# Drivers for utilizing pooled-use automated vehicles—empirical insights from Switzerland*

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*Abstract*— **Automated driving will trigger disruptive changes in the transportation system. Automated sharing and pooling options instead of private ownership are broadly discussed because of their possible contributions to climate change mitigation and sustainability. Despite the growing amount of literature on the adoption of these alternatives, little empirical evidence is available on the potential drivers of adoption, such as individuals' socioeconomic background, mobility characteristics, attitudes, and values. To address this gap, we utilize the results of an online choice experiment involving 709 participants from Switzerland, which tested future mode choices considering automated cars, automated pooled-use taxis, and automated public transport shuttles, both for short- and long-term mobility decisions. Exploratory regression analysis explains the experiment outcome with a broad set of underlying data predicting willingness to use. Our findings illustrate that automated cars and automated public transport often appeal to the user groups of their traditional non-automated counterparts. However, this does not seem to be the case for automated pooled-use taxis, which we find to be associated with higher-income groups. Attributes on current mobility characteristics and values cannot be significantly associated with automated pooled-use taxis. We also demonstrate that short- and long-term mobility decisions are worth studying together in AV adoption studies.**

## I. Introduction

Automated vehicles (AVs)—defined in this study as highly or fully AV requiring no manual steering (levels 4 and 5) [1]—will disrupt both transport markets and mobility behavior [2]. They are expected to make mobility cheaper [3], more comfortable [4], safer [5], and more accessible for non-driving people [5]; therefore, they could substantially increase the vehicle miles travelled (VMT) [6], which might lead to further urban sprawl [5, 7]. With regard to environmental and sustainability benefits, improvements are expected because of the electrification of power trains, more efficient traffic flows or possibilities for lightweighting [8], or more livable cities, in general [9]. However, "the marriage of self-driving cars and car sharing … [is expected to be the] true mobility game changer" [10], overcoming many of the existing barriers of shared mobility offers [11].

A vast amount of literature suggests the emergence of innovative sharing and pooling options with the introduction of AVs, along with opportunities of mobility as a service (MaaS) [12]. Whereas sharing means collective ownership and utilization of vehicles (car-sharing, bike-sharing, ride-hailing), pooling further intensifies collaborative mobility, as it involves utilizing vehicles together with other non-related passengers on specific trips. MaaS means integrating "various forms of transport services into a single mobility service accessible on demand" [13]. Simulation studies from all over the world have demonstrated that overall fleet sizes and required parking spaces could be substantially reduced with the use of shared AV [9, 14, 15, 16]. Even a reduction in overall VMT is realistic if pooling is enabled [17]. Depending on the degree of sharing or pooling, AVs could lead to energy savings of 40% or an increase in energy consumption of up to 100% [18]. Because of operations by commercial players, shared AVs are predicted to foster electrification [7, 19]. Despite drawbacks like induced demand [8], a more sustainable transport system in the context of AVs seems to be strongly linked to sharing (especially pooling) options, such as automated taxis (auto-taxis) or automated public transport shuttles (auto-shuttles), instead of privately owned automated cars (auto-cars). However, the systemic switch to the former alternatives requires incremental changes in the socio-technical basis of mobility, which poses an important question to be critically reflected: Are users willing to adopt these alternatives? What are the possible drivers for acceptance?

The first question has already been studied intensively, but user acceptance has only been partially explored. In experimental settings that compared mode choice between conventional cars (or the current transport means chosen by the respondent on a specific trip) and shared or pooled-use AVs, about 30% of the respondents selected the sharing alternatives based on travel cost, travel time, and waiting time [11, 20]. Pakusch et al. (2018) [21] compared the current mode choice of cars, car-sharing, and public transport with the future condition enabling additional automated alternatives. They found no difference in car utilization (the total use of conventional cars and auto-cars), but they observed a significant shift from public transport to automated car-sharing. In an experiment that involved only automated alternatives (auto-car, auto-taxi, and auto-shuttle) to study explicitly the pooling assumption, about 60% of Swiss respondents preferred pooled-use automated modes over auto-car utilization [22] both for short-term (mode choice for a trip) and long-term mobility decisions (car purchase vs. sharing and public transport subscriptions).

With regard to the second question, Acheampong et al. (2019) [23] argued that most studies consider a limited set of behavioral factors explaining AV adoption behavior. They

* This research is a part of the activities of SCCER CREST, which is financially supported by Innosuisse. The study has substantially benefited from access to the SHEDS dataset.

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proposed a research framework including socio-demographic data, perceived benefits and anxieties, attitudes, and subjective norms. Given our extensive dataset on behavioral attributes and stated willingness to use shared AVs (see Section III), we are able to extend the knowledge of behavioral factors of pooled-use AV adoption and propose the following research question for the study presented in this paper:

RQ1: What socio-demographic, attitudinal, and personal normative drivers can be identified to explain willingness to adopt pooled-use AVs?

