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Abstract - Neighbourhood mobility hubs may play an important role in mitigating the impact of passenger cars on climate change and urban public space. As a relatively new concept, academic research on the user potential of neighbourhood mobility hubs is so far limited. This research aims to identify which user groups are likely to adopt services offered by a neighbourhood mobility hub. A survey was distributed in the Netherlands (N=298), an Exploratory Factor Analysis (EFA) executed and a Latent Class Cluster Analysis (LCCA) estimated. Four distinctive groups of intended users are uncovered. Two of the clusters have intentions to use neighbourhood mobility hubs. Two other clusters do not (yet) intend to use neighbourhood mobility hubs. The clusters indicate that people who currently already travel more by sustainable modes (train or (e-)bicycle) are more likely to be adopters of neighbourhood mobility hubs than the traditional car users. In practice, this may limit the positive effect of hubs or even increase car use. However it could also facilitate those travelling sustainably to do so for longer as additional shared modes become available to them via hubs. Limitations and directions for further research are discussed.

Keywords – mobility hubs, behaviour, latent class modelling, shared mobility

I. INTRODUCTION

Neighbourhood mobility hubs may play an important role in mitigating the impact of passenger cars on climate change and urban public space. A neighbourhood mobility hub is a physical location where different shared transport options are offered at permanent, dedicated and well-visible locations which are available at walking distance from home [1], [2]. By offering these mobility services at a hub, personal car use (and ownership) may be reduced by providing beneficial features (e.g. increased mobility, accessibility, flexibility) without the negative aspects (e.g. spatial use, high emissions, congestion) of owning and using a car [3].

As a relatively new concept, mobility hubs are starting to gain attention in academia and practice. However, the focus is mainly on medium to large-sized mobility hubs (such as train stations and park & rides), that are located in urban areas or at the edge of cities [4]. From a commercial and sustainability perspective, the success of a neighbourhood hub depends mainly on the number of users and their mobility service selection. However, potential user insights are currently lacking. Therefore, this research aims to identify which user groups are likely to adopt mobility offered by neighbourhood mobility hubs, using a case study in the Netherlands.

II. METHODOLOGY

To identify different potential mobility hub user groups, a literature study is carried out to identify factors that might influence the intention to use mobility hubs [5]. Different theories exist in scientific literature, aiming to explain if people merely intend to or actually will use new technologies. Based on a literature review, we apply the UTAUT2 model in this study [6]. The UTAUT2 conceptual model is chosen because it builds upon eight proven technology acceptance models, the model has been shown to have a high prediction accuracy and it has a focus on consumer technologies [7]. We consider a mobility hub to be a consumer technology as it involves the use of shared vehicles (which have to be accessed by IT technologies) and other technical artefacts (such as parcel machines) by consumers. Based on our conceptualization with UTAUT2, we were able to identify factors and constructs that might explain potential mobility hub use. These factors and constructs (see later) form the basis for our survey and interpretation of the results.

Next, based on the model conceptualisation, a questionnaire is constructed, consisting of categorical 5-point Likert scale questions and two open questions. The respondents were approached on the streets in the Dutch cities of The Hague, Leiden and Utrecht and also reached via social media. The central part of the survey was based on the conceptual model and included 30 questions to capture various indicators. Furthermore, the questionnaire was used to capture individual characteristics of the respondents, including socio-demographics, their current mobility patterns, past experiences with shared transport and questions regarding their intention to use mobility hubs in the future.

Third, a factor analysis is executed, to (1) understand the structure of the set of variables and to (2) reduce the dataset

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to a feasible size while keeping as much of the original information as possible. Also, the factor analysis enabled us to execute a cluster analysis [8]. Since this research aims to gain insight into the factors influencing a neighbourhood mobility hub rather than checking whether the conceptual model holds, the Exploratory Factor Analysis (EFA) is chosen for further analysis [9]. IBM SPSS Statistics (version 28) is used for the EFA, using the Principal Axis Factoring and Direct Oblimin rotation technique. The determination of the number of factors is done using three measures: the Kaiser rule (eigenvalue > 1) that is verified by a scree plot [8], [10]. Furthermore, each factor must have at least three acceptable factor loadings (≥ 0.40) [11].

After determining the number of factors, the next step is to determine which variables belong to which factor. This is checked using three criteria: the factor loading (≥ 0.30) [10], the cross-loading (≤ 75% of highest indicator loading) [11] and communality (≥ 0.20) [12].

