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An analysis of the potential adoption of Mobility as a Service across different age groups and lifestages: A mixed-methods approach

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Abstract

An important issue for policy makers and transport planners who wish to promote Mobility as a Service (MaaS) initiatives is to find out whether and to what extent citizens are willing to adopt this new mobility concept. In general, young people are supposed to be the early adopters of new technologies and innovative services, but are they among the early adopters of MaaS? This study aims to explore potential MaaS adoption considering age groups and lifestages of potential users. We employ two methods: i) a Delphi study with international transport experts, with the respondents of n=89, 46 and over the three rounds; ii) a discrete choice modelling approach based on stated choice data related to 1078 respondents. Overall, the findings of the study suggest that younger age groups are more likely to subscribe to MaaS and that lifestage is a critical determinant of MaaS adoption.

Keywords: Mobility as a Service; MaaS users; Lifestage; Delphi study; Stated Choice Experiment

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1. Introduction

There is an increasing number of challenges that transport professionals and policy makers are facing with the on-going global trend of urbanization (UN-DESA, 2018). One of these is the enhancement of the sustainability of the transport system (European Parliament, 2016). Given this challenge, numerous new transport concepts and services have emerged, based on electrification, automation and sharing of vehicles, and digitalization and integration of transport modes.

Mobility as a Service (MaaS) has recently emerged as one of the most promising transport concepts. It aims to provide travellers with a seamless and user-oriented mobility experience through the integration of the available transport modes and other relevant services (See Jittrapirom et al. (2017) for a review on MaaS). The services will enable users to plan, reserve, and pay for their journeys conveniently, offering improved individual flexibility and multimodality (Hietanen, 2014; Kamargianni et al., 2016). Such a service can lead to an increasing use of public transport and shared modes, thus reducing personal car use and limiting car ownership in the longer term. In that way, MaaS can accelerate the shift toward a more sustainable and better quality of life (Giesecke et al. 2016; König et al. 2016).

The implementation of a novel service like MaaS needs addressing several complications. We highlight some of them here (See Jittrapirom et al. (2018) for an extended list). The first potential issue is the willingness to collaborate among different stakeholders, such as transport service providers, public authorities, and MaaS operators. Then, there may be uncertainty associated with users' adoption, subscription, and usage (Hietanen, 2014; Karlsson et al., 2017; Audouin and Finger, 2018). Finally, the public acceptance of such a service is unknown but highly important to ensure a successful implementation of the service.

With the spread of innovative mobility concepts, such as mobile ticketing, bike-sharing, car-sharing and ride-sourcing, several studies have looked to identify factors that affect the adoption of these novel services. Attitudes, contextual factors and perceptions are used to better understand potential adoption of new mobility services. For example, Munkàcsy and Monzòn (2018) identified different adopters' categories and investigated how certain personal characteristics and perceived attributes influence the time of adoption of an innovative bike-sharing scheme launched in Madrid (Spain). Similarly, Mallat et al. (2008) studied the adoption of mobile ticketing service in public transport and provided evidence that contextual factors and user perceptions of the service attributes represent important determinants of adoption. Among the individual characteristics as main determinants of the adoption of innovative mobility services, socio-demographic variables, such as age, household composition and employment status are considered significantly influential (Efthymiou et al., 2013; Rayle et al., 2014; Kim et al., 2017; Prieto et al., 2017; Alemi et al., 2018). These variables have been used to define individual and household lifestages (Hunecke et al., 2010; Van Acker, 2017). Furthermore, previous literature has suggested that individual travel behaviour appears to change across different lifestages (Ryley, 2006). For example, a millennial student living at home with her parents may have different daily activities and travel needs than an employed millennial living as a couple with children. These circumstances of individuals and their households' daily activities can affect their travel behaviors, for example, in terms of trip frequency, mode choice, and mode availability.

Various other studies focused on the observed intergenerational differences in people's travel patterns (Raimond and Milthorpe, 2010; Goodwin, 2012; Kuhnimhof et al., 2012; Delbosc and Currie, 2014; Wee, 2015). These works highlighted that over the last decades, the share of persons holding a driving license or owning a personal car among young adults has been decreasing, resulting also in a decline of car use among younger generations[2]. Many explanations for this phenomenon have been proposed, ranging from the economic and urban influence to the emergence of new social patterns and preferences that lead to lifestyle and cultural shifts. Furthermore, other researches showed the high propensity of young people to adopt new patterns in travelling, focused on on-demand and shared mobility services (Circella et al., 2016, 2017). However, it is still questionable if such a less-car oriented mobility pattern will continue to characterize the current younger generations as they age, or if their travel behaviours will change at a later stage in their life (Kuhnimhof et al., 2012).

[2] In this paper the terms "young adult", "young people", "young generation", "youth" are used interchangeably to indicate the younger age groups (generation Z and millennials).

While it may be difficult to predict how the travel behaviours of the younger generations will evolve in the future, understanding their current mobility patterns and stated preferences for new mobility services through different stages of life may help to implement effective policies aiming at promoting innovative mobility concepts.

The number of empirical studies aimed at investigating individual preferences for MaaS schemes is growing (Ratilainen, 2017; Caiati et al., 2019; Ho et al, 2018; Matyas and Kamargianni, 2018). However, none of these studies focused on lifestage. This study aims to address this gap, focusing on the potential adoption of MaaS between the younger and the older generations. Firstly, given that young people are typically the early adopters of new technologies and innovative services (Rogers, 2003; Correia and Viegas, 2011; Circella et al., 2016; Alemi et al. 2018), we will examine whether this holds for MaaS. Secondly, we zoom in to understand whether preferences for MaaS adoption vary across different lifestages and travel behaviour groups.

