Contributory Factors Affecting Willingness to Use Shared Autonomous Vehicles in Greece

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SHORT SUMMARY

The aim of this paper is to investigate the factors that affect willingness to use Shared Autonomous Vehicles in Greece. To achieve this goal, an on-line questionnaire survey was designed and distributed via various different channels, with a final sample size of 164 questionnaires. The designed questionnaire explored modal choice through a stated preference experiment, while revealed preferences related travel characteristics, traveler perceptions and attitudes, as well as demographic characteristics were also collected. Statistical analysis was performed through the design of multinomial logit models, with the dependent variable being modal choice. Results indicated several contributory factors including travel cost, travel time, trip purpose, transport mode, preferences and attitudes considering privacy and flexibility, technology familiarisation and traveller age and income. The results of this work can be utilized for the design of targeted policies towards promoting the use of shared autonomous vehicles in the future.

Keywords: shared autonomous vehicles, discrete choice analysis, questionnaire survey, smart urban mobility.

1. INTRODUCTION

Urban transport policies and their respective aims and focus display substantial changes over the years. In the 80's the term "integrated" transportation system was introduced, and comprised the design objective throughout the 80's and 90's (May and Gardner, 1989). This was replaced by the "sustainable" transport system in the 00's (Gudmundsson et al., 2005), while policy and decision makers, researchers and practitioners now opt for "smart, equitable and green cities" (Batty et al., 2012; Ahvenniemi, et al., 2017). Autonomous shared mobility services provide a promising alternative transport mode offering all three elements of such cities. The objective of

this research is to explore factors affecting citizens' willingness to use shared autonomous vehicles (SAVs). SAVs may be public or private, and can serve successive trips performed by single passengers or several passengers performing overlapping trips (Lavieri and Bhat, 2019).

Traveller preferences considering such systems are affected by various factors, which are associated with the pros and cons of autonomous vehicles and shared services. Several researchers have explored elements related to traveller acceptability and willingness to use either autonomous vehicles or shared services. However, research on SAVs is not as extensive. The main motive for travellers to use SAVs is the low cost associated with their use (König and Grippenkoven, 2019), due to which their use is anticipated to precede the wide distribution of autonomous vehicles (Carteni, 2020). Safety and security issues on the other hand, comprise a discouraging factor (Carteni, 2020). While additional contributory factors have been found to be travel time (Lavieri and Bhat, 2019), trip purpose (Lavieri and Bhat, 2019), traveller gender (Abraham et al., 2017), age (König and Grippenkoven, 2019) and income (Howard and Dai, 2013; Lavieri and Bhat, 2019). The present research explores willingness to use SAVs, and considers the already established contributory factors via a stated preference questionnaire survey.

2. METHODOLOGY

Questionnaire Survey

A questionnaire was designed to collect the necessary data, comprising of 4 sections. The first section of the questionnaire collected information considering trip characteristics, for example, typical trip duration, purpose, transport mode, walking frequency and so on, familiarisation with different technologies and applications, and perceptions relative to factors affecting modal choice. The second section explored traveller perceptions and attitudes considering the environment, safety and productivity, while the fourth section collected sociodemographic data. A stated preference experiment was designed, and formed the main part of the questionnaire (3^{rd} section). A short description of SAVs accompanied by an SAV picture was presented at the front "page" of the survey, to make clear to respondents what an SAV is and what it would look like. In the 3^{rd} section of the questionnaire participants were asked to select the transport mode they would use between private car, public transport and SAV under a number of set scenarios. These were defined through the variables of trip cost and trip duration. The latter was determined by the different elements of: time inside the mode, walking time and waiting time, thus leading to a total number of 10 different variables, with 3 levels each (Table 1), resulting in 3^{10} different scenarios. Appropriate software (Ngene) was utilized to apply a fractional factorial design ensuring orthogonality leading to a subset of 27 scenarios, divided in three blocks of 9 scenarios each.

Table 1: Variables and variable levels

Variable	Level 1	Level 2	Level 3
Private car cost (€)	4.5	6	7.5
Public transport cost (€)	0.7	1.2	1.7
SAV cost (€)	1.5	3	4.5
Private car time inside (mins)	15	25	45
Public transport time inside (mins)	10	20	30
SAV time inside (mins)	10	20	30
Public transport walking time (mins)	5	10	15
SAV walking time (mins)	2	6	10

Public transport waiting time (mins)	5	10	20
SAV waiting time (mins)	2	6	15

It should be noted that generally lower trip times (inside the mode) were allocated to the SAV and public transport, as it is anticipated that they will have access to dedicated traffic lanes with lower traffic flow volumes and higher driving speeds. Furthermore, SAVs provide more tailored services compared to public transport, thus lower walking and waiting times are selected. It should be noted though, that this is not a pattern that is followed in all scenarios, i.e. some scenarios may present higher times for SAVs compared to public transport, or lower times inside the vehicle for private cars compared to public transport and SAVs.

