From Bold Innovators to Anxious Observers,
who will use shared micromobility as a train station egress mode?
A Latent Class Cluster Analysis approach

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SHORT SUMMARY

Shared micromobility is often cited as a solution to the first/last mile problem of public transport (train) travel. In this paper, we use latent class cluster analysis, combined with attitudinal statements based on the UTAUT2 technology acceptance framework, to study the potential adoption of shared micromobility and to assess the various drivers and barriers as perceived by different user groups. Our findings suggest there are six distinct user groups with varying intention to use shared micromobility. We label the groups as: Progressives, Conservatives, Hesitant Participants, Bold Innovators, Anxious Observers and Skilled Sceptics. Technological savviness, ease-of-use, the physical safety while using micromobility and societal perception seem to be the biggest barriers to wider adoption. Younger, highly educated males are the group most likely and open to using shared micromobility, while older individuals with lower incomes and a lower level of education tend to be the least likely.

Keywords: First/Last-mile problem, Latent class cluster analysis, Micromobility, Multi-modal transport, Shared mobility

1. INTRODUCTION

With the continuous growth of demand for mobility, a sustainable transition within the transport sector remains a challenge. For distances beyond the reach of active modes: 5km (Jonkeren & Huang, 2024), rail-based public transport (PT) is a sustainable alternative to the private car. However, challenges remain in making rail-based PT more attractive, including the first/last mile problem. Reaching the station and final destination can often be cumbersome and time-consuming.

Cycling offers many benefits as an access/egress modes, increasing the catchment area compared to walking, while being more flexible than local PT (Kager et al., 2016). Promoting cycling as an access mode has shown to be highly successful (Netherlands), resulting in 39% of train travellers arriving to the station by bicycle. On the activity-end, cycling only holds a 13% share (Schakenbos & Ton, 2023). This is mostly because Dutch travellers do not have a bicycle available on the activity-side and taking it on the train can be cumbersome. Shared micromobility (SMM), including bicycles, e-bikes, e-scooters, etc. can fill this gap. Dutch Railways introduced their OV-fiets (PT-bike) service in 2003 and in 2023, bicycles located at over 300 stations facilitated 5.9 million trips. Despite this success, the discrepancy between SMM modal splits on the home-end and activity-end shows the potential for SMM on the activity-end remains high.

Literature reviews on SMM by Abduljabbar et al. (2021) and Zhu et al. (2022) mention that SMM has the potential to improve access/egress to PT, yet they both point to a lack of studies analysing the level of integration and its benefits. Users of SMM are primarily younger, male, highly-educated, with a higher income and living in urbanised areas (Badia & Jenelius, 2023; Reck & Axhausen, 2021). Chahine et al. (2024) cite safety, reliability, health and convenience as the most important factors when considering using SMM.

Despite many studies on the topic, we were not able to find a study using a broad array of characteristics relating to (potential) adoption of SMM. We also include aspects related specifically to using SMM as an access/egress mode. To that end, we adapt an existing framework to study the perception of SMM as a train station access/egress mode and cluster the population based on how they perceive the different characteristics of SMM, giving us valuable policy recommendations on how to make SMM more attractive for specific user groups.

2. METHODOLOGY

To study the perception of SMM, we adjust the UTAUT2 framework (Venkatesh et al., 2012), an established framework to analyse the adoption potential of new technologies. Two recent studies utilising this approach studied the potential of MaaS (van 't Veer et al., 2023) and mobility hubs (van der Meer et al., 2023). Both studies used the framework to design attitudinal statements and estimate a latent class clustering analysis (LCCA), identifying different user groups and how they perceive and would potentially use a new service.

Based on the findings of previously mentioned studies, we developed nine constructs, featuring (1) performance expectancy, (2) effort expectancy, (3) social influence, (4) facilitating conditions, (5) hedonic motivation and (6) habit, (7) perceived risk, (8) sustainability and (9) health. Behavioural intention is also measured using attitudinal statements. This results in a total of 48 statements. Additionally, we include moderators, i.e. socio-demographic (age, gender, income, education,…) and travel behaviour (car ownership, experience with SMM,…) characteristics.