In the next section, we describe the methodological underpinnings of this study. We detail the findings from our empirical analysis in section 3 and conclude the paper in section 4 with a discussion of policy implications and future work.

2. Methodology

The data used in this research were collected in the context of the project "Smart Cities' Responsive Intelligent Public Transport System" (SCRIPTS). The research program aimed at developing an integrated modelling framework for new demand-driven mobility solutions supported by ICT platforms in smart cities and regions. One of the main objectives of the project is to identify early market adopters of MaaS and to investigate consumer preferences for this new mobility concept. We addressed these goals by using different methods of data collection and analysis, including a Delphi study and a stated choice experiment. The two activities were conducted in the Netherlands between 2017 and 2018. This paper brings together some findings of these efforts to provide a wider perspective of the research problem.

2.1. The Delphi study

2.1.1. Research design and analysis

The Delphi method is a structured group communication technique on specific topics and complex societal problems. It involves multiple rounds of anonymous enquiry and systematic feedbacks with a panel of experts. This research method has been extensively applied in various disciplines and fields (Linstone & Turoff, 2002). The motivation behind using the Delphi method was the lack of structured and consensus knowledge on MaaS (Jittrapirom et al., 2017). We employed the Delphi method to systematically capture and explore the divergent opinions on MaaS and its implementation and the motivations behind these diverging opinions.

In total, we invited 312 experts, of which 89 participated in the first round, 46 in the second round, and 35 in the third and final round. The participants were international transport and MaaS experts from various sectors (e.g. academic, public organization, public transport provider). We used SPSS and ATLAS.ti (Friese, 2014) to process and analyse the information (see Jittrapirom et al. (2018) for the detailed description of our Delphi survey).

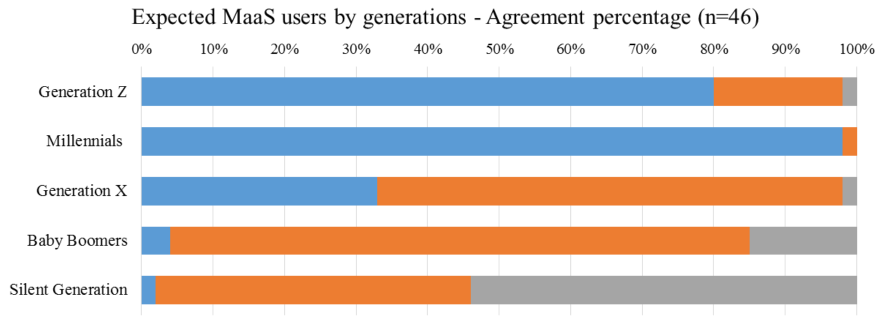
In this paper, we present a selection of our findings which a focus on the early adopters of MaaS. We asked the respondents to express their opinions on the potential early adopters of MaaS, with regard to their age, mode of transport most frequently used, and trip purpose. We present here the survey outcomes that provides perspectives and insights into the adoption of MaaS by the different age groups and the experts' level of agreement on this expectation.

2.1.2. Panel's expectation on potential early adopters of MaaS across different age groups

We adopted a simplified classification of innovation adopters based on Roger's diffusion of innovation (Rogers, 2003). The three categories are the early adopters (first 15% of total users), the followers (potential users of MaaS, but expected to adopt it at a later stage), and the non-users. Five age classes were identified, namely: generation Z (under 20), millennials (21-34), generation X (35-49), baby boomers (50-64) and silent generation (65+).

The results of the Delphi survey indicate that experts strongly believe that the younger generations (generation Z and millennials) will lead MaaS adoption. Only a marginal group of experts (2%) believe the millennials would be the followers, and none of them expect them not to use MaaS. Generation Z are also expected to be the early adopters by most experts (80%), while only 2% of the panel believes them to be non-users. Generation X and baby boomers are expected to be the followers by the majority of the panel (65% and 81%, respectively). Nevertheless, 33% of the experts believe generation X can be the early adopters of MaaS. Finally, more than half of the panel (54%) thought that the silent generation will not adopt MaaS, while 44% expects them to be the followers.

Fig. 1 shows a high level of stability of the group results between round 1 and 2. At the individual level, the exposure to the group results triggered between 2% to 9% of experts to change their selections in the second round after they saw the group's results, which indicates high confidence in their opinions. The participants also pointed out that the expectation for the perceived added value of MaaS by the younger generations needs to take into account several related contexts. For instance, the youth's mobility patterns are, in general, less complicated than the older generations. Also, the younger generations are likely to have a lower purchasing power, which may limit their ability to afford MaaS. Moreover, in certain countries, such as the Netherlands, students are provided with subsidised transport access as part of their social support. These contextual aspects may affect how individual preferences for MaaS differ between and within generations.



