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Commitments and sunk costs in private mobility: A study of Swiss households facing green transport choices

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Commitments and sunk costs in private mobility: A study of Swiss households facing green transport choices*

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Abstract

This paper experimentally investigates the existence of behavioural deviations from the oft-assumed rationality in private transport decisions, avoiding the selection-biases in revealed data. Through a choice experiment answered by 995 Swiss respondents, we explore the linkages between long- and medium-term travel investment decisions, and the choice of transport mode. We test the existence of commitment device usage in car and public transport pass purchases, and the sunk cost fallacy, as well as the impact of electric vehicles on mode choice. We find little evidence to support the existence of commitment devices, and no sunk cost fallacy. We further show that electric vehicle owners are equally likely to commute in their car, however use a greater mix of transport modes for leisure and long-distance trips. Our results support the importance of marginal travel costs in transport policy, as well as demonstrate the wide impact of rising EV consumption.

Keywords: Transport; Behaviour; Choice experiment; Commitment; Sunk cost; Electric vehicles; Energy technology adoption; Environmental policy.

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1 Introduction

Transport mode choices are multi-layered decisions that depend on past long- and medium-term choices. Using this decision structure, we bring together a number of theories of consumer behaviour and test them in the context of private transport. We additionally test the impact of green transport investments on travel mode. A range of behavioural economic and psychology literature in other areas indicates that consumers may use commitment devices to lock themselves into particular future choices (eg. Thaler and Shefrin, 1981; Gul and Pesendorfer, 2004; DellaVigna and Malmendier, 2004; Laran, 2010; Kivetz and Simonson, 2002), or may fall for the sunk cost fallacy (eg. Friedman et al., 2007; Just and Wansink, 2011; Garland and Newport, 1991; Arkes and Blumer, 1985; Thaler, 1980; Staw, 1976). These theories, however, have largely not yet been applied to the context of private transport decisions. We thus provide the first tests for deviations from classical rational travel behaviour.

In the context of mobility choices, consumers can create commitment devices through the long- to medium-term ownership of a car or public transport pass. A car purchase could provide a pre-commitment (or an allowance) to indulging in irrational car-use at the time of travel (i.e. a non-optimal transport mode choice given the available alternatives) (Steg, 2005). A public transport pass, on the other hand, could be purchased to commit themselves to using that mode in light of potential future temptation to indulge in driving a car (Kivetz and Simonson, 2002). The sunk-cost fallacy would indicate that a consumer would irrationally overuse their car due to regret about its purchase or self-justification (Aronson, 1968; Arkes and Blumer, 1985). Importantly, this effect would rise the greater the 'investment', i.e. the cost of the car (Garland and Newport, 1991).

The rising proportion of global electric vehicle (EV) purchases benefits air pollution emissions from transport, however could be subject to a rebound effect in car use (see, for example, Dimitropoulos et al., 2018). Increased EV usage could then exacerbate other negative transport externalities such as congestion and noise. However, the question remains as to whether EV owners, ceteris paribus, modify car usage patterns.

We conducted a choice experiment to test these behavioural theories in the private mobility context, and to reveal the potential for behavioural change. An experimental approach avoids selection issues inherent in revealed transport choice data (as in, for example: Simma and Axhausen, 2001; Ho et al., 2018). We surveyed a sample of 995 respondents across German- and French-speaking regions of Switzerland. Exploiting the hierarchical structure of transport decisions, we can analyse trade-offs and preferences within as well as between each of three decision levels: long-term car purchase, medium-term public transport pass purchase, and time-of-travel transport mode choice. The main focus of the analysis is the commitment device usage and sunk cost fallacy outlined above, plus the relative effect of EV purchases on transport mode choices.

We provide the first experimentally controlled evidence that consumers do largely act rationally in transport decision-making, and do not fall prey to common behavioural traits observed elsewhere. We find that transport consumers display little commitment device usage, with one exception that car owners are slightly less reactive to marginal public transport costs. We further do not find any evidence of a sunk cost fallacy among respondents. We finally find that purchasers of EVs are significantly more likely to use a mixture of transport modes, including reduced car usage and more public transport, for leisure and weekend trips, but not for commuting.

Our findings demonstrate the importance of marginal travel costs in private mobility decisions, as well as the impact of new green car technologies. Our findings have repercussions for government policy-making around transport, especially over the transition to more sustainable transport consumption patterns. We show that consumers can be incentivised to change mobility patterns through marginal cost adjustments such as fuel taxes, and fees for parking and road use. Additionally, incentives to increase EV market share will have broad impacts on mode choices, including greater public transport use.

The remainder of this paper is structured as follows. Section 2 provides an overview of the relevant literature and details the behaviours we aim to test. Section 3 outlines our methodology, with 3.1 describing the choice experiment, 3.2 explaining our econometric framework, and 3.3 summarising the specific tests to be conducted. Section 4 then summarises our data. Section 5 presents our estimation results, and, finally, section 6 concludes.

2 Background

Choice of travel mode, a seemingly simple decision, has in fact a sequential and hierarchical structure. This sequence starts from relatively long-term investment choices (occurring once every few years), such as purchasing a car of a given type and size. This is followed by intermediate-term decisions such as purchase of a public transport pass/subscription (occurring once or a few times a year). The sequence is ended with the choice at the time of transport use, occurring at a high frequency rate (on a daily basis).

Much research has been conducted on the car purchase choice and on travel mode choice, but little work has been undertaken to combine these into a joint framework of the entire, hierarchical, inter-dependent mobility choice structure. Particularly, little attention has been given to the deviations in consumer behaviour from the standard assumptions of rational expected utility maximisation inherent in behavioural economics. It is by now commonly acknowledged that consumers do not always act in a rational manner as is classically assumed. The hierarchical, inter-temporal transport decision-making structure and the interdependencies between choices gives the private transport sector prime opportunity for the appearance of such behavioural deviations. This also gives us the opportunity to study such behaviours.

The choice of car type, size and fuel has been covered by, for example: Lave and Train (1979); Hess et al. (2012); Brownstone et al. (2000); Train (1983); Bunch et al. (1993); Batley et al. (2004); Golob et al. (1996); Spissu et al. (2009); and Tompkins et al. (1998). Bhat and Sen (2006) additionally analysed the number of cars owned, and Choo and Mokhtarian (2004) focussed on the impact of psychological factors such as lifestyles and attitudes. Liao et al. (2017), Jong et al. (2004) and Choo and Mokhtarian (2004) provide reviews of a large number of studies of car ownership, with the former focussing on EVs and other alternative fuel cars.

