A latent class approach to classify e-scooter non-users in Helsinki, Finland

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SHORT SUMMARY

The rapid expansion of electric scooters (e-scooters) worldwide began in 2017 and has expanded to over 200 cities. Despite the global adoption, the majority of urban residents are still not using e-scooters and are also those who often bear the negative consequences of e-scooter deployment. This study investigates the attitudes and characteristics of the e-scooter non-users in Helsinki, Finland using latent class clustering analysis. Our finding reveals 5 classes of e-scooter non-users with very negative perspectives to positive perspectives towards e-scooters. Non-users mostly do not feel the necessity of using an e-scooter as well as lack of competency and having safety concerns. Classes with negative perceptions mostly have safety concerns while classes with positive perceptions and low income tend to avoid e-scooters due to high price of renting an e-scooter. The findings of this study could help e-scooter operators to design a safe and personalized e-scooter usage package for low-income interested groups. On the other hand, policy-makers could try to govern this emerging technology in a better way that satisfies all the e-scooter user or non-user groups while considering their safety concerns regarding e-scooters.

Keywords: Emerging mobility technology, latent class analysis, micromobility, personal mobility device, rental e-scooters

1. INTRODUCTION

The recent advances in technology and sharing economy business models have contributed to the most recent wave of development in battery-electric standing two-wheel scooters (e-scooters) (Rechkemmer et al., 2017). The rapid deployment of shared e-scooters has taken advantage of the governance void, as there have been very little to no previous regulation as well as a lack of institutional capacity within city authorities (Kostareli et al., 2021; Riggs et al., 2021; Sareen et al., 2021). Nowadays, according to some estimates, shared e-scooters are available globally in over 200 cities (Kazemzadeh & Sprei, 2024; McKenzie, 2020; Yang et al., 2022). While the e-scooter companies have been also increasing their operating areas and introducing more vehicles into the fleet, this emerging mobility technology has also found its niche by responding to some users' mobility needs. For example, e-scooters offer a fun and low-cost travel mode to fill the first and last mile gaps that public transport cannot cover (Dibaj et al., 2021; McQueen & Clifton, 2022). This development has already led to significant changes in the urban landscape and in how people move around cities, with the potential to contribute to the broader transformation of urban mobility systems.

Despite these global developments, a very small percentage of people use e-scooters on a daily basis. Thus, the majority of urban residents are still not using e-scooters and are also those who often bear the negative consequences of e-scooter deployment. For example, some e-scooter users do not follow traffic regulations (Speak et al., 2023; Tuncer et al., 2020), contributing to the substantial degradation of traffic safety in urban environments (Janikian et al., 2024; Kazemzadeh et al., 2023). In addition, uncontrolled e-scooter parking (Kostareli et al., 2021) and sidewalk riding

(Speak et al., 2023) have also caused problems for the visually impaired and elderly (Caspi & Smart, 2022; Che et al., 2021). Besides the direct negative impacts on urban residents, e-scooter usage might not contribute to the societally-desired mode shift, mostly replacing walking and public transport modes rather than private car driving (Christoforou et al., 2021; Kopplin et al., 2021). The scale of undesired impacts can also be observed from an increase in media discussions, mostly dominated by negative feedback from non-users (Wallgren et al., 2023).

The socio-demographic characteristics of non-users vary in different studies. Based on a study in the UK, non-users are mainly older than 25 years old. Furthermore, 26% of students and 74% of university staff have never tried e-scooters before (Speak et al., 2023). Another study showed that the probability of being a non-user rises with getting older and female gender (Pourfalatoun et al., 2023).

The main barriers for e-scooter non-users in general are mainly external and infrastructural (Teixeira et al., 2023). One of the main reasons for not using an e-scooter is that people do not find it necessary to use and they have more convenient modes to choose compared to e-scooters (Teixeira et al., 2023) followed by safety concerns, poor road conditions (Nikiforiadis et al., 2021), and destinations being too far away (Teixeira et al., 2023). The elevated rental expenses associated with shared e-scooters appear to discourage their usage, especially among males and young individuals. (Kostareli et al., 2021). In another study, the primary obstacle for current non-users appears to be the perceived lack of control over e-scooter usage combined with the belief that e-scooters are challenging to operate (Ozturk & Akay, 2023). On the other hand, some non-users might be interested in riding an e-scooter. However, they are afraid of riding an e-scooter due to a lack of prior experience. These potential riders express a desire for instructional support from others to acquire the necessary skills for e-scooter operation (Speak et al., 2023).