The questionnaire was distributed on-line via various channels, while effort was made to achieve a somewhat equal distribution of the three different blocks in the collected data. The questionnaire survey had a two-three month duration, and the final sample size was 164 questionnaires, yielding a total of 1476 (164x9scenarios) modal choice answers.

Statistical Analysis

Discrete choice analysis was performed, and in particular, multinomial logit models were designed in RStatistics Programming Language, in the RStudio environment utilizing the "mlogit" library. The independent variable was the modal choice that the survey respondents' had made under each scenario, while the dependent variables were the scenario parameters (which differed for each scenario) and the data from the 1st, 2nd and 4th questionnaire sections (which only differed between participants).

3. RESULTS AND DISCUSSION

Table 2 presents the sample characteristics.

Table 2: Sample characteristics

Variable	Level	Number
Gender	Male	72
	Female	91
	Other	1
Age group	<18	4
	18-25	56
	26-35	59
	36-45	19
	46-55	16
	56-65	7
	>65	3
Family status	Single	86
	Married/relationship	73
	Widow/er	1
	Divorced	4
Household members	1	26
	2	41
	3	32
	4	50
	>4	15
Number of	0	11

vehicles in the household	1	60
	2	64
	>2	29
Accessibility frequency to household vehicles	Never	14
	Rarely	7
	Sometimes	19
	Often	29
	Always	95
Residence area type	City centre	70
	Suburb	84
	Rural	10
Monthly family income (€)	<900	22
	901-1500	48
	1501-2500	44
	2501-3750	25
	3751-5000	5
	>5000	14
	na	6

Women constitute about 55% of the total sample size. In the most recent population census about 51% of the Greek population were women, thus the sample displays a representative gender distribution. At the same time, the vast majority of the survey respondents were rather young, as the age groups 18-25 and 26-35 consisted about 70% of the total sample size. Overrepresentation of young people is a potential issue in web-based surveys, and possibly different dissemination channels should have been sought. However, assuming that SAVs will not operate in the near future, these people will comprise the most active part of the population when SAV services will be offered. Under this perspective, further representation of older people was not sought.

The distribution of the main mode used at present for a typical trip was calculated to be 56.7% for the private car (as a driver), 3.7% for the private car (as a passenger), 4.3% for the motorcycle, 27.4% for public transport and 7.9% for walking/cycling. Initial descriptive analysis indicated that out of the 1476 scenarios, the private car was selected in 553 scenarios (37.47%), public transport in 429 (29.06%), while the SAV was selected in 494 scenarios (33.4%). Last, the number of participants selecting the same transport mode irrespectively of the scenario characteristics was 15 respondents who always chose the private car (13 of which had noted to be using their private car as their main transport mode), 2 respondents always selecting public transport and 1 respondent always selecting the SAV.

Table 3 presents the results of the multinomial logit model design considering the selection of public transport and SAV over the private vehicle.

Table 3: Multinomial logit model

Variables	**Estimate**	**Std. Error**	**z-value**	**Pr(>|z|)**
Cost	-0.261	0.036	-7.222	5.14E-13
PUBLIC TRANSPORT RELATED PARAMETERS				
Constant	-1.483	0.827	-1.793	0.0729835
Scenario Parameters				
Time inside the vehicle	-0.072	0.008	-8.609	< 2.2e-16
Walking time	-0.060	0.016	-3.686	0.0002274
Waiting time	-0.082	0.011	-7.338	0.0000000

Trip characteristics				
Main trip purpose [work/education]	-0.752	0.228	-3.292	0.0009933
Main transport mode [walking/cycling]	0.538	0.340	1.581	0.1138271
Main transport mode [private car as a driver]	-0.743	0.185	-4.006	0.0000618
Utilizing more than one modes in a typical trip	0.259	0.093	2.802	0.0050819
Walking more than 500m in a typical day	0.211	0.070	2.994	0.0027568
Perceptions on factors affecting modal choice				
Trip cost	0.410	0.084	4.870	0.0000011
Privacy	-0.215	0.083	-2.583	0.0098032
Independence/flexibility	0.197	0.092	2.126	0.0335277
Familiarisation (use frequency)				
Pc/laptop	0.216	0.088	2.468	0.0135881
Public transport telematic application	0.275	0.070	3.955	0.0000764
Perceptions				
Vehicle emissions affect my selection of transport mode	0.178	0.084	2.117	0.0342813
When I am in a vehicle with other passengers I am cautious	-0.243	0.078	-3.092	0.0019913
During my trip as a passenger I find time to finish some tasks	0.153	0.070	2.177	0.0294514
Sociodemographic				
Age group	0.011	0.008	1.432	0.1520670
Income	-0.227	0.056	-4.057	0.0000497
SAV RELATED PARAMETERS				
Constant	-3.634	0.740	-4.911	0.0000009
Scenario Parameters				
Time inside the vehicle	-0.071	0.008	-9.131	< 2.2e-16
Walking time	-0.077	0.019	-3.983	0.0000681
Waiting time	-0.069	0.012	-5.794	0.0000000
Trip characteristics				
Main trip purpose [work/education]	0.517	0.239	2.161	0.0307015
Main transport mode [walking/cycling]	0.987	0.343	2.880	0.0039750
Main transport mode [private car as a driver]	-0.090	0.181	-0.496	0.6201237
Utilizing more than one modes in a typical trip	0.195	0.090	2.166	0.0302856
Walking more than 500m in a typical day	0.211	0.067	3.167	0.0015416
Perceptions on factors affecting modal choice				
Trip cost	0.206	0.077	2.674	0.0074980
Privacy	-0.242	0.080	-3.041	0.0023561
Independence/flexibility	0.174	0.086	2.034	0.0419915
Familiarisation (use frequency)				
Pc/laptop	0.068	0.077	0.879	0.3793685
Public transport telematic application	0.403	0.067	6.009	0.0000000
Perceptions				
Vehicle emissions affect my selection of transport mode	0.162	0.080	2.022	0.0431399
When I am in a vehicle with other passengers I am cautious	-0.087	0.071	-1.212	0.2256748
During my trip as a passenger I find time to finish some tasks	0.188	0.067	2.829	0.0046692
Sociodemographic				
Age group	0.040	0.007	5.893	0.0000000

