Factors of successful implementation and diffusion of services based on autonomous vehicles: users' acceptance and operators' profitability

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Abstract

The use of autonomous vehicles (AVs) is becoming more and more likely as they offer promising solutions to improve urban mobility. They have the potential to reduce energy consumption and traffic jams. As a result, they could replace a significant part of other modes of transport and provide more dynamic services to users. This paper examines the level of receptiveness of AVs while considering their adoption time, user attitudes, and their intention to share AV-trips. We explore the results of a stated-preferences survey, conducted among 600 people in Palaiseau, a city south of Paris. Collected data is analysed using a reduced dimensional space that is dedicated to the field of multifactorial analysis (MFA) in order to apply a hierarchical cluster analysis (HCA) and to segment the surveyed population. Five classes were identified on the basis of (i) socio-demographic criteria of the respondents; (ii) their mobility habits; and (iii) how they use AV cars. The classes were entitled: Conservatives (22% of the sample), Sceptics (14%), Late adopters (21%), Early Adopters (25%) and Explorers (18%). The results of an economic analysis indicate the implications for operators and public policies designed to encourage optimal forms of adoption in terms of fare and level of service.

Keywords: users' acceptance, stated-preference survey, autonomous shuttles, clustering analysis, business models, service performances

JEL Code: R4

1. Introduction

1.1. Context

Autonomous Vehicles (AVs) can be defined as vehicles used to move passengers or freight with some level of automation that aims to assist or replace human control [1]. In particular, the Society of Automotive Engineers (SAE) has defined six levels of automated functionality [2], ranging from fully manual (Level zero) to full automation (Level five). The classification is based on the degree of driver intervention required rather than vehicle capabilities. It implies no particular order of market introduction. As of 2020, automakers have reached Level 3 (i.e. conditional automation), and Level 4 (i.e. high automation) has been tested without a human in the driver seat on public roads [3, 4, 5]. Therefore, this study will focus on the high automation level (Level 4), as the next targeted automation level and an inevitable step to reach full automation.

There are many reasons for the growing interest in AV technology [6]. Probably one of the most important motivations of developing AV technology is the wide belief that major safety challenges associated with motorized vehicles could be overcome thanks to automation. According to the World Health Organization (WHO), over 3,400 people die on the world's roads every day and 20 to 50 million of people are injured or disabled every year [7]. The National Highway Traffic Safety Administration (NHTSA) found that 94 % of crashes in USA in 2017 were human caused [8]. Social benefits also include the potential to increase trip comfort by enabling people to be less stressed and more productive while traveling. Thus, traveling generalized costs would be significantly lower due to the drastic cut of driving costs. Moreover, accessibility to jobs, education and health care will be improved, especially for elderly and disabled persons, the latter generating benefits to the economy as a whole. From an environmental perspective, automation would most likely be combined to electric vehicles. Consequently, AVs are expected to contribute to air pollution and greenhouse gas reduction, and thus improved public health.

AVs are also expected to generate systemic changes in urban mobility and even reshape cities. They will enable cities to actively manage available parking spaces, reduce 'dead miles' travelled in search of parking space, and reduce congestion in city downtown areas. On the other hand, by providing better convenience to passengers, the adoption of AVs is likely to increase car travel (i.e. caused by the shift of people from public transport to AVs or the increase of daily trips and general mobility). Finally, on the microeconomic side, reduction of transportation costs will induce a significant increase in users' purchasing power. On the other hand, the demand of new conventional vehicles will plummet, which could result in total disruption of the car value chain (manufacturers, maintenance companies, insurance companies, etc.), while new products and services around autonomous driving will emerge, including mobile apps, special equipment, MaaS, and infrastructure [9]. For car manufacturing stakeholders, two adaptation options seem possible: becoming high-volume assemblers of AVs, or providers of AV-based services [10]. Goldman Sachs Group Inc. predicts that autonomous taxis will help the shared mobility services grow from 5 billion USD in revenue today to 285 billion USD by 2030 [11]. Moreover, without drivers, operating margins could be in the 20 percent range, more than twice what automakers generate today. In any case, both strategies will be characterized by high levels of competition and with new entrants from other industries.

1.2. Literature review

In view of the above, it seems necessary to prepare the development of autonomous roadway mobility. Among the main challenges that have been identified in the European [12], American [13] and Asian contexts, we can cite: users' acceptance, policy and regulation laws (to encourage deployment and testing), infrastructure equipment (e.g. advanced communication, near-perfect pavement, etc.) and technology development (e.g. vehicles' perception and connectivity, etc.). In order to deal with these challenges, it has been general practice in several countries to encourage the deployment of level 4 pilots and level 3 Field Operational Tests (FOT), in order to gain users' acceptance and to validate vehicles' technology [14]. Threlfall [15] have developed an index based on factors affecting autonomous vehicle development, in order to measure how 25 countries are guiding autonomous vehicles. Netherlands ranked first overall in the report thanks to the developed infrastructure and high level of users' acceptance. Singapore came in first in terms of policy and legislation and the users' acceptance. Users' acceptance, indeed, have been identified with the emergence of new business models as a key to understanding the development of autonomous cars [16].

In order to assess users' acceptability, several studies were conducted using online surveys [17, 18], interviews and paper-based surveys [18] and/or focus groups interviews [19]. One of the first studies was conducted online in 2012 and have involved about 17400 U.S vehicle owners [20]. In general, online surveys enabled to reach a wide enough number of participants: 556, 2039, 2167, and 8500 US respondents in respectively [17], [21], [22] and [23]; but also to perform cross-countries surveys: [24] questioning 4886 respondents from 109 countries, [25] questioning 23000 from 19 countries, [26] involving 7755 persons from 116 countries and [27] 1533 from US, UK and Australia. In France, [18] combined in 2014 online surveys with interviews and paper-based surveys. In particular, they used interviews and paper-based surveys (5 and 45 respondents resp.) to elicit public motivations and concerns, then the online survey have enabled to infer the results to the general population with a sufficient sample size. Similarly, [28] collected answers of 779 participants by combining paper-based and online questionnaires. They found that experience and knowledge of AV, such as taking a test ride, will help to enhance the intention to use AVs. Even if interviews and paper-based surveys could be more costly than online surveys, they are more adapted to explore the relevance of a concrete service. Indeed, users of AVs would be more open to new technologies, inducing then a bias in online surveys which involve only web users. The number of paper-based surveys is very limited: [29] conducted a survey in Berkeley in 2014 and found that among the 107 respondents, 45% would not use an AV-based taxi service. [17] have interviewed 44 persons and showed that 50% of the sample would use the AVs every day while 23% would be motivated by reduction of vehicle ownership. [30] realized a questionnaire study among 384 individuals who physically experienced an automated shuttle on an office campus in Berlin. Therefore, in addition to being rarely used, face-to-face SP surveys have involved low numbers of respondents.

Focusing on the acceptability of the new technology, several issues were addressed: [31] whether users regarded the technology as important, [22, 32, 33] expected frequency of the technology's use, [24, 18, 34] acceptance rate , and [35] modal choice vs alternative modes. Some other studies focused on the issue of willingness to pay for using autonomous vehicles [22, 35, 36], proposing in some experiments to pay an option of a premium feature to enjoy autonomous functions [22, 24, 20, 27]. [35, 37, 38] have found that users' willingness to share

rides vary by trip type and depend on added travel times. They suggested that discounted fares for sharing rides encourages dynamic ridesharing. [39] have showed that the willingness to pay (WTP) to share rides will rise over time, for a variety of reasons. Shared autonomous vehicles use will be particularly popular for long-distance business travel and when used in tandem with smart pricing. In addition, elasticity estimates have suggested that privacy may not be an important concern in the future for AV-based travel.