This study will provide a meaningful contribution to understanding the attitudes and characteristics of the e-scooter non-users in Helsinki, Finland using latent class clustering analysis. The paper is organized as follows: The Methodology section consists of data collection and the analysis framework. The Results and Discussion section presents the different classes of non-users while discussing their differences. Finally, the conclusion summarizes the study and the implications.

2. METHODOLOGY

Data collection

To understand users' and non-users' characteristics, reasons, as well as their perceptions towards e-scooter riding, rule awareness, and proposed improvement for better e-scooter usage, an online questionnaire was developed. The questionnaire involves questions on private e-scooter ownership, e-scooter usage frequency, trip purpose, reasons for using, not using or stopping e-scooter usage, mode substitution, perceptions towards different problematic implications of e-scooters, and socio-demographic characteristics such as gender, age, income, and occupation. At the time of this study in 2022, Helsinki had five shared e-scooter operators with several thousands of vehicles deployed mostly in the city center.

The online questionnaire in Helsinki was disseminated through social media, some e-scooter operators' apps, and the website of the City of Helsinki. The survey was conducted from June 20, 2022, until July 12, 2022, and received 7,724 responses in 23 days for Helsinki (Mladenović et al., 2022). After removing incomplete or invalid responses, 1,984 non-users with complete information in Helsinki were selected for further analysis.

Analysis framework

In this study, Latent Class Analysis (LCA) is utilized to identify latent groups among e-scooter non-users with similar combinations of socio-demographic characteristics, reasons for not using e-scooters, perspectives on e-scooter riding practices, and awareness of associated issues. Among all, the clustering approach has previously been employed to identify shared e-scooter user segments (Degele et al., 2018) and classify cyclists into latent classes (Fraboni et al., 2022; Pantelaki et al., 2023). This involved assigning a conditional probability of belonging to one latent class over another for each individual (Magidson & Jeroen, 2004). To determine the number of latent classes that fit our sample of e-scooter non-users in Helsinki, models with several distinct numbers of classes have been estimated as shown in **Table 1**. After the classification of the non-users in latent groups, the predicted percentages of belonging to the identified latent classes are presented in **Table 2** for Helsinki. In this study, the poLCA Plugin in STATA[1] has been employed (Lanza et al., 2015).

3. RESULTS AND DISCUSSION

Determination of the number of classes

To determine the number of classes, three goodness-of-fit indices can be employed: Log Likelihood (LL), Akaike Information Criterion (AIC), and Bayesian Information Criterion (BIC). BIC, unlike AIC and log-likelihood, is an index that takes into account the sample size, and that it is appropriate to use the information criterion to determine the number of classes when the sample size is large (Akaike, 1974; Lanza et al., 2015; Pantelaki et al., 2023; Schwarz, 1978). According to the values of the three indices presented in **Table 1**, we opted to categorize e-scooter non-users into 5 classes, considering the lowest BIC value.

Table 1: Model-fit latent class analysis in Helsinki

Models	df	Helsinki		
		LL	AIC	BIC
1 Class	68	-42002.34	54061.2	54435.9
2 Classes	136	-40119.2	50430.8	51185.8
3 Classes	204	-39390.3	49108.9	50244.3
4 Classes	272	-38753.5	47971.4	49487.1
5 Classes	**340**	**-38157.2**	**46914.8**	**48801.8**
6 Classes	409	-37894	46524.4	48853.7

df = degree of freedom, LL = log likelihood, AIC = Akaike information criterion, BIC = Bayesian information criterion

Analysis results of 5-class e-scooter non-user model

Table 2 shows the percentages of each of the five classes in the sample as well as the characteristics of e-scooter non-users in the five predicted classes estimated by conditional probabilities.

