Am I willing to give up my car?

An analysis about the willingness of Dutch citizens to adopt MaaS and the triggers affecting their choices.

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ABSTRACT

Mobility-as-a-Service (MaaS) is a new way to understand mobility, which integrates services such as car-sharing, bike-sharing, public transport, etc. Its goal is that mobility requirements be no longer privately-owned mobility resources, but requested on-demand. In this paper we considered the willingness to adopt MaaS services, choices between different kinds of MaaS subscriptions as well as the choice between MaaS and private vehicle ownership by means of two choice-experiments, address simultaneously on the basis of an HDCM framework.

The results show that the willingness to adopt MaaS is greatly influenced by the socio-demographic characteristics of the individuals, while the WTP for different mobility services within MaaS subscriptions lies below the current prices paid for those services individually. However, the WTP exhibits a large variation across individuals indicating that MaaS may be interesting for specific user groups.

Keywords: mobility-as-a-service, MaaS, car ownership, mobility choices

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1. INTRODUCTION

For the majority of the population, a large share of their mobility requirements can be fulfilled by sustainable transportation modes, such as public and non-motorized transportation. However, these forms of transportation offer significantly less flexibility than private motorized transportation. Therefore, many households opt for the acquisition and use of private vehicles. While they are associated with large fixed costs, they are also characterized by low usage costs, convenience, and flexibility. Consequentially, once private vehicles are already available, the use of sustainable transportation modes and multi-modality decreases (Le Vine and Pollack, 2009).

MaaS is a new way to understand mobility, promising to integrate several mobility tools and services such as car-sharing, bike-sharing, public transport, etc. Its ultimate goal is that mobility requirements be no longer fulfilled by privately-owned mobility resources, but by requesting mobility services on-demand (Shaheen and Cohen, 2013; Jittrapirom et al., 2017; Goodall et al., 2017). A switch from privately-owned transportation modes to MaaS is seen as a chance to increase the use of sustainable modes of transportation and to promote a more rational use of mobility supply and livable cities (Chen and Kockelman 2016; Hopkins and Schwanen, 2018).

However, granting access to mobility options that are currently available to owners of private vehicles only also carries the risk of weakening sustainable transport alternatives (e.g. if users of sustainable alternatives switch to motorized transport, or if occupancy rates decrease). In the immediate term, *ceteris paribus*, the deployment of MaaS should have a non-negative impact on the use of private motorization, as automobiles and other private motorized transportation modes become immediately available to users, who previously did not have access to them and relied exclusively on public transportation and non-motorized transportation. This impact can only be compensated if in the short/medium term individuals who previously had access to private motorization, replace this alternative with MaaS subscriptions, or if individuals who would have purchased private vehicles otherwise refrain from doing so, in light of the existence of MaaS services (implying a reduction in car-ownership). In both cases, an alternative with large fixed and low marginal costs would have been replaced by an alternative that promises a more rational use of resources (which in turn, should diminish the use of private motorized vehicles). Hence, the net effect of MaaS on improving the sustainability of cities will depend on how the aforementioned effects balance out, as subscriptions may reduce car ownership while still increasing the vehicle kilometer traveled (Hörcher and Grahan, 2020).

In this paper, we consider the users' preferences for MaaS services and how MaaS may impact car ownership on the basis of two stated-preferences experiments. The first experiment targets choices between different kinds of MaaS services, while the second considers the decision of choosing between Maas and ownership of private transportation. The answers to both choice tasks are analyzed in an integrated fashion considering common parameters across experiments and that answers provided by the same individuals in both experiments are correlated. We also consider underlying preferences for MaaS based on a latent variable.

2. EXPERIMENTAL DESIGN

In the past, several studies have addressed the willingness to adopt MaaS on the basis of stated preferences (SP). However, the construction of MaaS bundles in SP-experiments is not straightforward. Given the large number of possible combinations between mobility options and the way to access them, it becomes prohibitive to consider all dimensions in a single SP-experiment, as it would easily exceed the cognitive capacity of the respondents (Caussade et al, 2005). Consequentially, most studies have centered their efforts upon a limited range of attributes, offering mostly a single pricing scheme to access different transportation modes (e.g. within a bundle access to shared-bikes may be offered in terms of a given amount of hours per month or in terms of a given price per hour, but both dimensions are not addressed jointly in the same experiment).

In light of the literature research and given that the focus of this study is to address how access to MaaS may impact car-ownership, we can identify two main challenges: first, whether individuals are likely to replace the ownership of private vehicles with MaaS subscriptions depends on the attributes of the MaaS subscriptions being offered, which, consequentially, implies that different kinds of bundles have to be considered. Second, MaaS subscriptions can be constructed in so many ways and include so many dimensions that they can easily overwhelm SP respondents (especially, if they are also required to weigh these bundles against car ownership).