The choice of transport mode has been studied using choice experiments by, amongst others: Hess et al. (2018); Richter and Keuchel (2012); and Waerden and Waerden (2018). Stated choice surveys about travel mode have been conducted and analysed by, for example: Vovsha (1997); Schwanen and Mokhtarian (2005); Shen (2009); Buehler (2011); Collins and Chambers (2005); and Kamargianni et al. (2014). In the psychological literature, indepth interviews have been a common tool: for example, Mann and Abraham (2006), and Schneider (2013).

In a few focussed studies, we see emerging evidence that transport decisions are not made rationally. Busse et al. (2015) show that consumers purchasing cars are subject to a salience and projection bias based on the weather at the time of purchase. Fluctuations in weather conditions lead to consumers buying significantly different vehicles types – more convertibles on especially sunny and warm days, and more 4-wheel drives after snowfall. Steg (2005) shows that car use is not purely practical ("instrumental"), but is greatly influenced by psychological factors. Specifically, car users are moved by symbolic and affective motives often to a greater extent than classical, economic incentives.

The existence of commitment devices has long been postulated and demonstrated in other fields. This fundamentally stems from the psychological work of Schelling (1978, 1984), Thaler and Shefrin (1981), and others, who analysed consumers' problems with self-control. It is shown that individuals restrict their future self's choice set by pre-committing to a certain course of action, if they believe they will have a future lack of self-control, or temptation into short-run gratification.[1,2]

This behaviour has been studied in a variety of contexts but there is hardly any application to mobility decisions. Laran (2010) shows evidence for the use of commitments in experiments related to healthy versus indulgent food consumption and money saving versus spending. DellaVigna and Malmendier (2004) demonstrate the implications of this for contract design in gym memberships, credit cards and more, and add a layer of consumer naivety about their own self-control. Gul and Pesendorfer (2004) create a theoretical model anticipatory self-control where those who know that they are susceptible to temptation restrict their future choice options. However this is still fundamentally a rational expectations model.

Related research based on Kivetz and Simonson (2002) indicates that some consumers need to pre-commit to indulgences in a future time period. They show that if people tend

[1] This has been called anticipatory self-command, or the planner-doer model of self-control (Thaler and Shefrin, 1981)

[2] See also Congdon et al. (2011) for an overview and expansion of bounded self-control and bounded rationality and its impact on public policy.

to choose the more 'necessary' or cheaper option when making decisions, they can commit themselves to allowing some future luxury consumption by a present decision to restrict the future available options. If cars are seen as a luxury or an indulgence rather than a necessity, as indicated in Steg (2005), the purchase of a car could be a commitment to indulgences in their transport consumption.

Private mobility choices are full of occasions for such self-control problems and commitment behaviours to arise. Buying a car could be considered as a pre-commitment device for indulging oneself in an 'irrational' choice at the time of use.[3] Alternatively, the purchase of a public transport pass/subscription could be seen as a classic commitment device to avoid the future temptation to drive.[4,5]

Essentially just one strain of research (Simma and Axhausen, 2001, 2003; Loder and Axhausen, 2018) has discussed the existence of commitment devices within private mobility. Simma and Axhausen (2001) and (2003) focus on the difference in car and public transport use between those who own a car or a transport pass. Loder and Axhausen (2018) additionally include data on trips made by soft transport (cycling or walking). The fundamental results of these papers are that consumers who own or have access to a particular mobility device (i.e. a car or public transport using a discount pass), use that mode more, at the expense of the alternatives. However, this is not evidence of commitment device usage. Ownership of such devices will inherently increase the mode's usage, as they decrease the marginal trip costs. The key factor to consider is how the device owners react to the encountered marginal trip costs. On the contrary, these papers consistently assume full rationality outside of the device ownership. They explicitly state that once an investment in a long-term commitment is made, drivers should "only consider those direct out of pocket costs ... at the point of use", and season ticket holders "consider public transport free [or discounted] at the point of use" (Loder and Axhausen, 2018).

For evidence of a commitment effect, we would expect device owners to be so committed

[3] Alternatively, a car commitment could be seen as a method for reducing the regular burden of choice by giving a convenient default option, on which a habit is formed - as per Garcia-Sierra et al. (2015).

[4] (such passes are otherwise called a "season ticket" by Simma and Axhausen, 2001, etc.).

[5] Generally, such public transport passes reduce the trip cost of this transport mode significantly (eg. by half) or entirely to 0.

to that travel mode that changes in marginal trip costs will engender a significantly smaller behavioural reaction than for non-device owning individuals. To our knowledge there is no empirical study that robustly tests this factor, and therefore credibly tests the existence of commitment devices in private mobility.

The sunk cost fallacy has a long history and is rooted in the same psychological literature of bounded rationality. Fundamentally, the sunk cost fallacy states that consumers will consume more of a good, the larger the investments they have previously made in relation to the good, even though the investments are 'sunk' and should have no bearing on the consumption decision. This has been explained in that people feel a level of regret about their past investment and now continue to consume the good as self-justification for the previous expenditure (Aronson, 1968), or out of a desire to not appear wasteful (Arkes and Blumer, 1985). Some of the original studies of sunk costs include Staw (1976), Thaler (1980), and Arkes and Blumer (1985). The last is often seen as "the best" or most classic field experiment on the sunk cost fallacy (Eyster, 2002). They demonstrate that sunk costs have an impact on theatre attendance - the more paid for season tickets, the higher the rate of attendance across the season. In rational theory, however, the consumers should continue to consume theatre performances until their marginal benefit of attending reaches 0. Further studies reinforce that the greater the sum invested, the greater the impact it has on later consumption or further investment decisions (Garland and Newport, 1991); and demonstrate the fallacy's existence in a range of areas, including food consumption (eg. at all you can eat buffets: Just and Wansink, 2011), and business investments (Putten et al., 2010). However, the evidence is not always positive. Friedman et al. (2007) show a mixture of findings across the broader literature, and their own computer-based lab experiment found a small and inconsistent sunk cost fallacy.