The final step is to perform a Latent Class Cluster Analysis (LCCA). In LCCA, individuals are grouped in different clusters according to an unobserved latent class variable that explains their responses on a set of observed indicators [13]. The advantages of LCCA include the use of statistical criteria to determine the optimal number of classes, the ability to deal with various scale types of variables (i.e. nominal, ordinal, continuous, count) and computing the significance of the model parameters. Moreover, the probabilistic-based clustering mechanism introduces uncertainties when assigning individuals into different segments, generating more homogeneous segments than deterministic-based clustering techniques. The LCCA is executed using Latent GOLD (v5.1) [14]. Firstly, we estimate the measurement model without the covariates, to determine the appropriate number of classes. The purpose of this step is to find the most parsimonious model: the model with the smallest number of classes, which can sufficiently describe the associations between the indicators. A combination of statistical tests (BIC) and interpretability of the models is used to select the optimal number of classes. When the number of classes is known, the covariates are added.

III. RESULTS

A. Factors

In our conceptual model, based on literature, eight constructs and 12 moderators are expected to influence the intention to use mobility offered by mobility hubs [5]. Since mobility hubs are not yet implemented on a large scale and most users are still in the innovators' stage, the direct measuring of user behaviour is not possible. Therefore we measured only intention to use. It is decided to exclude habit in the conceptual model, as it is seen as a prior behaviour [7], which is hard to measure with technology that has not yet gained sufficiently widespread among users. The eight constructs that are expected to influence the intention to use neighbourhoods hubs are (1) performance expectancy (PE): the degree to which a person believes that using new technology can improve his or her performance (e.g. in travel time and convenience), (2) effort expectancy (EE): the perception that using a new technology is free from effort, (3) social influence (SI), (4) facilitating conditions (FC): the degree to which a person believes to be in control of the technical conditions of the new technology, (5) hedonic motivation (HM): the fun or pleasure derived from using a technology, (6) price value (PV), (7) environmental concern (EC): the awareness of consequences or effects held by an individual on environmental problems, and (8) individual innovation (II): the ability of an individual to be skilled in discovering and accepting new technologies.

Additionally, moderators are added to the model, as they are expected to influence the relationship between the constructs and the intention to use mobility hubs. The moderators are: age, education, income, gender, experience, car ownership, car availability, work situation, degree of urbanity, household composition, main mode of transport and hub functionalities. We apply the grouping from the Dutch Institute of Statistics [15].

B. Survey and latent classes

In total, 298 people completed the survey which was carried out in the Netherlands, 16-30 May, 2022. The sample is not fully representative of the Dutch population [5]. It has an above average share of men, younger people (≤ 35 years old), higher income households and people living in a highly urbanised areas. Despite the overrepresentation of some groups, there is still sufficient and representative variation in the sample to derive groups with specific preferences and characteristics. This is discussed further in section V.

The EFA resulted in a four-dimensional structure, having a KMO of 0.874. The four factors explain a total of 60.227 % of the variance between them. Bartlett's Test of Sphericity is significant ($p<0.001$) and all communalities are larger than the required value of 0.20. The determinant of the correlation matrix is <0.001 and is higher than the required value of 0.00001. In Table I, the results of the factor analysis are presented. Each construct (PE1, PE2 etc.) relates to a particular question in the survey [5]. Here, different constructs are captured by a single item. The four factors are: mobility hub beneficials (F1), facilitating conditions (F2), individual innovation scepticism (F3) and social-environmental responsibility (F4). As can be seen in Table I, not all factors of the conceptual model are included after the EFA. The factor price value (PV) did not withstand the factor analysis: the communality of PV1 was too low and PV2 is removed because it is found to have factor cross-loadings which are too high.

Performance expectancy, Effort expectancy and Hedonic motivation together form Factor 1: 'Mobility hub beneficials'. This, may have to do with the fact that all these constructs are related to the advantages of mobility hubs.

The constructs forming Factor 2 (Facilitating conditions) and Factor 3 (Individual innovation) are the same as in the conceptual model discussed under paragraph 'A. factors'. The items of Factor 3 however have negative factor loadings, indicating that people who score high on this construct, have a lower degree of individual innovation. The factor name is therefore adjusted to 'Individual innovation scepticism' to reflect this. Social influence and Environmental concern together form the fourth factor: Social-environmental responsibility, indicating that there seem to be similarities between individuals' social influence and their concern about the environment.