Consequentially, it was decided to approach the problem considering two different SP-experiments. The first experiment would consider the choice between different MaaS bundles, while the second experiment would contrast a MaaS bundle against the options offered by private car ownership. The attributes considered by the different MaaS bundles would differ in both experiments, in order to cover a wider range of attributes. However, some attributes would appear in both experiments to allow connecting the answers provided in both of them following the approach suggested by Morikawa (1994). This would allow comparing the attributes contained in both experiments and deriving trade-offs between them. Furthermore, to link individual preferences and personal valuations in both experiments, each respondent was faced with both of them. This allows assessing a possible correlation among the answers provided in both tasks.

The first experiment consisted of choices between different MaaS bundles, akin to experiments previously reported in the literature. It considered two unlabeled MaaS bundles and an opt-out alternative, for individuals not being interested in MaaS at all. In general terms, the bundles considered in these experiments provided access to different mobility options on the basis of reduced prices. The attributes considered were the following:

a) **MaaS subscription pric**e: Representing the monthly price paid for MaaS subscriptions. The price ranged between 50€ and 300€.
b) **Public transport price:** Starting from the price per kilometer defined by Nederlandse Spoorwegen (0.2€ per km), the bundles considered different discounts, depending on whether the trip was conducted during peak or off-peak periods.
c) **Car-sharing price:** Starting from a price of 0.3 € per km (which aligns with the price used by different car-sharing providers in the country), the bundles considered different discounts, ranging from 0 to 60%.

d) **Car-renting:** This attribute considered the unlimited use of a car for a longer period of time (akin to car-rentals). Each bundle considered a given number of free days ranging from zero to six days.
e) **Bike-sharing price:** This attribute considered the use of shared-bikes. The base price was 0.2€ per hour, which aligns with the prices used by Nederlandse Spoorwegen.

The second experiment represented a choice between a given MaaS bundle, and a privately-owned vehicle. In general terms, the MaaS-bundles considered in this experiment focus on limited free access to mobility options followed by full prices. The attributes considered were the following:

a) **Fixed costs of car ownership:** Representing all fixed costs associated with car-ownership, namely road taxes, mandatory insurance, and age-related depreciation. Prices ranged between 150€ to 350€ with an average of ca. 270€.
b) **MaaS subscription pric**e: Representing the monthly price paid for MaaS subscriptions. Price ranged between 75€ and 250€.
c) **Variable costs of car ownership:** It represents the costs per kilometer associated with privately owned vehicles. It includes fuel costs, maintenance costs and usage-related depreciation. The average costs are 0.16€ per km.
d) **Car-sharing:** It considered a given amount of free hours of car-sharing usage within the MaaS bundle. It ranged between 1 and 30 hours, with an average of 8 hours.
e) **Public transport:** It considered a given amount of free trips per month within the MaaS bundle. It ranged from 5 to 100 trips with an average of 30. No differences between peak and off-peak periods were made.
f) **Shared scooters:** It considered a given amount of free trips using shared-scooters within the MaaS bundle. It ranged between 5 and 30 trips with an average of ca. 12 trips.
g) **Distance to the vehicles:** Represents the distance that the users have to walk to reach the vehicles (i.e. it represents how good the coverage of MaaS-services is).

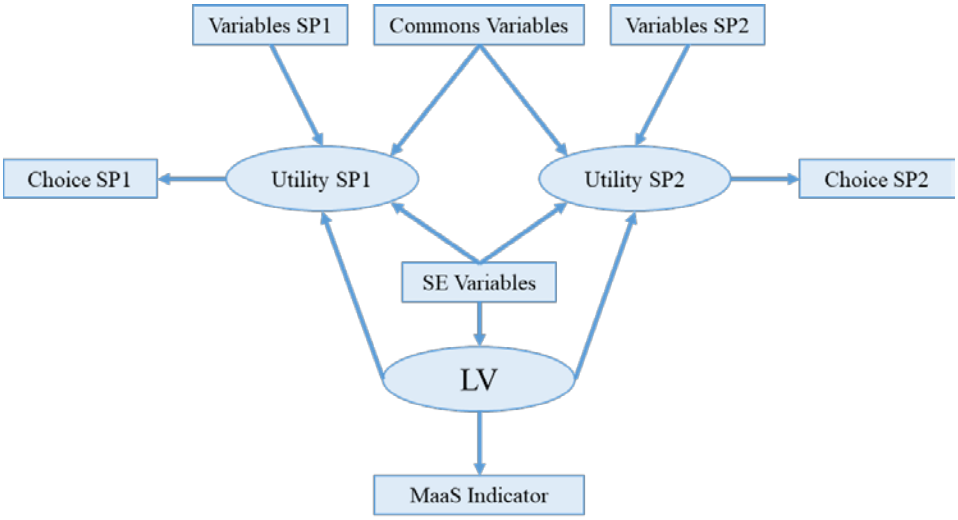
Each individual faced four scenarios from each experiment (i.e. eight answers were collected per individual). Finally, each individual was asked regarding their willingness to use MaaS services in the future, having the options to answer likely, maybe and unlikely. This indicator was used to the model the underlying willingness of different individuals to adopt MaaS and is referred as the Maas Indicator throughout the paper.