On the other hand, some research studies were interested in linking the use of autonomous vehicles to sociodemographic variables [18, 19, 24, 34] or to the trip characteristics [19, 22, 40, 41]. In particular, most of these studies have suggested that younger men [22, 27, 20, 42, 43, 44, 45] and persons living in urban areas [20, 22] would be more open to AVs. Only [30] and [34] observed a stronger intention to use AVs with an increasing age. Assessing the income of the respondents as a factor, [22], [24] and [36] found that higher-income participants were willing to pay more for an automation feature. However, none of the existing studies showed that income have a significant effect on the intention to use an AV-based service. [26] suggested that the GDP per capita of the respondents' country was predictive of countries' mean general acceptance. On the other hand, they observed that correlations between sociodemographic characteristics and general acceptance are low.

Regarding the impact of trip characteristics, [35] and [41] have stated resp. that the trip purpose and the trip distance do not have a significant effect on the intention to use AVs. On the other hand, [46] showed that the effect of current travel characteristics on AV adoption is significant : respondents who drive alone to work, those who travel less than 30 minutes every day for all their trips and those who travel less than 8 km for their commute are less unlikely or extremely unlikely to adopt an AV.

Finally, few cross-countries surveys have investigated the regulation aspects as fundamental to the successful adoption of AVs [47, 48, 49, 50]. They showed that today there is no clear and commonly shared regulation for AVs and their operation on the road. [51] have stated that automation technology may be rejected by people because they are not certain of what is legal and what is illegal in terms of its use. Therefore, while new laws still in process, policies should be defined in order to suit the new traffic regime [52] and to enable the broad introduction of highly and conditionally automated vehicles [53]. In addition, [54] have identified security, liability, cybersecurity, privacy, and industry influence as the main potential risks that can hinder AVs' acceptance.

In most of these studies, surveys' analysis is based on descriptive statistics to assess the acceptability of using autonomous vehicles. The classification of users' profiles is proposed in a limited number of studies [35]. However, this classification is a necessary input for operators and for planners and would help to prepare the implementation of this new technology- based service. Generally, the perspective of planners / service providers has been rarely considered and no clear recommendations regarding the service performances are provided. Studies of [55, 35, 37] have conducted discrete choice experiments to investigate factors influencing mode choice for conventional modes, private and pooled shared autonomous vehicles. However, these studies did not establish the relation between service provider's operating strategies and users' profiles.

Furthermore, previous studies do not target specific population segments or sites that would be first concerned by AV service development. However, it is well known that early deployment

will concern specific sites where education level, income, and acceptability are supposed to be high. Finally, a certain bias exists in responses to general acceptability questions, especially if they are web-based, as a concrete real service is not proposed and described.

1.3. Objective and approach

The present paper contributes to the limited evidence on users' attitudes towards AVs by identifying clusters based on their socioeconomic characteristics and their AV-related attitudes and intentions. The study is based on a face-to-face stated-preferences (SP) survey that was conducted in a developing area located in the south of Paris that is often referred to as the 'French Silicon Valley'. It describes and evaluates acceptability towards a real network of autonomous taxis that will be deployed in 2020 [56]. Two simulation studies have been conducted to evaluate the impact of such this service [57, 58, 59]. However, they have focused on the supply side development while assuming some values for users' preferences.

This study assesses two forms of services: non-autonomous shuttle service and an autonomous shuttle (aTaxi) service. A multiple factor analysis (MFA) and a hierarchical agglomerative clustering (HAC) are used to classify users' profiles depending on their willingness to use AVs.

This paper brings about original contributions by:

(a) Being based on an SP survey which explores the acceptability of a AV-based service, which *will be deployed in 2020*.
(b) Being based on an SP survey which is conducted *face-to-face* and that involves more than 500 participants.
(c) Acceptability is not measured as a binary outcome (i.e. yes or no) but time-dependent (i.e. immediately, 3-6 months etc.) in order to eventually capture two trends (i) initial use just for the experience and then abandon, (ii) initial skepticism and later adoption.
(d) Proposing a methodology to analyze such surveys, through multiple factor analysis that enables to group variables.
(e) Applying a clustering analysis on collected data and defining users' clusters.
(f) Proposing strategies for providing AV-based services based on defined clusters.

2. Users' perspective: factors of aTaxis acceptance

2.1. Survey design

Service area

The survey was conducted in Palaiseau, a 12 km² French city located in the Paris metropolitan area, 17 km south from the center of Paris. It is home to about 32 000 inhabitants and provides about 22 000 jobs. The distribution of homes and jobs is heterogeneous. Palaiseau is becoming an area of interest because it is a part of a growing scientific cluster in France, which concentrates universities, graduate schools, research institutes and research labs of companies. The connection to the rest of the urbanized area is mainly ensured by the train line RER B, which traverses Palaiseau along a north-south axis and serves three stations. In particular, the Massy-Palaiseau station is a junction of RER B, RER C and a French high-speed rail line (TGV).

Sampling method

The survey was designed by [60] to understand and quantify users' acceptance towards an aTaxi service. The respondents received a description of the new service that will be launched in 2020 and were encouraged to answer as their contribution would be used by decision-makers to define the exact operating characteristics of the service. The target group included both inhabitants and commuters or visitors to Palaiseau. The interview was conducted for two weeks.

The respondent is chosen as the fifth person arriving on the platform or in the station hall. Before approaching him, the interviewer records the date and time of the interview and its location, plus the gender and age of the respondent.

The sample over time and space was distributed as follows: 5% of respondents going to Paris and 13% going to suburbs by train between 8h00 and 13h00, 18% going to Paris and 9% to suburbs by train between 13h00 and 22h00, 5% going to Paris and 4% going to suburbs by train between 22h00 and 5h00 (End bus service), and 46% of drivers in the companies' car parks.

In addition, the interview consists of four consecutive parts. The first two parts aim to evaluate respectively the users' acceptability towards an on-demand service and automation technology. The tariff is not mentioned in order to not influence the decision of respondents. The third part confronts the respondent with a choice between an aTaxi service and a bus service, with respect to their tariff and quality of service characteristics. Finally, the last part determines the sociodemographic profiles and travel habits.
In particular, these four parts are introduced as follows:

Part 1: On-demand shuttle service.

The shuttle service is presented without mentioning the word "autonomous". It is presented as an "on-demand service" consisting of a fleet of 20 vehicles of 5 places which provides the connection between the Massy-Palaiseau suburban railway station and the Polytechnic school at a speed of 30 km/h. The service is offered during off-peak hours when buses have a low frequency (9h30 – 16h30 and 20h – 7h).

Part 2: Autonomous shuttle service (aTaxis).

The respondents are informed that the service will be based on level-4 autonomous vehicles that will use a dedicated lane shared also with non-autonomous cars and buses. Acceptability is then assessed by reiterating the questions asked in the first part and comparing answers received.

Part 3: Choice games between aTaxis and bus services.

Each respondent is confronted with four scenarios of choice between an aTaxi and bus service. Each scenario confronts aTaxis and buses with respect to tariff, travel time, waiting time and access time. In addition, aTaxis could propose shared or private rides.

Part 4: Sociodemographic profiles.

The respondents provide general information on their age, profession, education level and average yearly income.

The network presented in **Figure 1** is presented to the respondents.

Figure 1 Autonomous taxi service network

2.2. Sample

The survey was conducted among 600 respondents during the month of July 2018 by the IESEG-Conseil (Junior Company at the School of Commerce in Paris and Lille). 92% of participants are aged more than 18 and 52% are men. 94% of respondents (564) have answered all questions administered by investigators

Respondents were interviewed in three different places:

- On board trains connecting Massy-Palaiseau to Paris in both directions (63 people).
- In the Massy-Palaiseau station (261 people)
- In companies' car parks (276 people).

In addition, **Figure 2** shows the distribution of respondents during the day.

