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Commuter segmentation and openness to sharing services

A Swiss Case Study

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The transportation sector is experiencing increasing pressure from emerging megatrends. Digitalisation, individualisation and the aging of society are leading to increasing traffic, mobility demand and capacity shortages. At the same time, new mobility concepts and offers are under development. In this highly dynamic environment, decision-makers and transport planners are under pressure to react. As society requests new and more comfortable mobility services, car-as well as ridesharing are seen as a part of the solution. Tailor-made mobility services have the potential to meet customer needs and increase the acceptance and use of public transport. In order to better understand the needs, we propose a classification of the commuter society into easily distinguishable groups based on an extensive commuter survey conducted in the city of Basel, Switzerland. This classification should enable more precisely targeted policy measures that save costs and increase adoption of sustainable ways of commuting. Key parameters influencing users' openness towards car- and ridesharing are derived through an ordinal logistic regression analysis. Together with the classification based on a cluster analysis, they serve as starting points for a sustainable transformation of the commuter environment. The paper further places the findings in context by discussing how recent trends in mobility could support acceptance of new mobility concepts. Successfully transforming today's commuting realm requires a coordinated effort from both policy-makers and society itself, integrating new and innovative mobility solutions in a public–private form of cooperation.

1 Introduction

Transportation systems face challenges due to increasing traffic, mobility demand and prices for energy and infrastructure (European Commission, 2011), driven partly by concerns for economic competitiveness, further raising the demand for mobility and accessibility. Dealing with this growth in different areas is a main issue, as pressure to react to rising costs of transport systems and to global warming is increasing at the same time (OECD/ITF, 2009). Many of these problems are related to the high dependence upon fossil-fueled personal cars, leading to capacity shortages and sustainability disputes.

In line with the Paris agreement of 2015, Switzerland obliged itself to reduce both CO2 emissions and dependence on imported fossil fuels by adopting the Swiss "Energy Strategy 2050" in 2017 (UVEK, 2018).

One approach is to support the change of mobility behavior towards more sustainable systems. In this context, especially public transport (PT) and shared mobility services are seen as ways to solve these problems (Hoerler et al., 2019).

However, behavior change is not an easy issue. Mobility decisions and behavior are not only rooted in personal preferences, attitudes and habits, but depend on many factors. People live in spatial and socioeconomic systems, leading to different mobility needs and options (Geurs, 2006). Locations and regions differ in quality of economy, regional development and infrastructure, creating an uneven space with diverse centers of attractions for different purposes. This land use structure combined with individual human (mobility) behavior has led to the commuter-societies we live in today, producing car traffic with negative consequences and side effects, as mentioned.

Housing, working or leisure activities are distributed in this space based on individual decisions and abilities. Thus, there is no "one size fits all" approach. Supporting behavior change towards sustainable mobility requires considering differences in peoples' mobility needs with their underlying drivers and relations to contextual factors.

In order to do so and lower the negative effects of traffic, mobility demand should be met by PT replacing the car and increased sharing of unavoidable car trips. To support this mode shift, it is crucial not only to provide PT infrastructure, shared mobility and combined intermodal services. It is also necessary to understand the factors influencing passengers' use of these services in order to design and communicate mobility solutions in a way that increases user acceptance and supports the hard task of behavior change.

An online-based survey was carried out in Switzerland to shed light on these drivers for mobility behavior. Users' openness to innovative and shared mobility services (such as, for example, car- or ridesharing) has been analyzed, in order to draw conclusions about the potential of these options. Socioeconomic aspects, such as age, income, place of residence and work or household characteristics, were considered as well as characteristics of mobility behavior, such as preferred mode, length and duration of commute, use of car and PT tickets, activities during and satisfaction with commuting.

Based on these data, different types of passengers were identified through cluster analysis. This typology should lead to a better understanding of service design aspects that are important for different user groups and provide a basis to develop alternative services, which meet the specific needs of these groups – resulting, in the end, in higher acceptance of shared mobility and increased attractiveness of PT.

The paper argues that addressing passenger groups more specifically according to their differing needs would promote the use of PT and shared services and thus support mobility that is more sustainable in the sense of resource consumption and resulting emissions. The findings can support decision-makers in transport planning and transport operation as well as in policymaking – by revealing how to support the transformation of the transport system towards sustainability by forcing mobility behavior change.

The paper is structured as follows: Chapters one and two give a general overview of the current mobility situation, factors influencing mode choice and trends relevant for mobility with their potential influence on shared mobility. Chapter three describes the methods used in this study followed by the results in chapter four of i) a typology of users considering socioeconomic characteristics and ii) their openness for shared mobility solutions built on a regression analysis of survey data of the Swiss case city of Basel. Lastly, chapters five and six discuss recommendations for increasing the acceptance and use of shared mobility and provide a final conclusion.