	Gen-Z	Millennials	Gen-X	Baby Boomers	Silent Gen
Early Adopter	80%	98%	33%	4%	2%
Follower	18%	2%	65%	81%	44%
Non-user	2%	0%	2%	15%	54%
Stability of the results - Group level					
Median* (IQR**) Rd 1 / Rd 2	1 (0) / 1 (0)	1 (0) / 1 (0)	2 (1) / 2 (1)	2 (0) / 2 (0)	3 (1) /3 (1)
Stability of the results - Individual level					
% of experts changed their views in the 2nd round	2%	0%	0%	9%	4%
More optimistic, toward the median	2%	0%	0%	9%	0%
More optimistic, away from the median	0%	0%	0%	0%	0%
Less optimistic, toward the median	0%	0%	0%	0%	4%
Less optimistic, away from the median	0%	0%	0%	0%	0%

Fig. 1 Expected MaaS users by generation and the levels of stability of results (* group opinion by a media; ** degree of group consensus by interquartile range (IQR), i.e. the interval containing the middle 50% of responses)

2.2. The stated choice method

A limitation of the Delphi method is that it is based on the opinion of experts, which is not the same as intentions of consumers. To complement the findings of the Delphi study, we constructed and administered a state choice experiment, capturing the intention of consumer to adopt MaaS, dependent on its implementation.

2.2.1. Questionnaire design and data used

A traditional and powerful approach to empirically investigate individual preferences for adopting an innovative service is the use of a stated choice experiment, for collecting data under hypothetical market situations, and the subsequent estimation of a discrete choice model. In order to better understand individual preferences for MaaS, a conceptualisation of the key issues that determine MaaS adoption, which integrates all of them in a single

Table 1. Selected attributes and attributes levels

Experimental attributes	Attributes levels
Transport modes	
Public transport (bus, metro, tram)	Unlimited rides; Unlimited rides in one zone and for the others pay per ride; Pay per ride with 20% of discount on standard fare; Pay per ride
E-bike sharing	Unlimited rides; 1 free hour per day and then pay per ride; Pay per ride with 50% of discount on standard fare; Pay per ride
E-car sharing	300 min included and then pay per ride; 120min included and then pay per ride; Pay per ride with 20% of discount on standard fare; Pay per ride
Taxi	50 km included and then pay per ride; 30 km included and then pay per ride; Pay per ride with 40% of discount on standard fare; Pay per ride
Car rental	4 days included and then pay per ride; 2 days included and then pay per ride; Pay per ride with 20% of discount on standard fare; Pay per ride
Ride sharing	Unlimited rides; 100 km included and then pay per ride; Pay per ride with 20% of discount on standard fare; Pay per ride
On demand bus	Unlimited rides; Unlimited rides in one zone and for the others pay per ride; Pay per ride with 20% of discount on standard fare; Pay per ride
Subscription	
Monthly subscription price (€/month)	150; 180; 210; 240
Minimum time commitment (months)	1; 3; 6; 12
Data required for the registration	Full name, email address and phone number; Full name, email address, phone number and payment information; Full name, email address, phone number and permission to use GPS; Full name, email address, phone number, payment information and permission to use GPS
Social influence	
Service reviews from the general public	Only positive; Mostly positive but also some negative; Mostly negative but also some positive; Only negative
MaaS users among relatives (%)	0; 25; 50; 75
MaaS users among friends (%)	0; 25; 50; 75
MaaS users among colleagues (%)	0; 25; 50; 75

modelling framework, needs to be developed. Conceptualizing the choice process implicates defining the possible available options, the frame of how these alternatives can be presented, and the factors that might affect the choice (Viney, Lancsar, & Louviere, 2002). This process is highly challenging considering that a unique common characterization of MaaS is still lacking, despite the increasing interest in MaaS (Utriainen & Pöllänen, 2018). Moreover, the current MaaS initiatives and projects are highly diverse with different characteristics, attributes and levels of integration (Kamargianni et al., 2016). This diversity makes the identification of drivers and inhibiting factors affecting individuals' MaaS adoption highly challenging.

By examining the current literature centered on MaaS and the existing MaaS applications and projects developed around the world, a set of core characteristics of MaaS was selected (Jittrapirom et al., 2017). This helped us to identify the potential determinants of individuals' decision to adopt MaaS, which were used to design a stated choice experiment. Because we were interested in exploring individual preferences for MaaS as an innovative subscription-based mobility service based on bundling, the attributes were derived, also looking at the literature on innovation adoption, bundling and multipart pricing in the context of subscription-based services (See Caiati et al. (2017, 2019) for a more comprehensive description of the conceptualization and the design and administration of the questionnaire based on a sequential portfolio choice experiment). In this experiment, respondents were first asked to indicate whether they are interested to subscribe to MaaS and choose the transport modes to include in their subscription. Also they were asked for their preferences on which extra set of features of the service they would like to include. In this paper, we report our findings on the respondents' decision on MaaS subscription.

The attributes and their levels used to generate the experimental design are listed in Table 1. Attributes were grouped into three main subsets: attributes related to the transport modes that can be available on the platforms, attributes related to the subscription, and attributes related to social influence. An orthogonal fractional factorial design was employed to generate the choice situations. Ngene (ChoiceMetrics, 2014) was used to generate 128 unique combinations of the selected attributes and attributes levels from a total of 4^{14} possible combinations, and to block the experiment in 16 blocks, assigned to the respondents randomly.

The stated choice experiment represented the core part of the web-based questionnaire administrated in the Netherlands in August 2017 and March 2018. The survey started with an introduction about MaaS and a description of its key functionalities, to give the respondents some insights into this innovative and unfamiliar concept. In addition to the choice experiment, we presented the respondents with a series of questions about their demographic and socioeconomic background and travel-related characteristics. We also used a set of Likert scale statements to measure their personal traits (i.e. individual attitudes and perceptions of innovative and tech-enabled services). In the present study, only the background information of respondents was used and incorporated into the modelling framework. Bearing in mind the main research question of the present study, particular attention was given to lifestage categories, based on age, household structure, and work status.

