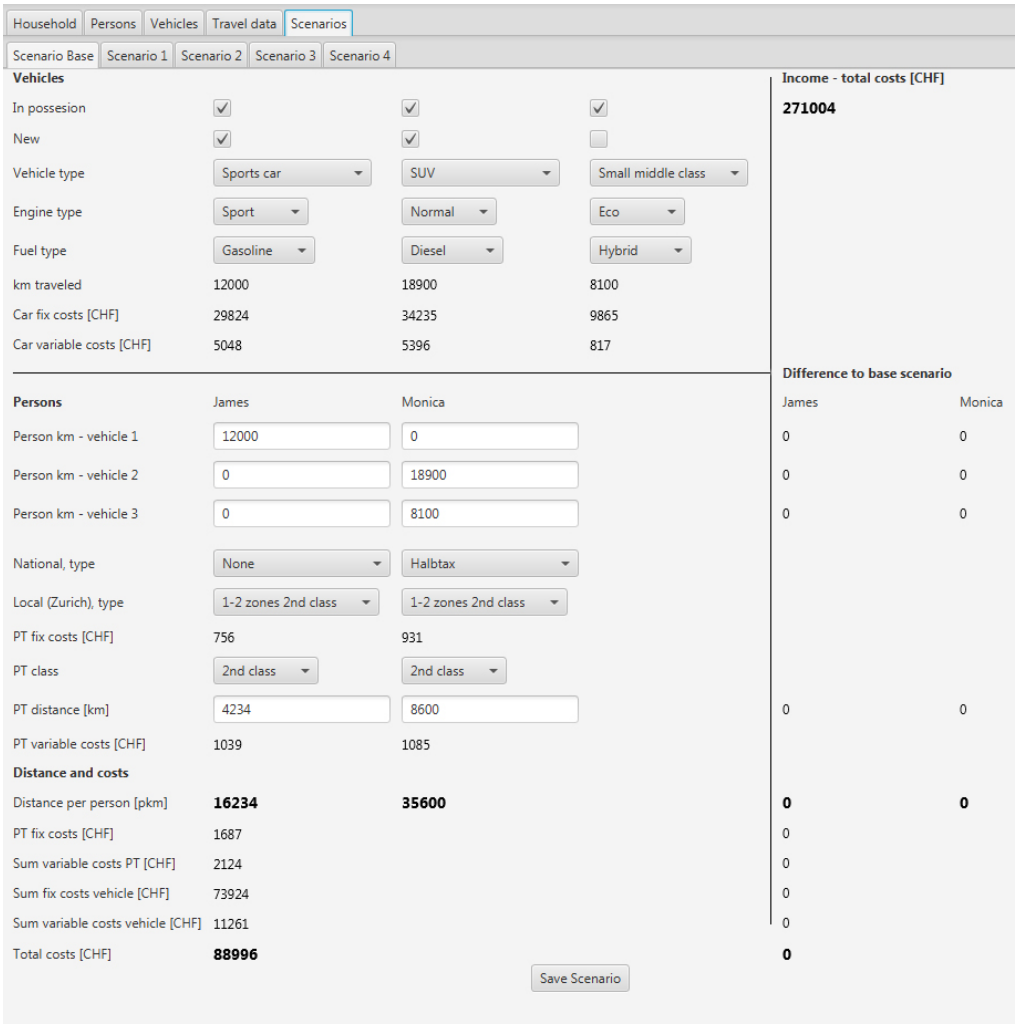


Figure A.34: Example choice situation (base scenario): Adaptations in mobility tool ownership (tool II).



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