2 Background

2.1 Influencing factors for commuter mode choice

Job location, place of residence and car availability together with socioeconomic factors and attitudes build a complex environment of interrelations affecting mobility behavior (Stead, 2001). Accessibility to different activities is altered through the built environment influencing travel time and, therefore, mode choice (Ewing & Cervero, 2010; Handy, Cao, & Mokhtarian, 2005). City centers and their surroundings are usually highly accessible due to a densely constructed transportation infrastructure, increasing the share of PT and thus foster sustainability in transportation. The most relevant socioeconomic factors affecting mobility behavior are found to be income and age (Hoppe, Castro, & Seppänen, 2015; Turner & Niemeier, 1997). While income enables people to choose the transport mode for commuting and leisure activities as well as the location of residence, the latter affects mode choice behavior. Young commuters opt for more non-car transportation modes compared to older commuters (Prillwitz & Barr, 2011; Vredin Johansson, Heldt, & Johansson, 2006).

In respect to psychological influence parameters, travel mode preferences are found to be guided by reasoned action rather than habitual effects (Kerr, Lennon, & Watson, 2009; Sandow & Westin, 2010). Accordingly, the authors argue the need to focus on the reduction of behavioral intentions to use the car by addressing the social acceptability of car commuting and the perceived high level of personal control. Similarly, (Abrahamse, Steg, Gifford, & Vlek, 2009) investigated the effect of perceived behavioral control, which refers to peoples' perception of their ability to perform a particular behavior (Ajzen, 2006), on personal norms and personal intentions. They concluded that behavioral control has a moderating effect. With high levels of perceived behavioral control, commuters are more open towards alternatives to the car, while people with low levels of perceived behavioral control need a strong moral obligation to intend to reduce their car use. A disruption in the location of residence or workplace could therefore open windows of opportunities to enhance the perceived behavioral control and foster a sustainable paradigm change in commuting (Bamberg, 2006). Likewise, easy-to-use sharing systems, designed for easy access and practicability, could enhance the perceived behavioral control over these sharing modes and thus increase the likelihood of adoption. Still, a stratification of these offers to specific customer segments is essential, as the needs and scope of action differ strongly among commuters (Schaefers, 2013).

2.2 Mobility trends pushing or preventing transformation towards sustainability

Different mobility-related trends are relevant when it comes to the future development of mobility demand and the potential for shared mobility services. Switzerland has experienced trends of growth in many respects in the past years and decades (refer to Figure 1). These developments are likely to continue into the future. This applies especially to economic and related growth of jobs, gross domestic product and increasing income together with population growth. All of these factors have led to increasing mobility demand in the past, as population growth took place in large agglomeration areas and both the number of commuters and commuting distances increased (Mathys et al., 2016). Related to this, relevant trends in mobility itself in Switzerland were those of growth, as reflected in several aspects:

- Travel time and the share of distance travelled by car increased
- Journeys became more intermodal, increasing the complexity of travel chains
- Commuting mobility gained in importance
- Share of mobile people remained at a high level and is expected to rise
- Leisure mobility gained importance in recent years

If these developments and growth continue as expected, a change towards sustainable mobility will become increasingly necessary in order to reduce emissions and resource consumption and difficult at the same time, as increasing mobility demand might be mainly covered by private car use. Further, PT utilization has also increased, especially train trips in work-related commuting, thanks to improved train connectivity with direct connections that have enabled longer commuting distances and fast travel – again leading to increased demand. At the same time, the share of people over 24 years old possessing a driving license has been increasing in recent decades, while owning a driving license for people between 18 and 24 years old has been decreasing. These numbers reflect a postponement of having a driving license, which may open an opportunity for establishing mobility habits of public transportation use and active modes within the younger population.

Besides the described demand-related trends relevant to mobility, technological developments also were investigated. Many new technologies are being developed and may enter the markets soon – even if integration in the given transport system, acceptance and use are not yet clear. Thus, the potential for reducing CO2 emissions and externalities from transport will depend on how these technologies will be integrated into new services. For example, for autonomous driving, it will be crucial whether such vehicles will be a new form of private cars or they will be offered in carsharing systems. Only in the latter case would the high potential to save CO2 emissions and reduce further externalities such as noise and congestion be stimulated; the same applies to electric mobility (Moriarty & Wang, 2017). Concerning emerging shared mobility services, a study from the Swiss Federal Office for Spatial Development (ARE) predicts increasing use of carsharing for the younger generation (18–24 years), whereas the older generation (60 years and older) will most probably stick to private car use (Prognos, 2016).

To summarize, current trends rather seem to endanger a transition towards sustainable mobility. Nevertheless, some of these trends also come with the opportunity of increasing the pressure to go for strategies and measures supporting behavior change and to reduce the negative consequences of overall increasing mobility demand. Seen in this light, the megatrends of urbanization and ecologization together with an increased connection of public and private mobility services will foster the use of shared mobility offers (Wittmer & Linden, 2017).