Through the stated choice experiment, we collected 8,624 observations (related to a total of 1,078 respondents) on the decision to subscribe or not to a MaaS platform, assuming that the service characterized by the given list of attributes and their levels was available in the market.

2.2.2. Data analysis

2.2.2.1. Respondents' background information

Table 2 depicts the distribution of the respondents' background information for each age group and the entire sample. In the first row, the percentage of the samples in each group is shown. The sociodemographic data reported in the table illustrate a distinctive pattern in the frequency distribution between the age groups in the household situation and the work status categories. They give a first glimpse about the fact that there are certain differences in life circumstances within and across generations. For example, with regard to the millennials, a significant share of the youngest sample group (aged 18 - 24) are students (50.4%) live together with their parents (43.9%). Whereas others belonging to the same age cohort have initiated a career (40.3%) or have started a family (18%). These differences are likely to influence their general needs and autonomy, and consequently their travel-related behaviour and choices.

The data also depicts specific trends in driving licence and car ownership. On average, 79.8% of the entire sample has a driving license. A closer observation reveals differences within the millennial generation; only 69.1% of the young millennials have driving licences, compared with 83.2% of the older millennials. Furthermore, while 30.7% of the sample stated to have more than one car available in the household, 34.5% of the younger millennials and 28.1% of the older millennials has more than one cars available to them. The higher percentage in the younger millennials can be explained as most of the young millennials respondents declared to live with their parents (43.9%). Thus, it is reasonable to think that in these household situations usually more cars are needed. Considering all age groups, the collected data reveal that car ownership is generally higher for the older age groups.

About the possession of a season ticket for public transport, the highest percentage was registered for young millennials (59.7%), followed by the silent generation (42.0%) and the old millennials (40.7%). This can be due to the subsidized public transport for students and older people in the Netherlands. Accordingly, the average percentage of public transport usage for young millennials was about 25%, a higher percentage, compared with the average and that of the old millennials (both around 15%). A similar pattern can be observed for train usage, with the highest percentage of 9% for young millennials and 5% for the average. In contrast, young millennials appear to use car as drivers (14%) less than the older respondents of the same cohort (25%). The highest percentage of car driving was registered for the generation X (30.8%). The collected data also revealed that the use of bike is more common for baby boomers, generation X and old millennials than young millennials and silent generation.

2.2.2.2. Developing lifestage categories

As pointed out by the Delphi study, it is generally believed that the younger generations will be the early adopters of MaaS. However, the interviewed panel of experts pinpointed that this expectation might be rethought in light of individuals' travel needs and mobility resources.

Table 2. Frequency distribution of respondents' background information stratified by age groups

Characteristics	Young Millennials	Old Millennials	Generation X	Baby Boomers	Silent Generation	Entire Sample
	18-24	25-35	36-50	51-65	>65	>18
% of total respondents	12.9%	20.5%	25.9%	26.8%	13.9%	100% (1078)
Household situation						
Single without children	23.0%	22.6%	32.3%	40.8%	38.0%	32.2%
Single with child(s)	1.4%	6.3%	11.5%	6.2%	3.3%	6.6%
Couple without children	13.0%	29.0%	16.5%	32.5%	54.0%	28.1%
Couple with child(s)	3.6%	27.6%	38.4%	19.7%	3.3%	21.8%
Living at parent(s)/family	43.9%	6.8%	0.7%	0.0%	0.0%	7.2%
Living with others (no family)	13.7%	6.8%	0.4%	0.0%	0.7%	3.3%
Others	1.4%	0.9%	0.4%	0.7%	0.7%	0.7%
Occupational status						
Student	50.4%	7.2%	0.0%	0.4%	0.0%	8.1%
Employed	40.3%	77.8%	81.7%	61.9%	2.0%	59.2%
Unemployed/job seeker	6.5%	9.5%	9.0%	9.0%	0.7%	7.6%
Retired	0.0%	0.0%	0.4%	9.3%	96.7%	16.1%
Others	2.9%	5.4%	9.0%	19.4%	0.7%	9.1%
Driving License Ownership						
No	30.9%	16.7%	19.4%	20.1%	17.3%	20.2%
Yes	69.1%	83.3%	80.7%	79.9%	82.7%	79.8%
Car available in the households						
More than 1 car	34.5%	28.1%	26.9%	35.3%	29.3%	30.7%
1 car	41.7%	59.3%	59.5%	54.0%	64.7%	56.4%
None	23.7%	12.7%	13.6%	10.7%	6.0%	12.9%
Public transport seasonal ticket ownership						
No	40.3%	59.3%	64.9%	67.5%	58.0%	60.3%
Yes	59.7%	40.7%	35.1%	32.5%	42.0%	39.7%
Average percentage of use of transport modes						
Walk	21.5%	21.4%	21.5%	22.5%	24.9%	22.2%
Bike	19.5%	23.4%	23.9%	29.8%	18.0%	24.0%
Car as driver	13.9%	25.0%	30.8%	22.1%	27.1%	24.6%
Car as passenger	6.7%	6.0%	4.2%	4.2%	8.5%	5.5%
Public transport	25.2%	14.7%	11.6%	13.6%	12.4%	14.6%
Train	8.8%	7.2%	4.2%	3.9%	4.3%	5.3%
Other	4.5%	2.4%	3.8%	4.0%	5.0%	3.8%

For example, a millennial student living with her parents is expected to have different travel needs than a person belonging to the same generation, who is employed and have started a family. Therefore, the developed approach was built around a lifestage perspective. We assumed that different travel needs and preferences emerge at each of these lifestages, which might affect individuals' decisions to subscribe to MaaS.