The transport sector is well-suited to the study of the fallacy given the large and variable investments in mobility devices and infrastructure, and the frequent, repeated transport decisions made. One paper has tried to analyse the sunk cost fallacy in transport – Ho et al. (2018). With data on car odometer readings across a number of years and changes in car registration costs in Singapore and Hong Kong, they show that the higher the amount invested in registering a car, the more the car gets driven. However, this could be due to selection bias, as the higher registration costs leave only those who gain the greatest benefit from having a car (those who use it more). It could also be due to a non-psychological path – higher registration costs could induce more car sharing, at a minimum amongst family and friends, generating a reduction in the average number of cars per household but increasing the use of those existing. Our experimental approach avoids such selection issues. Additionally, we again focus on marginal trip costs. Existence of a sunk cost fallacy would mean that larger sunk costs lead consumers to react less to variations in marginal costs.

3 Methodology

3.1 Experimental design

We designed a sequential choice survey and embedded this within the annual Swiss Household Energy Demand Survey (SHEDS) 2018.[6] In total 5514 individual households took part in the 2018 survey wave, and 995 of these were randomly assigned to take our experiment. This assignment ensured a representative sample along gender, age, region, and housing status.

The choice experiment was designed in a sequential structure to mimic the natural decision-making process. We first asked respondents to make a 'long-term' choice regarding a transport investment – car purchase. This was followed by the 'medium-term' choice of a public transport pass. Finally, the immediate, time-of-travel mode decisions were made.

The choice tasks were designed with attribute levels of the car and transport mode tasks depending on the respondent's previous choices. This setup allowed us to obtain accurate and reliable responses, and to accurately estimate the effect past investments have on consumers' transport mode choices. The questionnaire is provided in Appendix A for reference.

In more detail, the experiment proceeded as follows. We initially primed the respondents by providing a script to encourage accurate and truthful responses, in line with the literature on preference revelation in stated preference studies (Vossler et al., 2012). We additionally included a reminder about the respondents' household budget constraints, and that the deci-

[6] For more details on SHEDS see Weber et al. (2017).

sions here would require trade-offs to be made (as per, for example, Johnston et al., 2017).[7] Following this, we asked respondents to imagine that they had to make a choice about purchasing a primary household car "within the next year". This is a familiar task for Swiss households as our data show an average car replacement period of 5.5 years.[8]

The first choice task, then, was to choose the car size, between 'micro', 'small', 'small-medium', 'mid-size', 'large' and 'SUV'.[9] We also gave respondents the option of choosing not to buy a car. Those who chose some car size proceeded on to the second choice task, which asked the respondents to choose a specific car. This task was a labelled choice table with 6 options and 5 attributes, as shown in Figure A.3. The labels were each car's engine type, with two options as 'electric' (i.e. BEV), two 'plug-in hybrid' (PHEV), one 'hybrid', and one 'internal combustion engine' (ICE). The attributes were 'price', 'driving cost per 100km', 'battery range', 'max. speed', and 'CO_2 emissions (g/km)'. Upon hovering the mouse over each label or attribute title, a brief explanation popped up. Levels were set using data from the Touring Club Switzerland (TCS) on all cars currently available in Switzerland (TCS, 2018).

Next, all respondents answered the medium-term question of whether to buy a public transport pass. Such passes are ordinarily renewable on a monthly or yearly basis and give free access to public transport across the entire country or a specific region.[10,11] The pass options provided were: '1st class GA' (unlimited national public transport access pass), '2nd class GA', a local 'regional pass', or 'none'. The single attribute was the pass price and this was also asked just one time.

Finally, all respondents received a series of choice tasks regarding the transport mode for specific trips. We repeated the transport mode task three times for each of three trip types (commute, local leisure, and weekend trip), giving nine choice sets per respondent in total. Respondents who did not ordinarily commute (did not work or worked from home)

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7 See Appendix A, Figure A.1 for the script.

8 This number is also externally validated by a Comparis (2013) survey which found Swiss households replace their car every 5 years.

9 These categories are based on the standards given by the Touring Club Switzerland (TCS, 2018).

10 https://www.sbb.ch/en/travelcards-and-tickets.html

11 After a lump sum payment, the marginal cost of public transport use is 0. Note we did not ask about the Swiss Half Fare Travelcard, which reduces public transport ticket prices by half.

were only given leisure and weekend trip choice sets. Choice tasks were composed of two attributes, trip cost and trip duration, and were labelled with the transport mode (see Figure A.5). There was a maximum of five mode alternatives available: public transport (PT), respondent's private car (CR), bicycle or foot (BF), car sharing (CS), and 'car with a driver' eg. taxi (CD), with available alternatives and attribute levels depending on previous choices and responses. Respondents who chose to buy a public transport pass had a cost of 0 for using this mode. Those who bought a car received different trip cost values depending on the efficiency of car that they purchased and the trip distance. The displayed attribute levels for each alternative additionally varied randomly between respondents and choice tasks, applying weights of 0.5, 1, or 1.5 to the calculated average values.

3.2 Econometric framework

Our primary objective is to analyse the impact of the sequential, hierarchical transport decision-making process on the transport mode choice at the time of travel, while controlling for the various socio-demongraphic and behavioural characteristics that affect the same. To do this we propose a comprehensive choice model that embeds the various choice-level decisions into the final outcome. We also allow for mode preferences to vary across trip types and consumer segments.

We use a standard random utility model framework as the basis of our estimations. We estimate the choice of transport mode, between public transport, private car, and soft transport. Using the following utility function, respondent *n*'s utility for mode *i* in choice task *t* is estimated by:

$$U_{nit} = \alpha A_{nit} + \beta_i + \gamma_i T_{it} + \delta_i X_n + \eta_i K_{nt} + \varepsilon_{nit} \quad (1)$$

where α is the vector of coefficients of the choice task-mode-respondent specific attributes A_{nit}. Specifically this includes the cost (CHF) and duration (minutes) of the specified trip. The alternative specific constants (ASC) for each mode are represented by β_i. We estimate coefficients γ_i for each trip type (commute, leisure, and weekend) and allow the trip type utility to vary by mode, T_{it}. We also include the respondent's individual characteristics and responses to the previous levels of transport choices through X_n. The impact of these choices and characteristics varies by transport mode, therefore the set of coefficients is given as δ_i. With K_{nt} we account for variables that vary by both choice set and respondent, but not between alternatives. Finally, the error term ε_{nit} is a type I extreme value term, identically and independently distributed (IID) across respondents and alternatives.