Table 2: Characteristics of e-scooter non-users in predicted classes in Helsinki

[1] https://www.stata.com/

	Latent class indicator	*Class 1H*	*Class 2H*	*Class 3H*	*Class 4H*	*Class 5H*
	Labels	***Most negative***	***Concerned negative***	***Old or retired***	***Young and low income***	***Most positive***
	Latent class prevalence	**15.7%**	**36.3%**	**8.3%**	**11.7%**	**28.0%**
Gender	Female	56.1%	70.9%	62.9%	63.3%	55.1%
Age	Under 24 years old	2.6%	1.2%	0.0%	25.3%	1.5%
	25 to 34 years old	14.4%	23.9%	0.6%	43.7%	26.0%
	35 to 44 years old	32.7%	39.2%	1.2%	23.6%	32.6%
	45 to 54 years old	26.0%	23.5%	2.4%	4.4%	21.9%
	55 to 64 years old	22.8%	12.0%	18.0%	3.1%	16.2%
	Over 65 years old	1.6%	0.3%	77.8%	0.0%	1.8%
Income	Higher than average income	58.0%	61.4%	46.7%	10.9%	68.1%
Occupation	Employed	82.7%	100.0%	0.0%	0.0%	100.0%
	Unemployed or laid off	3.2%	0.0%	0.0%	12.7%	0.0%
	Student	7.4%	0.0%	0.0%	63.3%	0.0%
	Pensioner	0.6%	0.0%	98.2%	0.9%	0.0%
	On a parental or care leave	2.6%	0.0%	0.0%	20.1%	0.0%
	Other job	3.5%	0.0%	1.8%	3.1%	0.0%
Education level	Above high school	76.9%	84.9%	78.4%	71.6%	82.7%
Cycling experience (self-assessment)	No experience	3.5%	0.4%	8.4%	1.3%	1.7%
	Beginner	0.6%	1.5%	0.6%	1.7%	1.7%
	Moderate	17.9%	16.2%	25.1%	27.1%	21.7%
	High	29.2%	40.7%	41.9%	39.7%	41.6%
	Very high	48.7%	41.2%	24.0%	30.1%	33.3%
Impact of shared e-scooters on your personal mobility	Completely beneficial	0.0%	0.0%	0.0%	0.4%	0.4%
	Beneficial	0.0%	0.3%	0.6%	0.4%	1.1%
	No change	15.7%	25.4%	31.1%	33.6%	64.1%
	Damaging	24.7%	41.2%	45.5%	45.4%	30.2%
	Completely damaging	59.6%	33.2%	22.8%	20.1%	4.2%
Impact of shared e-scooters on the society	Completely beneficial	0.0%	0.0%	0.0%	0.4%	0.7%
	Beneficial	1.0%	3.1%	8.4%	12.2%	22.1%
	No change	4.5%	4.1%	9.6%	12.2%	20.1%
	Damaging	31.4%	59.9%	61.7%	55.5%	54.5%
	Completely damaging	63.1%	32.9%	20.4%	19.7%	2.6%
Awareness of the issue: sidewalk riding	Not problematic	0.0%	0.1%	1.8%	1.7%	1.1%
	Slightly problematic	0.0%	0.0%	2.4%	7.4%	9.0%
	No idea	0.3%	0.0%	0.6%	2.6%	2.0%
	Problematic	1.6%	5.5%	13.8%	25.3%	51.9%
	Very problematic	98.1%	94.4%	81.4%	62.9%	35.9%
Awareness of the issue: improper parking behavior	Not problematic	0.0%	0.1%	1.8%	0.0%	0.4%
	Slightly problematic	0.0%	0.0%	1.8%	4.4%	5.9%
	No idea	0.0%	0.0%	0.0%	0.9%	0.9%
	Problematic	4.2%	7.1%	19.8%	16.2%	23.8%
	Very problematic	95.8%	92.8%	76.6%	78.6%	69.1%
Awareness of the issue: not keeping a safe distance while riding e-scooters	Not problematic	0.6%	0.1%	0.6%	0.9%	0.9%
	Slightly problematic	0.3%	0.0%	2.4%	5.7%	7.7%
	No idea	0.0%	0.7%	1.2%	4.4%	7.6%
	Problematic	0.6%	6.1%	19.8%	21.0%	50.1%
	Very problematic	98.4%	93.0%	76.0%	68.1%	33.7%
Awareness of the issue: underaged people riding e-scooters	Not problematic	0.0%	0.0%	0.0%	2.6%	2.8%
	Slightly problematic	0.3%	0.5%	5.4%	14.0%	19.3%
	No idea	0.0%	2.2%	4.8%	7.0%	16.0%
	Problematic	5.8%	17.3%	25.7%	26.6%	41.6%
	Very problematic	93.9%	79.9%	64.1%	49.8%	20.3%
Awareness of the issue: multi-riding	Not problematic	0.6%	0.0%	0.0%	0.9%	2.6%
	Slightly problematic	0.3%	0.4%	1.8%	9.6%	11.2%
	No idea	0.6%	1.8%	1.8%	6.6%	12.2%
	Problematic	3.2%	8.3%	12.6%	20.1%	40.0%
	Very problematic	95.2%	89.5%	83.8%	62.9%	34.1%
Awareness of the issue: flock-riding	Not problematic	0.0%	0.4%	0.6%	5.2%	5.5%
	Slightly problematic	1.0%	1.5%	5.4%	7.9%	19.3%
	No idea	3.8%	4.8%	6.6%	12.7%	21.5%
	Problematic	4.8%	14.9%	18.0%	26.6%	35.7%