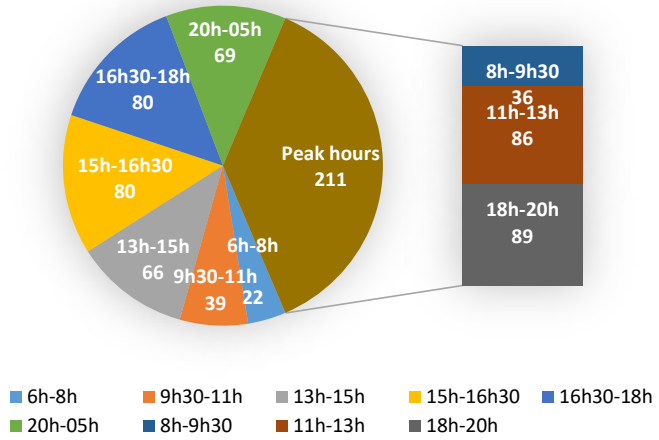

Figure 2 Distribution of respondents during the day

2.3. Survey instrument

The questionnaire conducted by the investigators contained 34 elements, including those relating to the socio-demographic characteristics of the respondents, travel habits, use of the on-demand shuttle service without mentioning AV and use of the AV:

- **Socio-demographics**: Respondents were asked to report their gender, age, socio-professional category, and their monthly income.
- **Travel habits**: Collected information related to the respondents' motorization, their most preferred transport mode, currently used transport mode, the number of trips on weekdays and weekends and the distances travelled on home-to-work and home-to-leisure trips.
- **Uses of shuttle service without mentioning AV:** in the beginning the respondent did not know that the proposed service was based on AV. Thus, they were asked about their intention to use a conventional on-demand shuttle service. In addition, they stated their expected attitude regarding the frequency, distance and travel purpose.
- **Use of aTaxis (with mention of AV**): The knowledge of respondents regarding AV is evaluated. Their historic experience in testing AV trials is also considered. Then, they are asked about their intention to use AV. Possible answers were ordered in the following scale: (1) as soon as it starts, (2) one to two months after deployment, (3) three to four months after, (4) five to six months after and (5) never.

The variables and descriptive statistics for each survey element are presented in **Table 1**.

Table 1 Variables and descriptive statistics

Variable	Type	Description
Socio-demographic		
Age	Categorical	Less than 18 years (8%), 19-40 years (62%), 41-60 years (26%), more than 60 years (4%).
Gender	Categorical	Male (51%), Female(49%).
Profession	Categorical	Student (31%), Researcher/Teacher (2%), Middle Manager (32%), craftsman/Seller (11%), Unemployed persons (10%), Retiree (4%), Others (8%).
Travel habits		
Ownership of transport means	Categorical	Car owner (51%), Bike (43%), Motorbike (8%), Hoverboard (14%), Nothing (5%).
Preferred means of transport	Categorical	Public Transport (68%), Taxi (4%), Walking (36%), Bike (14%), Motorbike (4%), Private Car (56%), Hoverboard (1%), UBER (6%).
Currently used means of transport	Categorical	Public Transport (37%), Taxi (1%), Walking (18%), Bike (10%), Motorbike (3%), Private Car (29%), UBER (2%).
Number of trips per day in weekdays	Discrete quantitative	AVG=3.49 ; SD=1.33 ; MIN= 2 ; MAX=7.
Number of trips per day in weekends	Discrete quantitative	AVG=4 ; SD=1.51 ; MIN= 2 ; MAX=7.
Subscription to mobility services	Categorical	Taxi (6%), Transit (Navigo pass) (63%), Other (carsharing, bikesharing, etc.) (14%), No Subscription (23%).
Home-to-work distance	Categorical	Less than 1 km (6%), 2-6 km (78%), More than 6 km (16%)
Home-to-leisure distance	Categorical	Less than 1 km (0%), 2-6 km (81%), More than 6 km (19%)
Use of Taxis before mentioning AV		
Intention to use	Binary	No (51%), Yes (49%).
Frequency (times per week)	Categorical	Once to twice (27%), Three to Five times (17%), Every day (5%), Never (51%).
Purpose	Categorical	Work/Study (16%), Sport/Leisure (30%), Other Purpose (3%), No Purpose (51%).
Use of Taxis with mentioning AV		
Intention to use	Binary	No (18%), Yes (82%)
Knowledge about existence of AV	Binary	No (63%), Yes (37%)
Historic experience of use	Binary	No (83%), Yes (17%)
Time required for test and adoption	Categorical	As soon as it starts (18%), One to Two mounths after (25%), Three to Four mounths after (21%), Five to Six mounths after (14%), Never (22%)
Expected frequency of use	Categorical	Once to Twice (30%), Three to Five times (32%), Everyday (18%), Never (20%).
Expected purpose of use	Categorical	Work/Study (30%), Sport/Leisure (30%), Other Purpose (20%),

		No Purpose (20%).
Expected distance of use	Discrete quantitative	AVG=3.86 ; SD=1.41 ; MIN= 1 km; MAX=8 km.
Willingness to share	Categorical	No share (25%), With One person (11%), Two persons (15%), Three persons(16%), more than Four persons (33%)

2.4. On-demand shuttle service and aTaxis acceptability

Table 1 have presented statistics for variables related to using shuttle and aTaxis services. Regarding the intention to use the non-autonomous shuttle service, we observe almost equal splits between adopters and non-adopters (49% of adopters), and also almost an equal split between adopters willing to use AVs less than two-times per week and more than two times per week (55% and 45% resp.). In addition, 63% of adopters have stated using the service for leisure trips, which are less constrained trips in terms of arrival time.

The introduction of automation to the system had a significant effect on the intention of using the service (49% before versus 82% after). Respondents' self-reported knowledge of AVs was low (37%). However, the frequency of using aTaxis increases compared to the shuttle service (22% for non-autonomous and 42% for autonomous service) as well as the intention to use AVs for commuting (16% for non-autonomous and 31% for autonomous service). aTaxis would be mostly used for trips of 1 to 4 km. Respondents are divided regarding the adoption time. Five groups emerge: those refusing using AVs, those willing to use AVs as soon as they are launched, one to two months, three to four months and five to six months after the launch. Finally, the AV-based service is perceived by respondents as a shared mode. Thus, almost all of them would share rides (97%) and with more than 4 persons for 42% of them.

3. Users' clustering analysis

3.1. Data analysis

Automatic segmentation, also called classification or clustering, is widely used as a descriptive method of data analysis [61]. It is used in cases of a large volume of data within which a distinction of subsets, for decision-making purposes, is desired.

Since data is multidimensional in our case of study (**Table 1**), it should be represented in a reduced dimensional space before performing an hierarchical cluster analysis (HCA) and to facilitate the analysis of clusters [62].

The Multiple Factor Analysis (MFA) is a factorial method enabling to assess and analyze tables of multivariate data, where individuals are described through quantitative and qualitative structured in groups [63, 64, 65] according to the subject of the question posed to the respondents. The MFA considers the contribution of all these groups of variables to define the distance between individuals. The number of variables in each group is not fixed and the nature of variables (i.e. qualitative or quantitative) varies from a group to another. In practice, individuals are respondents and variables are questions of the survey.

The ascending hierarchical cluster analysis (HCA) [61] is "an iterative classification method whose principle consists in producing sequences of nested partitions of increasing heterogeneities between the partition in N classes where each object is isolated, and the partition in 1 class which groups all the objects".

HCA can be applied when some notion of distance is considered: this can be either in a space of individuals or in a space of variables. It is necessary to first define the distance of two objects, which is generally natural, and the distance of two classes, which leaves more possibilities. It is precisely this distance that constitutes the criterion of dissimilarity in classification.

The algorithm of the HCA is established according to the following scheme:

1. The initial classes are the objects.
2. The distances between classes are calculated.
3. The two closest classes are merged and replaced by one.
4. Resume from 2) until you have only one class, which contains all the objects.

It should be noted that the dissimilarity criterion used here is Ward's distance. This choice is justified by the fact that the distance of Ward minimizes the loss of information following the regroupings of the data and maximizes inter-class inertia. This distance is defined by:

$$d_w(X,Y) = \frac{d(x,y)^2}{\frac{1}{n_X} + \frac{1}{n_Y}}$$

Where X and Y are classes, x and y their centroids, □□ and □□ their sizes.