TABLE I: RESULTS EXPLORATORY FACTOR ANALYSIS

Factors	F1: Mobility hub beneficials	F2: Facilitating conditions	F3: Individual innovation scepticism	F4: Social-environmental responsibility
PE1	0.540			
PE2	0.702			
PE3	0.515			
EE1	0.839			
EE2	0.628			
HM1	0.486			
HM2	0.481			
FC1		0.829		
FC2		0.781		
FC3		0.626		
II1			-0.752	
II2			-0.799	
II3			-0.702	
SI1				0.634
SI3				0.752
SI4				0.705
EC1				0.508
EC2				0.519
EC3				0.468
EC4				0.635

To perform the LCCA, the factor scores of the previous section are calculated by summing up the items belonging to each of the four factors and dividing them by the number of items per factor. An extra factor is added to the model regarding the intention to use mobility hubs. The factor is added to make interpretation of each class easier.

Model fit and the Bayesian Information Criterion (BIC) of models with up to 10 clusters are shown in Table II. The 10-cluster model seems to have the lowest BIC, but this model is not well explainable. A solution for this is to calculate the relative change in BIC between clusters, to determine the optimal number of classes, as well as to check for the interpretability of the models. By analysing model outcomes from more to fewer classes, we concluded that the 4-cluster model forms a parsimonious model that could account for the associations between the variables. Although BIC improvement is higher in the 3 cluster model, we lose heterogeneity and thus interesting and relevant policy information included in the 4-cluster model. The 4-cluster model also shows a high level of covariance between mobility hub benefits and behavioural intention on one hand, as well as between individual innovation scepticism and social-environmental responsibility on the other. Direct effects are applied between those indicators. Only the BVR value between social-environmental responsibility and mobility hub benefits is found to be insignificant . After analysing the relative change in BIC, the BVR values and its corresponding clusters, the 4-cluster model is found to be the most suitable for further analysis and interpretation.

The next step is to add all the covariates to the model as active covariates and remove the ones which are non-significant (Wald <3.84 and p > 0.05). Using backwards elimination, insignificant covariates are removed from the model, but are still present as inactive covariates. Lastly, the Entropy R-squared is determined. This checks how accurately the model defines the classes and is based on the observed variables. The Entropy R-squared is 0.9412, meaning that the model performs well and that the four found classes are a good classification of all individual cases.

TABLE II: NUMBER OF CLUSTERS AND MODEL FIT STATSTICS

#-clusters	LL	BIC	Npar	Class. Err.	%change BIC
1-Cluster	-1756.80	3570.57	10	0.0000	-
2-Cluster	-1538.70	3197.04	21	0.0416	-10.46%
3-Cluster	-1248.36	2679.02	32	0.0262	-16.20%
4-Cluster	-1170.72	2586.41	43	0.0400	-3.46%
5-Cluster	-1118.94	2545.53	54	0.0514	-1.58%
6-Cluster	-1085.23	2540.77	65	0.0790	-0.19%
7-Cluster	-1035.52	2504.01	76	0.0489	-1.45%
8-Cluster	-996.53	2488.72	87	0.0537	-0.61%
9-Cluster	-970.82	2499.96	98	0.0582	0.45%
10-Cluster	-914.23	2449.45	109	0.0436	-2.02%

The combination of the active covariates, together with the indicators, result in the final model presented in Table III. The inactive covariates are included at the bottom of the table. The three variables regarding the effects of a mobility hub on car usage and car ownership were not included as moderators in the conceptual model, but are included in the final LCCA table because of their relevance for this study. Moreover, it is decided to exclude the moderator hub functionalities.

A description of each cluster can be found below (more details in [5]).

Hub huggers

The members of the cluster hub huggers have the highest intention to use mobility hubs in the future. They have the highest (resp. lowest) scores for all indicators, highlighting their strong intention to use neighbourhood mobility hubs. The cluster consists of relatively young people (≤35 years old) who are typically higher educated (89%). The majority of the sample have a job (full-time or part-time) or are still studying. The latter probably likely explains why 47% of the sample do not own a car. Of the sample, 82% have used shared transport in the past. At present, cluster members primarily travel to work and/or study by train or (e-)bicycle. 25% of the cluster members indicate that they would use their car less if a hub were present, 17% would sell their second (third) car in the household and 9% would sell their only car.