Furthermore, the AV adoption literature has so far mostly dealt either with short- or long-term mobility decisions. In the context of the latter, life events are broadly discussed to contribute to a re-evaluation of mobility options [24] and to overcome habits [25]. Besides pooled-use AV adoption on a specific trip as a short-term mobility decision, our choice experiment [22] additionally tested a choice situation in which the respondents re-evaluated their overall mobility behavior after home relocation and stated their willingness to buy an auto-car or to subscribe to automated sharing or public transport offers. Therefore, we are able to differentiate between these two different levels of individual decision making and explore the following research question:

RQ2: What differences between short- and long-term mobility decisions can be identified with regard to pooled-use AV adoption?

Our paper is organized as follows. Section II summarizes the existing knowledge on different drivers, with a special focus on the AV and sharing literature. Section III describes our choice experiment, the underlying data, and the analysis. Section IV presents the results, and Section V concludes with a discussion of the lessons learned and the limitations of our study.

## II. State of the Art

In the following, we summarize the existing knowledge on the drivers of AV adoption and sharing, separately for different types of drivers according to RQ1: socio-economic situation, current mobility behavior, attitudes, and values.

### A. Socio-economic situation

Age and gender: Acceptance studies provide different and even partially contradicting results [21, 26, 27] on AVs, as well as vague results for shared AV [20]; the latter alternatives tend to be preferred by groups younger than 30 [14] and older than 50 [21]. By contrast, the typical user groups of traditional car-sharing and ride-hailing generally tend to be younger [27]. Menon et al. (2019) [28] identified higher probabilities of relinquishing car ownership among millennials and women with the introduction of AVs.

Housing location: Urban characteristics, such as a limited parking space, good public transport access, and high density, are linked to greater car-sharing [27]. With the introduction of AVs, automated sharing could increase market share at the expense of public transport, especially in cities [21].

Education and Income: A higher standard in education, as well as greater income, can be associated with higher car use. The study of Pakusch et al. (2018) [21] suggests that this could still be true with the introduction of AVs.

Socio-economic drivers are already well studied for AV adoption, with different results on gender and age. The additional value of our study is the use of an experimental setting with realistic choice situations linked to the underlying data.

### B. Mobility characteristics

According to Whittle et al. (2019) [12], consumers who often use public transport are also more in favor of car-sharing. In a more general context, MaaS offers will appeal more to infrequent car users [29]. With regard to AV introduction, [21] found that current car users and car owners tend not to change their preferred transport mode, whereas members of car-free households switch more often from public transport to auto-cars or to automated car-sharing.

### C. Attitudes

Attitudes represent several beliefs focused on a specific object or situation [30]. According to Whittle et al. (2019) [12], attitudes refer to expectations, either affective (emotions or perceptions) or instrumental (degree of personal advantage). While the literature on AV and sharing adoption remains limited, the first field trials show positive perceptions of sharing characteristics going along with user satisfaction, such as simplicity and flexibility, whereas others show barriers to adoption [12]. As a consequence, we additionally tested several concerns and expectations toward AV and sharing, along with individual estimations of importance with regard to willingness to adopt pooled-use AVs.

### D Values

Values, unlike attitudes, are individual standards that guide actions, attitudes, comparisons, evaluations, and justifications [30]. To the best of our knowledge, values have not been examined so far with regard to AV adoption. We refer to the concept of Steg et al. (2016) [31], which rates the importance of 16 single values (e.g., equality, respecting the earth, pleasure) and extracts 4 value types—hedonic values focusing on pleasure and comfort, egoistic values increasing personal resources, altruistic values focusing on the well-being of others, and biospheric values focusing on nature and the environment. With regard to sustainable development, especially for the energy sector, engagement is particularly associated with strong biospheric values, whereas strong egoistic values decrease the likelihood of engagement [31]. With regard to transportation, the value belief norm theory has successfully predicted car use intention [32].

## III. Methodology

To answer the research questions, we combined data from an online choice experiment with data on socio-economic, behavioral, and personal data from the respondents. Both the online experiment and the underlying dataset are embedded in the Swiss Household Energy Demand Survey (SHEDS), which was designed to collect comprehensive data on household energy consumption, consumption changes, and the predictors for three primary domains of consumption—heating, electricity, and mobility. SHEDS is conducted in four waves between 2017 and 2020. For a detailed description of the survey, see [33].

### A. Description of the choice experiment

In this section, the parts of the choice experiment relevant for this study are presented together with the choice-relevant parameters. Further insights into the experiment and the parameters utilized can be obtained from [22].