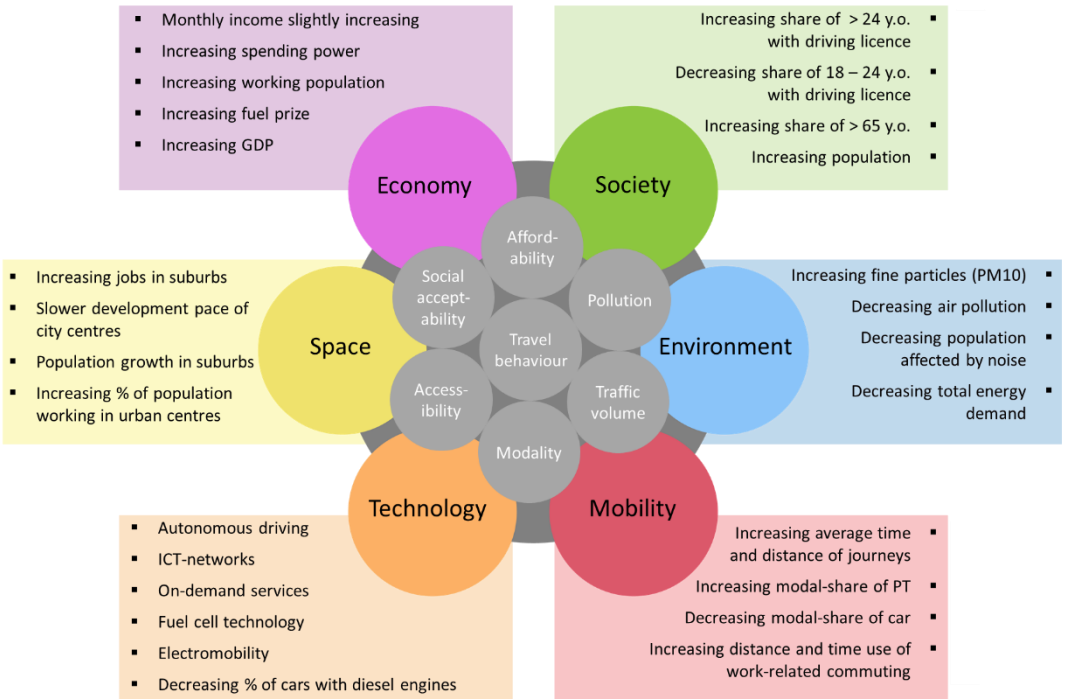

Figure 1: Overview of mobility-related trends in Switzerland (BFS and ARE, 2017; Mathys et al., 2016; Bundesamt für Statistik, 2017; Bundesamt für Statistik, 2016; BFS, 2017; Ecoplan, 2016), own illustration.

3 Methodology

To estimate the potential of commuters' behavior change on Swiss mobility, three different approaches, based on the survey data of the case study in Basel (Switzerland), were applied. As a first step, various questions about the mobility behavior were asked (e.g. combination of commuting with other activities). Secondly, the openness of commuters to new forms of mobility systems, such as car- or ridesharing, were investigated in detail by the use of an ordinal logistic regression model. Lastly and building on the results of the latter analysis, cluster analysis was conducted with the aim of dividing the commuters into easily distinguishable groups. Around 550 completed datasets were considered for the study. The sample is not representative for the whole population of Basel as it includes commuters only, with 57% females, a mean age of 45 years and a mean household income of 9049 CHF.

The openness to car-/ridesharing has been defined as the outcome (dependent) variable in the ordinal regression model. All explanatory (independent) variables described in Table 1, which might influence the openness to car-/ridesharing, together with all possible two-way interactions, were included in the model. Non-significant interactions were eliminated from the model, leaving the significant interaction of gender and mode choice (more details in chapter 4.2.1).

The goal of clustering is to identify homogenous groups of objects (also referred to as observations or cases) from a collection of records (Gelbard, Goldman, & Spiegler, 2007). In our work, cluster analysis can therefore help to group the population into segments with different characteristics (such as household income, residence location, etc.), for which transport services can be designed and addressed by political strategies and measures.

Many different researchers already have applied cluster analysis to transportation research (Beckman & Goulias, 2008; Davidson & Ryerson, 2018; Haustein & Nielsen, 2016; Silver, 2018; Ye, Chen, Bai, & Yue, 2018). Still, a specific focus on the typification of commuter groups has not yet been done in Switzerland. Due to its complexity, the clustering method has been a niche application used by specialists. However, many different statistical packages that can easily perform various clustering methods exist today (Filho et al., 2014).

One of the newer clustering methods is the so-called two-step approach. It allows for the use of continuous as well as categorical variables in the model, combining the advantages of the hierarchical method and the k-means procedure. Furthermore, the two-step clustering algorithm determines the optimal number of clusters automatically and therefore mitigates perception bias (Gelbard et al., 2007).

Considering the fact that both continuous and categorical variables are present in our study and we do not know the optimal cluster beforehand, the two-step clustering method was used to analyze the survey data. An iterative, explorative approach was chosen to find cluster groups with the highest separation from each other and best interpretability. Table 1 gives an overview of the variables used in the regression and cluster analysis.

Table 1: Overview and definition of the variables used in the regression and classification.