Exploratory factor analysis

To obtain factors from the attitudinal statements, we carry out an exploratory factor analysis (EFA). We employ the Kaiser-Meyer-Olkin (KMO) measure (Schreiber, 2021), Bartlett's test of sphericity and the correlation matrix determinant (Field, 2013) to assess if the data is suitable for EFA. To extract the factors, we apply the maximum likelihood method. The number of factors is based on the Kaiser-rule, i.e. factors which have an eigen value above 1 (Schreiber, 2021). Factors are rotated using an oblique method (oblimin), as it allows for factor correlations (Schreiber, 2021). Assessing the individual items, we accept factor loadings above 0.3 (Field, 2013) or above 0.162 (Stevens, 2001). Cross-loadings should be kept below 0.4 (Taherdoost, 2016) or loadings at most 75% of the main factor loading are accepted (Samuels, 2017). Communality should be above 0.2 (Child, 2006).

Latent class cluster analysis

Using the obtained factors, we calculate the values for each respondent, which is then used for the LCCA. We start by determining the ideal number of clusters, using only indicators (factors). (van der Meer et al., 2023), by assessing the BIC value and bivariate residuals (BVR). The best fitting and most parsimonious model should have the lowest BIC (Vermunt & Magidson, 2005), whereas BVR values should be below 3.84 (Schreiber, 2021). We also consider the relative change in BIC and size of the smallest cluster (van der Meer et al., 2023). Next, we add the covariates and conduct a backwards elimination. We iteratively remove (keep as inactive) insignificant covariates ($p < 0.05$) until only significant ones remain.

3. RESULTS

The survey was distributed through an online panel in August 2024, resulting in 1,892 validated responses. Using SPSS software we perform the EFA and removed unacceptable items due to low loadings, high cross-loadings and low communalities. The final model retains 25 items, loading onto eight factors. The KMO-value is 0.84 (meritorious), Bartlett's test is significant and the matrix determinant is acceptable ($1.13 \cdot 10^{-5}$). The final model is depicted in Table 1 and the factor descriptions in Table 3.

Table 1. Final EFA model, with 25 items loading onto eight factors

Items	Factors							
	1	2	3	4	5	6	7	8
intention_1	0.937							
intention_2	0.800							
intention_3	0.850							
intention_4	0.479							
reliability_1		-0.699						
reliability_2		-0.977						
sustainability_1			-0.882					
sustainability_2			-0.773					
sustainability_3			-0.668					
social_1	0.655							
social_3				0.924				
social_4				0.851				
effort_1					0.619			
effort_3					0.862			
effort_4					0.664			
health_4						-0.850		
health_5						-0.768		
hedonic_2							-0.832	
hedonic_4							-0.857	
risk_1							-0.635	
facility_1					*0.246*			0.550
facility_2								0.605
facility_3								0.655
facility_5								0.722
habit_5								0.589

The LCCA estimation results are shown in Table 2. A 9-cluster model is optimal according to the BIC value, 4-cluster according to % change of BIC and a 6-cluster model according to maximum BVR value. Considering also the interpretability, we continue with the 6-cluster model. We add the moderators and iteratively remove insignificant parameters. The final model can be seen in Table 3, the socio-demographic characteristics (active and inactive) in Table 4 and the weekly travel pattern in Figure 1. The clusters are named and described below.

Table 2. Overview of the number of clusters and associated model fits

#_Clusters	BIC	%_change_BIC	max(BVR)	min(cluster_size)
1	40,833.7559	-5.68%	660	100%
2	38,512.8045	-2.60%	387	40%
3	37,511.1194	-1.37%	168	23%
4	36,998.5287	-0.95%	145	15%
5	36,645.5117	-0.54%	104	10%
6	36,448.5807	-0.81%	41	8%
7	36,153.1827	-0.37%	45	9%
8	36,021.1373	-0.83%	40	8%
9	35,721.3596	0.20%	31	8%
10	35,791.9871	-5.68%	36	4%

The biggest cluster are the **PROGRESSIVES (C1)**. They show the second highest intention to use SMM, are digitally savvy and climate aware. Interestingly, they are the only ones who think SMM is perceived positively. They tend to be younger, highly educated and with a high income. They are the second most experienced with all shared modes. They use all modes, although are less likely than the sample to use the private car.

The **CONSERVATIVES (C2)** show mainly opposing views to the *Progressives*. They think SMM has a bad social image and that it is not easy to use. Interestingly, they do not see it as dangerous or stressful. They tend to not have a university degree, have a low-to-middle income and live in a household with children. They also have the highest household car ownership and highest weekly car use.