Respondents select the transport mode i that maximises their level of utility - i.e. $U_{nit} > U_{njt}$ $(\forall j \neq i)$. We conduct this estimation using a standard multinomial logit (MNL) model, where the probability of a respondent selecting a particular transport mode is given by:

$$P_{nit} = \frac{e^{U_{nit}}}{\sum_{j \in C} e^{U_{njt}}} \tag{2}$$

where C is the set of possible mode alternatives.

In our model we set public transport as the base transport mode for comparative estimation. Thus every mode-dependent variable is set to 0 when $i = PT$. Precisely:

$$\beta_i = \gamma_i = \delta_i = 0 \quad \forall \quad i = PT \tag{3}$$

Due to the low number of choices for the car with driver CD and car sharing CS alternatives, we exclude these two modes from the estimation. This leads us to drop one whole respondent who always chose these alternatives, and 230 choice sets in total from 123 respondents. This additionally means that 372 choice sets were left with only one mode alternative, PT, thus we also exclude these. Out of 8259 transport mode choice sets, we therefore remove seven percent. We test this restriction and see that it does not significantly alter the results.

The mode-specific variables that we include in X_n include the respondent attributes: commute distance (natural log); residential location (city, agglomeration, rural); household size (1 person, 2 people, 3 or more people); renting status; and biospheric value. We additionally include the responses to their previous transport choices: car yes/no; car size; car engine type; car price (natural log); and purchase of a PT pass.

In K_{nt} we add variables for the cost (in CHF and time) of the trip by personal car (if CR is available), and the duration of the same trip by public transport. We use PT trip time here as a proxy for cost in CHF because of the lack of variation in PT trip cost due to the number of respondents with public transport passes rendering the cost 0. In this way we allow the impact of these trip costs to vary from the average for those with specific mode alternatives available. Finally, we also interact the above variables with the public transport pass dummy to allow pass holders to react still differently. We additionally interact the car price with the above costs.

The biospheric values come from the broader SHEDS survey. Using a 5-point Likert scale from “not important” to “extremely important”, we measured respondents’ values for environmental protection and pollution prevention. Constructing an aggregate of 5 questions, we obtain a respondent’s total biospheric importance level.

3.3 Empirical behavioural tests

To test the existence of mode-commitment device usage and the sunk cost fallacy we focus on a few key variables. We summarise these tests in Table 1. We additionally test the effect of EV ownership on mode choice, compared to ICEs. This impact is allowed to vary by trip type. We expect that higher trip costs in terms of money and time will both decrease respondents’ utility. Thus the coefficients of *trip cost* and *trip time* are expected to be negative.

If respondents were to display evidence of purchasing a car as a commitment device, we would expect them to be less reactive to differences in the marginal travel costs than average. Specifically, car purchasers should react less to variation in the cost of a trip by car, *CR trip cost*$_{CR}$ and the duration of a trip by car, *CR trip time*$_{CR}$, as they are predisposed to using their car regardless. The coefficients on these two variables are thus expected to be positive, effectively reducing the absolute size of the negative *trip cost* and *trip time* variables for car trips. Additionally, we would expect car owners to react less to changes in the costs of the key alternative transport mode, *PT trip time*$_{CR}$. As the base *trip time* variable is negative, an increase in trip duration by public transport leads to a concurrent rise in the use of the key alternative mode – car. From this, we would expect the variable *PT trip time*$_{CR}$ to be negative, effectively reducing the size of the car-use reaction to PT costs.

As for consumers purchasing a PT pass as a commitment device to use PT, here we compare respondents who chose to buy a PT pass and a car to those with only a car. Specifically,

Table 1: Summary of behavioural tests

	Variables	Direction	Reason
Given:	*trip cost*	<0	
	trip time	<0	
Car commitment	*CR trip cost*$_{CR}$	>0	react less to CR trip costs than to costs of other modes
	CR trip time$_{CR}$	>0	react less to CR trip duration than to duration of other modes
	PT trip time$_{CR}$	<0	react less to PT trip duration than non-car owners
Pass commitment	*PT pass* $\times$ *CR trip cost*$_{CR}$	<0	react more to increases in CR trip cost than non-pass-holding car owners
	PT pass $\times$ *PT trip time*$_{CR}$	<0	react less to increases in PT trip time than non-pass-holding car owners
Sunk cost fallacy	*ln(car price)*$_{CR}$	>0	increase car use the more expensive the car owned
	ln(car price) $\times$ *CR trip cost*$_{CR}$	>0	react even less to CR trip costs the more expensive the car owned
	ln(car price) $\times$ *CR trip time*$_{CR}$	>0	react even less to CR trip duration the more expensive the car owned

for evidence of a PT pass commitment device, PT pass holders should reduce car usage more than car owners without a pass as car trip costs rise. Thus *pass* $\times$ *CR trip cost*$_{CR}$ is expected to be negative. Importantly, they should also react less to changes in the cost of using PT, *pass* $\times$ *PT trip time*$_{CR}$, as they are pre-committed to using this mode. This variable should therefore be negative.

The logic for evidence of the sunk cost fallacy follows a similar pattern to the above, however, car use depends on the amount invested, i.e. the car price. If respondents were to display evidence of the sunk cost fallacy we would expect consumers to use their car more the greater the amount they paid for it. Therefore, the consumers' utility gained from using the private car mode should rise the greater the price of the car. Thus *ln(car price)*$_{CR} > 0$. We would also expect car owners' reaction to the trip costs from using the CR alternative to be increasingly dampened the greater the car price. Thus we would expect *ln(car price)* $\times$ *CR trip cost*$_{CR}$ to be positive. The same idea holds for the other cost involved - trip duration. Therefore, we should also see a positive *ln(car price)* $\times$ *CR trip time*$_{CR}$.

4 Data

The SHEDS sets sample targets to ensure its representativeness at the national Swiss-level (excluding Ticino) (Weber et al., 2017). Our choice experiment respondents largely match these targets. Specifically, the age group targets are 18-34: 30%, 35-54: 40%, 55+: 30%. We slightly under-sample the youngest group and over-sample the older, with 24 and 35 percent, respectively (Table 2). Further, we achieve sample proportions for renting versus owning that are close to the target of 62.5% tenants and 37.5% owners.