These successive groupings called a classification tree, or a dendrogram, whose root does not correspond to the class grouping all the individuals. This dendrogram represents a hierarchy of partitions. A partition can then be chosen as such at a given level, depending on the level of the constraints of the user.

The advantage of the HCA over other classification methods such as the k-means is in the reading of the tree which makes it possible to determine the optimal number of classes and does not impose the number of classes in starting [66].

3.2. Clustering analysis outcomes

3.2.1. Multivariate Factorial Analysis Outcomes

The MFA is applied using statistical package R by considering a group of variables for one to ten factorial axes (FA). The variables are grouped into eight groups according to the topic of the question. These are described below:

1. **Sociodemographics**: gender, age, socio-professional category and the monthly income.
2. **Ownership-related characteristics:** motorcycle, bike, hoverboard or e-scooter, car, nothing.
3. **Alternative mode**: hoverboard, e-sccoter, motorcycle, taxi, bike, private car, public transit and Uber.
4. **Daily trips**: number of trips in weekdays and in weekends.
5. **Travel habits**: PT enrollement, the means of transport currently used, the distance between home and work and the distance between home and leisure.
6. **Use of on-demand shuttle service**: intention to use, frequency and purpose.
7. **Previous AV experience:** already used AV
8. **Use of aTaxis:** willingness to use, frequency, distance and purpose, and willingness to share a vehicle.

The proportions of the total variance for each FA as well as the cumulative variance are presented in **Table 2**.

	Eigenvalues	Variances (%)	Cumulative Variances
FA.1	2.31	18.02	18.02
FA.2	1.24	9.41	27.43
FA.3	1.08	8.20	35.63
FA.4	1.02	8.01	43.64
FA.5	0.56	4.30	47.95
FA.6	0.52	4.06	**52.01**
FA.7	0.51	3.95	55.96
FA.8	0,45	3,54	59,50
FA.9	0,43	3,34	62,85
FA.10	0,41	3,22	66,07

Table 2 Proportion of variances explained by the different dimensions

We observe that the majority of information (more than 50%) is explained by six FA (**Table 2**).

3.2.2. Hierarchical cluster analysis outcomes

The HCA is applied for one to twenty clusters. The choice of the optimal number of clusters is based on the analysis of the inter-class inertia and the relative inertia criteria (results shown in **Figure 3**). It shows that the relative inertia is minimized for 2 clusters. However, in order to propose a more detailed classification, we should increase the number of clusters. In particular, for five clusters, the inertia drops greatly while the relative inertia does not vary. This choice is in addition supported by the dendrogram (**Figure 4**).

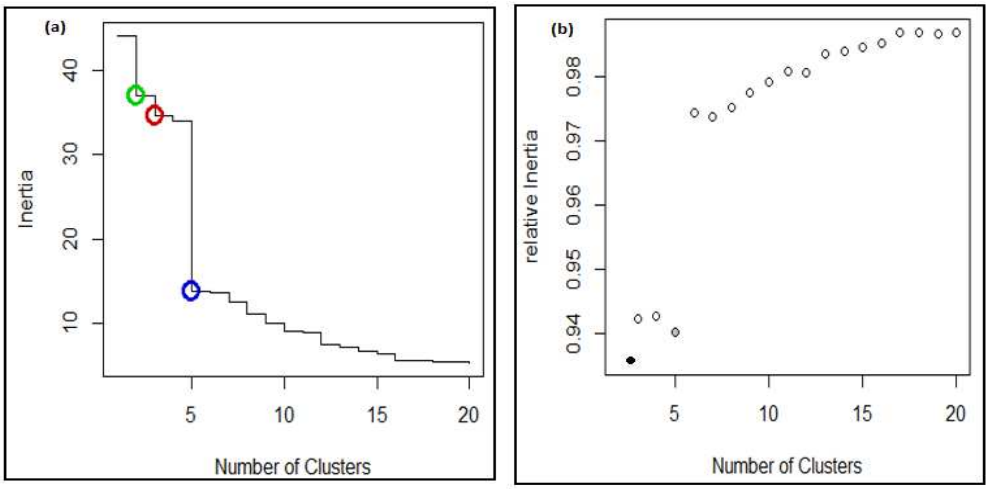

Figure 3 (a) Inter-class inertia w.r.t number of clusters, (b) Relative inertia w.r.t number of clusters

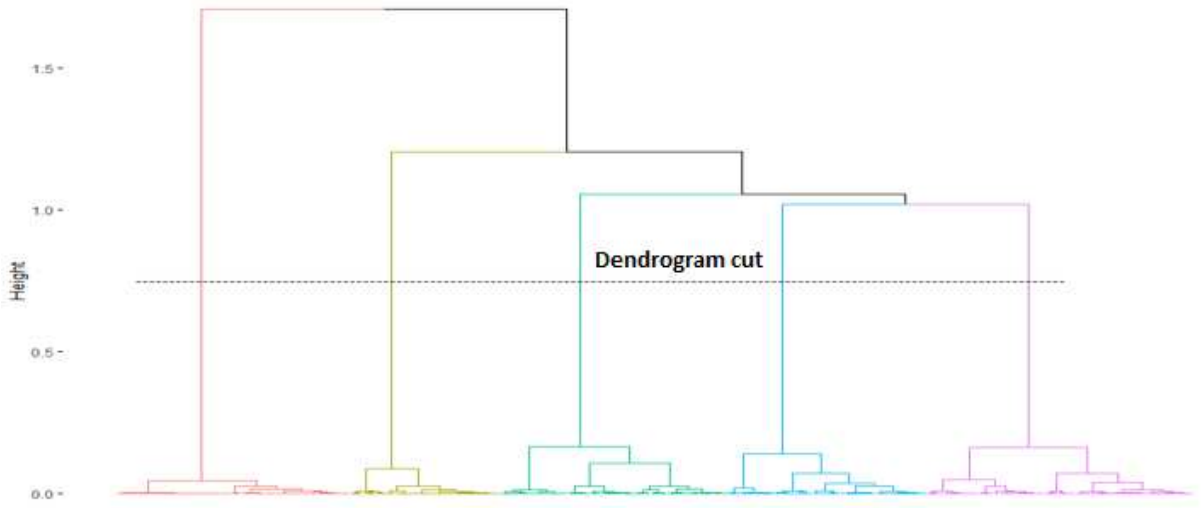

Figure 4 Dendrogram

The individuals factor map enables to visualize individuals on the principal component map and to color individuals according to the cluster they belong to. **Figure 5.b** draws the individual factor map for two axes FA.1 and FA.2. For instance, the results of **Figure 5.b** indicate that individuals in cluster 1 (red color) have low coordinates on axes 1 and 2. In turn, **Figure 5.a** shows the variables factor map. It shows that members of cluster 1 are those who will never use AVs.