In the first step, the participants were presented the three mode options with increasing levels of pooling: auto-cars, pooled-use auto-taxis, and auto-shuttles. The same three mode options were available as choice options throughout the experiment.

In the second step, the short-term decision part of the experiment, the respondents were asked to imagine a leisure trip to a friend's place 50 km away and to rate the relative likelihood that they would use each of the three mode options using a five-point Likert scale (ranging from 1 – very unlikely to 5 – very likely). For auto-shuttles, a combination with trains was implemented, as auto-shuttles are often discussed as operating as a secondary transportation mode to high-capacity public transport [2]. Table 1 depicts the parameters of the short-term choice set.

TABLE I. PARAMETERS OF THE SHORT-TERM CHOICE SET

| Parameters | Trip mode options | | |
|---|---|---|---|
| | ***Auto-car*** | ***Auto-taxi*** | ***Auto-shuttle/train*** |
| Price | 0.50 CHF/km → 25.00 CHF | 0.35 CHF/km → 17.50 CHF | 0.40 CHF/km → 20.00 CHF |
| Walking distance | 0 km | 0 km | 0.4 km |
| Vehicle used with others | NO | YES | YES |
| Number of persons in the vehicle | 1 | 3 | Shuttle: 4 |
| Level of reliability | MEDIUM (traffic jam) | MEDIUM (traffic jam) | MEDIUM (delays) |
| Waiting time | 0 min | 15 min | 15 min |
| Travel time | 65 min | 65 min | 65 min |

In the third step, the long-term decision part of the experiment, the respondents were asked to imagine that they had received a job offer requiring them to relocate. This represented a window of opportunity for changing habits (see Section I). The respondents were asked to re-evaluate the mode options in this new situation. They estimated the likelihood of choosing each of the following three offers, again on a five-point Likert scale: the purchase of an auto-car, subscription to an online platform of auto-taxis, or the purchase of an updated version of the Swiss general public transport pass (includes free use of all public transport modes), which additionally includes auto-shuttle door-to-door services. Table II depicts the parameters of the long-term choice set.

In the fourth part of the experiment, the respondents reflected on their attitudes toward automated driving and sharing, in general, evaluating respective expectations and possible concerns. They estimated each of the following attributes on a five-point scale with respect to either becoming better or worse and to their personal importance:

- Automated driving: Productive use of travel time, access to driving without having a license, access to public transport, possibility to combine different transport modes, control over the trip, safety, others
- Sharing options with respect to automated driving: Flexibility, mobility costs, convenience, reliability, security, others

Furthermore, in the second and third steps, the experiment tested different instruments that are potentially suitable for increasing the mode share of collaborative mobility. This part of the experiment is neither described nor analyzed in this paper.

TABLE II. PARAMETERS OF THE LONG-TERM CHOICE SET

| Parameters | Trip mode options | | |
|---|---|---|---|
| | ***Purchase auto-car*** | ***Subscription auto-taxis*** | ***General public transport pass*** |
| Investment | 45 000 CHF | 550 CHF/year | 5 000 CHF/ year |
| Variable km-price | 0.25 CHF/km | 0.35 CHF/km | 0.00 CHF/km |
| Vehicle used with others | NO | YES | YES |
| Walking distances | No distances | No distances | Between transport systems |
| Maximum waiting time | 0 min | 15 min (fixed in contract) | 15 min (fixed in contract) |

### B. Description of the SHEDS dataset

SHEDS contains a powerful dataset on socio-economical, mobility-related, sociological, and psychological data. In order to explore the potentially relevant parameters for willingness to use pooled-use AVs, we selected the common socio-demographic and mobility-related parameters to account for any confounding effects (see Table III). A plethora of attitudinal questions related to the use of AVs or sharing, as well as the four values according to Section II were included in the study. Table III provides an overview of all parameters.

### C. Sample

From a total of 5,014 respondents who completed the SHEDS wave 2018, 709 respondents were randomly assigned to our experiment. The SHEDS sample represents the population of German- and French-speaking Switzerland with regard to gender, age, region, and home ownership status. The experiment sample reflects well the overall SHEDS sample and differs only slightly with regard to age and gender. However, SHEDS is not primarily designed for mobility studies. Compared with the sample of the official Swiss mobility survey 2015 (Mikrozensus) [34], our sample contains more car-free households. We therefore weighted the experiment sample according to car ownership status based on the Swiss Mikrozensus data.