Table 3. Clustering model outcomes, with average factor values for each cluster

	Factors	Clusters					
		C1	C2	C3	C4	C5	C6
F1	Intention to use SMM	0.21	-0.14	0.02	1.01	-1.55	0.03
F2	Concern about SMM vehicle availability	0.15	-0.23	0.16	-0.93	0.66	-0.06
F3	Climate indifferent	-0.35	0.72	-0.40	-0.41	0.85	0.21
F4	Bad social image of SMM	-0.81	0.77	0.22	0.62	0.11	0.26
F5	Find SMM easy to use	0.44	-0.27	-0.53	0.61	-0.96	0.37
F6	PT is an unhealthy way of travel	0.04	0.18	-0.20	-0.49	0.32	0.22
F7	E-mopeds are dangerous and stressful	0.07	-0.45	0.53	-0.99	0.97	-0.44
F8	Digital savviness	0.30	-0.14	-0.44	0.84	-1.14	0.41

The **HESITANT PARTICIPANTS (C3)** are labelled as such because they show some potential for using SMM, but think it is difficult to use, dangerous and stressful. They are not confident using smartphones and think SMM has a bad reputation. They are on average the oldest of the clusters within the sample, highly educated, living in a household without kids, have the lowest car ownership and highest likelihood of having a train travel subscription. They have experience with shared bicycles (OV-fiets) but not with other modes.

BOLD INNOVATORS (C4) are the most enthusiastic of all, having the highest intention to use SMM, lowest availability concern, and strongest climate awareness. They are confident in using SMM, find it exciting, not dangerous, and are highly tech savvy. Interestingly, they do think SMM has a bad image, but they likely do not care or find it important. They are the most maledominated, the youngest, with a high income. They travel a lot, with multiple modes, making them the most multimodal of the groups.

Table 4. Socio-demographic characteristics of each cluster (red indicates below average value, green above average)

		Sample	C1	C2	C3	C4	C5	C6
	Cluster size		*35%*	*20%*	*17%*	*10%*	*10%*	*8%*
Gender	Female	49%	52%	45%	**61%**	32%	**55%**	41%
	Male	51%	48%	55%	39%	**68%**	45%	**59%**
Age	18-34	13%	13%	18%	**5%**	**21%**	**8%**	14%
	35-49	23%	27%	25%	15%	24%	22%	25%
	50-64	31%	35%	26%	28%	31%	29%	33%
	65+	33%	**26%**	30%	**53%**	**24%**	**42%**	**27%**
Education	Low	9%	4%	**18%**	5%	9%	**16%**	6%
	Middle	29%	**22%**	**43%**	**21%**	31%	**37%**	31%
	High	62%	**74%**	**38%**	**74%**	60%	**46%**	62%
Income	Low	11%	8%	15%	10%	10%	**16%**	6%
	Middle	45%	45%	47%	45%	49%	40%	41%
	High	28%	**35%**	**18%**	22%	**34%**	**17%**	**39%**
	n/a	17%	13%	20%	22%	8%	27%	13%
Status	Working	60%	63%	**65%**	48%	**67%**	**47%**	**71%**
	Retired	20%	15%	18%	**38%**	**13%**	**27%**	**14%**
	Other	19%	22%	18%	14%	20%	**26%**	15%
Household	Single	25%	22%	23%	**31%**	**19%**	**33%**	22%
	Couple (no kids)	40%	39%	36%	**46%**	36%	43%	41%
	With kids	22%	23%	**27%**	**15%**	**27%**	13%	25%
	Other	13%	15%	13%	8%	18%	11%	12%
Cars	0	29%	33%	**15%**	**36%**	**23%**	**34%**	24%
	1	53%	53%	55%	55%	50%	53%	50%
	2+	18%	13%	**30%**	9%	**26%**	13%	**26%**
	mean	0.93	0.83	1.23	0.73	1.11	0.80	1.05
Train subscription	None	48%	46%	**65%**	**28%**	**39%**	51%	**67%**
	Off-peak	36%	39%	**20%**	**59%**	31%	35%	**22%**
	Other	16%	15%	15%	14%	**30%**	14%	12%
Shared-bike experience	Yes	57%	**72%**	33%	**67%**	**73%**	17%	59%
	No	43%	28%	**67%**	33%	27%	**83%**	41%
Other shared modes	Yes	27%	29%	23%	18%	**59%**	3%	29%
	No	73%	71%	77%	**82%**	41%	**97%**	**71%**

ANXIOUS OBSERVERS (C5) are the most negative and thus the most opposite to the *Bold innovators*. We refer to them as observers because they show the lowest intention to use SMM and also have the least experience with any shared modes. And anxious because they find it (very) dangerous, difficult to use and are concerned about its availability. They tend to be older and female. They have the highest share of individuals not working or retired: having an above average share of stay-at-home partners and those unable-to-work. They are more likely to not travel much at all.