Variable	**Definition**
Dependent variable (DV)	
Openness to car-/ridesharing	Indicates if a respondent is willing to use car-/ridesharing in the future: 0, Never; 1, Willing to use either car- or ridesharing; 2, Willing to use both car- and ridesharing
Independent variable (IV)	

Enjoyment of travel[1]	Degree to which commuter enjoys his or her commute: 1, Very low; 2, Low; 3, Medium; 4 High; 5, Very high
Dominant mode choice	1, Multimodal; 2, Private motorised transport; 3, PT; 4, Active modes (bicycle, walking)
Household size	1, Single person; 2, Small (2–3p); 3, Large (gt3p)
Residence location	1, Rural; 2, Semi-urban; 3, Urban or centre
Gender[2]	1, Female; 2, Male
Combination with other activities[1]	How many times a participant indicated to combine commuting with other activities at least often, from 0 to 6 activities (e.g. shopping, sports, leisure)
Commuting distance[2]	Total distance driven for commuting in kilometres
Commuting time[1]	Total daily time used for commuting in minutes
Income per active person	Income of household members considered active (working or studying) in CHF
Age[2]	Age of the respondent in years
Private car[2]	Owning a private car: 0, No; 1, Yes

[1]Marks variables used only in the cluster analysis; [2]Marks variables used only in the regression analysis.

4 Results

4.1 Openness to shared mobility and classification of commuters

Studies on the behavior of commuters and travelers have gained much attention in recent years, especially within the continuing megatrend of digitalization (Canzler & Knie, 2016). Access to mobility is expected to become simplified through the development of automated vehicles and information and communication technologies (ICT) leading to an increasing number of user groups that have to be considered (e.g. disabled or elderly people) (Vesanen-Nikitin & Åkermarck, 2017). Furthermore, the upcoming offers of shared mobility expand the interaction of different personalities. In this context, transport providers need to not only understand the current trends in mobility described in the chapter above, but also the needs and characteristics of various groups to be able to provide tailored mobility options.

4.1.1 Starting points addressing the openness to use car- and ridesharing

As we aim to foster a shift from private motorized transport to PT and shared mobility, a descriptive analysis of the satisfaction of users towards commuting by car as opposed to PT, as well as their openness towards new mobility options such as car- and ridesharing serves as a first overview (Figure 2). On a Likert scale from one (not at all satisfied) to five (very much satisfied), the respondents rated their satisfaction with their car and PT commuting regarding several aspects. While ease of use, reliability, service frequency and travel time do not seem to differ strongly between PT and private cars, aspects such as comfort and enjoyment of travel still favor the private car. In the second chart, the openness of commuters to use various sharing systems is shown. A general lack of willingness to use such a system is apparent, yet car- and ridesharing were found to have the greatest attraction.

Figure 2: (a) Difference in commuters' satisfaction regarding commuting aspects between PMT and PT users (scale: 1, not at all satisfied – 5, very much satisfied), (b) openness to use shared mobility options.

Based on this first descriptive overview, we investigated the influence of the set of parameters discussed in Table 1 on the openness to using car- and ridesharing through an ordinal logistic regression analysis.

The omnibus test of model coefficients was statistically significant, $\chi 2$ (df = 15, N = 302) = 45.94, p = < 0.001, indicating that the independent variables (IV) improved the model compared to the baseline model without any variables, and can significantly predict the dependent variable (DV) Openness for car-/rides-haring. The Nagelkerke R-squared estimate showed that the model explained 17% of the variance from the DV. Additionally, the Hosmer–Lemeshow test of the goodness of fit suggested the model is a good fit to the data as the chi-square statistic was a non-significant p = 0.264 (> 0.05), indicating that there is no lack of fit in the estimated model. Nonetheless, the results should be interpreted with care as parameters not covered in this study might also affect openness to car-/ridesharing. Subsequently, the Wald chi-square

statistic (Wald $\chi 2$) was used to test the statistical significance of individual regression parameters (B) (refer to Table 2).

Table 2: Ordinal logistic regression model for openness to car-/ridesharing.

Variable	**B**	**S.E.**	**Wald χ^2**	**OR**	**Sig.**
Level: Openness car-/ridesharing 0	-1.839	.745	6.094	0.16	.014
Level: Openness car-/ridesharing 1	-.840	.741	1.285	0.43	.257
Multimodal	.223	.562	.158	1.25	.691
Private motorised	-1.297	.616	4.430	0.27	.035
PT	.056	.500	.013	1.06	.911
Active modes (reference)	-	-	-	-	-
Household size: 1p	.509	.451	1.273	1.66	.259
Household size: 2-3p	.242	.333	.526	1.27	.468
Household size: gt3p (reference)	-	-	-	-	-
Residence: Rural	.516	.374	1.904	1.68	.168
Residence: Semi-urban	.034	.387	.008	1.03	.929
Residence: Urban or centre (reference)	-	-	-	-	-
Female	-1.627	.563	8.350	0.20	.004★
Male (reference)	-	-	-	-	-
Commuting distance	.003	.006	.351	1.00	.554
Income per active person	-9.271E-5	5.263E-5	3.103	1.00	.078
Age	-.041	.013	10.362	0.96	.001★
Private car: no	-.518	.318	2.659	0.60	.103
Private car: yes (reference)	-	-	-	-	-
Multimodal*Female	-.192	.803	.057	0.83	.811
Private motorised*Female	2.130	.846	6.345	8.41	.012★
PT*Female	.004	.740	.000	1.00	.995

Active modes*Female (reference)	-	-	-	-	-
Multimodal*Male (reference)	-	-	-	-	.
Private motorised *Male (reference)	-	-	-	-	-
PT*Male (reference)	-	-	-	-	-

*Significant at $p <= 0.05$; B, parameter estimate; S.E., standard error; OR, odds ratio; -, not applicable.