3. DATA COLLECTION

The data collection was conducted between June 1st and June 12th of 2021 making use of an online tool. Participants were randomly approached via printed invitations delivered door-to-door in accordance with random walk procedures. Starting points for the random walks were also randomly selected from different districts of Utrecht. In addition, surveys invitations were distributed in the nearby located communities of Driebergen-Rijsenburg and Montfoor. Given the sampling method, all residents were equally likely of being sampled. In total, 186 respondents answered the survey, but only 124 of them completed it, in such a way that it could be used for analysis purposes. An adequate distribution of households inhabiting city centers, transition zones, and suburbs was achieved.

4. MODELING FRAMEWORK

Due to space constraints, it is unfeasible to present a full description of the modeling framework. Thus, we present a schematic depiction of the model and the likelihood function that characterizes it.



$$L = \prod_q \int_\phi \int_\upsilon \int_\varphi \int_\zeta \prod_t \begin{matrix} P(y_1 \mid X_1, \varphi, \upsilon, \eta, \phi; \beta, \gamma, \delta, \theta, \Sigma_{\varepsilon 1},) \cdot \\ P(y_2 \mid X_2, \varphi, \upsilon, \eta, \phi; \beta, \gamma, \delta, \theta, \Sigma_{\varepsilon 2},) \cdot \\ P(I \mid \eta; \Sigma_{\varepsilon_{LV}}) \cdot f(\eta \mid X; \alpha, \Sigma_\zeta) \cdot \\ f(\varphi \mid \Sigma_\varphi) \cdot f(\upsilon \mid \Sigma_\upsilon) \cdot f(\phi \mid \Sigma_\phi) \end{matrix} \cdot d\zeta \cdot d\varphi \cdot d\upsilon \cdot d\phi \quad ,$$

where *y1* and *y2* represent the choices in the first and the second experiment, respectively. *I* represent the MaaS indicator. Consequentially, the first three terms of the integral represent the probabilities of observing a given choice in the first choice-task (SP1), in the second choice-task (SP2), or that a given level is stated for the indicator, respectively. The first two probabilities respond to an MNL specification while the third is given by an OL. However, because of the scale parameter, the estimators associated with different probability functions are not directly comparable. Then, for comparison purposes, one of them has to be normalized, while the others are expressed as a function of the former. This is done by multiplying all elements of the non-normalized utility functions by a scale parameter to be estimated (Morikawa, 1994).

5. RESULTS AND DISCUSSION

Two models have been selected. The first model considers no common variable across SP1 and SP2 (note that they are still correlated, as *LV_MaaS* affects both utility functions). The second model considers that the valuation of the subscription price of MaaS and of the fixed costs of car ownership are common across both experiments. Similarly, it was considered that the costs of car-sharing per kilometer were perceived similarly to the variable costs of car ownership per kilometer. The results for the estimated models are presented in Table 2.