### D. Statistical analysis

After removing outliers, a final sample of 685 respondents for the short-term questions and 692 respondents for the long-term questions remained. In order to increase the statistical power of our model, we combined the first three points of the likert scale (very unlikely, unlikely, neither likely nor unlikely) to “not willing to adopt” and the last two points (likely, very likely) to “willing to adopt”. As such, we applied multiple binary logistic regression models to explore if any of the variables described in Table III have a significant effect on willingness to use auto-cars, auto-taxis, or auto-shuttles in the short- and long-term scenarios. All variables included in the regression analysis were checked for multicollinearity; no correlation higher than r = 0.7 was found. Lastly, the model fit statistic (Hosmer–Lemeshow test) was used to test for goodness of fit of the regression model. The Hosmer–Lemeshow test was non-significant for all models, indicating a good fit to the data. Furthermore, the attributes included in the model to test the openness to use an auto-car, auto-taxi, or auto shuttle/train explained 48%, 32%, and 46% of the variance, respectively. For the long-term situations, the model for auto-car purchase, auto-taxi subscription, and Swiss General Public Transport Pass (GA) purchase explained 44%, 31%, and 42% of the variance, respectively.

TABLE III. ATTRIBUTES SELECTED FROM SHEDS

| **Socio-economics** |
|---|
| Age in years (18–34, 35–54, 55+) / Gender (male, female) / Education (apprenticeship, high school, higher education) / Place of residence (city, agglomeration, countryside) / Household (HH) gross income per month in CHF (less than 3,000; 3,000–4,500; 4,501–6,000; 6,001–9,000; 9,001–12,000; more than 12,000) / HH structure (single person HH, couple without children, single parent with one or more children, patchwork family, non-family shared household) / HH size |
| **Mobility characteristics** |
| Train ticket (none, Swiss General Public Transport Pass (GA), half fare, point-to-point/regional) / Number of cars in HH (0, 1, 2, 3, 4, or more) / Transport mode from home to work (private car, public transportation, soft mobility bike/foot, motorbike, does not work, works from home, multimodal) / Transport mode leisure activities (private car, car-sharing, public transportation, soft mobility bike/foot, motorbike, multimodal) / Car-sharing usage (never, at least every few months) |
| **Attitudes towards mobility** |
| Importance of having own car / privacy / being comfortable / productive use of travel time / access to driving without license / access to PT / possibility to combine modes / control over the trip / safety / flexibility / mobility costs / convenience / reliability / security |
| **Attitudes toward AV** |
| Estimated improvement of the productive use of travel time / access to driving without license / access to PT / possibility to combine modes / control over the trip / safety |
| **Attitudes towards sharing** |
| Estimated improvement of flexibility / mobility costs / convenience / reliability / security |
| **Values** |
| Biospheric, egoistic, altruistic, hedonic |

## IV. RESULTS

In the following, we provide the results according to the four attribute types analyzed: socio-economic situation, mobility characteristics, attitudes, and values. Figure 1 summarizes all attributes that have a significant influence on willingness to adopt pooled-use AVs, either for short- (blue) and long-term (red) mobility decisions.

### *A. Socio-economic situation*

Older generations (55+) tend to be more willing to use public transport modes of AVs ($p \leq 0.1$) instead of the auto-car ($p \leq 0.05$) or the pooled-use auto-taxi ($p \leq 0.05$) for a single trip. However, no preferences were found for long-term decisions. With regard to gender effects, women are less willing to use a pooled-use auto-taxi for a single trip ($p \leq 0.05$) and are slightly more willing to choose an auto-shuttle/train combination ($p \leq 0.1$). Only weak effects can be associated with the urban situation. Living in agglomeration leads to slightly higher willingness to use an auto-car ($p \leq 0.1$), whereas living on the countryside decreases the willingness to subscribe to a sharing platform of auto-taxis ($p \leq 0.1$) Income seems to have a strong influence on auto-taxi use. The respondents from low-income households prefer pooled-use auto-taxis less ($p \leq 0.01$ for 3,000–4,500 CHF/month and $p \leq 0.05$ for 4,500–6,000 CHF) than those from high-income households do (> 16,000 CHF/month). Instead, those from households with income between 4,5000 and 6,000 CHF/month stick slightly more often to using or buying an auto-car ($p \leq 0.1$) and are less often willing to subscribe to an auto-taxi sharing platform ($p \leq 0.05$). With regard to the household structure, we are only able to identify the effects for couples without children compared with single households—they are more hostile toward using auto-taxis for a specific trip ($p \leq 0.05$), toward subscribing to a sharing-platform of auto-taxis ($p \leq 0.1$), and toward the GA, including auto-shuttle door-to-door services ($p \leq 0.05$). All other drivers tested within our regression model did not provide significant differences in preference, namely education attributes.