To perform this analysis, a preliminary step was to develop lifestage groups. These were obtained from the combination of the following categorical variables: age, household composition and employment status. These sociodemographic variables have been used to define lifestage categories in other previous studies (Ryley, 2006; Hunecke et al., 2010). Differently from these works, in our study lifestage groups were not generated using pre-existing classifications or cluster analysis. On the basis of the categories used for the sociodemographic variables included in our study, we divided our sample into meaningful groups. First of all, it was considered desirable to create a manageable number of groups characterized by a sufficient number of respondents. The total number of lifestage groups obtained by all possible combinations of the three sociodemographic variables was 175. It represents not only an unmanageable number of levels for a categorical variable, but it also results in unrealistic combinations (e.g. young millennials retired, silent generation living with parents). Firstly, the age categories were collapsed in two groups: millennials (i.e. including both young and old millennials) and older cohorts (i.e. generation x, baby boomers and silent generation). This implies that there are age differences within the two groups. Then, apart from removing those combinations with 0% of occurrence, we iteratively applied a grouping rule to reduce the number of possible lifestage categories as much as possible, while at the same time minimize the loss of information and avoid overlaps. This grouping procedure produced 12 lifestage categories, shown in Table 3.

Furthermore, the estimation of the interactions between lifestages and transport background information may help

Table 3. Frequency and percentage distribution of lifestage groups

		Frequency	Percent
1	Millennials living at parents' house	71	7%
2	Millennials students living on own	41	4%
3	Millennials employed living on own	68	6%
4	Millennials employed in a couple without children	67	6%
5	Millennials employed single or couple with children	67	6%
6	Millennials unemployed/job seekers/others	46	4%
7	Older cohorts employed living on own	140	13%
8	Older cohorts employed couple without children	98	9%
9	Older cohorts employed couple with children	131	12%
10	Older cohorts employed in other household situations	41	4%
11	Older cohorts unemployed/job seekers/others	135	13%
12	Older cohorts retired	173	16%

to understand their combined effects on MaaS adoption. For instance, the interaction effect between the lifestage category “Millennials living at parents’ house” and the car availability category “cars available in the household” conveys how this specific combination affects the decision to subscribe, thus adding further information to the general effect of being millennials living with parents and having one car available in the household. Interaction effects for those combinations with a small percentage of occurrence were not estimated. We specifically considered mobility resources (e.g. private car availability, public transport seasonal ticket ownership) and modes of travelling (e.g. car as driver). Regular public transport users are, in fact, expected to be the early adopters of MaaS, while regular car users and cyclists are expected to adopt MaaS at a later stage or not switch to MaaS at all (Jittrapirom et al., 2018).

2.2.2.3. Modelling MaaS subscription decision

A binary random parameter logit model (McFadden & Train, 2000; Train, 2003) with interaction effects was estimated to investigate individuals’ preferences for a MaaS subscription and explore whether the probability of subscribing to a MaaS scheme is affected by individuals’ lifestages and transport related characteristics. According to the random utility framework, the utility that person *n* derives form alternative *j* can be expressed as:

$$U_{nj} = V_{nj} + \varepsilon_{nj} = \mathbf{x}_{nj}\boldsymbol{\beta} + \varepsilon_{nj} \tag{1}$$

where V_{nj} is the deterministic part of the total utility, specified as $\mathbf{x_{nj}}\boldsymbol{\beta}$, where $\mathbf{x_{nj}}$ is the vector of explanatory variables including the characteristics of the alternative and of the decision makers, and $\boldsymbol{\beta}$ is the vector of the unknown parameters to be estimated. The error term ε_{nj} is the unobservable part of the total utility U_{nj}. What is known from the choice experiment is a choice variable y_j that is equal to 1 if respondents chose to subscribe, 0 otherwise. If the error terms ε_{nj} are iid Gumbel distributed, the probability of choosing alternative *j* is:

$$\text{Prob}\left[y_j = 1 \mid \mathbf{x_{nj}}, \boldsymbol{\beta}\right] = \frac{1}{1 + \exp(\mathbf{x_{nj}}\boldsymbol{\beta})} \tag{2}$$

The random parameter logit model allows the parameters (any or all of them) to vary across individuals due to certain heterogeneity in preferences. Thus, differently from the standard logit model, it requires the specification of a distribution for the parameters of interest, $\boldsymbol{\beta}$. The normal distribution is used more often, and we used it also in this study. The probability of choosing alternative *j* becomes:

$$\text{Prob}\left[y_j = 1 \mid \mathbf{x_{nj}}, \boldsymbol{\beta}\right] = F\left(\mathbf{x_{nj}}\boldsymbol{\beta}\right) \tag{3}$$

Parameters were estimated using 1000 Halton draws. For the estimation, we assumed that only the constant term is random. The independent variables were all effect coded, with the last category serving as the reference category. The model was estimated using Nlogit (Greene, 2012).

3. Results

As a result of the subscription decision, respondents stated in only 17% of the choice situations that they would be interested in the subscription. By zooming in, this percentage increases to 28% and 24% for the young and old millennials, respectively, while lower values were registered for the older generations (i.e. 18% for generation X, 10% for baby boomers and 11% for the silent generation). Overall, this small percentage did not come as a surprise, considering that MaaS is considered an innovation, and it is still an unfamiliar concept to many.