Table 2 – Model results

Variable	Equation	Model 1			Model 2		
CarOwnership	*S.E. LV_MaaS*	**-2.74**	*0.333*	(-8.25)	**-2.72**	*0.326*	(-8.37)
Female	*S.E. LV_MaaS*	**1.53**	*0.26*	(5.88)	**1.52**	*0.249*	(6.11)
Old	*S.E. LV_MaaS*	**-1.09**	*0.448*	(-2.43)	**-1.37**	*0.43*	(-3.18)
HingInc	*S.E. LV_MaaS*	**1.11**	*0.277*	(4.01)	**0.976**	*0.259*	(3.77)
AccTrnSt	*S.E. LV_MaaS*	**0.753**	*0.315*	(2.39)	**0.954**	*0.29*	(3.29)
ACS1_SP1	*SP1_Utility_1*	**2.19**	*0.621*	(3.53)	**2.62**	*0.492*	(5.33)
ASC2_SP1	*SP1_Utility_2*	**2.67**	*0.703*	(3.8)	**2.94**	*0.635*	(4.62)
LV_MaaS	*SP1_Utility_1*	**0.754**	*0.377*	(2)	**0.847**	*0.288*	(2.95)
LV_MaaS	*SP1_Utility_2*	**0.525**	*0.389*	(1.35)	**0.643**	*0.282*	(2.28)
Fixed_Cost_SP1	*SP1_Utility_1,2*	**-0.0294**	*0.00549*	(-5.36)	-	-	-
φ Fixed_Cost_SP1	*SP1_Utility_1,2*	**-0.012**	*0.00445*	(-2.69)	-	-	-
Cost_Carsharing_SP1	*SP1_Utility_1,2*	**-4.38**	*4.14*	(-1.06)	-	-	-
φ Cost_Carsharing_SP1	*SP1_Utility_1,2*	**-6.84**	*3.73*	(-1.83)	-	-	-
CostProxy_PT_Peak_SP1	*SP1_Utility_1,2*	**-0.263**	*0.174*	(-1.51)	**-0.365**	*0.166*	(-2.2)
φ CostProxy_PT_Peak_SP1	*SP1_Utility_1,2*	**0.647**	*0.221*	(2.93)	**0.617**	*0.228*	(2.71)
Cost_PT_Valley_SP1	*SP1_Utility_1,2*	**-8.88**	*3.1*	(-2.86)	**-7.22**	*2.71*	(-2.67)
φ Cost_PT_Valley_SP1	*SP1_Utility_1,2*	**11.2**	*3.24*	(3.45)	**10.7**	*3.33*	(3.21)
Car_Rent_SP1	*SP1_Utility_1,2*	**0.602**	*0.215*	(2.8)	**0.407**	*0.196*	(2.07)
Discount_Bike_SP1	*SP1_Utility_1,2*	**3.87**	*1.27*	(3.06)	**4.49**	*1.08*	(4.15)
φ Discount_Bike_SP1	*SP1_Utility _,2*	**5.43**	*1.36*	(3.99)	**6.35**	*1.21*	(5.25)
Fixed_Cost_Common	*SP1_Utility_1,2 SP2_Utility_MaaS,PV*	-	-	-	**-0.0267**	*0.00536*	(-4.98)
υ Fixed_Cost_Common	*SP1_Utility_1,2 SP2_Utility_MaaS,PV*	-	-	-	**0.0114**	*0.00269*	(4.24)
Variable_Cost_Common	*SP1_Utility_1,2 SP2_Utility_MaaS,PV*	-	-	-	**-8.52**	*2.85*	(-2.99)
υ Variable_Cost_Common	*SP1_Utility_1,2 SP2_Utility_MaaS,PV*	-	-	-	**6.53**	*2.27*	(2.88)
Scale parameter	*SP2_Utility_MaaS, PV*	-	-	-	**0.735**	*0.222*	(3.3)
ASC_MaaS_SP2	*SP2_Utility_MaaS*	**4.16**	*1.35*	(3.07)	**-5.89**	*1.76*	(-3.34)
CarToWork	*SP2_Utility_MaaS*	**2.1**	*0.89*	(2.36)	**-1.65**	*0.966*	(-1.7)
LV_MaaS	*SP2_Utility_MaaS*	**1.29**	*0.277*	(4.65)	**1.84**	*0.528*	(3.48)
Fixed_Cost_SP2	*SP2_Utility_MaaS,PV*	**-0.0197**	*0.00501*	(-3.94)	-	-	-
φ Fixed_Cost_SP2	*SP2_Utility_MaaS,PV*	**0.0124**	*0.00392*	(3.15)	-	-	-
Cost_Car_SP2	*SP2_Utility_MaaS,PV*	**-9.68**	*3.3*	(-2.93)	-	-	-
φ Cost_Car_SP2	*SP2_Utility_MaaS,PV*	**-6.92**	*3.39*	(-2.04)	-	-	-
PT _SP2	*SP2_Utility_MaaS,PV*	**0.0536**	*0.0281*	(1.91)	**0.0858**	*0.0336*	(2.55)
φ PT _SP2	*SP2_Utility_MaaS,PV*	**-0.0863**	*0.0234*	(-3.69)	**-0.104**	*0.0313*	(-3.31)
Carsharing _SP2	*SP2_Utility_MaaS,PV*	**0.0522**	*0.0326*	(1.6)	**0.0887**	*0.0402*	(2.21)
Scooter _SP2	*SP2_Utility_MaaS,PV*	**0.066**	*0.0329*	(2.01)	**0.0751**	*0.0447*	(1.68)
Distance_SP2	*SP2_Utility_MaaS,PV*	**-0.212**	*0.0712*	(-2.98)	**-0.288**	*0.0942*	(-3.06)
Threshold_1	*OL*	**-2.95**	*0.424*	(-6.95)	**-2.81**	*0.415*	(-6.76)
Threshold_2	*OL*	**0.555**	*0.411*	(1.35)	**0.695**	*0.396*	(1.75)
Log-likelihood			**-910.05**			**-912.96**	
Equiprobable Log-likelihood			**-1433.62**			**-1433.62**	
ρ2			**0.365**			**0.363**	
Number of parameters			**34**			**31**	