The results of the ordinal logistic regression analysis with the DV openness to car-/ridesharing suggests that the openness to these sharing modes mostly depends on age, gender and the interaction between gender and mode choice ($p < 0.05$). A trend ($p < 0.1$) towards more openness to car-/ridesharing with lower incomes is also present in the data. Other factors, such as household size, location of residence or commuting distance, were not found to have a significant influence.

The Wald chi-square statistic implies that age is the strongest predictor of openness to car-/ridesharing, followed by gender and the interaction of gender and mode choice. The odds ratio of age is 0.96. Thus, a one-unit increase in age leads to a 4% decrease in likelihood to demonstrate a higher level of openness for car-/ridesharing and, hence, underlines the findings from (Sioui, Morency, & Trépanier, 2013) that younger commuters are significantly more open towards these mobility options. Gender interacts with mode choice and, therefore, the odds ratio has to be calculated separately by taking the exponent of the sum of B values corresponding to the interaction. This leads us to the following results: male commuters using multimodal modes are 6.2 times more likely to demonstrate a higher level of openness to car-/ridesharing than their female counterparts. Likewise for PT (by a factor of 5.1) and active modes (by a factor of 5.1). Yet for private motorized transport, the odds ratio of male/female is 0.6, defining the interaction. Figure 3 depicts this phenomenon in a graph with the y-axis representing the average openness score (from 0 "not open" to 2 "open to both car-/ridesharing") and gender on the x-axis.

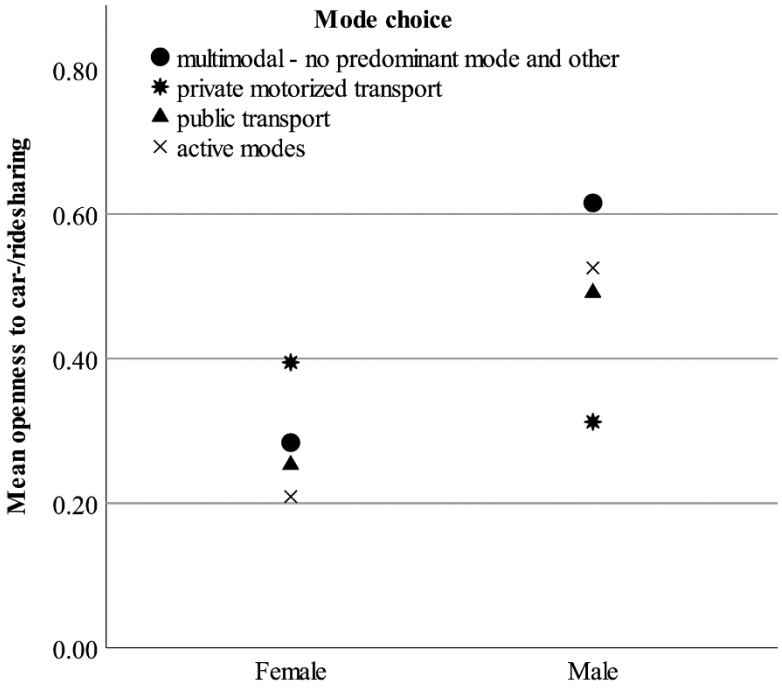

Figure 3: Interaction between gender and mode choice in openness to car-/ridesharing (mean of variable 'openness to car/ridesharing', see Table 1).

This effect might be explained by male travelers still seeing the private car also as a status symbol. This leads to a reluctance to share or even not owning a car, which might be less important for women. At the same time, women dominantly using PT, active or no predominant mode for commuting are less inclined towards sharing a car. (Polk, 2004) investigated whether a car as a status object influences car use for men and women, finding a significant influence for men but no effect for women and underscoring our results.

Lastly, the income of commuters gives a further indication whether or not the person is open towards car- and ridesharing, as those participants with below-average income tend to be more open to use such offers.

4.1.2 Classification of commuters – case study Basel

The cluster grouping algorithm of the two-step approach suggests four different cluster solutions with specific characteristics of the seven variables included in the analysis (see Table 1). The results are visualized in a spider chart (Figure 4). The percentage for the degree of urbanization, enjoyment of travel, commuting time, combination of commuting and income are relative to the highest value among the four groups. The mode choice values are relative to the most used mode within the same group.