Income	-0.079	0.049	-1.618	0.1055884
Log-Likelihood	-1270.3			
Initial Log-Likelihood	-1613.7			
McFadden	0.21278			
Likelihood ratio test (p.value $\leq 2.22e^{-16}$)	686.73			

Several parameters were found to affect modal choice, including parameters associated with scenario characteristics, trip characteristics, traveller perceptions, familiarisation with technology and applications and sociodemographic characteristics. The constant for both public transport and SAVs is negative indicating a reduced probability of being selected over the private car. It should be noted that in the scenario design, all participants were assumed to have access to a private car, which is not always the case. Time, whether walking or waiting, presents negative utilities for both modes, while four other factors presented negative values. These were using the private vehicle as the main transport mode (only for public transport), valuing privacy in modal choice, being affected by the presence of other passengers and family income.

4. CONCLUSIONS

The present study explores willingness to use SAVs over the private car and public transport. Considering the first alternative, SAV use is mainly associated with lower cost, different safety levels (others anticipate it as more safe, others as less safe), while it allows travellers to utilize the time inside the vehicle to perform other tasks (from reading a book, to working). Compared to public transport SAV offers a more personalized service, with reduced trip duration, higher comfort levels, but is associated with higher costs.

The approach followed in this work involved the design of a stated preference questionnaire survey on modal choice, where respondents had to choose their transport mode between private car, public transport and SAV under specific given scenarios. The questionnaire was distributed on-line, and data was collected for 164 travellers yielding a total of 1476 scenarios. A multinomial logit model was designed to explore the factors affecting SAVs and public transport preferences over the private car, and reveal potential patterns.

Results indicated that public transport and SAVs present similarities and differences as anticipated, while several factors were found to affect the choice of SAVs. Considering time, time inside the vehicle displayed negative values, reducing their use probability over the private car. The mode estimates though were quite similar between the public transport and SAVs. This indicates that travellers perceived their time spent inside the shared vehicles in a similar manner. Still, SAVs are expected to be more spacious (space allocated per passenger) and a seat is expected to be guaranteed for all travellers, which the respondents might not have been aware or considered. On the other hand, respondents demonstrated higher expectations for SAVs considering walking time compared to public transport, and lower expectations considering waiting time. Still, the differences were not that great.

A substantial difference is observed considering main trip purpose. Travellers, whose main trip purpose was work or study, preferred the private car over public transport, while they preferred SAVs over the private car. This might be a key element when promoting SAV use in the future. Considering factors affecting modal choice, three were found to affect SAV use, however presenting similar behaviour between public transport and SAVs. These were trip cost, privacy and independence/flexibility. Travellers who value their privacy presented higher probability to use

a private vehicle, while travellers who consider trip cost and flexibility when selecting a transport mode preferred SAVs over the private vehicle. Privacy is an issue for SAVs, however, SAVs can be also utilized for single passengers increasing their popularity and targeting such population. At the same time, travellers whose main transport mode is the private car do not present statistically significant differences in preferences between the private car and the SAV. This is promising, as main objective of SAVs adoption is the shift from private transport to SAVs.

SAVs are also appealing to travellers whose modal choice is ecologically conscious, as results indicated that they prefer public/shared transport to private. Last, travellers who feel cautious in the presence of co-passengers are less probable to use public transport over the private car, while this factor does not seem to affect them in the choice of SAVs. Considering sociodemographic characteristics, only age was found to affect travellers' selection of SAVs over the private vehicle, with travellers' preference of SAVs over the private car increasing with age. It should be noted though that the majority of the explored population was young people. SAVs are also anticipated to be a valuable service for older drivers with reduced driving capabilities. Traveller gender or income were not found to affect travellers' willingness to use SAVs over the private car.

The present study is a first attempt to explore factors affecting travellers willingness to use SAVs in Greece, and can form the basis of further research and the determination of targeted policies to increase SAV acceptance and use when they become operable in the future.

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