For our analysis, we also specifically targeted nine segments based on household size and region. We segment by single, 2-person and multi-person households, and city, agglomeration, and rural locations, as shown in Table 2. Over half of respondents live in the city, 50.8 percent, compared to 20.8 percent that are rural inhabitants and 28.3 in an agglomeration.

Respondents clearly vary in their real-life transport decisions, providing a good starting point for our experiment. 26 percent of respondents did not own a car (Table 2). This is slightly more than in the last Swiss national mobility census, which showed nearly 80 percent household car ownership in 2015 (FSO, 2017). Further, 45 percent of respondents owned a public transport pass, slightly less than the 57 percent observed in the 2015 mobility census, however that also included some other forms of passes (FSO, 2017). The majority of the public transport passes in our sample were a GA of either 2^{nd} or 1^{st} class - 23.7 percent of all respondents.

4.1 Descriptive choice statistics

From the actual experiment choice task responses, we gain an idea of the decision trends and variation. Overall, 89 percent of respondents chose to buy a car. This is slightly more than the historically stable Swiss car ownership rate of around 80 percent (FSO, 2017). Among the 882 respondents who decided to purchase a car, the majority chose a small or small-medium sized car. Over a third (34.5 percent) of respondents chose to buy a pure-electric vehicle (BEV), and a similar proportion (33.5 percent) chose an ICE. In total 17 percent chose a PHEV and 15 percent a traditional hybrid.

Importantly for estimation of the sunk cost fallacy, respondents who chose to purchase a

Table 2: Descriptive statistics - respondent characteristics

	Frequency	Percent	SHEDS target (%)
Age group			
18-34	239	24.0	30
35-54	406	40.8	40
55+	350	35.2	30
Gender			
Female	483	48.5	51
Male	512	51.5	49
Housing			
Rent	606	60.9	62.5
Own	389	39.1	37.5
Flat	696	70.0	
House	299	30.1	
Location			
City	506	50.9	
Agglomeration	282	28.3	
Rural	207	20.8	
Household size			
1	277	27.8	
2	426	42.8	
3+	292	29.4	
Public transport passes			
GA 1st class	43	4.3	
GA 2nd class	193	19.4	
Regional pass	212	21.3	
None	547	55.0	
Car ownership			
Car owner	732	73.6	
No car	263	26.4	

car ‘spent’ 35 000 CHF at the median. The chosen prices ranged from 24 000 to 53 000 CHF at the 25th and 75th percentiles, respectively. The car prices selected naturally varied between fuel-types, and on average respondents buying a BEV or PHEV were willing to spend more. The median BEV price was 40 000 CHF and PHEV price was 51 000 CHF. By comparison, the median ICE price was 24 000 CHF.

Respondents largely chose to purchase the same public transport pass that they had in real life. 53 percent chose not to buy a pass at all, 24 percent chose a regional pass, and 23 percent a GA of either class. About 45 percent of respondents who chose to buy a car also chose to purchase a PT pass, thus allowing for our analyses of the two potential commitment device behaviours.

Following from the relatively high purchasing of transport devices, a car and/or public transport pass, most respondents chose to use these two modes for all all three trip types in the experiment. Overall, the private car was the most selected transport mode, followed closely by public transport. Among commuters, public transport was the chosen transport mode 41 percent of the time, followed by the respondent's own car at 40 percent. Respondents chose to use soft transport 16 percent of the time for commuting. For local leisure trips, public transport, private car, and soft transport were each chosen around a third of the time. For longer distance, weekend trips, the car was by far the most popular travel mode chosen at 60 percent. 36 percent of choices made were for public transport.

These broad results hint at some differences in mode chosen based on the trip distance. Focusing on commuting behaviour, we observe significant differences by the household location. In the city most respondents chose to commute with public transport, 51 percent. A private car was chosen about 27 percent of the time. Conversely, among respondents living in agglomerations and in the countryside, the majority chose to use their own car, 53 percent in each group. 30 and 32 percent of agglomeration and rural household choices, respectively, were for public transport commutes. City-based respondents had the highest proportion of soft transport chosen at 19 percent. 14 percent of agglomeration respondent choices were for a soft transport commute, and 11 percent among rural respondents.

We see that the transport mode chosen varies according to the car chosen. The proportion of times the respondent's car was selected as the commute transport mode was highest for those who previously chose an ICE car, 56 percent, and lowest amongst BEV purchasers, 37 percent. ICE owners were correspondingly less likely to use public or soft transport compared to the other car buyers.

5 Results

We present here our econometric estimation of transport mode choices including the impacts of past decisions (long- and medium-term) to test the existence and extent of commitment device usage and sunk cost fallacy behaviours. We provide the estimation of equation 1, including the full variable set covering all hierarchical transport choices. The primary estimation results from our multinomial logit model are shown in Table 3. The upper panel shows the utility coefficients for the trip attributes, namely the cost and duration of the trip. The lower panel shows the estimated coefficients for the alternative specific variables.

The trip attribute coefficients are both significant and of the correct sign. Specifically, higher travel costs in money and time both lead to decreases in utility. This means that increases in the costs of any particular transport mode alternative renders the selection of that mode less likely.

Among the respondent characteristics and sample segments that we include, we find that compared to city-dwellers, those living in an agglomeration or the countryside are much more likely to use a car. Additionally, rural-inhabitants are more likely to walk or cycle on average than those in other regions. Renters are generally predisposed to using public transport more than a car or soft modes, ceteris paribus. Commute distance has an impact on the probability of taking soft transport (negative), however does not influence car usage when controlling for other factors. Finally, respondents who place a high importance on biospheric issues are less likely to drive a car.