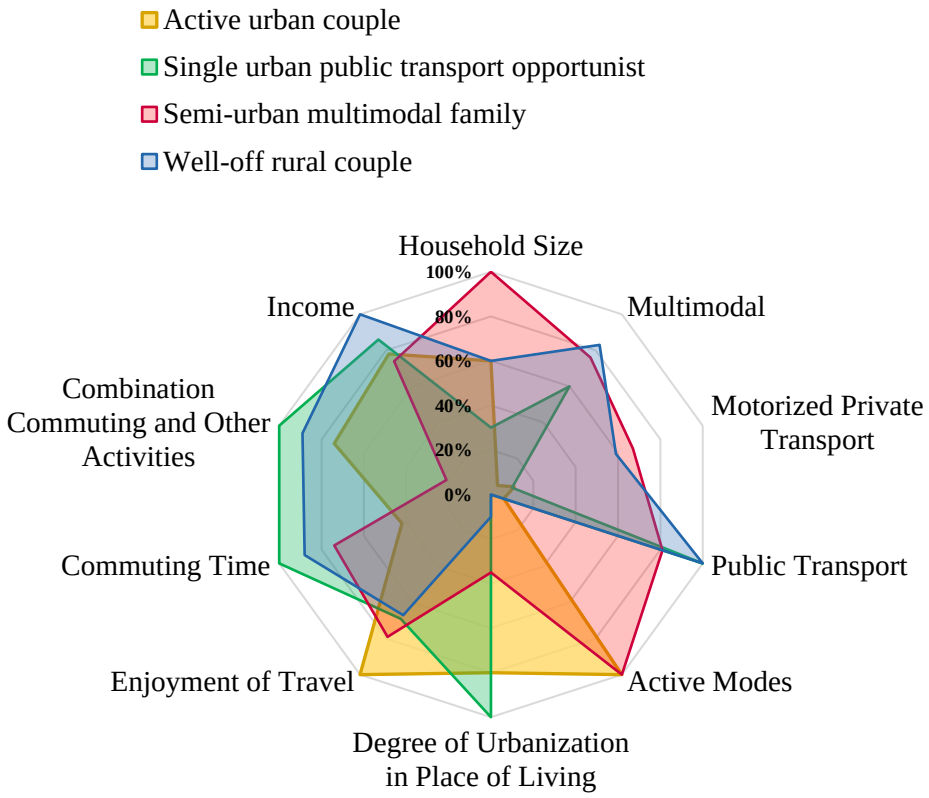

Figure 4: Characteristics of commuter groups.

The first cluster (yellow, 25% of respondents) is characterized by a small household size (2–3 persons). Commuters belonging to this cluster almost exclusively use active modes for commuting and live in urban areas or in the city center. They very much enjoy commuting and often combine commuting with approximately 0.9 other activities on average. Generally, they have a low commuting time and average income per active person. We therefore call this cluster the active urban couple.

The second cluster (green, 22% of respondents) is dominated by single households (1 person) that mostly use PT for commuting. They tend to live in urban areas or in the city center, moderately enjoy commuting and show a high openness to combining commuting with other activities (1.3 activities on average). Further,

a high commuting time and average income characterizes this group. Such a person can be summarized as the single urban public transport opportunist.

The third cluster (red, 22% of respondents) mostly comprises larger households (more than 3 persons). They use all available modes for commuting and are evenly distributed in rural, semi-urban and urban areas. The group has an above average enjoyment of commuting and yet rarely combines commuting with other activities (0.3 times on average). Their commuting time and income lie in the medium range. We therefore call this group the semi-urban multimodal family.

The fourth and last cluster (blue, 31% of respondents) is dominated by households of two to three people, no preference for active modes and a rural place of residence. They moderately enjoy commuting, combine commuting with approximately 1.1 other activities on average and have a high commuting time. A standout characteristic is their above average income. They are thus referred to as the well-off rural couple.

4.1.3 Reasons for commuting of the four commuter groups

In order to investigate the reasons for mode choice between the four commuter groups explained above, answers to the survey question "Why do you use the car/PT for commuting?" are analyzed. Participants of the survey were shown a list of reasons, from which they could choose between "yes" and "no" (multiple choice). First, a detailed overview of attributes important for the reason to choose the car for commuting is shown, followed by the reasons for choosing PT (Table 3 and Table 4).

Table 3 presents the percentage of "yes" answers for each reason to use the car for commuting distinguished by the four commuter groups. The three most frequent answers are shaded in dark grey (bold in addition), grey and light grey, respectively. Differences and similarities between the groups are apparent. Most interestingly, the active urban couple and the single urban PT opportunist both see the possibility to transport goods as a reason to use the car for commuting. These two groups rarely take the car for commuting but for the rare occasions, having to transport goods could be the main reason for an increase in car use.

Being more flexible and faster are the second and third most given reasons for choosing the car. In contrast, being faster is the most important reason for choosing the car for commuting for the semi-urban multimodal family. Here, it can be reasoned that people belonging to this group want to spend time with their family and, thus, value time more than other attributes. Still, flexibility and the transportation of goods are strong reasons to commute by car for this group as well.