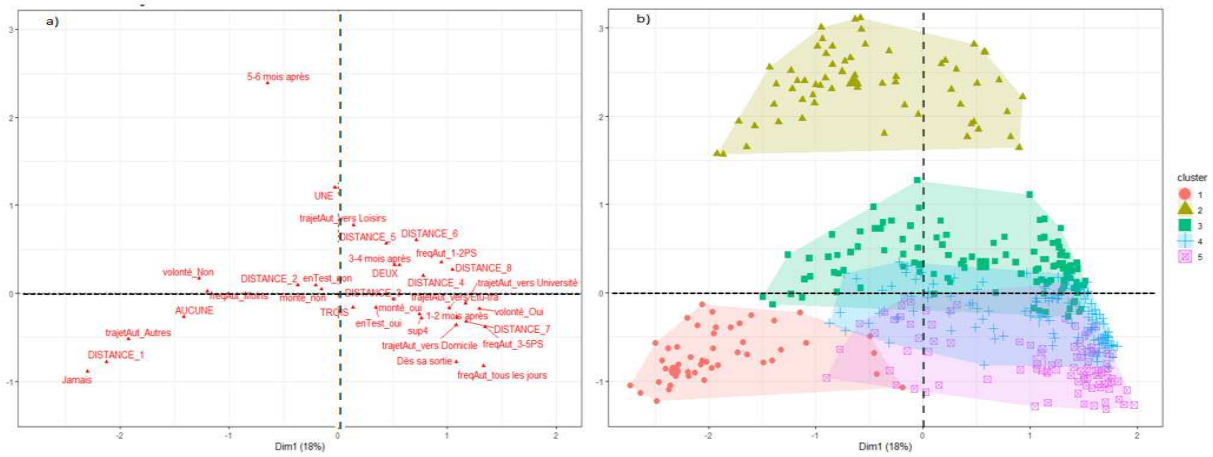

Figure 5 (a) Variables factor map, (b) Individual factor map

3.2.3. Description of Clusters

Table 3 presents statistics for each cluster with respect to the analyzed variables. It focuses in particular on variables which are significant (p-value < 0.05) for at least one cluster. The variables that are not significant for all cluster (e.g. using AV for leisure purpose or sharing AV with three persons) are removed from the Table. In the following, we describe the five clusters, one by one.

Cluster 1: Conservatives (22%)

Participants of cluster 1 stated that they would never use AVs, or they would use it only for occasional and short trips (less than 1 km). In terms of sociodemographic characteristics, they were more likely to be over 50 years old (44%) to 80 years old (62.5%), retirees (67%), motorized persons (77%) and living close to their work (55%).

Cluster 2: Sceptics (14%)

High use of public transit (78% members of the cluster and 68% from the total sample), and low intentions to use the non-autonomous shuttle service (96% of the cluster). All members of this cluster have expressed their low confidence in using aTaxis by stating that they will adopt them at least 5 months after their implementation. This cluster was titled "sceptics". In terms of use purpose, 57% of riders would use aTaxis for leisure/ sport trips and 20% for home-to-work trips. This cluster is differentiated from others by containing all participants who have stated using AVs for trips that are "without any importance". In terms of sociodemographic characteristics, this cluster is dominated by adults between 19 and 30 years of age (54%), mostly senior executives, engineers and/ or managers (45%).

Cluster 3: Late adopters (21%)

Testers, who accept to use AVs 3 to 4 months after their introduction, for an average frequency of one to two times per week. This cluster has no specific defining sociodemographic characteristics and has never boarded an autonomous vehicle (89%). They would be ready to share it with two persons (62%) and would use it for minimum-distance trips (4 to 8 km). In addition, 60% of cluster 3 would use the shuttle service even if it is not autonomous.

Cluster 4: Early Adopters (25%)

Relatively high interest in using aTaxis (three to five times per week) one to two months after the establishment. This group is dominated by students and active population (i.e. retirees are absent), in particular senior executives, engineers and/ or managers (45% of the cluster). All participants of this cluster own at least one transport mean (i.e. private car, moto, bike, etc.) while 43% are using their personal private car for their daily trips. They showed a high interest in the non-autonomous shuttle service (76%) and 50% of them would share their rides on aTaxis with more than 4 persons.

Cluster 5: Explorers (18%)

Participants in this cluster reported the highest interest in adopting aTaxis. They have stated their intention to use AVs as soon as they are implemented. It is dominated by young individuals (i.e. 42% have less than 18 years old) and adults between 31 and 40 years old (23%). The majority of individuals are not motorized (60%), opting mainly for transit modes (i.e. 73% have a subscription to transit modes). Regarding the usage of aTaxis, participants would use AVs for commuting trips (75%), 3 to 5 times per week (47%), while sharing rides with more than 4 persons (45% to 91%). Finally, this cluster is differentiated from the other clusters by the highest number of persons having a prior knowledge of AVs (57%) and having already tested AVs (25%)

Table 3 Results for variables of the five clusters (not-significant p-value in grey, Cl/Mod : percentage of cluster dominance on each variable, Mod/Cl : percentage of individuals that are characterized by the variables in each cluster)

	Cluster 1			Cluster 2			Cluster 3			Cluster 4			Cluster 5			Global
Variables	**Cl/Mod**	**Mod/Cl**	**p.value**	**Cl/Mod**	**Mod/Cl**	**p.value**	**Cl/M**	**Mod/Cl**	**p.value**	**Cl/Mod**	**Mod/Cl**	**p.value**	**Cl/Mod**	**Mod/Cl**	**p.value**	
Sociodemographic characteristics																
Age																
19-30	12.44	22.95	1.34E-05	19.11	54.43	4.52E-03	23.11	42.29	4.65E-01	25.78	37.14	6.99E-01	19.56	41.90	6.21E-01	39.68
31-40	25.62	25.00	2.90E-01	9.92	15.18	1.97E-01	25.62	25.61	2.42E-01	28.10	20.00	3.89E-01	10.74	22.50	4.45E-03	21.34
51-60	44.12	12.29	2.48E-03	14.71	7.49	1.00E+00	14.71	4.13	4.49E-01	20.59	2.86	7.14E-01	5.88	1.92	1.73E-02	6
61-70	69.23	26.37	2.74E-04	7.69	1.26	8.01E-01	7.69	0.80	3.83E-01	0.00	0.00	2.32E-02	15.38	1.90	1.00E+00	2.29
71-80	62.50	26.20	4.27E-04	12.50	2.51	1.00E+00	6.25	0.80	2.36E-01	12.50	1.43	3.94E-01	6.25	1.90	3.47E-01	2.82
Profession																
Craftsman/seller	20.31	10.56	9.02E-01	26.56	32.51	4.45E-03	26.56	0.14	3.57E-01	14.06	5.71	5.24E-02	12.50	7.62	2.67E-01	11.29
Middle manager	21.01	20.32	9.37E-01	6.72	45.10	2.30E-04	26.05	0.26	1.99E-01	31.93	46.95	4.96E-02	14.29	16.19	2.49E-01	20.99
Retiree	66.67	14.75	2.99E-07	11.11	3.78	1.00E+00	3.70	0.00	1.26E-02	7.41	1.42	2.30E-04	11.11	2.86	4.59E-01	4.76
Student	5.56	1.64	9.30E-03	22.22	10.12	2.17E-01	11.11	0.00	1.81E-01	22.22	5.71	8.77E-01	38.89	42.46	1.38E-08	6.35
Travel behavior																
Ownership of transport mode																
Not an owner	46.67	88.52	1.78E-03	16.67	93.67	8.62E-01	16.67	47.93	6.80E-01	10.00	97.87	4.46E-02	10.00	96.19	3.32E-01	94.71
Bike owner	14.05	27.05	6.61E-05	14.88	39.24	6.62E-01	23.97	95.04	2.25E-01	23.97	37.14	8.05E-01	23.14	53.85	7.72E-03	42.68
Car owner	29.41	73.93	4.27E-04	11.42	42.26	1.01E-01	18.34	94.21	9.38E-02	26.30	84.29	4.20E-01	14.53	40.38	1.73E-02	56.22
Home-to-work distance																
Less than 1km	52.78	55.57	2.48E-03	2.78	1.27	3.09E-02	5.56	1.65	9.94E-03	19.44	17.73	1.26E-02	19.44	12.38	2.30E-04	6.35
5-6km	11.72	12.30	1.46E-03	30.47	49.37	1.38E-08	21.09	62.67	9.30E-03	24.22	22.14	9.81E-01	12.50	15.38	4.84E-02	22.57
Home-to-leisure distance																
Less than 1km	47.22	43.93	4.27E-04	5.56	2.51	8.04E-02	5.56	1.65	9.94E-03	27.78	8.51	2.01E-02	13.89	4.76	6.24E-01	6.34
Preferred transport mode																
Walking	28.46	60.66	2.30E-04	10.38	34.18	2.47E-02	20.77	55.00	8.39E-01	19.62	36.17	7.72E-03	20.77	51.43	2.06E-01	45.86
Public transport	17.78	55.74	1.95E-03	15.98	78.48	6.61E-05	22.42	71.90	4.15E-01	23.97	57.14	6.30E-01	19.85	72.64	2.13E-01	68.43
Private Car	24.84	63.93	4.87E-02	13.52	54.43	8.44E-01	20.75	54.55	7.78E-01	27.67	52.86	7.80E-02	13.21	40.38	4.01E-04	56.08
Not a Bike	23.46	92.62	1.03E-02	12.55	77.22	2.79E-02	22.02	88.43	4.15E-01	24.49	74.29	8.89E-01	17.49	40.85	4.27E-04	85.71
Not a Taxi	21.96	96.00	6.47E-01	14.21	97.43	5.61E-01	21.22	86.01	9.34E-01	23.62	91.49	9.94E-03	19.00	99.04	6.61E-05	95.59
Not walking	15.96	39.34	2.30E-04	16.94	65.82	3.37E-02	21.82	48.00	8.39E-01	28.99	63.83	1.34E-05	16.29	47.62	2.06E-01	54.14
Number of trips in weekdays																
4 trips	29.14	41.80	3.88E-03	7.43	51.46	8.82E-04	16.00	23.14	3.64E-02	28.57	42.13	2.33E-02	18.86	41.35	3.61E-03	30.86
Number of trips in weekends																
2 trips	28.47	31.97	3.04E-02	12.41	18.99	6.03E-04	16.06	17.36	4.08E-02	23.36	2.84	4.79E-03	19.71	9.28	4.32E-01	24.33
4 trips	24.75	40.65	7.27E-01	7.43	25.32	2.81E-07	22.77	5.79	2.96E-02	26.73	2.3	9.07E-01	18.32	34.28	9.40E-02	35.62
Transit subscription																
Navigo	15.32	44.26	1.34E-06	13.93	62.50	4.27E-04	23.12	22.44	1.73E-02	26.18	21.02	3.52E-02	21.45	73.08	2.12E-02	63.32
Currently used transport mode																
Car	17.96	24.39	2.00E-01	14.37	30.37	9.51E-01	16.77	0.00	1.08E-01	36.53	43.26	2.47E-02	14.37	22.86	1.44E-01	29.45
Transit	24.69	55.74	8.82E-04	12.96	50.10	4.87E-02	29.01	38.8429752	5.91E-03	21.60	20.2624113	5.25E-05	11.73	18.27	1.42E-02	28.57
Uses of Taxis without mentioning AV																
No use	40.91	95.90	1.11E-34	21.33	77.21	9.30E-03	16.78	40.00	2.81E-07	11.89	25.00	1.03E-02	9.09	25.00	1.76E-08	50.44
Use Purpose																
Sport/Leisure	7.91	10.66	3.74E-09	25.42	56.96	2.47E-02	21.47	0.00	1.00E+00	29.94	38.2978723	3.90E-02	15.25	25.71	2.45E-01	31.21
Not-important	0.00	0.00	1.00E+00	100.00	2.53	1.92E-02	0.00	0.00	8.99E-03	0.00	0.00	1.53E-13	0.00	0.00	1.00E+00	0.35
Work/Study	4.21	7.38	2.28E-17	7.48	20.25	1.03E-02	28.50	50.41	1.41E-03	34.58	52.48	8.99E-03	25.23	51.92	5.50E-18	37.74