### *B. Mobility characteristics*

The respondents who currently own public transport subscriptions are more likely to use the mode combination auto-shuttle/train for a typical trip ($p \leq 0.01$), on the one hand, and to purchase the automated counterpart of the GA, on the other hand ($p \leq 0.01$ for GA hand half-fare holders). However, the subscribers of a point-to-point or regional ticket load weaker ($p \leq 0.1$) for this offer than current GA or half-fare owners do. With regard to the auto-car, we find significant effects for short-term decisions: GA ($p \leq 0.1$) or half-fare owners ($p \leq 0.01$) are less willing to use this option. With regard to car ownerships, the respondents from households with one car are more likely to be willing to use or buy an auto-car ($p \leq 0.05$). Ownership of two cars also explains willingness to purchase an auto-car ($p \leq 0.05$). Furthermore, this group is more likely to use an auto-taxi for a specific trip ($p \leq 0.05$). When we tested for the current mode choice in commuting trips, the respondents using a private car are slightly more likely to choose the auto-shuttle/train combination ($p \leq 0.1$). Furthermore, car use in leisure mobility slightly influences positively both auto-car purchase ($p \leq 0.1$) and the use of the auto-shuttle/train combination for a trip ($p \leq 0.1$). Finally, car-sharing users are slightly more likely to prefer the auto-taxi/train combination.

### *C. Attitudes*

In Table III, the effects of all attitudinal attributes included in the model are listed separately into three groups: general attitudes toward mobility (1), attitudes toward AVs (2), and attitudes toward sharing in the context of AVs (3).

(1) The attitudes that positively influence willingness to use auto-cars are as follows: importance of having an own car both with regard to a typical trip ($p \leq 0.05$) and to auto-car purchase ($p \leq 0.01$), as well as the importance of privacy ($p \leq 0.05$). Instead, importance of comfort ($p \leq 0.05$) is negatively associated for short-term mobility decisions. Access to public transport and the possibilities of combining different modes are negatively associated both for short-term ($p \leq 0.05$ for the former and $p \leq 0.1$ for the latter) and long-term decisions ($p \leq 0.1$ for the former and $p \leq 0.05$ for the latter). Interestingly, different attitudes traditionally associated with car use, such as flexibility, convenience, reliability, and security, do not provide significant results for auto-cars. When it comes to willingness to adopt pooled-use auto-taxis, the importance of possibilities to combine modes ($p \leq 0.05$), the importance of safety ($p \leq 0.05$) and the importance of flexibility ($p \leq 0.1$) are positively influencing attributes—the first for short-term mobility decisions and the latter two for long-term ones. However, the strongest predictor in our model is the importance of mobility costs for both choice situations ($p \leq 0.01$). The importance of public transport access and the importance of having control over the trip are negatively associated with auto-taxis ($p \leq 0.05$). The attitudinal attributes explaining willingness to adopt mode combinations with the auto-shuttle are the importance of access to public transport ($p \leq 0.05$ for short-term and $p \leq 0.01$ for long-term decisions), the importance of possibilities to combine modes ($p \leq 0.01$) for long-term decisions, and the importance of safety ($p \leq 0.1$) for short-term decisions. The importance of mobility costs is the strongest attitude negatively associated with the auto-shuttle for a specific trip ($p \leq 0.01$), accompanied by the importance of control over the trip ($p \leq 0.1$).

(2) Only a few effects from attitudes toward AVs explain willingness to adopt pooled-use AVs. The respondents who believe that safety improves with the introduction of AVs more likely stick to auto-car or auto-taxi use ($p \leq 0.05$) or auto-car purchase ($p \leq 0.01$). Furthermore, believing that AVs contribute to a more productive use of travel time and to more control over the trip weakly increases the likelihood of being willing to adopt auto-taxis ($p \leq 0.1$).

(3) Again, with regard to attitudes toward sharing, only a few significant effects are observed. The respondents who believe that sharing contributes to lower mobility costs state that they are less willing to purchase auto-cars ($p \leq 0.01$). When flexibility is positively associated with sharing, there is lower willingness to use auto-taxis ($p \leq 0.1$). The same is true for convenience referring to auto-car purchase ($p \leq 0.1$).

### *D. Values*

The respondents who strongly load on biospheric values are strongly hostile toward adopting auto-cars on a specific trip ($p \leq 0.01$). However, no effect has been found for auto-car purchase. At the same time, biospheric values are highly associated with willingness to use auto-shuttles, both in the short- ($p \leq 0.01$) and long-terms ($p \leq 0.05$). More or less, the opposite tendency is found for egoistic values. They go along with higher willingness to use ($p \leq 0.05$) or to purchase an auto-car ($p \leq 0.1$), as well as slightly lower willingness to use the auto-shuttle/train combination for a typical trip ($p \leq 0.1$).