For each model, the first column (in bold) indicates the estimated parameter, the second column (in cursive) indicates its standard deviation, while the third column (in parenthesis) indicates the t-statistic against zero. The final value for the log-likelihood is also reported. As a null-model does not exist for ordered models, the log-likelihood of the estimated models is contrasted with the log-likelihood of an equiprobable model.

The model considering common parameters across experiments does not offer a statistically superior performance to the restricted model (LRT = 5.82 < $X^2_{3,10\%}$). Hence, respondents do not seem to consider the price of MaaS subscriptions differently in both models, which supports the proof-of-concept that different attributes of MaaS can be considered simultaneously by using different SP experiments. Furthermore, it indicates that the respondents seem to value differently neither the money spent on fixed costs for MaaS and on private vehicle ownership nor the money spent per kilometer for private vehicles and for car-sharing. This is consistent with the rationality assumptions. Note, however, that it does not imply that individuals value MaaS subscriptions and car-ownership alike, as both exhibit different ASCs.

Regarding the valuation of MaaS, individuals currently owning private vehicles or older than 70 years, exhibit a substantially lesser willingness to try MaaS. Women and individuals with higher incomes are more likely to be interested in MaaS. Living near a train station also increases the likelihood of being interested in MaaS. As expected, the willingness to try MaaS has a positive effect on likelihood of opting for MaaS instead of private vehicle ownership. On top of that, individuals regularly commuting by car appear to be much less willing to change private vehicles by MaaS.

Regarding the valuation of pricing schemes, the average individual exhibits a willingness-to-pay (WTP) of ca. 3.2€ in monthly fixed costs in order to reduce the variable costs per km. of either car-sharing or private vehicles by 1¢. This valuation does not statistically significantly differ from the WTP to reduce the costs per km. of PT during off-peak hours, which amounts to ca. 2.7€ in fixed costs. The WTP to reduce the costs per km. of PT during peak hours cannot be directly compared, as it depends on the commuting time, but for individuals commuting for 30 min. (close to the average of our sample) it amounts to ca. 4.1€ of fixed costs. The WTP for one day or car rental amounts to ca. 15€ per month, which is below current prices. Finally, the WTP for any kind of discount for bike-sharing is implausible high (amounting to more than 160€ of fixed costs per month), which is indicative of a rather psychological effect, implying that individuals expect that bike-sharing has to be included in any MaaS subscription bundle. This can be understood given the key role that bikes play in the Dutch society.

The WTP of the average individual for one free trip by PT, one free hour of car-sharing or one free trip by scooter is ca. 3.2€, 3.3€ and 2.8€ of monthly fixed costs, respectively. While the price for one free trip by PT aligns with actual prices, the WTP for free hours of car-sharing or free trips by scooter seems to be below actual prices. Finally, the average individual exhibits a WTP of ca. 11€ of monthly fixed costs to reduce the average distance to the vehicles by one minute.

From a policy perspective, the WTP of the average individual for free access to mobility options is consistently below the prices currently paid for single access to these transportation modes. Consequentially, offering MaaS subscriptions that are attractive to the average individual may not be profitable. However, it is important to note that the fixed price disutility of MaaS exhibits a significant variability across individuals (CV ca. 43%); hence, even if some MaaS bundles may not be attractive to the average individual, they still have the potential to be attractive to individuals exhibiting a smaller fixed price disutility than the average. In fact, for the 80th percentile, the WTP is 56% higher than for the average individual, while for the 90th percentile, it is 120% higher.

Also, it must be considered that from a policy viewpoint, the deployment of MaaS does not only aim at successful business models but also at enhancing the sustainability of transportation systems and reducing car-captivity. When considering these goals, it is possible that the ideal configuration of MaaS bundles from a societal viewpoint may differ from the ideal configuration from a business perspective. Hence, the aforementioned trade-offs among Maas bundles attributes should not only be contrasted with actual prices but with societal costs, including positive and negative externalities.

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