The respondents' choice of car is related to the travel mode decision. We estimate the effect on mode choice of the interaction of car and trip type. For commuting we find no significant difference in car usage between ICEs and the EV car options (i.e. excluding traditional hybrids). However, for leisure and weekend trips, we find that EV purchasers (both BEV and PHEV) are significantly less likely to use their car. Moreover, we specifically see a shift towards public rather than soft transport, and the results hold even as we control for respondent characteristics such as environmental attitudes, and household location and size. These findings indicate a genuine move towards increased mixed mobility among EV owners, rather than a reliance on a single mobility instrument. It additionally matches research

Table 3: Primary estimation results

Trip attributes		
Trip cost (CHF)	-0.038***	
	(0.006)	
Trip time (minutes)	-0.029***	
	(0.002)	
Alternative specific variables	**CR**	**BF**
ASC	0.684	1.159**
	(3.730)	(0.451)
Trip: Commute	*base*	*base*
Trip: Leisure	0.652**	-0.435
	(0.285)	(0.338)
Trip: Weekend	0.984**	–
	(0.449)	
City	*base*	*base*
Agglomeration	0.441***	0.067
	(0.110)	(0.141)
Countryside	0.581***	0.422***
	(0.124)	(0.155)
Renting	-0.319***	-0.297**
	(0.103)	(0.128)
Single person household	0.136	-0.034
	(0.110)	(0.138)
2 person household	*base*	*base*
3+ person household	-0.127	0.059
	(0.112)	(0.137)
ln(commute distance)	0.061	-0.685***
	(0.081)	(0.117)
Strong biospheric values	-0.184*	0.195
	(0.095)	(0.124)
Car: Yes	–	-1.943
		(4.508)
Car: Micro	-0.410	0.537
	(0.333)	(0.440)
Car: Small	-0.127	0.310
	(0.161)	(0.206)
Car: Small-medium	*base*	*base*
Car: Mid size	0.530***	0.816***
	(0.183)	(0.233)
Car: Large	0.378	0.219
	(0.356)	(0.459)
Car: SUV	0.821***	0.483
	(0.301)	(0.383)
Car: ICE	*base*	*base*
Trip: Commute × Car: BEV	-0.431	-0.040
	(0.288)	(0.360)
Trip: Commute × Car: PHEV	-0.261	0.012
	(0.291)	(0.363)

Continued on next page

Table 3 – *Continued from previous page*

	CR	**BF**
Trip: Commute × Car: Hybrid	-0.541**	0.053
	(0.258)	(0.360)
Trip: Leisure × Car: BEV	-0.695**	-0.245
	(0.291)	(0.352)
Trip: Leisure × Car: PHEV	-0.607**	-0.373
	(0.295)	(0.335)
Trip: Leisure × Car: Hybrid	-0.434	-0.152
	(0.266)	(0.294)
Trip: Weekend × Car: BEV	-0.996***	–
	(0.332)	
Trip: Weekend × Car: PHEV	-0.751**	–
	(0.296)	
Trip: Weekend × Car: Hybrid	-0.593**	–
	(0.270)	
PT pass	-1.632***	-0.767***
	(0.141)	(0.236)
ln(car price)	0.000	0.231
	(0.368)	(0.446)
CR trip cost	-0.143	–
	(0.255)	
CR trip time	0.035	–
	(0.029)	
PT trip time	-0.018***	-0.015***
	(0.003)	(0.005)
ln(car price) × CR trip cost	0.014	–
	(0.024)	
ln(car price) × CR trip time	-0.002	–
	(0.003)	
PT pass × CR trip cost	0.037*	-0.317
	(0.020)	(0.234)
PT pass × PT trip time	0.004*	0.000
	(0.002)	(0.008)
N choice sets	7,657	
N respondent-trip types	2,604	

Notes: The dependent variable is U_{nit}. Standard errors clustered at the respondent-trip type level reported in parentheses. *, ** and *** respectively denote significance at 10%, 5% and 1% levels. PT: public transport; CR: private car; BF: soft transport (bike/foot).

indicating the importance of EV battery range and charger availability for longer distance travel.

Consumers' decisions to purchase a public transport pass also affected their transport mode choices. Those who bought a GA or regional pass were significantly more likely to use public transport than a car or soft transport – seen through the significant negative alternative specific coefficients on the *PT pass* dummy for both CR and BF modes.

To specifically test our behavioural theories, we rely on the variables summarised in section 3.3. Table 4 provides again a summary of the tests for each behaviour and the variable direction required for confirmation, as well as the direction of our estimates and a decision on whether this leads us to accept or reject the behaviour.

To see whether respondents' car purchasing acts as a commitment device, we would expect to see evidence of reduced reactivity to changes in marginal trip costs. We find no evidence of this in our car trip cost tests. Table 3 shows that *CR trip cost*$_{CR}$ is not significantly different from zero, indicating that respondents who chose to purchase a car react the same to changes in the cost of a trip by car as they do to the cost of other modes, and as non-car owners do to the cost of public transport. The second test variable, *CR trip time*$_{CR}$ is also no different from zero, meaning that car owners do not respond any differently to the trip duration of the car mode compared to other modes and non-car owners. However, *PT trip time*$_{CR}$ is slightly but significantly negative. This indicates that car owners react slightly less to changes in PT trip durations than to other modes, and than non-car owners. This confirms our test hypothesis. In summary (Table 4), we find that the reactivity of car owners to changes in marginal trip costs is not dampened by the device ownership for car costs, however is slightly affected for alternative mode costs. We thus conclude that there is slight evidence of cars being used as commitment devices, however not enough to confirm the behaviour overall.

We conduct similar tests for the use of public transport passes as commitment devices to that mode. Both the interaction terms *PT pass* $\times$ *CR trip cost*$_{CR}$ and *PT pass* $\times$ *PT trip time*$_{CR}$ in our model are slightly significantly positive (Table 3). This indicates that respondents who purchased both a car and a public transport pass were no more committed to using public transport than car owners without a pass. Increases in the costs of using the car did not lead them to use more public transport than non-pass holders. Also, these respondents did not react any less to increases in the cost of taking a trip by public transport (trip duration) than non-pass holders. In fact, for both of these variables we find the opposite, although only significant estimates at the 10 percent level. As shown in Table 4, we conclude that there is no evidence of public transport passes being used as commitment devices.