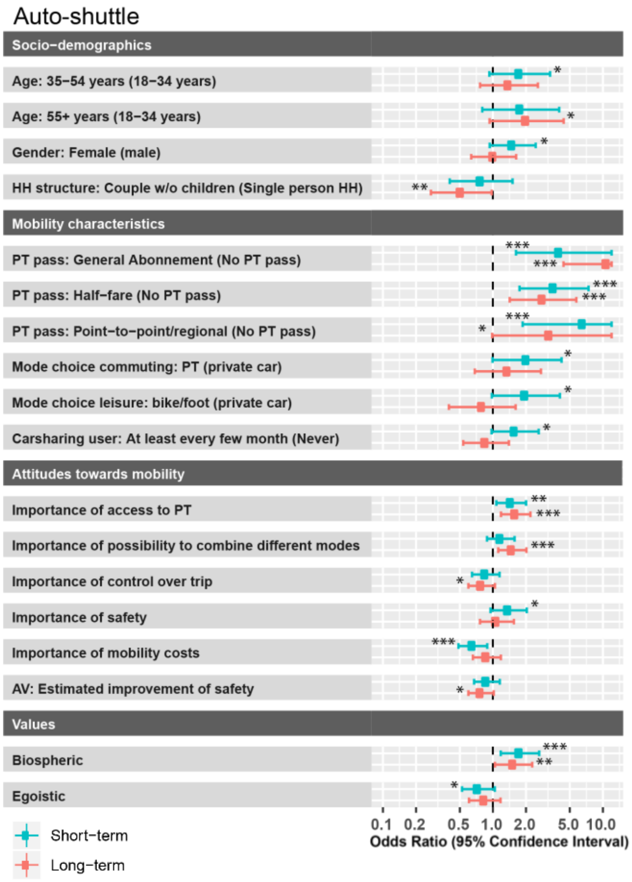


Figure 1. Drivers for willingness to use auto-car, auto-taxi, and auto-shuttle, both in the short- and long-term choice situation (***, **, and * signs on the p < 0.01, 0.05, and 0.1 levels).

## V. Discussion

As a high degree of pooling is strongly associated with the potential of AVs to contribute to more sustainable mobility, our experiment tested the willingness of users to adopt different modes of AVs: auto-cars, auto-taxis, and auto-shuttles. For RQ1, we tested socio-demographic data, current mobility characteristics, attitudes, and values in terms of whether they explain willingness of adoption. For RQ2, we differentiate between short- and long-term mobility decisions, i.e. preferences for a specific trip versus overall organization of the mobility (vehicle purchase or subscriptions to services).

Results for RQ1: The literature on AV and sharing is not univocal in terms of the socio-demographic situation (age and gender) of users. Our results suggest that younger respondents tend to stick to auto-cars and auto-taxis, whereas older respondents prefer a more transit-oriented mode of AVs. Further research is required on whether the different evaluation of taxi- or shuttle-oriented forms of pooled-use AV is systematic. Pakusch et al. (2018) [21] observed that women have a weaker tendency to shift from public transport to automated sharing. Our results are consistent with this observation, identifying women as being more hostile toward auto-taxi adoption. We capture a very interesting effect regarding income. Higher-income groups seem to have a preference for subscription to auto-taxi sharing platforms. Whereas the current literature suggests the relationship of higher income and higher auto-car use [21], our result could indicate that auto-taxis are attractive for other user groups currently not primarily associated with sharing. This finding requires further testing in future research. Analyzing current mobility characteristics, we find for auto-car and auto-shuttle options that respondents prefer remaining within their current mobility system in an AV future, which is in line with the results from the meta-analysis conducted by Whittle et al. (2019) [12]. However, we find no mobility characteristics explaining systematically the adoption of auto-taxis.

To the best of our knowledge, our study links an extensive set of attitudinal data with an experiment on AV adoption for the first time. Our exploratory analysis identifies different classic associations, such as the importance of having an own car being related to auto-car use. However, the observation on mobility costs is important, suggesting a shift from automated public transport to auto-taxis for respondents stating the high importance of this attribute. The cost structure of our experiment was chosen based on the work of [3], who suggested that auto-taxis are very likely to become the cheapest mode of transportation in the future. We observe that cost-sensitive respondents find auto-taxis an attractive transport mode, motivating them to shift away from (automated) public transport. This effect could be intensified in relation to the study of Pakusch et al. (2018) [21], who observed a similar trend for a different reason. Furthermore, our study analyzes values for the first time in the context of pooled-use AV adoption. In this context, we can confirm the classic observation that a high share of biospheric values is negatively related to individual modes (auto-cars) and positively related to public modes (auto-shuttles). Conversely, egoistic values are more linked to auto-car use. However, we do not find any value characteristic to provide an explanation for auto-taxi adoption.