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TABLE III: 4-CLUSTER MODEL INCLUDING ITS ACTIVE AND INACTIVE COVARIATES

		Hub huggers	Hub-ready impacting travellers	Anti-new mobility individuals	Traditional car owners	Sample %
	Cluster Size (%)	45%	25%	22%	8%	
	Cluster Size (number of respondents)	n= 134	n = 74	n = 66	n = 24	
Indicators (mean)						
	Mobility hub beneficials	3.69	3.43	2.69	2.36	
	Facilitating conditions	5.00	4.01	3.76	4.82	
	Individual innovation scepticism	1.43	1.52	2.53	2.38	
	Social-environmental responsibility	3.45	3.38	2.73	2.36	
	Behavioural intention	3.66	3.62	2.35	1.94	
Active covariates						
Age	18-25	44%	30%	8%	36%	32%
	26-35	41%	25%	21%	20%	31%
	36-45	7%	13%	14%	20%	11%
	46-55	6%	13%	18%	16%	11%
	56-64	2%	17%	27%	4%	11%
	65+	0%	3%	12%	4%	4%
Education	Primary- or secondary education	9%	7%	5%	0%	7%
	MBO, or similar	2%	30%	13%	24%	13%
	HBO / WO Bachelor or similar	54%	27%	43%	52%	45%
	Master's Degree	35%	36%	39%	24%	36%
Work situation	I work full time	55%	48%	52%	48%	52%
	I work part time	12%	30%	32%	8%	21%
	Unemployed, looking or unfit for work	0%	4%	3%	8%	2%
	I am retired	1%	3%	8%	8%	3%
	I am a student	32%	15%	5%	28%	22%
Household income	<€20,000	23%	17%	2%	8%	16%
	€20,000 until €30,000	6%	4%	11%	0%	6%
	€30,000 until €40,000	14%	22%	13%	19%	16%
	€40,000 until €50,000	13%	12%	14%	0%	12%
	€50,000 until €100,000	27%	29%	40%	33%	31%
	€100,000 or more	8%	6%	5%	12%	7%
	I would rather not say	9%	10%	15%	28%	12%
Car ownership	No car	47%	36%	13%	8%	34%
	One car	40%	37%	45%	20%	39%
	Two cars or more	13%	27%	42%	72%	28%
Travel behaviour towards work or study	Walking	0%	0%	7%	0%	2%
	(e-)bicycle	34%	24%	11%	36%	27%
	Bus/tram /metro	4%	6%	0%	12%	4%
	Train	40%	36%	25%	12%	33%
	Car	20%	34%	49%	36%	31%
	Moped	1%	0%	0%	0%	1%
	Other	1%	0%	8%	4%	2%
Experience shared transport	Yes	82%	69%	50%	20%	66%
	No	18%	31%	50%	80%	34%
Inactive covariates						
Gender	Female	43%	44%	31%	16%	38%
	Male	57%	56%	66%	84%	61%
	I'd rather not tell	0%	0%	3%	0%	1%
Household composition	Single	19%	11%	17%	8%	15%
	Living together, without children	36%	38%	43%	28%	37%
	Living together, with children	13%	27%	32%	28%	22%
	Single with children	1%	1%	2%	0%	1%
	With roommates / student house	28%	20%	6%	8%	20%
	With my parents	3%	3%	0%	28%	4%
Urbanity	Very strongly urban	57%	43%	28%	24%	44%
	Strongly urban	15%	20%	27%	36%	21%
	Moderately urban	6%	13%	9%	4%	8%
	Little urban	10%	12%	16%	16%	13%
	Non-urban	3%	5%	6%	4%	4%
	No postal code	9%	7%	14%	16%	10%
Do you have easy access to a car?	Yes, whenever I want	31%	47%	69%	56%	46%
	Yes, consult with people in my HH	25%	23%	20%	36%	24%
	No, consult with people outside my HH	31%	18%	6%	4%	20%
	No, would use a shared car or rent a car	13%	12%	5%	4%	10%

Hub-ready impacting travellers

Members of the second cluster also have relatively high indicator scores, but likely require some assistance making reservations and/or paying with their phones as they score lower on facilitating conditions. 30% of cluster members have a low level of education and 36% of the households do not own a car. Regarding commute trips for work or study: 34% travel by car, 24% by (e-)bicycle and 36% by train. The share of people who already used a form of shared transport is also quite high: 69%. If a mobility hub were present, 29% of the clusters members expect to use their own car less often, 20% expect to sell their second car and 11% expect to sell their only car, which is the highest among all clusters. This may be due to the lower share of students (resp. higher incomes and age; compared to hub huggers) and a higher share of households with more than two cars per household compared to the hub huggers. Moreover, cluster members of hub-ready impacting travellers live in less urbanised areas.