Table 4 shows the results of the estimated model. McFadden Pseudo R-Squared is 0.32, indicating a good model fit. For what concerns the monthly subscription price, results indicate that the utility to subscribe monotonically decreases with increasing price, as expected. Furthermore, it seems that respondents prefer their subscription for longer time commitments rather than short ones. An explanation can be found in people habits, and specifically in the fact that people use to have long term subscription plans for other kinds of services, like public transport pass. As for the data required for the registration, results indicate a positive coefficient when GPS access was asked for the subscription. This could also be read through the lens of people habits since many smartphone applications ask for permission to access user’s real-time location. However, it resulted to be not significant.

The estimated parameters for the social influence attributes are in line with theoretical expectations. The probability of subscribing to MaaS increases as positive reviews from the general public become available. Regarding the hypothetical adoption of MaaS among different members of a social network, the results show that overall, the probability to subscribe increases with an increasing percentage of adoption. Overall, fewer transport modes attributes appear to be significant at this stage of the decision process. Here, we are interested in modelling the decision to subscribe, and not the bundling configuration decision, in which the pricing schemes are expected to play a more important role. However, the results reveal that generally, respondents are more likely to subscribe if the transport modes were presented with more inclusive pricing schemes (i.e. unlimited rides or a certain amount of travel allowances). The estimated coefficient for the alternative specific constant confirms that all else equal, respondents prefer to not subscribe to the service. The standard deviation also reveals significant heterogeneity in individual preferences for MaaS subscription.

Table 4 continues with the estimates of the main effects of the individual background variables. As for the lifestage, the likelihood of subscribing to MaaS is higher among millennials who are employed and have children, millennials living with their parents and older generations employed living on their own. In comparison employed millennials living with partner without children, older generations employed living with partner, older generations retired, and unemployed millennials and older generations are less likely to subscribe to MaaS. These findings confirm and enrich the results of the Delphi study. Overall, they reveal that the millennials will lead MaaS adoption, as foreseen by the surveyed experts, but the likelihood to subscribe to MaaS also depends on their lifestage. Millennials living on their own, without children or not working are less likely to subscribe compared to the persons of the same age groups employed that have started a family with children. The latter are expected to have more complex travel patterns; thus, they can see MaaS as an additional and convenient mobility tool to satisfy their needs. Furthermore, unemployed and unoccupied millennials seem to be the ones who are less likely to subscribe, as they may have lower purchasing power or have fewer regular activities leading them to travel.

Interestingly, these findings confirm the experts' concern on the negative effect that the less complex mobility patterns and the low purchasing power characterizing younger generations might have on MaaS adoption.

As for the travel-related characteristics, a significant positive coefficient is found for respondents who live in a household with at least one car. Respondents that own a season ticket for public transport are also more likely to subscribe, while respondents that use more frequently their personal car as drivers or usually walk or bike for their daily trips seem to be less likely to subscribe.

To better understand the impact of lifestages and travel-related characteristics on MaaS adoption, we also estimated the coefficients for the interaction terms. The estimation of the interaction parameters augmented the analysis of potential adoption of MaaS with new insights, allowing us to go beyond the results of the Delphi study based on the differentiation across age categories. Concerning private car availability, millennials living with their parents or unemployed millennials with at least one car in the household are less likely to subscribe. A negative coefficient was also found for unemployed respondents in older cohorts who are not working and own at least one car. This means that for them MaaS might not represent a convenient solution, maybe because they think that they can sufficiently satisfy their travel needs with their own cars. By contrast, people living on their own, both millennials and older generations, or people from older cohorts living in other household situations and owning at least one car might find MaaS as a better solution to travel, probably as an alternative to car ownership.

Furthermore, the results show that holding a seasonal ticket for public transport and being millennials, employed, with children increases the likelihood to subscribe to MaaS. This finding may suggest that they can continue to express their transit friendly attitude to satisfy their more complex travel needs due to the presence of children, by taking advantage of a subscription plan that can offer the integration of public transport with other means of transport. Inversely, those millennials who hold a seasonal ticket for public transport, employed and living on their own or in a couple without children are less likely to subscribe. Positive and significant coefficients were also estimated for older cohorts employed, living in a couple without children or in other household situations and holding a public transport seasonal ticket, while negative and significant coefficients were found for older cohorts employed living on their own or in a couple with children and owning a public transport seasonal ticket.

Inspection of Table 4 also reveals that those millennials who are students and live independently or those living at their parents' house are more likely to subscribe if they frequently use cars (as drivers). This may be indicative of their preference to use the mobility services available with the platform over driving a costly car. A positive coefficient for the interaction term with the frequency of use of cars as drivers for daily trips was also found for respondents in older cohorts, unemployed or those who are employed and live in other household situation. Young employed adults with children and older employed adults living independently, who use car more frequently are less likely to subscribe. According to these findings, MaaS cannot substitute the use of private cars for their daily trips, probably because of their less flexibility to arrange car-based trips by a MaaS platform.

Lastly, regarding the interaction terms with the use of non-motorized modes of transport (i.e. walk and bike) for daily travelling, positive coefficients were estimated for childless and employed millennial, younger and older adults who are not working, and respondents belonging to older cohorts who are employed and live as a couple with children. Inversely, millennials employed and having children, older adults employed living on their own or in other household situation are less likely to subscribe if they usually bike or walk during their daily trips. The results also reveal which interactions do not significantly affect MaaS adoption.

