TRANSPORT FINDINGS

Factors Affecting e-Scooter Mode Substitution

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Findings

What transport modes do e-scooters replace? This article analyses the results from a web survey conducted among customers who were registered with five different shared e-scooter apps in Norway in October-November 2021. It is found that the context of the e-scooter trip, as well as characteristics of the users and their choice situation, impact the answer to that question. In all circumstances but for night rides, e-scooters most often replace walking. However, e-scooters are also found to replace cars as a transport mode, especially with longer e-scooter trips, if the user is male, if the e-scooter is privately owned (as opposed to shared), and to destinations that are poorly served by public transport.

1. Questions

As e-scooters become increasingly popular, the debate over their contribution, or lack thereof, to user health as well as motorized transport substitution continues (Fearnley 2020, 2021; Fearnley, Johnsson, and Berge 2020; Luo et al. 2021; Reck, Martin, and Axhausen 2022; Wang et al. 2022; Ziedan et al. 2021). This article poses the research question: What factors affect e-scooters' replacement of car use, public transport (PT) use, walking and cycling?

2. Methods

A web-survey was sent to registered customers of five different e-scooter rental companies in Norway (who cannot be named for commercial reasons). 2585 respondents completed the full survey and a further 991 respondents started the survey but did not complete it. This means that the maximum number of respondents for any part of the survey was 3576. Unfortunately, the e-scooter companies cannot disclose information about how many customers they sent invitations to and hence the response rate is unknown.

The survey covered numerous topics, including e-scooter usage, details about last e-scooter trip, preferences, and other background information. Table 1 provides some sample characteristics. In this study, we analysed the responses to questions about how respondents would have hypothetically travelled if an e-scooter were not available on their last e-scooter trip.

3. Findings

Walking was found to be the most common alternative to e-scooters if an e-scooter were not available during daytime. There are, however, nuances to this finding which depend on the user/journey circumstance. In more detail:

- 73.1% of respondents used e-scooters as their *main transport* mode on their last e-scooter trip. Almost half (46.9%) of these would have walked as an alternative, with others choosing PT (32.0%), car/taxi

Table 1. Sample attributes, completed surveys. N=2585. Details about 39 non-users not included.

	All (N=2585)	Inexperienced users: Used e-scooter between 1 and 10 times in total (N=459)	Experienced users: Used e-scooter more than 10 times in total (N=2087)
Average age (SD)	34.4 (13.0)	37.7 (14.4)	33.5 (12.3)
Gender (%)			
Female	41.9	45.8	41.2
Male	56.7	52.5	57.5
Other/will not answer	1.4	1.7	1.3
Education (%)			
Lower	40.5	42.1	40.3
BSc	32.8	29.8	33.5
MSc or higher	27.4	26.1	24.2
Driving license holder (car or MC/moped) (%)	79.2	83.4	78.2
Driving license and car owner (self or household) (%)	64.7	79.9	60.8

(12.6%) or cycling (6.0%) as their main alternatives. For these trips, therefore, 44.6 percent of e-scooter trips replaced motorized modes, and 52.9 percent replaced active modes (the remainder would not travel)

- 25.1% of respondents used e-scooters *to/from another transport mode* during their travel.
    - Among those who would only change the *e-scooter leg* of that combined trip, most (77.9%) would have walked as an alternative, with others choosing PT (14.2%), car/taxi (4.5%) or cycling (3.5%). Here, 18.7 percent of e-scooter trips replaced motorized modes, and 81.4 percent replaced active modes
    - Almost a fifth (19%) of these would have made the *entire combined trip* differently, of whom half (50.9%) would have chosen PT for the whole journey, with others choosing car/taxi (29.5%), walking (13.4%) or cycling (6.3%). Here, 80.4 percent of the trips replaced motorized modes, while 19.7% replaced active modes of transport
- About two-thirds of respondents have used an e-scooter *at night*. For these night rides, a similar percentage would have used car or taxi (38.4%) or walked (34.3%) as an alternative, with others choosing PT (21.8%) or cycling (1.9%). This means that 60.2% of e-scooter trips at night replaced motorized modes, while 36.2% replaced active transport modes

Binary logistic regression models were developed to provide more insight into factors that affect mode replacement of car, PT, cycling, and walking with e-scooters (Table 2), night trips excluded. These included area factors, trip attributes, user attributes, and various user choice indicators.

The models were developed such that they produced (fairly) significant coefficient estimates with an expected sign – and with a view to the models' overall goodness-of-fit. Several variables did not produce robust estimates (e.g. trip purpose, education level and different indices of experience with e-scooters) and were not included. Blank cells in table 2 mean the variable was excluded due to the lack of explanatory power. The model for bicycle replacement performed poorest due to low number of observations. Conversely, a large number of observations of replacement of walking produced the model with best goodness-of-fit.

Looking at area variables, results showed that in Oslo (Norway's capital and largest city), e-scooter trips mostly replaced PT and to a lesser degree car use and walking, which is likely due to longer trip distances and city car restrictions (Fearnley, Johnsson, and Berge 2020). City centre trips replaced car use to a lesser degree, again likely because of car restrictions and poor car accessibility. Where users enjoyed three or more PT departures per hour where they live, e-scooters tended to replace PT trips to a larger degree.

Moving to trip attributes, the model results confirm that the longer an e-scooter trip was, the more likely it was to replace motorized modes of transport. This is also the case for trips where e-scooters were used as the main transport mode (i.e. not in combination with other modes).