Anti-new mobility individuals

This cluster consists of members which are not (yet) willing to use hubs, characterized by the lowest score on 'facilitating conditions', implying that the people in this cluster experience the most difficulty using their mobile phones. The cluster contains all age groups, with a relatively high share (39%) of individuals older than 56 years. The scepticism of using new technologies, paired with the higher share of older individuals who do not intend to change their travel behaviour in the future, result in the typical anti-new mobility individual. The cluster consists of households that live in a surprisingly varying level of urbanization, of which 87% have at least one car. This also explains the high car use to travel to work and/or study (49%). Of these cluster members, 44% have a high households income (> 50,000 €/year). Members of this cluster show little interest in changing their travel behaviour: 64% state that a mobility hub will not change their car use in the future, only 9% think it would lead them to sell their second car and 6% would sell their only car.

Traditional car owners

The behavioural intention to use hubs is the lowest among all in this cluster. This means that the 'traditional car owners' have limited intention to make use of mobility hubs in the future, were they available. The cluster largely consists of men (82%) and car ownership is high: 92% of the households has at least one car and 72% even own two or more. Furthermore, the majority of the cluster has no prior experience with shared mobility. Besides the car (36%), the (e-)bicycle is also a relatively popular mode of travel to work or study (36%). This may be explained by the large share of people who live with their parents (28%) and possibly use their (e-)bike to school. The expected effect of a hub on car usage and ownership is limited: 71% of the members think that the presence of a mobility hub in their neighbourhood would not affect their car usage in the future. No person would sell their only car in the household and only 4% would sell their second car. Considering the relatively small sample size of this cluster (n= 24), a larger error may be expected here.

IV. Conclusion and Discussion

This study identified the user groups who are likely to adopt mobility offered by neighbourhood mobility hubs. From the outcomes of a Latent Class Cluster Analysis (LCCA), four groups are uncovered, with varying levels of intention to use neighbourhood mobility hubs. Two of the four identified clusters show strong intention to use neighbourhood mobility hubs in the future, namely the 'hub huggers' (young people, highly educated) and 'hub-ready impacting travellers' (experienced shared mobility users, low car ownership, lower education). The first group has the highest intention to use mobility hubs, where the second group need some guidance when making reservations and/or paying with their phones. The other two clusters, namely 'anti-new mobility individuals' (scepticism of using new technologies, older people) and 'traditional car owners' (no experience, high car ownership), have less or no intention to use neighbourhood mobility hubs. These findings imply that for a part of the population, neighbourhood hubs would prove beneficial, indicating that neighbourhood hubs may be successful in areas where a large share of hub huggers and hub-ready impacting travellers live, providing them with additional travel options. However, as car use and ownership is relatively low among members of these clusters, neighbourhood hubs may not have the expected impact on emissions and urban public space use.

V. Limitations and Recommendations

This research entails some limitations and recommendations. A limiting factor is that the sample of respondents is not fully representative of the Dutch population: there is overrepresentation of young people, males, higher educated individuals and those living in higher density areas. Therefore, it is unknown which share of the total population may intend to use mobility hubs, although an estimate could be made by projecting the cluster's socio-demographics on the total Dutch population. A follow up of this study with a more representative sample is therefore recommended. Moreover, this study employed a stated preference approach for measuring 'behavioural intention', where respondents indicated their intention to use mobility hubs. In reality, not all of them may in fact use hubs, even if they have indicated so in the survey. It is thus recommended to set up revealed preference studies to capture actual behaviour. This will be particularly interesting when more neighbourhood hubs are deployed and used by more people than the typical 'pioneer'. A better understanding of hub users can help tailor its services and ensure targeted communication.

Regarding recommendations for practice, a reliable location choice for neighbourhood mobility hubs are inner-cities. These areas are a fertile ground, as a number of typically urban factors are positively associated with the intention of using hubs: a maximum of five minutes walking time to a hub, high levels of urbanization and lower car ownership. Furthermore, when planning a network of mobility hubs, a socio-demographic scan of different neighbourhoods can be performed and compared to the clusters and factors identified in this study. This might aid in selecting successful hub locations. Particularly for neighbourhood hubs in new developments, it can be worthwhile to actively target and communicate with existing and future in order to seize the opportunity of travel behaviour change that comes with a life changing event.

Finally, our results indicate that creating mobility hubs as a stand-alone policy will not have a large impact on sustainability. A mix of policies such as higher parking fees, improved cycling infrastructure, maximum parking norms, reliable public transport, and mobility hubs seem more effective. Mixing the sour with the sweet (and the hubs can be seen as of one of the 'sweets') may help increase public and political support for policies to ensure accessible, sustainable, and attractive cities.

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