4. Conclusions and discussion

Recently, policy makers, businesses and authorities are attracted to MaaS as a potential mobility solution that may persuade car drivers to give up their cars in favour of a more sustainable way of travelling. In ensuring the implementation of MaaS is a success, it is essential to understand whether people are willing to adopt it. Scientific research can contribute to better understand the complexities and uncertainties related to the implementation and adoption of MaaS.

In this study, the emphasis is concentrated on the exploration of the early adopters of MaaS, focusing on the distinction between younger and older generations across different lifestages. The panel of experts interviewed with the Delphi approach expected the younger generations to be the early adopters of MaaS, although they believed that their uncomplicated mobility patterns and limited purchasing power might reduce their perceived added value of MaaS. Therefore, care should be taken to ensure the affordability of the service in light of the

Table 4. Parameter estimates and their significance for individual MaaS subscription decision

		Coeff.	*Std. Error*	*p-value*
MaaS attributes				
Subscription attributes				
Price	150 €/month	**0.688**	0.048	0.000
	180 €/month	**0.122**	0.058	0.037
	210 €/month	**-0.304**	0.064	0.000
	240 €/month	-0.506		
Time commitment	1 month	-0.047	0.062	0.447
	3 months	**-0.110**	0.065	0.090
	6 months	0.105	0.066	0.113
	12 months	0.052		
Data required for the registration	Full name, email address and phone number	**-0.158**	0.064	0.014
	Full name, email address, phone number and payment information	-0.013	0.065	0.836
	Full name, email address, phone number and permission to use GPS	0.089	0.060	0.140
	Full name, email address, phone number, payment information and permission to use GPS	0.082		
Social influence attributes				
General public reviews of the service	Only positive	**0.121**	0.060	0.044
	Mainly positive	0.010	0.059	0.869
	Mainly negative	-0.063	0.062	0.303
	Only negative	-0.067		
MaaS adoption among relatives	0%	**-0.116**	0.053	0.028
	25%	-0.019	0.055	0.730
	50%	0.074	0.051	0.149
	75%	0.061		
MaaS adoption among friends	0%	**-0.120**	0.056	0.032
	25%	-0.017	0.057	0.761
	50%	**0.094**	0.055	0.087
	75%	0.043		
MaaS adoption among colleagues	0%	**-0.134**	0.063	0.034
	25%	0.008	0.063	0.903
	50%	0.090	0.060	0.133
	75%	0.037		
Transport modes attributes				
Public Transport	Unlimited rides	**0.198**	0.057	0.001
	Unlimited rides in one zone and for the others pay per ride	-0.009	0.060	0.876
	Pay per ride with 20% of discount on standard fare	-0.086	0.063	0.173
	Pay per ride	-0.102		
E-bike sharing	Unlimited rides	-0.004	0.061	0.950
	1 free hours per day and then pay per ride	0.001	0.061	0.988
	Pay per ride with 50% of discount on standard fare	0.070	0.061	0.251
	Pay per ride	-0.067		
E-car sharing	300 min included and then pay per use	0.006	0.057	0.910
	120 min included and then pay per use	0.078	0.058	0.178
	Pay per use with 20% of discount on standard fare	-0.038	0.057	0.501
	Pay per ride	-0.046		
Taxi	50 km included and then pay per ride	-0.034	0.066	0.607

	30 km included and then pay per ride	0.053	0.062	0.396
	Pay per ride with 40% of discount on standard fare	-0.022	0.061	0.716
	Pay per ride	0.003		
Car rental	4 days included and then pay per use	0.024	0.061	0.692
	2 days included and then pay per use	0.009	0.067	0.898
	Pay per use with 20% of discount on standard fare	-0.023	0.065	0.723
	Pay per ride	-0.009		
Ride sharing	Unlimited rides	**0.184**	0.059	0.002
	100 km included and then pay per ride	-0.010	0.063	0.876
	Pay per ride with 20% of discount on standard fare	**-0.134**	0.064	0.036
	Pay per ride	-0.040		
On demand bus	Unlimited rides	0.071	0.061	0.250
	Unlimited rides in one zone and for the others pay per ride	-0.056	0.063	0.374
	Pay per ride with 20% of discount on standard fare	-0.057	0.063	0.369
	Pay per ride	0.043		
Alternative specific constant - Mean		**-1.423**	0.101	0.000
Alternative specific constant - Standard deviation		**3.410**	0.098	0.000
Individual background variables				
Lifestage variables				
Millennials living at parents' house		**0.773**	0.239	0.001
Millennials students living on own		0.029	0.386	0.940
Millennials employed living on own		-0.054	0.322	0.866
Millennials employed in a couple without children		**-0.544**	0.325	0.095
Millennials employed single or couple with children		**4.424**	0.348	0.000
Millennials unemployed/job seekers/others		**-1.289**	0.364	0.000
Older cohorts employed living on own		**1.381**	0.246	0.000
Older cohorts employed couple without children		**-0.944**	0.298	0.002
Older cohorts employed couple with children		**-0.802**	0.301	0.008
Older cohorts employed in other household situations		0.178	0.357	0.619
Older cohorts unemployed/job seekers/others		**-1.956**	0.338	0.000
Older cohorts retired		-1.195		
Travel-related characteristics				
Availability of at least one household’s car		**0.394**	0.191	0.000
Holding a seasonal ticket for public transport		**0.413**	0.040	0.000
Use of car as driver for daily traveling		**-1.970**	0.152	0.000
Use of non-motorized modes (walk or bike) for daily traveling		**-1.523**	0.050	0.000

