Identifying the factors affecting the use and adoption of urban air mobility

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Abstract

Transportation systems in urban environments are facing an increasing number of challenges. Growing mobility demand imposes additional pressure on existing infrastructure and public transportation systems, leading to the need for a shift towards sustainable transportation (Rodrigue et al., 2016). The deployment of shared mobility services are providing users with more efficient travel, characterized by a lower demand for parking spaces, lower vehicle ownership, but also reduced environmental impacts resulting from lower emissions (Baptista et al., 2014). At the same time, autonomous vehicles promise safe and comfortable transportation, and most automobile manufacturers are likely to launch fully autonomous vehicles in the coming decade (Bimbraw, 2015). This trend leads to a research interest in ground shared autonomous mobility (Fagnant & Kockelman, 2014) and possibly to the exploration of the third dimension: the skyscape. The latter has gained a growing interest, notably observed in the so-called"urban air mobility (UAM)" research community. Different business models for the service have emerged; for instance, Airbus (2017) introduced UAM as the on-demand sharing mobility operated by fully-automated vertical take-off and landing aircraft (VTOL) for intra-city passenger trips. Still, this mobility concept is constrained to many aspects related to regulations, infrastructure availability, air traffic control, environmental impacts, but also community acceptance (Vascik, 2017). Relevant research is focusing on different aspects of urban air mobility; for instance, modeling the service using agent-based simulation (Rothfeld et al., 2018) or understanding its implications and the changes it brings on the inhabitants and the city (Straubinger & Verhoef, 2018). However, compared to ground autonomous vehicles, only little has been done to investigate the acceptance of this mobility service. Recently, Fu (2018) conducted a study in Munich on passenger adoption through choice modeling in a UAM environment.

In an attempt to expand research on UAM, this study aims to identify the factors that affect the use and adoption of UAM outside a mode choice context, to be able to develop a framework for UAM acceptance in general and its time adoption in particular. The investigation is based on the development of a novel stated preference survey design with time adoption as a dependent variable. The designed survey aims to reveal significant factors in the adoption of this service and includes common factors in technology and automation adoption, mostly from ground autonomous vehicles acceptance studies. First, a pilot study is conducted to gain useful insights on potential biases in the survey design, which are then incorporated in the final survey that was published online. The survey was publicly available for two months starting the 18th of July 2018. The survey was structured in four parts, with a total of 31 questions (or question groups[1]) and required around 10 to 15 minutes to be completed. The first and last parts of the survey targeted respondents' travel behavior and socio-demographics, respectively. In the second part, UAM was introduced by presenting some of its properties found in the pertinent literature. At the end of this part, the stated preference question on the intended time adoption was presented and respondents were asked to state when they were most likely going to use UAM. Alternatives included options ranging from the first year of operation (Y1), the second or third years of operation (Y2-Y3), the fourth or fifth year of operation (Y4-Y5),

[1] A question consisted sometimes of a matrix including several agreement statements, focusing on one attribute for instance.

starting the sixth year of its operation (Y6+), to never (non-adopters), and unsure (uncertain adopters). The second and third parts of the survey aimed at investigating some aspects that affect automation and perceived as latent variables. Therefore, several questions were asked in the form of five-point Likert scale agreement statements to reveal the hidden variables; for instance, these included data and ethical concerns, value of trust and safety (or even the locus of control), cost perception, value of travel time savings, social attitudes such as the familiarity with various on-demand services (Airbnb, DriveNow/Car2Go, Uber, BlablaCar), the use of social media platforms (Facebook, WhatsApp, Instagram, Twitter), the comfort with online services (online booking, banking, shopping), with flying, the willingness to share a ride (such as in a taxi or BlaBlaCar) with strangers, the enjoyment of driving a car, the environmental awareness, and previous crash experiences. The methodology of this study consisted of a preliminary analysis of the survey results, followed by two commonly used analysis techniques: exploratory factor analysis and discrete choice modeling, namely multinomial logit model and ordered logit model.