	Latent class indicator	*Class 1H*	*Class 2H*	*Class 3H*	*Class 4H*	*Class 5H*
	Labels	***Most negative***	***Concerned negative***	***Old or retired***	***Young and low income***	***Most positive***
	Very problematic	90.4%	78.4%	69.5%	47.6%	17.9%
Reasons for not using e-scooter	Not necessary	84.0%	94.0%	91.0%	92.6%	90.4%
	Safety reasons	23.7%	50.2%	29.3%	51.5%	38.1%
	Expensive	9.9%	15.8%	3.6%	33.6%	23.0%
	Low competence	5.1%	13.4%	15.6%	16.6%	17.7%
	Improper infrastructure	2.9%	17.9%	10.8%	18.8%	12.0%
	Practical reasons	3.8%	12.4%	1.2%	16.6%	11.0%
	Unavailability of necessary material	1.9%	2.0%	2.4%	3.9%	5.2%
	Other reasons	27.6%	21.6%	9.0%	22.7%	15.5%
Improvements regarding e-scooter usage	Street infrastructure	3.2%	16.9%	13.2%	27.5%	26.3%
	Improving rules for other road users (car speed, etc.)	0.0%	4.6%	1.2%	8.3%	5.5%
	E-scooter riding rules	44.9%	97.8%	80.8%	88.2%	80.5%
	E-scooter vehicle design	2.6%	35.5%	12.6%	26.2%	17.1%
	Proper e-scooter parking behavior	23.1%	96.5%	68.9%	89.1%	85.3%
	Educate people on how to ride e-scooters properly	14.4%	82.8%	56.3%	76.0%	60.0%
	Educate other road users on how to use the shared space	1.0%	4.6%	2.4%	7.0%	5.9%
	Other	66.0%	20.5%	18.0%	19.2%	15.5%

According to **Table 2**, people in *Class 1H* are mostly employed or have other jobs with almost high income. They are between 35 to 65 years old. They also have very high cycling experience. The majority of non-users in *Class 1H* found e-scooters completely damaging to their personal mobility as well as the society. Furthermore, they found all the issues regarding e-scooters very problematic compared to other classes. As with other classes, this class also does not find e-scooter as a necessary mode of transport. They mainly have other reasons for not using e-scooter such as proposing a total ban on e-scooters in the urban areas (Anderson et al., 2021; Mladenović et al., 2022; Speak et al., 2023). This suggestion has been extracted by investigating the open-ended text responses in our questionnaire. *Class 1H* also proposed their own recommendation for e-scooter usage improvement in Helsinki which is a total e-scooter usage ban. This negative perspective towards e-scooters in this class could be elevated by the increased number of e-scooter-related injuries in Helsinki in 2021 (Vasara et al., 2022) and a vast media dispute regarding e-scooter usage and its burden on the healthcare team as well as the society. Overall, *Class 1H* consist of the most negative e-scooter non-users that might never try to become an e-scooter user.
Class 2H is the largest class in the data with 36.3% of the sample. According to **Table 2**, people in *Class 2H* are generally highly educated young to middle-aged females with high income, employed, and with the highest cycling experience. They have a negative perspective about the impact of shared e-scooters on their personal mobility and society. They are completely aware of the specific shared e-scooter issues and find all of them problematic and very problematic. Besides not feeling the necessity to use e-scooters, they do not use e-scooters because of safety concerns, lack of proper infrastructure, and some practical reasons such as traveling with children which is also in line with the previous studies (Krier et al., 2019). They strongly believe e-scooter usage rules and regulations, proper parking, and educating the e-scooter riders should be improved (Kostareli et al., 2021; Speak et al., 2023). This group mostly consists of people who are very much concerned about safety and have a very negative perspective regarding e-scooters. Therefore, it is very unlikely to count them as future potential e-scooter users.
Class 3H has the smallest share in the sample with the highest proportion of elderlies and pensioners. According to **Table 2**, *Class 3H* has a slightly low income compared to other classes (except *Class 4H*). In addition, they have the least cycling experience. They are aware of the

issues of e-scooters and find them mostly problematic rather than very problematic. Beside not finding the e-scooters necessary, low competence and practical reasons are the other reasons for not using e-scooters. They believe that e-scooter usage rules and regulations should be improved as well as some other improvements (Kostareli et al., 2021; Speak et al., 2023). One of the improvements suggested by *Class 3H* is applying penalties for inappropriate e-scooter riders which has been also suggested by Kostareli et al. (2021).