Trial	0.00	0.00	5.24E-01	20.00	0.00	1.00E+00	0.00	0.00	5.34E-01	0.00	0.00	4.44E-01	80.00	3.85	1.53E-07	0.88
Uses of Taxis with mentioning AV																
Once it starts	0.00	0.00	5.59E-13	0.00	0.00	2.86E-08	0.00	0.00	7.29E-13	0.00	0.00	3.15E-15	100.00	100.00	1.04E-116	18.34
1 to 2 mos after	0.00	0.00	5.50E-18	0.00	0.00	2.52E-11	0.00	0.61	8.02E-18	100.00	99.29	8.4E-135	0.00	0.00	4.16E-15	24.69
3 to 4 mos after	0.00	0.00	2.77E-15	0.00	0.00	1.12E-09	100.00	100.00	5.3E-127	0.00	0	5.74E-18	0.00	0.00	7.29E-13	21.34
5 to 6 mos after	0.00	0.00	9.19E-10	100.00	100.00	7.86E-99	0.00	0.00	1.12E-09	0.00	0	2.06E-11	0.00	0.00	2.86E-08	13.93
Never	100.00	100.00	1.8E-125	0.00	0.00	7.56E-10	0.00	0.00	2.02E-15	0.00	0	1.58E-16	0.00	0.00	4.28E-13	21.69
Use Frequency (times per week)																
3 to 5	0.00	0.00	8.47E-12	3.16	3.80	2.20E-04	20.00	23.97	4.56E-02	47.37	31.91	1.53E-07	0.00	46.92	7.56E-10	16.75
1 to 2	0.61	0.82	6.70E-20	15.15	32.00	6.87E-01	36.97	70.41	1.34E-06	26.67	34.75	7.29E-05	20.61	22.12	1.60E-09	29.10
Everyday	0.00	0.00	2.58E-04	0.00	0.00	6.04E-03	15.15	27.96	5.50E-18	27.27	1.91	1.53E-07	57.58	18.27	2.32E-07	5.82
Do you know that the AV is already in test?																
Yes	16.19	27.87	1.71E-02	10.48	27.50	8.96E-02	18.57	32.23	2.59E-01	26.19	39.29	5.93E-01	28.57	57.69	1.03E-02	37.04
Historic experience																
No	24.15	93.44	1.71E-03	15.04	95.30	8.02E-18	22.88	89.25	4.87E-02	21.40	71.63	4.97E-05	16.53	75.00	2.81E-07	83.25
Use purpose																
To home	3.85	2.46	4.15E-06	3.85	3.80	2.44E-03	25.64	23.14	1.23E-02	35.90	19.86	5.3E-127	30.77	23.08	4.27E-04	13.76
To work/Study	3.57	3.28	2.81E-07	8.33	7.59	2.87E-02	30.36	50.14	2.81E-07	32.74	7.80	2.26E-10	25.00	7.69	1.23E-07	15.52
AV Sharring																
4+ persons	10.16	14.75	4.39E-07	5.35	12.66	1.19E-05	21.93	33.88	8.97E-01	37.43	50.35	2.02E-15	25.13	45.19	2.12E-02	32.98
2 persons	6.98	4.92	1.14E-04	16.28	9.00	6.08E-01	32.56	62.14	8.38E-03	24.42	13.57	1.00E+00	19.77	16.19	8.26E-01	15.16
1 Person	12.50	66.00	8.30E-02	42.19	56.96	2.02E-15	17.19	22.35	1.28E-22	17.19	5.71	1.85E-01	10.94	6.67	1.46E-01	14.33
No Person	52.86	60.66	1.28E-22	14.29	12.50	1.00E+00	15.71	19.00	2.87E-02	10.00	9.93	6.82E-07	7.14	9.62	1.53E-07	24.69
Distance																
1 km	76.00	62.00	1.41E-40	6.00	7.59	7.58E-03	6.00	4.96	6.38E-06	2.00	1.41	1.33E-11	10.00	9.62	1.37E-02	17.63
3 km	10.00	9.84	2.75E-04	9.17	27.50	6.20E-02	22.50	5.68	4.15E-06	32.5	27.66	3.33E-02	25.83	79.81	5.59E-13	21.16
4 km	3.53	3.28	4.59E-09	18.58	18.99	2.91E-02	22.12	52.67	3.74E-09	33.62	26.95	1.91E-02	22.15	23.80	7.62E-01	19.93

4. Operator's perspective: Business models design (Or Service performance sensitivities)

In this section, we focus on the service provider's perspective, for which the main concern is to attract the highest volume of users and then to maximize its profit. To achieve this goal, the provider usually convinces the user to choose its service (1) by proposing a competitive tariff and/ or (2) by offering a satisfying quality of service. The objective of the third part of the questionnaire was indeed to evaluate the sensitivity of users to tariff and quality of service in order to determine the strategy that would be beneficial to the operator. In addition, this evaluation was performed by analyzing the users' choice between an aTaxi service and a conventional bus service having different performances (fare, travel time, waiting time, etc.). The choice of the bus as an alternative to aTaxis is based on the fact that it is the unique public mode that competes with aTaxis in our study area.