The last group, the well-off rural couple, has the highest percentage of car users and lives in a rural environment, thus flexibility and being faster are key in choosing the private car for commuting as PT networks are sparse. The third most frequent reason for choosing the car is due to free parking spaces at work, which acts as a barrier to sustainable commuting. Nonetheless, parking-spaces are directly controllable and an easy target for companies, administrations or the government for the implementation of sustainable mobility management.

Generally, the most frequent reasons for car commuting are flexibility, transportation of goods and being faster than alternative modes. What is surprising, however, is the relatively low percentage of participants for whom privacy is a reason for choosing the car for commuting. Carsharing and carpooling would therefore see good chances of adoption, if these three most named reasons for commuting were addressed accordingly.

Table 3: Reasons for car commuting among commuter groups.

Commuter group / Reason	Active urban couple	Single urban PT opportunist	Semi-urban multimodal family	Well-off rural couple
No alternative	8%	3%	6%	9%
Security	11%	3%	4%	3%
Reliability	11%	14%	13%	16%
Medical reasons	3%	0%	0%	3%
Weather	14%	17%	6%	13%
Faster	22%	24%	**29%**	41%
Cheaper	6%	3%	6%	3%
More flexible	33%	38%	27%	**56%**
Privacy	8%	14%	10%	15%
Environmental concerns	0%	0%	2%	0%
Transportation of goods	**36%**	**41%**	25%	21%
To avoid traffic jams	0%	0%	0%	1%
Free parking-space at work	11%	3%	13%	23%
Bad access to public transport	8%	3%	6%	16%

Reasons for choosing PT in commuting are largely mirrored by the dominant mode of choice of the respective commuter group. During bad weather (52%), the active urban couple, which mostly uses active modes for commuting, would switch to PT. Still, they see environmental concerns (30%) as a strong reason for commuting by PT.

Environmental concerns (56%) are the strongest reason for commuting by PT for the single urban PT opportunist, closely followed by reliability (53%). Similarly, the semi-urban multimodal family values environmental concerns (42%) the most as a reason to choose PT in commuting. In general, they show very similar reasons for choosing PT in commuting as the single urban PT opportunist, yet value reliability (32%) slightly less.

The well-off rural couple has the highest share of private car users. Accordingly, their most important reason for choosing PT in commuting is to avoid traffic jams (58%).

Table 4: Reasons for PT commuting among commuter groups.

Commuter group / Reason	Active urban couple	Single urban PT opportunist	Semi-urban multimodal family	Well-off rural couple
No alternative	8%	24%	9%	19%
Security	7%	26%	15%	13%
Reliability	14%	53%	32%	36%
Medical reasons	4%	3%	5%	1%
Bad weather	**52%**	26%	32%	15%
Faster	8%	36%	20%	25%
Cheaper	7%	27%	25%	30%
More flexible	5%	20%	11%	4%
Privacy	1%	1%	0%	0%
Environmental concerns	30%	**56%**	**42%**	38%
Transportation of goods	12%	0%	5%	1%
To avoid traffic jams	16%	43%	35%	**58%**
Possibility to work while commuting	10%	30%	20%	13%

5 Discussion

The Swiss population adopted the Energy Strategy 2050 in May 2017 with the aim of reducing energy consumption, increasing energy efficiency, reducing dependence on imported fossil fuels and strengthening domestic renewable energies (UVEK, 2018). To be able to reach these set goals, while at the same time maintaining the high service quality of PT in Switzerland, requires an integrated approach. Not only do we need new infrastructure (such as e-fuel stations) or combined mobility services but also a strong focus on the relevant trends in the mobility sector and attitudinal and socioeconomic characteristics of the commuter society. Even though this study focused on Switzerland, the subject is relevant for other countries as well.

The literature suggests great potential for reducing car-based CO2 emissions by using sharing systems (Baptista, Melo, & Rolim, 2015; Briggs & Sundaram, 2016; Nijland & van Meerkerk, 2017). It is argued that through the sharing of cars, fewer cars are owned, vehicle miles travelled are reduced and PT usage increased, consequently leading to less CO2 emissions (Baptista et al., 2015). Yet it needs a throughout planning together with the municipality and existing PT providers so as to not pull customers away from PT (Clewlow & Mishra, 2017); but also PT is not per se sustainable as often assumed – there is still potential for efficiency increases when it comes to consumption of energy and other resources. Traditional PT combined with shared mobility provide opportunities for resource efficiency and emission reduction. This study has given insights into the extent to which socioeconomic and attitudinal characteristics might hinder or foster the openness and likely adoption of such shared mobility options. We recommend to specifically design measures targeting younger commuters, male multimodal users and female car users as they might

be more open towards these sharing options. Furthermore, a focus on low-income groups, offering shared mobility that could save costs in commuting, shows a higher likelihood of adoption as well. However, todays' shared mobility options are still seen as expensive alternatives (Kim, 2015). It is inevitable that these service providers need to demonstrate the possibility to save costs together with an easy and user-friendly interface.

In contrast to the recommendation to target already open-minded individuals when it comes to promoting new sharing services, this study also offers insights into the individuals and groups that are not open for these services and, as such, represent the biggest potential. These lie especially in the male private car user and older individuals. However, we need to keep in mind that the general openness to car- or ridesharing is low across all individuals (refer to Figure 2).