We finally test whether respondents fall prey to the sunk cost fallacy. After we control

Table 4: Summary of test results

	Variables	Hypothesis	Result	Decision
Given:	*trip cost*	<0	<0	
	trip time	<0	<0	
Car commitment	*CR trip cost*$_{CR}$	>0	=0	Reject
	CR trip time$_{CR}$	>0	=0	Reject
	PT trip time$_{CR}$	<0	<0	Confirm
Pass commitment	*PT pass* × *CR trip cost*$_{CR}$	<0	>0	Reject
	PT pass × *PT trip time*$_{CR}$	<0	>0	Reject
Sunk cost fallacy	*ln(car price)*$_{CR}$	>0	=0	Reject
	ln(car price) × *CR trip cost*$_{CR}$	>0	=0	Reject
	ln(car price) × *CR trip time*$_{CR}$	>0	=0	Reject

for car size and engine type, we isolate the impact of the car price. As shown in Table 3, *ln(car price)*$_{CR}$ is estimated as insignificantly different from zero, meaning the price has no impact in itself on car use. For the other two tests for the sunk cost fallacy, we additionally interact the price with the marginal cost and the duration of a car trip. These variables are also found to be no different from zero. Table 4 summarises the test results. We do not find any evidence that the magnitude of the sunk cost influences car use or consumers' reactivity to marginal travel costs. We conclude that we there is no evidence for the sunk cost fallacy.

6 Conclusion

In this study we have conducted a sequential choice experiment and analysed transport consumers' hierarchical decision-making process. We investigate the existence of travel mode commitment devices, the extent of a sunk cost fallacy among car owners, and the differing choices of 'green' car consumers. Our experimental approach avoids the selection-biases inherent in revealed transport data. We find that consumers largely behave rationally to travel costs. Despite level differences by the type of travel device owned, we observed little difference in consumer responses to marginal costs.

We show that the hierarchy of transport decisions has an important impact on the final travel mode selected. We confirm that the purchasing of a car or a public transport pass does lead consumers to use relatively more of that mode, as seen previously (Simma and Axhausen, 2001, 2003). However, we provide the first tests of commitment device usage, and specifically show that there is little evidence for this. Those who chose to purchase these long- and medium-term transport investments still responded rationally to variation in marginal trip costs. They did not behave differently to consumers who did not own the transport devices. One exception is a slight reduction in car-owner reactivity to marginal public transport costs.

We additionally provide the first tests in the literature for the sunk cost fallacy in private transport and contribute to the mixed results found across past studies of other sectors (see Friedman et al., 2007). We experimentally isolate the effect of car purchase price on transport mode choices. We find that the magnitude of the sunk cost does not influence travel mode decisions. Consumers do not change behaviour because of the price of their car and still react rationally to variation in the marginal trip costs.

We further demonstrate how travel decisions vary depending on the type of car purchased. Electric vehicles are as likely to be used for commuting as ICEs. However, for longer, more substantial trips, EV owners are significantly more likely to use public transport than ICE car owners. These results correlate with research demonstrating the importance of EV battery range and charging network for longer-distance EV trips. However, our findings hold also for PHEV purchasers and shorter-distance leisure trips. Thus we conclude that EV ownership is associated with greater mixed mobility, and, specifically, higher public transport use.

In conclusion, our paper demonstrates the importance of marginal costs in travel decisions. We find that transport consumers are largely rational and do not use or fall prey to the behaviours shown in other sectors. We also show the potential for more mixed transport mode usage as EVs become the norm. These findings are highly relevant for public policy makers. They support the manipulation of marginal transport costs to shift travel behaviour, such as fuel taxes, and road usage and parking fees. They also support policies to replace ICE consumption with EVs, and demonstrate the need for public transport services as this transition develops.

Appendix A Choice experiment questionnaire

Figure A.1: Priming script

English

In this part of the survey, we focus on **your transport choices** for different trip types. We will collect information on your current transport choices and ask you to choose amongst hypothetical future options.

The information that we collect will be used to **inform Swiss energy and transport policy**, and it is therefore important that **your answers reflect your specific situation and your personal tastes**. In particular, some of the following questions will involve costs to your own household; please give careful consideration to how these costs would affect your financial budget.

→

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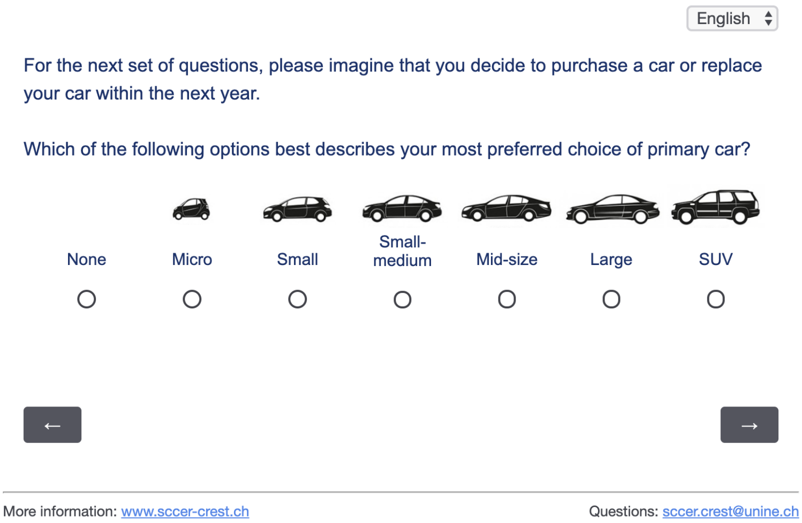
Figure A.2: Choice 1 car size


English

For the next set of questions, please imagine that you decide to purchase a car or replace your car within the next year.

Which of the following options best describes your most preferred choice of primary car?

None | Micro | Small | Small-medium | Mid-size | Large | SUV

← →

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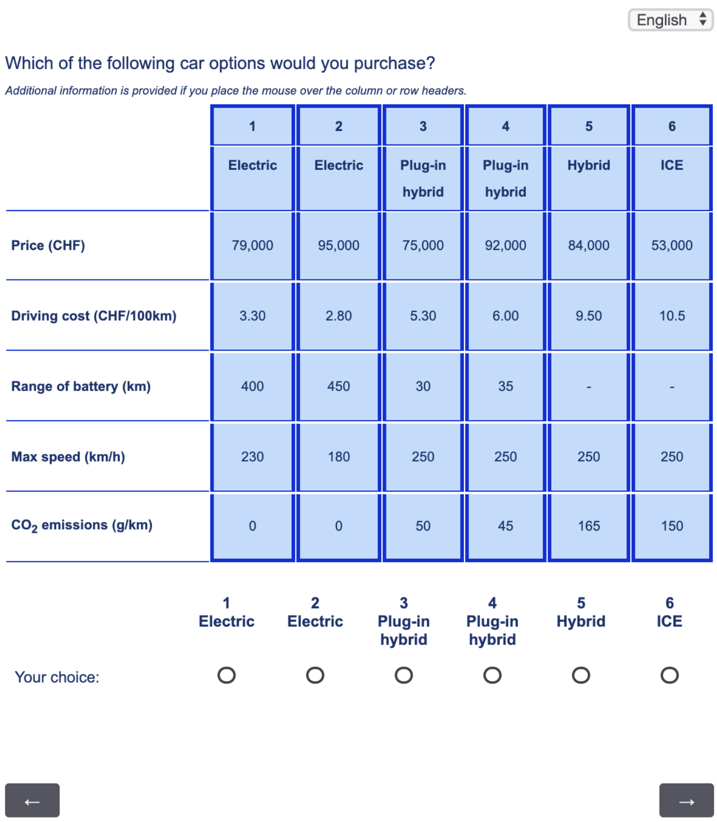
Figure A.3: Choice 2 car type choice set (example)


English

Which of the following car options would you purchase?