Therefore, we present here the analysis of the results of the third part of the questionnaire. This analysis is firstly presented for the whole population of respondents. Then, it is refined through an analysis by cluster in order to suggest more complicated business models.

4.1. Mean sensitivities to service attributes

The service attributes include four main categories: (a) monetary-related attributes (i.e. fare), (b) time-related attributes (i.e. travel time, waiting time and access time), (c) sharing-related attributes (i.e. private or shared trips) and (d) subjective-related attributes (mode preference).
Consider a baseline scenario where all performance attributes are the same for bus and aTaxis. The mode choice results indicate that 58% of respondents would prefer aTaxis.
In the following, we attempt to assess the sensitivity of respondents to each one of these categories.

(a) Monetary-related attributes
Different fare scenarios for bus and aTaxis were proposed, while all other attributes being equal. **Figure *6***Error! Reference source not found. draws the intention to choose aTaxis over the bus according to different reduction rates of aTaxis fares. It found that in general respondents are highly sensitive to aTaxis fares. However, the volume of potential riders is capped at 75% and does not increase beyond a reduction of 6 euros. In other words, a decrease in the price of 6 euros compared to the bus is enough to convince 75% of those surveyed to choose aTaxis. The remaining 25% are probably in majority members of the Cluster 1 of conservatives.

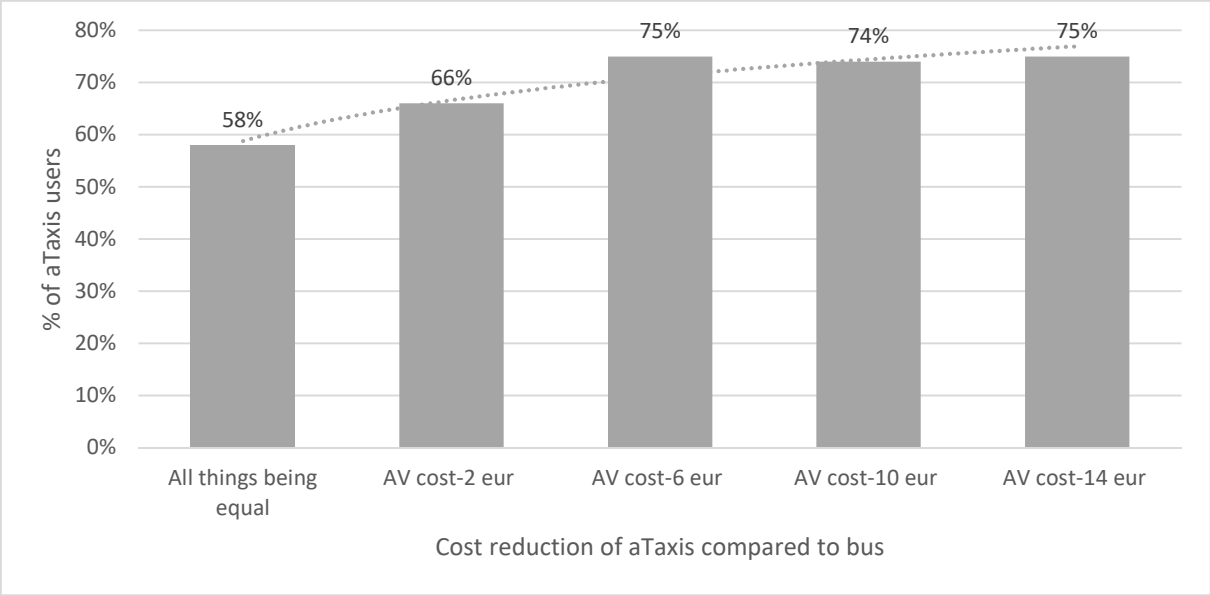

Figure 6 Intention to choose aTaxis over the bus for different AV cost reduction scenarios

(b) Time-related attributes

Time-related attributes include travel time, waiting time and access time. The travel time reflects the vehicles' average speed. The waiting time, on the other hand, is related to the average speed, but also to vehicle availability, so the supply-demand balance in a given instant. **Figure 7** shows that for a decrease in travel/ waiting time by 4 minutes, the intention to use aTaxis increases by only 1 to 3%. However, for higher reductions in travel/ waiting times (8 and 12 minutes), the time-sensitivities are much more important. In addition, **Figure 7** shows that the waiting time and travel time sensitivities are similar, all other things equal otherwise.

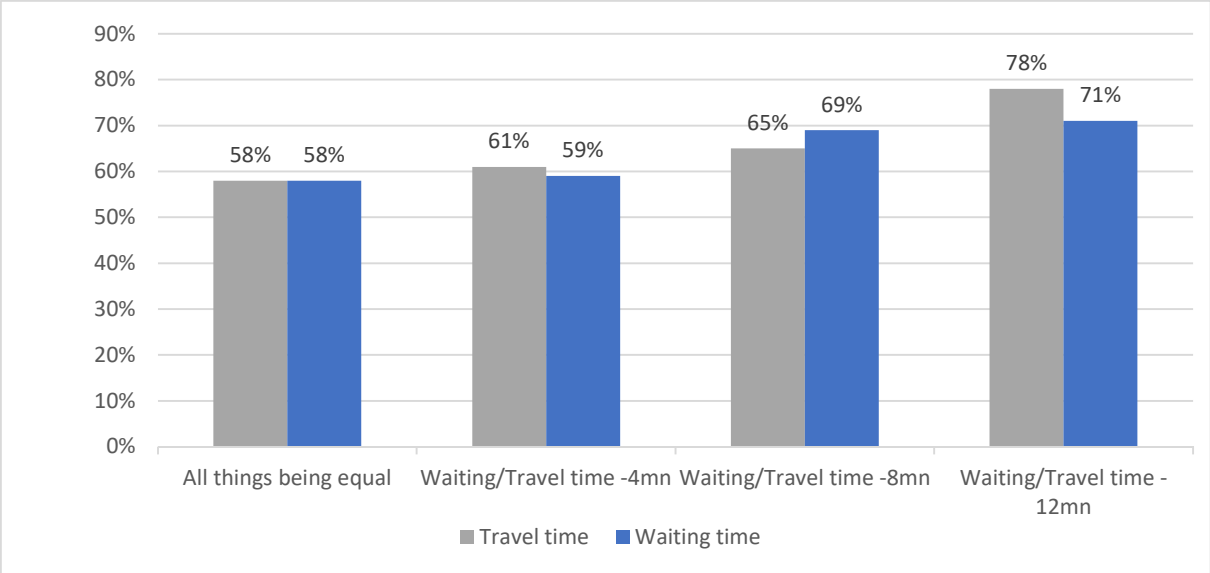

Figure 7 Intention to use aTaxis for different travel/ waiting times

Concerning the access time, the results found that its effect is less important than for travel time, waiting time and fare. In particular, if aTaxis' access time and bus fare decrease respectively by 4 minutes and 2 €, then the percentage of aTaxis potential users decreases from 58% to 51%. Similarly, if aTaxis access time and bus waiting time decrease both by 4 minutes, then the percentage of aTaxis potential users decreases from 58% to 50%.

(c) Sharing-related attributes

In general, the respondents prefer a shared vehicle to a private vehicle (54% versus 46%), all other things equal otherwise. This may be related to the probability that some users are feeling less reassured when they find themselves alone in a driverless vehicle. There may also be a cognitive bias, where respondents unconsciously think that the private option of the service will be more expensive than the shared option, choosing then the latter.