Class 4H mostly consists of people under 35 years old, students, unemployed or on leave from their jobs with the lowest income compared to other groups. Based on **Table 2**, they have less cycling experience compared to the previous classes. They have a slightly negative perspective about the impact of shared e-scooters on their personal mobility and on society. They are slightly aware of the potential issues of e-scooters. Beside not feeling the necessity, the second and third main barriers for *Class 4H* for not using e-scooters are safety concerns and the expensive rental cost of e-scooters, respectively which is in line with the findings of previous studies (Kostareli et al., 2021; Teixeira et al., 2023). Furthermore, not knowing how to ride is another reason that has been cited by *Class 4H* for not using an e-scooter which was also mentioned in Ozturk & Akay (2023). In Helsinki, improper infrastructure and practical reasons such as having a private e-scooter or traveling with others were other reasons selected by *Class 4H*. Similarly, improper infrastructure has been mentioned as a barrier to e-scooter usage especially, for females and middle-aged non-users in other studies (Nikiforiadis et al., 2021; Teixeira et al., 2023). In conclusion, this group might be willing to ride an e-scooter in the future. However, price and safety are some of the most effective parameters in their decision.

Class 5H of e-scooter non-users in Helsinki with a predicted proportion of about 28% are mostly highly educated young to middle-aged people. According to **Table 2**, the percentage of males in *Class 5H* is the highest compared to other classes. They are 100% employed with the highest income in comparison to other classes. They have high cycling experience. Compared to other classes, this class distinguishes the beneficial impacts of shared e-scooters for society. Even though *Class 5H* has the least awareness of some of the potential issues of e-scooters, they have not selected "no idea" as their awareness of the issue. Besides not feeling the necessity to use e-scooters, they are not an e-scooter user because of low competence, practical reasons such as traveling with children or having their own private e-scooter, as well as unavailability of materials such as no shared e-scooters in the origin or destination. They believe that the street infrastructure should be improved in order to improve e-scooter usage in the city. Furthermore, implementing rules for other road users such as reducing car speed is important to them. This group has the least negative perspective regarding e-scooters. Therefore, they could be potential e-scooter users in the future.

In general, unlike e-scooter riders who are mostly males and young (Dibaj et al., 2021), the majority of non-users are females and middle-aged to old, in Helsinki. This finding is in line with previous studies (Pourfalatoun et al., 2023; Speak et al., 2023). Interestingly, in the classes with a lower percentage of females, the members are relatively interested in e-scooter usage or at least have a less negative perspective towards e-scooters, such as *Class 5H* in **Table 2**.

4. CONCLUSIONS

This study contributes to understanding and identifying potential future e-scooter users by investigating the attitudes and characteristics of the e-scooter non-users in Helsinki using latent class clustering analysis. This implies a data driven focus due to the fact that the latent class analysis identified 5 classes of non-users. The data on e-scooter users and non-users were collected through an online questionnaire in 2022. Despite media reports and previous studies, e-scooter non-users' perceptions towards e-scooter vary from very negative to positive. The classes with a higher proportion of females who are highly educated and have higher income have the most negative

perspective towards e-scooters. This negative perspective eventually leads them to suggest a total ban on e-scooter usage in urban areas. This class mostly demands a very strict set of rules and regulations to govern e-scooters. The percentage of very negative to negative groups of non-users in Helsinki is about 52%. On the other hand, low-income students have a higher interest in using e-scooter. However, due to the relatively high price of renting an e-scooter and having safety concerns, they refuse to ride e-scooters. Furthermore, another group of non-users who have a high income and education level are not using e-scooters due to not being interested in e-scooters or low competency or unavailability of material. The percentage of very positive to positive groups of non-users, who can be potential future users, in Helsinki is about 40%. About 8% of the non-users are elderlies and retired people who have an almost negative perspective towards e-scooter and not using it due to not finding it necessary as well as having safety concerns.

The findings of this study show an ununiformed group of non-users in Helsinki with different socio-demographic characteristics, needs, and perceptions towards e-scooters. By understanding these differences, e-scooter operators could encourage specific groups of e-scooter non-riders by providing safe and personalized e-scooter usage packages. On the other hand, policy-makers could hear the voices of different e-scooter non-user groups and try to govern this emerging technology in a better way that satisfies the majority of user and non-user groups while considering their safety concerns regarding e-scooters. For future studies, we recommend applying a multivariate analysis to further investigate the effect of different parameters such as reasons, motives, suggestions, and perspectives regarding e-scooters on the level of negativity or positivity regarding e-scooters in Helsinki.

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