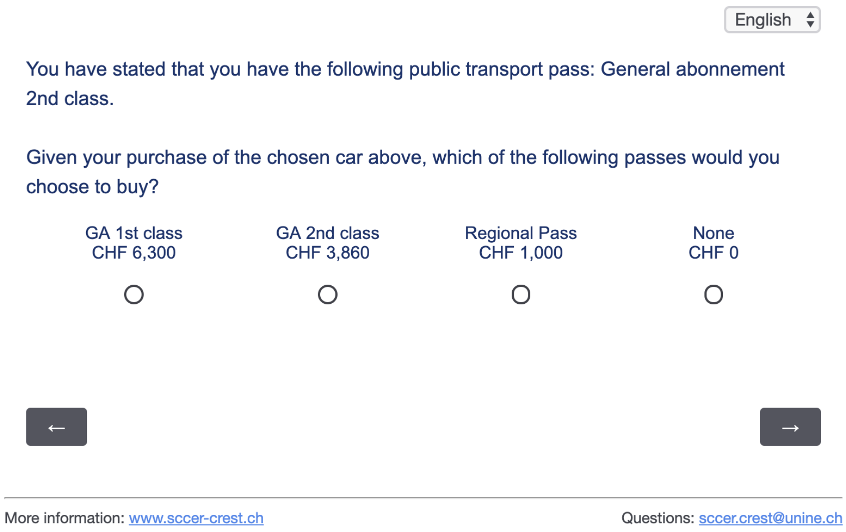
Additional information is provided if you place the mouse over the column or row headers.

	1	2	3	4	5	6
	Electric	Electric	Plug-in hybrid	Plug-in hybrid	Hybrid	ICE
Price (CHF)	79,000	95,000	75,000	92,000	84,000	53,000
Driving cost (CHF/100km)	3.30	2.80	5.30	6.00	9.50	10.5
Range of battery (km)	400	450	30	35	-	-
Max speed (km/h)	230	180	250	250	250	250
CO_2 emissions (g/km)	0	0	50	45	165	150

Your choice: 1 Electric | 2 Electric | 3 Plug-in hybrid | 4 Plug-in hybrid | 5 Hybrid | 6 ICE

← →

Figure A.4: Choice 3 public transport pass (example)



English

You have stated that you have the following public transport pass: General abonnement 2nd class.

Given your purchase of the chosen car above, which of the following passes would you choose to buy?

GA 1st class CHF 6,300	GA 2nd class CHF 3,860	Regional Pass CHF 1,000	None CHF 0
○	○	○	○

← →

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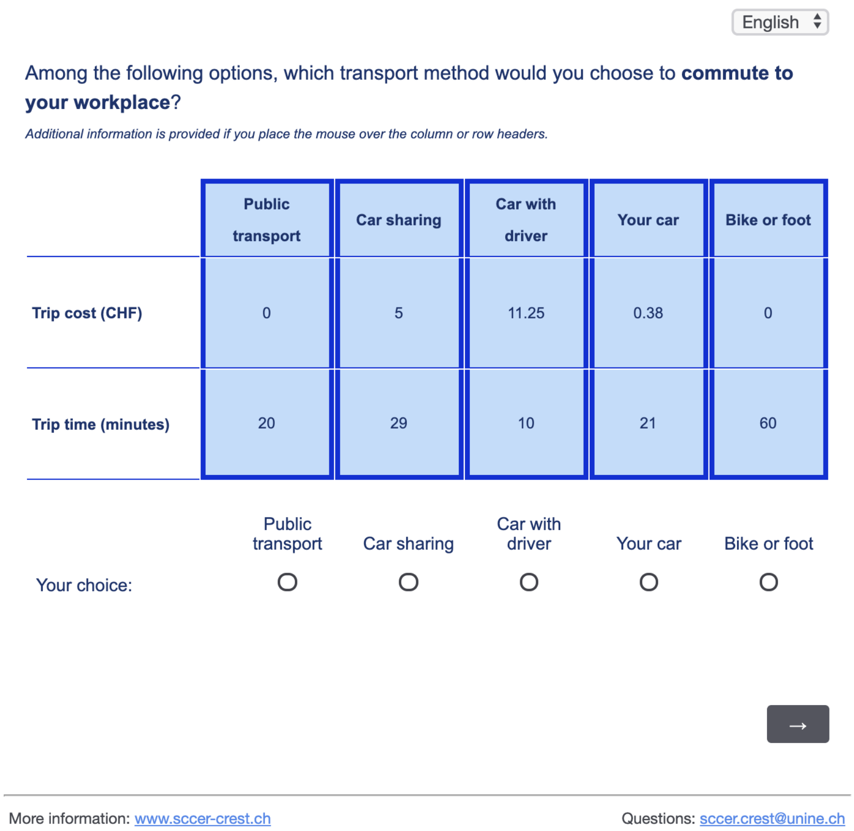
Figure A.5: Choice 4 transport mode choice set (example)



English

Among the following options, which transport method would you choose to **commute to your workplace**?

Additional information is provided if you place the mouse over the column or row headers.

	Public transport	Car sharing	Car with driver	Your car	Bike or foot
Trip cost (CHF)	0	5	11.25	0.38	0
Trip time (minutes)	20	29	10	21	60

	Public transport	Car sharing	Car with driver	Your car	Bike or foot
Your choice:	○	○	○	○	○

→

More information: www.sccer-crest.ch Questions: sccer.crest@unine.ch

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