(d) Subjective-related attributes

Mode preference factor, named also the modal constant in literature, is used to include all other factors that could not be measured and that are related to the quality of service (e.g. information, comfort, reliability, etc.) that affect the traveler's behavior. Very few studies have investigated the mode preference factor for taxis [67, 68, 69]. In order to estimate the impact of mode preference, we contented ourselves by observing the percentage of users who prefer aTaxis over the bus when all attributes of both are equal. As a result, we found, as mentioned above, that 58% of respondents prefer aTaxis for another subjective reason.

(e) Value of travel time

All other things being equal, if the fare of aTaxis increases by 4 euros, then the intention to use decreases by 3% and 12.5% in absolute and percentage terms respectively. As a result, the price-sensitivity is of 43%.

On the other hand, an increase of aTaxis travel time by 4 minutes, all other things being equal, induces a decrease in intention to use by 1% and 4.7% in absolute and percentage terms respectively. In addition, the travel-time sensitivity is of 17%.

Consequently, the price-sensitivity is 2.5 times higher than the travel-time sensitivity. In other words, a reduction of the fare by 1 € is equivalent to a reduction of travel-time by 4 minutes, or 1 minute of travel time is worth 0.4 euros.

4.2. Sensitivities to service performances by cluster

Consider now the five clusters that are defined above. **Table 4** presents the effect of reducing fare, travel time, waiting time and access time on the intention to use aTaxis for each cluster. The baseline scenario corresponds to the case where all service performances are similar for aTaxis and bus.

We observe that going from cluster 1 (conservatives) to cluster 5 (explorers) the percentage of intention to use aTaxis increases.

Table 4 Impact of service performances on aTaxis intention to use by cluster

	Cluster 1 Conservatives	Cluster 2 Sceptics	Cluster 3 Late Adopters	Cluster 4 Early Adopters	Cluster 5 Explorers
Baseline scenario	54%	39%	58%	61%	68%
-2€ of fare	54%	38%	60%	67%	100%
-4min travel time	69%	39%	58%	70%	68%
-4min wait time	75%	39%	67%	61%	68%
-4min access time	67%	36%	67%	67%	100%

In the following, we discuss the sensitivities to service performances cluster by cluster.

- **Cluster 1: Conservatives.** For a reduction of fare by 2€, the number of users does not vary. However, an improvement in quality of service, in terms of travel time, waiting time and access time would induce an increase of users among conservatives by 15%,

19% and 13% respectively. Note that this cluster contains respondents for whom the main mode is walk and trips distances are less than 2km.

- **Cluster 2: Sceptics.** This cluster is characterized, compared to other clusters, by high use of transit modes as a main transport mean (68% of transit riders are in this cluster). This high preference towards public modes is confirmed in Table 4, where only 39% state that they would use aTaxis instead of using a bus even for a better quality of service and lower fare.

- **Cluster 3: Late Adopters.** They are slightly affected by the fare (+2% for 2€ less). They are sensitive to out-vehicle time (wait time and access time) while on-board vehicle time seems to be not influential (+9% for +4min of travel/access time).

- **Cluster 4: Early Adopters.** An improvement in travel time would convince more early adopters to use aTaxis. That is in line with the fact that these respondents would use aTaxis for home-to-work trips. On the other hand, 67% (+6% compared to the baseline scenario) of early adopters prefer aTaxis when the fare is reduced by 2€ or when the access time by 4 minutes. To conclude, an increase of service quality and a reduction in price would have undoubtedly a positive effect on the percentage of users among early adopters.

- **Cluster 5: Explorers.** Finally, a reduction of fare by 2€ would allow attracting all explorers (100%). Similarly, reducing the access time by 4 min would be sufficient to convince all explorers to use the service. Improving the quality of service in terms of travel time and waiting time, on the other hand, would have a limited effect on the intention to use aTaxis.

5. Discussion and Conclusions

AV-based services attract general attention. Previous studies showed that specific population segments are expected to adopt such services to a greater degree and at an earlier stage, i.e mainly males, young, and living in urban areas [22, 27, 20, 42, 43, 44, 45]. By adopting the AV-based service, these segments are expected to influence broader market segments and increase overall acceptability by providing opportunities for trial and generating positive word-of-mouth communications about the benefits of the new technology [44]. Accident occurrences or non-occurrences are expected to be critical in this procedure. Consequently, it is important for policy makers and manufacturers to define suitable strategies that will facilitate uptake among early adopters, as well as promote AV use among other segments via broader approaches.

The present study aims to support the development strategies of AV-based services by shedding additional light on the heterogeneity of acceptability rates among different market segments at a specific site in Southern Paris region. The study area is relevant since a future AV-based taxi service will be deployed in 2020. An extended survey among 600 participants allowed us to quantify acceptability and cross it with sociodemographic and general travel attributes. Our study reveals a relatively low knowledge of AV possibilities (37%), but a great interest in using the aTaxis service (82%). The non-autonomous shuttle service seems to be less successful among participants (49%). These results suggest that AV technologies present a great potential to contribute to the promotion of shared mobility. On the other hand, ridesharing would increase

the users' confidence during trips, since it is more reassuring to be surrounded by peers in anticipation of a potential incident. There may also be a cognitive bias whereby respondents associate private rides with more expensive service, which would explain their preference shared and cheaper vehicles.

An economic analysis based on mode choice games between aTaxis and buses found that to maximize the service attractivity, a provider should propose an attractive price on average 6 euros cheaper than the bus (all other things being equal), or an efficient service with reduced waiting or travel times by 8 to 12 minutes compared to the bus (all other things being equal). In addition, an estimation of the travel time value found that 1 minute is worth 0.4 euros.

By combining the MFA analysis with the HCA analysis, five distinct population segments (cluster) were identified varying from 'explorers' to 'conservative' or non-users. It seems like youngsters and highly educated young professionals (cluster 5) are ready to use AV services and for regular trips. Consequently, policy makers and service providers should primarily target early and late adopters (clusters 3 and 4) in order to gain their confidence. Finally, sceptics and conservatives account for a total of 36% and seem more suitable to design targeted campaigns at a later deployment stage.

First insights into the impact of operating strategies have shown that a reduction of fare by 2€ compared to the bus would convince more explorers and early adopters to use aTaxis. However, in order to enable the diffusion of the service among late adopters and conservators, the policy makers / providers should focus on improving the quality of service. For this purpose, vehicles should be able to provide the service in higher speeds (i.e. more than 30 km/h), which involves lower travel and waiting times. That could be achieved in the short-term through using a dedicated infrastructure. In the mid-/long-term, vehicles' perception, connectivity and vehicle-to-infrastructure (V2I) communication will be necessary for a broader deployment. Another way to decrease waiting times is to increase the number of vehicles providing the service, which requires vehicles' validation and homologation from public authorities. Public policies should then focus, in terms of incentives, on factors that allow a deployment of high-quality, not necessarily free of charge, AV-based services. Finally, sceptics, as fans of public transit, would be more attracted by a service that is integrated into public transit network (i.e. MaaS vision), enabling then an improvement of the overall efficiency and quality of service of public modes.

There are some limitations to this work. The survey site has particular characteristics involving some bias, so results cannot be extrapolated to the whole population nor be transferred to other sites: one train station feeding the territory and high concentration of highly educated persons having a prior knowledge of AVs. However, the proposed methodology is enterable transferrable to other urban and suburban contexts. It should be outlined that the presented clustering is for our context and results could be replicable in other contexts that are structurally different. For instance, old persons are non-adopters in our area because of the proximity of work and leisure equipment. However, this result would not still true in a rural area where old persons are "quasi-isolated". Future works should suggest a cross-survey analysis that confronts context's particularities with different configurations of AV-based services: rural vs urban areas, last-mile vs door-to-door, taxi vs shuttles, and so on.

Finally, our study might have been supported by attitudes-oriented questions which attempts to understand the reason behind the intention of use.

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