The survey generated 221 responses, with a subsample of 97 respondents from the Munich region. Among the 221 respondents, 36.65% -i.e. the majority- stated that they would adopt UAM in the second or third year of its implementation, followed by 22.17% claiming an adoption during its first year, 14.03 % during its fourth and fifth year, 2.71 % starting its sixth year, and 3.17 % of non-adopters. Moreover, 21.27% of the respondents expressed uncertainty ("unsure") about their intended time adoption of UAM. The analysis of the results highlighted the importance of safety for UAM adoption as the majority of respondents (more than 50 %) ranked it as the most important factor in their intention to adopt UAM. Also, a strong indication towards the importance of UAM costs, trip duration, on-time reliability, and operation characteristics was observed. The analysis of the attitudes of different demographics showed the importance of these factors and their influence on the adoption intention. For instance, females were found to have a lower tendency of being early adopters and a higher of being "unsure" about their adoption time. This was also confirmed by an overall higher affinity to automation by male respondents due to a higher enjoyment and trust of automated systems, more experience in advanced driver assistance systems, and a higher perception of usefulness of such systems and of UAM. On the other hand, females seemed to accord a higher level of importance to service reliability (as a prerequisite for trust), the loss of jobs due to automation, and cyber-security in the context of UAM. In terms of safety requirements, females showed higher expectations in terms of the presence of in-vehicle cameras and more stringent requirements for an operator on the ground and to override the vehicle in case of emergency. A qualitative analysis of the comments left at the end of the survey showed skepticism on UAM's environmental impacts including noise and visual pollution, economic impacts, safety, purpose of use, and privacy concerns. Respondents also expressed their desire for a system integration of UAM (with the existing and future transportation systems), for information sharing inside the vehicle, and for a high frequency service with on-demand availability.

The exploratory factor analysis reduced the number of variables in the second and third parts of the survey from 20 and 17 variables to 11 and 10 variables, respectively. The new factors revealed underlying patterns in the datasets as well and were grouped into value of time savings, affinity to automation, data concerns, safety concerns, affinity to online services, environmental awareness, affinity to social media, and affinity to sharing. Multinomial logit models showed that adoption was ordered as attributes showed patterns across the different time adoptions. Overall, affinity to automation, data concerns, social attitudes, and socio-demographics were shown as highly influential in the time adoption of UAM. The ordered model also classified uncertain respondents as having a similar behavior to non-adopters or late adopters; the "unsure" category was ranked between late and non-adopters and could also be merged with them. The model findings pertaining to acceptance in general were incorporated in an extended Technology Acceptance Model for the application of UAM, where trust played a significant role and was in turn positively impacted by the perceived reliability of automation, the perceived vehicle's safety, the perceived locus of control, the previous experience with automation, and the service provider's reputation; data concerns in contrast negatively influenced trust. In this model (Figure 1), socio-demographics and affinity to automation were overarching parameters; perceived usefulness, social behavior, value of time, perceived costs and data concerns were all contributing factors in the behavioral intention. Perceived ease of use (in this case service booking or board-

ing) was not observed as influential and was therefore removed from the model. The findings of this work provide meaningful insights on UAM acceptance and use with strong recommendations and policy implications, such as according a higher importance to safety considerations, service attributes, and automation awareness especially for less enthusiastic groups.

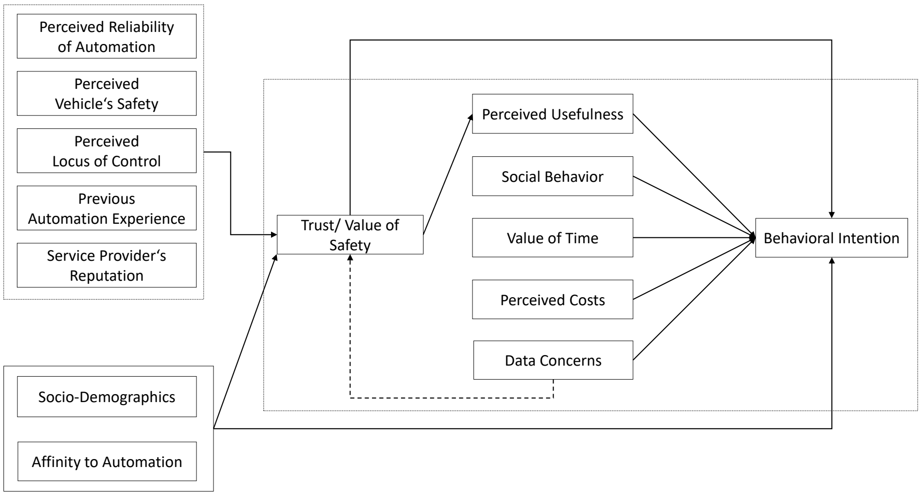

Figure 1: Extended Technology Acceptance Model for urban air mobility

Keywords: urban air mobility, adoption, acceptance, technology acceptance model, perception, stated preference

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