Results for RQ2: To the best of our best knowledge, our data enable, for the first time, the comparison of short- and long-term mobility decisions for AV adoption. Many attributes show that transport modes are evaluated differently for the two levels of decision making. For example, referring to biospheric values, our analysis has shown a strong negative association with using the auto-car on a specific trip but no association for auto-car purchase. The same is true for half-fare owners, who are not more likely to relinquish auto-car purchase compared with respondents who are not public transport subscription holders. Conversely, we do not find income effects on auto-taxi adoption with regard to a single trip. However, after a re-evaluation of the overall mobility after housing relocation, higher-income groups significantly state that they are more willing to subscribe to an online platform of auto-taxis.

In conclusion, our experiment outcome is well explained with socio-economic, behavioral, attitudinal, and personal normative data, at least for the auto-car and mode combinations with the auto-shuttle. However, data on current mobility characteristics and values do not have significant effects with regard to the willingness of auto-taxi adoption. Together with the observation for higher income (which is surprisingly associated with auto-taxi use), this could be an indication that auto-taxis could appeal to wider customer segments and are less ideologically framed. However, this is a highly speculative statement that requires further analysis.

# REFERENCES


[1] SAE International, “Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles” https://www.sae.org/standards/content/j3016_201806/, 2018 (last access: 14/12/2019).

[2] D. Milakis, Bart van Arem, and B. van Wee, “Policy and society related implications of automated driving: A review of literature and directions for future research,” Journal of Intelligent Transportation Systems, vol. 21 (4), 2017, pp. 324–348.

[3] P. M. Bösch, F. Becker, H. Becker, and K. W. Axhausen, “Cost-based Analysis of Autonomous Mobility Services,” Transport Policy, vol. 64, 2018, pp. 76–91.

[4] E. Fraedrich and B. Lenz, “Automated driving- Individual and societal aspects entering the debate,” 93rd Annual Meeting of the Transportation Research Board, 2014.

[5] J. M. Anderson, N. Kalra, K. D. Stanley, P. Sorensen, C. Samaras, and O. A. Oluwatola, “Autonomous Vehicle Technology: A Guide for Policymakers,” Rand Corporation, 2014.

[6] J. Meyer, H. Becker, P. M. Bösch, and K. W. Axhausen, “Autonomous vehicles: The next jump in accessibilities?” Research in transport economics, vol. 62, 2017, pp. 80–91.

[7] C. Legacy, D. Ashmore, J. Scheurer, J. Stone, and C. Curtis, “Planning the driverless city”, Transport reviews, vol. 39-1, 2019, pp. 84–102.

[8] J. B. Greenblatt, and S. Shaheen, “Automated Vehicles, On-Demand Mobility, and Environmental Impacts,” Current Sustainable Renewable Energy Reports, vol. 2, 2015, pp. 74–81.

[9] F. Duarte, and C. Ratti, “The Impact of Autonomous Vehicles on Cities: A Review,” Journal of Urban Technology, vol. 25 (4), 2018, pp. 3–18.

[10] R. Cervero, “Mobility Niches: Jitneys to Robo-Taxis,” Journal of the American Planning Association, vol. 83-4, 2017, pp. 404–412.

[11] C. J. Haboucha, R. Ishaq, and Y. Shiftan, “User preferences regarding autonomous vehicles”, Transportation Research Part C, vol. 78, 2017, pp. 37–49.

[12] C. Whittle, L. Whitmarsh, P. Haggar, P. Morgan, and G. Parkhurst, “User decision-making in transitions to electrified, autonomous, shared or reduced mobility,” Transportation research Part D, vol. 71, 2019, pp. 302–319.

[13] MaaS Alliance, “What is MaaS?” https://maas-alliance.eu/homepage/what-is-maas/, 2020, (last access: 29/06/2020).

[14] F. Fagnant, and K. Kockelman, “Preparing a nation for autonomous vehicles: opportunities, barriers and policy recommendations,” Transportation research Part A, vol. 77, 2015, pp. 167–181.

[15] International Transport Forum, “Urban Mobility System Upgrade. How shared self-driving cars could change city traffic,” https://www.itf-oecd.org/sites/default/files/docs/15cpb_self-drivingcars.pdf, 2015 (last access: 14/12/2019).

[16] M. Raubal, D. Jonietz, F. Ciari, K. Boulouchos, L. Küng, G. Georges, S. Hirschberg, W. Schenler, B. Cox, R. Kannan, R. Rudel, F. Cellina, N. Kovacs, M. Hoppe, and R. Michl, “Towards an Energy Efficient and Climate Compatible Future Swiss Transportation System: Working paper,” https://www.sccer-mobility.ch/export/sites/sccer-mobility/capacity-areas/dwn_capacity_areas/TowardsAnEnergyEfficientSwissTransportationSystem_Ver1.2.pdf, 2017 (last access: 14/12/2019).

[17] D. Fagnant, and K. Kockelman, “Dynamic ride-sharing and fleet sizing for a system of shared autonomous vehicles in Austin, Texas,” Transportation, vol. 45 (1), 2018, pp. 143–158.