Finally, the **SKILLED SCEPTICS (C6)** do not show strong positive or negative tendencies towards adoption of SMM, are confident they would not have difficulty using it, do not find it dangerous and are digitally savvy. Like the *Progressives*, they tend to be middle-aged, with a high income and average education profile. They are the most likely to be working, with 71% employed and have a high car ownership. They have more experience with shared modes (of any kind).

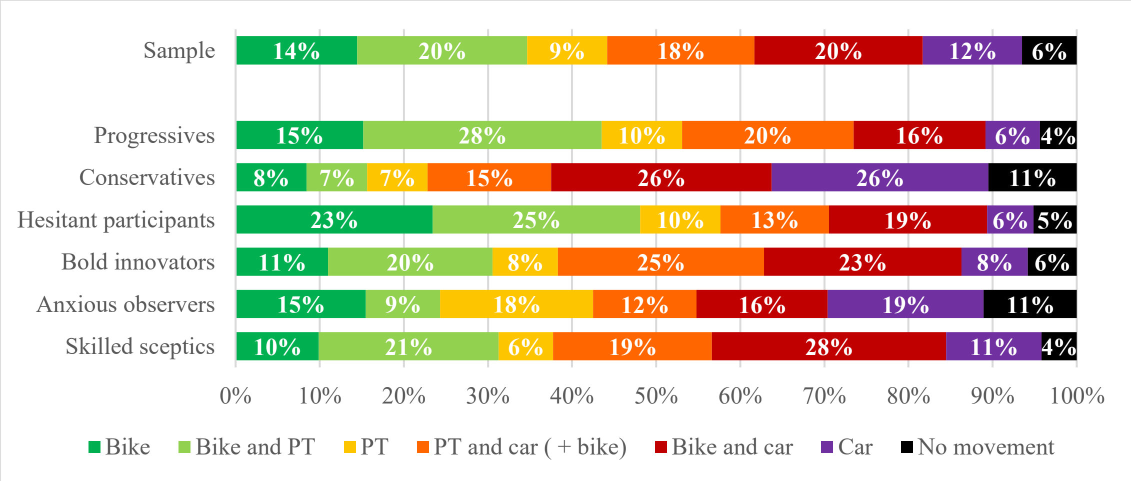

Figure 1. Modes used on a weekly basis by each cluster

4. CONCLUSION

We carried out a stated preference experiment, exploratory factor analysis (EFA) and latent class cluster analysis (LCCA) to uncover how different user groups perceive shared micromobility (SMM). Through the EFA, we obtain eight factors relating to different aspects of SMM such as safety, ease-of-use and danger/pleasure. The LCCA resulted in six clusters with different attitudes on all eight factors. The most polarising factors are on E-moped danger and stress, SMM ease-of-use, and the social image of SMM.

Looking at the individual clusters, it is interesting to consider what would motivate each of them to use/try SMM. ***Bold innovators*** do not seem to need additional encouragement, The main barrier for the ***Progressives*** seems to be vehicle availability and the danger/stress of using e-mopeds. ***Skilled sceptics'*** main issue is likely the bad social connotation. ***Hesitant participants*** find SMM dangerous and stressful, as well as difficult to use. Help from personnel and having non-digital options would be beneficial for the latter. A technological barrier can also be observed for the ***Conservatives***. In addition, they associate SMM with very negative social perception. Finally, ***Anxious observers*** would likely be the last to adopt SMM, finding almost all aspects as a barrier.

While giving a broad overview, our study also has limitations. As a stated preference approach, there is uncertainty in relation to the actual adoption of SMM. Further studies verifying the stated service adoption through revealed data should be undertaken. We also recommend additional studies, investigating SMM modes that could not be included here to see how their perception differs within the population. Finally, while the sample did include all socio-demographic groups, it was not proportional and thus not fully representative.

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