To overcome the reluctance of sharing a car, the still dominant emotional attachment to the private vehicle has to experience a shift towards a more open-minded and practical way of thinking. The current trend for more intermodality, together with new, connected mobility services is slowly pushing its way into the prevailing private car-based paradigm. By targeting those individuals with an already higher openness towards sharing systems, the awareness of these mobility options could rise and eventually accelerate the spread to the remaining population. At the same time, positive experience with the new sharing systems and stratified advertisements targeting the diverse needs of various commuter types are key in this respect.

The paper thus proposes a classification of the commuter society, not only to understand the factors leading to higher openness of sharing mobility in individuals, but also in order to gain insights into the reasons and motivations of commuter groups when it comes to mode choice behavior.

The active urban couple from the socioeconomic cluster analysis already acts as an optimal case. It is characterized by active commuters using their bicycle for travel or simply walking to their workplace. Therefore, their commuting trip does emit far less greenhouse gases as compared to the remaining groups. Furthermore, these commuters display a very high enjoyment of travel. We thus insist on the urge to increase the safety and promotion of slow modes, as these are associated with environmental as well as high personal benefits. At this point, the picture changes with the other cluster groups. People in the second cluster, the single urban public transport opportunist, do enjoy commuting less and they predominantly use PT. They are subject to very long commuting times. As the current trend indicates a continuing increase in travel time (see chapter 2.2), the situation and enjoyment of PT commuting might get even worse for this group. However, users in this group combine commuting with other activities, as revealed by the cluster analysis based on our survey. Special offers that link commuting with the combined activities may decrease additional travel demand otherwise satisfied separately. This could include for instance bike-sharing systems (including cargo bikes as transportation of goods was the main reason for commuting by car for this group, see chapter 4.2.3) designed to cover the miles from the train station to the sports center, shopping center or meeting points in the city.

The third cluster is characterized by no predominant travel mode but can be easily distinguished from the other groups due to their big household size (at least four people in the household and therefore called a semi-urban multimodal family). Here, special offers for families could enhance the low openness to combine commuting with other activities, while targeted information campaigns on the advantages of a PT pass subscription may foster a shift away from private motorized transport.

The well-off rural couple stands out with a high average income per active person and dominantly rural location of residence. In consequence, information campaigns incentivizing electric vehicles may be effective as they are still generally more expensive than a fossil fuel car and therefore more affordable for commuters belonging to this cluster. Provided that renewable energy is used to charge the batteries, this would

offer them the chance to switch to a more sustainable vehicle without loss of comfort. It is important to note, however, that in general these incentives and the promotion of sharing systems should be used with care as they might cause a shift from already sustainable modes of commuting, such as slow modes, to those with a higher carbon footprint. Careful planning of both the municipality or government together with service providers and the consideration of the varying characteristics of target groups is inevitable (Cohen & Kietzmann, 2014).

Besides addressing mobility users, it is also important to motivate practitioners in policy and planning. To do so, mobility management should be an integral part of companies by appointing a caretaker for mobility projects and their implementation. Administrations of cities and cantons as well as federal institutions could support the initiation by defining frame conditions and incentives. Innovative programs that consider the development and risk capital needed for new mobility solutions can support their implementation through open competitive bidding. Other forms of cooperation, such as a regional coalition of companies, initiated by economic promotion, for example, could facilitate the exchange of experience and success factors.

6 Conclusion

Understanding the behavior of commuters requires a versatile approach. This paper analyzed not only how attitudes and socioeconomic characteristics influence travel behavior, but also the impact of trends in new working models and flexible mobility offers. Different commuter groups as well as individuals' openness to car- and ridesharing were derived and placed in the context of emerging and ongoing mobility-related trends. Thus, the study was able to give insights into the factors that are relevant to a sustainable transformation of the mobility system and, as such, improve sustainability as a whole. Trends of growth in the economy and society (in Switzerland as elsewhere) are likely to further increase mobility demand as described. Within this context, political responsibilities with strategies and measures to address growth-related problems are of great importance. On the demand side, the case study revealed specific mobility patterns with different explanatory factors between the identified user groups. In order to improve mobility services and generate a sustainable mobility system, these would need to be addressed by tailor-made solutions.

The results of this research may serve as a guide for policy-makers and transportation planners by revealing the openness of individuals to mobility sharing and which characteristics define and influence the various groups of the commuter society. Furthermore, this study could serve as a basis for future research in the fields of commuting behavior and sustainable transportation planning. Identifying groups of commuters revealed some surprising insights into their characteristics. It is also clear that these characteristics will differ between different cities and regions according to their specific situation. Thus, the applicability of results to other cases needs to be critically reflected and the respective groups would need to be identified on a regional basis. Nevertheless, the behavior of commuters is a complex topic and further research, digging deeper into the attitudinal characteristics of the proposed differentiation of the commuter society, could provide valuable insights into the reasons and needs of the diverse groups. Environmental attitudes, for example, which were not covered in this study, may help in differentiating the commuter groups and understanding the reasons for mode choice.

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