Interaction effects between lifestages and travel-related characteristics				
Availability of at least one household’s car	Millennials living at parents' house	**-0.552**	0.153	0.000
	Millennials students living on own	-0.142	0.136	0.297
	Millennials employed living on own	**0.368**	0.135	0.006
	Millennials employed in a couple without children	-0.030	0.153	0.845
	Millennials unemployed/job seekers/others	**-0.465**	0.173	0.007
	Older cohorts employed living on own	**0.716**	0.132	0.000
	Older cohorts employed in other household situations	**0.448**	0.262	0.088
	Older cohorts unemployed/job seekers/others	**-0.293**	0.128	0.022
Holding a seasonal	Millennials living at parents' house	-0.147	0.105	0.162

ticket for public transport	Millennials students living on own	0.124	0.181	0.495
	Millennials employed living on own	**-0.292**	0.115	0.011
	Millennials employed in a couple without children	**-0.257**	0.124	0.039
	Millennials employed single or couple with children	**1.119**	0.126	0.000
	Millennials unemployed/job seekers/others	-0.101	0.100	0.316
	Older cohorts employed living on own	**-0.249**	0.125	0.045
	Older cohorts employed couple without children	**0.732**	0.100	0.000
	Older cohorts employed couple with children	**-0.954**	0.185	0.000
	Older cohorts employed in other household situations	**0.216**	0.108	0.045
	Older cohorts unemployed/job seekers/others	-0.147	0.105	0.162
Use of car as driver for daily traveling	Millennials living at parents' house	**1.677**	0.421	0.000
	Millennials students living on own	**3.386**	1.020	0.001
	Millennials employed living on own	-0.840	0.540	0.120
	Millennials employed in a couple without children	-0.740	0.528	0.161
	Millennials employed single or couple with children	**-2.999**	0.485	0.000
	Millennials unemployed/job seekers/others	1.087	1.016	0.285
	Older cohorts employed living on own	**-4.377**	0.520	0.000
	Older cohorts employed couple without children	0.216	0.431	0.617
	Older cohorts employed couple with children	0.198	0.463	0.669
	Older cohorts employed in other household situations	**1.026**	0.555	0.065
	Older cohorts unemployed/job seekers/others	**2.058**	0.679	0.002
Use of non-motorized modes for daily traveling	Millennials living at parents' house	0.080	0.438	0.856
	Millennials students living on own	0.125	0.555	0.822
	Millennials employed living on own	**1.574**	0.434	0.000
	Millennials employed in a couple without children	**1.421**	0.456	0.002
	Millennials employed single or couple with children	**-5.104**	0.554	0.000
	Millennials unemployed/job seekers/others	**2.098**	0.506	0.000
	Older cohorts employed living on own	**-2.133**	0.389	0.000
	Older cohorts employed couple without children	-0.385	0.489	0.431
	Older cohorts employed couple with children	**1.221**	0.413	0.003
	Older cohorts employed in other household situations	**-2.358**	0.691	0.001
	Older cohorts unemployed/job seekers/others	**2.386**	0.453	0.000

youth's purchasing power and available subsidies. For instance, the availability of such subsidies may require a unique configuration of the MaaS business model to ensure its attractiveness.

The results from the conducted stated choice survey confirmed and further elaborated these expectations. Though the development of lifestage categories entered in the model as independent variables, we found that the likelihood to subscribe to MaaS highly depends on the specific lifestage of a young or older adult. For example, young couples having children are more likely to subscribe than people of the same generation living with a partner and without children, probably because of their more complex daily travel patterns due to the child-related travel activities. Our analysis also showed that the effect of individual transport-related characteristics on MaaS adoption decision indeed varies between stages of life. While these results add further knowledge to the growing body of literature on MaaS, we need to note some caveats to not misinterpret the results. First of all, it must be remembered that only a small percentage of respondents stated that they would subscribe to MaaS. Furthermore, from our analysis it seems that the decision to subscribe is mainly influenced by travel needs and constraints, with lifestage viewed more as a moderator variable.

The findings of this study are relevant to the development of evidence-based policies and plans aimed to support MaaS initiatives and cater all the travellers. From a practical perspective, the model application helps in understanding individual preferences for MaaS adoption taking into account individual travel related characteristics in combination with lifestages. This can provide policy-makers and practitioners with a more nuanced understanding of which policies and programs would be more effective in encouraging MaaS adoption and for whom these might be more appropriate. For example, according to the study results, young adults employed with children who use car more frequently are less likely to adopt MaaS. This could mean that MaaS cannot replace their use of private cars, probably because they would experience less flexibility and more uncertainty in arranging car-based trips through a MaaS platform. Therefore, to reap the greatest benefits of MaaS in terms of increasing the modal share of all transport modes at the expenses of private car usage, policy makers and practitioners may look at the specific needs of this type of travellers and promote incentives on certain mode choices and design reliable and flexible services.

When it comes to long-term policy planning, it is crucial to understand how the needs, attitudes and preferences of the different generations will evolve over time. We also want to point out that to have a more comprehensive understanding about how individual preferences for MaaS adoption changes among the different cohorts, according to the various life events, that might occur over time, we need to rely on more complex survey methods aimed to collect data over a longer period.

Moreover, this study is limited to the investigation of the potential demand for MaaS. In our future work, we intend to explore the behavioural impact of this innovative platform on daily travel patterns using a stated adaptation approach (Feneri et al., 2019), modelling the switch in travel behaviour after the adoption of MaaS. Merging our findings on travel demand for MaaS and activity-travel adaptations will ultimately contribute to gaining an overall understanding of the factors that could assist the actual transition towards innovative sustainable transport solutions.

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