[18] Z. Wadud, D. MacKenzie, and P. Leiby, “Help or hindrance? The travel, energy and carbon impacts of highly autonomous vehicles,” Transportation Research Part A, vol. 86, 2016, pp. 1–18.

[19] Z. Wadud, “Fully autonomous vehicles: a cost of ownership analysis to inform early adoption,” Transportation Research Part A , vol 101, 2017, pp. 163–176.

[20] R. Krueger, T. Rashidi, and J. Rose, “Preferences for shared autonomous vehicles,” Transportation Research Part C, vol. 69, 2016, pp. 343–355.

[21] C. Pakusch, G. Stevens, A. Boden, and P. Bossauer, “Unintended Effects of Autonomous Driving: A Study on Mobility Preferences in the Future,” Sustainability, vol. 10 (7), 2018, pp. 1–22.

[22] T. Stoiber, I. Schubert, R. Hoerler, and P. Burger, “Will consumers prefer shared and pooled-use autonomous vehicles? A stated choice experiment with Swiss households,” Transportation Research Part D, vol. 71, 2019, 265–282.

[23] R. A. Acheampong, and F. Cugurullo, “Capturing the behavioural determinants behind the adoption of autonomous vehicles: Conceptual frameworks and measurement models to predict public transport, sharing and ownership trends of self-driving cars,” Transportation Research Part F, vol. 62, 2019, 349–375.

[24] I. Walker, G. O. Thomas, and B. Verplanken, B., “Old habits die hard: travel habit formation and decay during an office relocation.” Environmental Behavior, vol. 47, pp. 1089–1106.

[25] M. Matyas, and M. Kamargianni, M., “Exploring Individual Preferences for Mobility as a Service Plans: A Mixed Methods Approach”, MaaSLab Working Paper Series, vol. 18-02, 2018.

[26] J.C. Zoellick, A. Kuhlmey, L. Schenk, D. Schindel, and S. Blüher, “Amused, accepted, and used? Attitudes and emotions towards automated vehicles, their relationships, and predictive value for usage intention,” Transportation Research Part F, vol. 65, 2019, pp. 68–78.

[27] C. A. Spurlock, J. Sears, G. Wong-Parodi, V. Walker, L. Jin, M. Taylor, A. Duvall, A. Gopal, and A. Todd, “Describing the users: Understanding adoption of and interest in shared, electrified, and automated transportation in the San Francisco Bay Area,” Transportation Research Part D, vol. 71, 2019, pp. 283–301.

[28] N. Menon, N. Barbour, Y. Zhang, A. R. Pinjari, F. Mannering, “Shared autonomous vehicles and their potential impacts on household vehicle ownership: An exploratory empirical assessment,” International Journal of Sustainable Transportation, vol. 13 (2), 2019, pp. 111–122.

[29] R. Hoerler, A. Stünzi, A. Patt, and A. Del Duce, “What are the factors and needs promoting mobility-as-a-service? Findings from the Swiss Household Energy Demand Survey (SHEDS)”, European Transport Research Review, vol. 12 (1), 2020.

[30] M. Rokeach, “Beliefs, attitudes, and values,” San Francisco: Jossey Bass Publishers, 1976.

[31] L. Steg, G. Perlaviciute, and E. Van der Werff, “Understanding the human dimensions of a sustainable energy transition,” in T. Brosch, D. Sander and M. K. Patel, “Understanding the human factor of the energy transition,” Lausanne: Frontiers Media, 2016, pp. 10–25.

[32] P. Burger, V. Bezençon, B. Bornemann, T. Brosch, V. Carabias-Hütter, M. Farsi, S. L. Hille, C. Moser, C. Ramseier, R. Samuel, D. Sander, S. Schmidt, A. Sohre, and B. Volland, “Advances in understanding energy consumption behavior and the governance of its change – outline of an integrated framework. Frontiers in Energy Research, vol. 3, 2015, pp. 1–25.

[33] S. Weber, P. Burger, F. Mehdi, A. Martinez-Cruz, M. Puntiroli, Il Schubert, B. Volland, “Swiss Household Energy Demand Survey (SHEDS): Objectives, Design, and Implementation,” SCCER CREST (Swiss Competence Center for Energy), https://www.sccer-crest.ch/fileadmin/FILES/Research/Weber_Burger_et_al_2017_SHEDS_Official_description.pdf, 2017 (last access 12/14/2019).

[34] Bundesamt für Statistik, Bundesamt für Raumentwicklung, “Verkehrsverhalten der Bevölkerung. Ergebnisse des Mikrozensus Mobilität und Verkehr,” https://www.bfs.admin.ch/bfs/en/home/news/whats-new.assetdetail.1840477.html, 2017 (last access: 12/14/2019).