Regarding user characteristics, the model results showed that male riders replaced car trips to a larger degree (and walking to a lesser degree). E-scooter trips by students, whose car ownership is generally low (Grue, Landa-Mata, and Flotve 2021), replaced cars to a lesser degree. The older the respondents, the less likely they replaced PT. E-scooter trips by those over 40 years of age replaced walking to a larger degree. When users paid for each e-scooter ride as opposed to various rebate schemes (monthly pass etc.) they are likely more discrete travelers, and their e-scooter trips replaced walking to a larger degree and cars to a lesser degree. Not surprisingly, e-scooter trips by those with access to bikes replaced bike trips to a large degree. Those with privately-owned e-scooters tended to replace trips by other privately-owned transport modes: car and bike.

Table 2. Binary logistic regression, models with car, PT, bike, and walk, respectively, as dependent variable.

		Last trip replaced car (166 cases)			Last trip replaced PT (686 cases)			Last trip replaced bike (135 cases)			Last trip replaced walk (1105 cases)		
		B	Sig.	Exp(B)	B	Sig.	Exp(B)	B	Sig.	Exp(B)	B	Sig.	Exp(B)
Area	Usually rides e-scooter in Oslo (dummy)	-0.347	0.065	0.707	0.323	0.003	1.381				-0.290	0.003	0.748
	Used e-scooter in city centre (dummy)	-0.412	0.039	0.662									
	3 or more PT departures at nearest stop				0.507	0.002	1.660						
Trip attribute	Trip duration (5 intervals: 0-4 min, 4-9 min, 10-14 min, 15-19 min, 20 minutes or more)	0.241	0.003	1.273	0.521	0.000	1.683				-0.667	0.000	0.513
	Used e-scooter as main transport mode (dummy)	0.705	0.013	2.025	1.069	0.000	2.912						
	Used e-scooter to/from another transport mode (dummy)							-0.861	0.003	0.423	-0.950	0.000	0.387
User attribute	Male (dummy)	0.413	0.030	1.511							-0.177	0.070	0.838
	Student	-0.955	0.001	0.385									
	Age				-0.018	0.000	0.982						
	Over 40 years old (dummy)										0.279	0.010	1.322
	Usually pay for each trip separately (PAYG; dummy)	-0.405	0.039	0.667							0.200	0.091	1.221
	Owns or has access to (city)bike (dummy)				-0.273	0.018	0.761	1.711	0.000	5.533	-0.194	0.082	0.824
	Used privately owned e-scooter (dummy)	0.992	0.001	2.697	-0.520	0.051	0.595	0.668	0.050	1.950			
Choice situation	Used e-scooter to/from another transport mode *and would have changed the whole trip chain* if e-scooter were not available (dummy)	2.092	0.000	8.098	2.282	0.000	9.798				-3.176	0.000	0.042
	Chose e-scooter because (dummies):												
	- It was quickest	-0.593	0.002	0.553	0.399	0.003	1.491	-0.481	0.014	0.618			
	- It was most reliable				0.442	0.026	1.555				-0.776	0.000	0.460
	- It was cheapest				0.547	0.000	1.729				-0.820	0.000	0.440
	- It was most flexible				0.440	0.000	1.553	-0.329	0.075	0.720	-0.403	0.000	0.668
	- It was most accessible	-0.389	0.057	0.678	0.262	0.014	1.299						
	- Car parking makes it difficult to use car	1.900	0.000	6.685	-0.552	0.016	0.576				-0.811	0.000	0.444
	- I didn't have to make effort	-0.883	0.017	0.414									
	- I don't have car	-1.320	0.006	0.267									
	- PT didn't go where I was going	0.542	0.026	1.720									
	Constant	-2.894	0.000	0.055	-3.568	0.000	0.028	-3.665	0.000	0.026	3.006	0.000	20.201
Model fit statistics	Cox & Snell R Square		0,099			0,148			0,025			0,209	
	Nagelkerke R Square		0,240			0,208			0,070			0,279	
	McFadden R-squared		0,196			0,128			0,057			0,169	
	LL null model (intercept only)		966,079			2533,617			128,782			1836,469	
	LL final model		734,891			2188,586			70,143			1308,695	

Finally, we looked at how respondents' choices affected mode substitution. Results showed that those who would have changed the entire combined trip replaced motorized transport modes (car, PT) to a larger degree. This is also intuitive since trip distances would be longer and walking may not be an alternative.

Respondents had indicated up to three reasons why they chose e-scooters for their last trip. If we focus on PT, the results suggest that users substituted e-scooters for PT when e-scooter were the quickest, most reliable, cheapest, and most flexible alternative. In more detail, results showed that:

- Respondents who selected an e-scooter because it was *quickest*, replaced PT to a larger degree and bikes and cars to a lesser degree
- Respondents who selected an e-scooter because it was *reliable*, replaced PT to a larger degree and walking to a lesser degree
- Respondents who selected an e-scooter because it was *cheapest* replaced PT to a larger degree and cars to a lesser degree
- Respondents who selected an e-scooter because it was *most flexible* replaced PT to a larger degree and walking and cycling to a lesser degree
- Respondents who selected an e-scooter because *car parking is difficult* had a greater probability of replacing cars and a reduced probability of replacing PT and walking
- Respondents who selected an e-scooter because it *didn't require physical effort* tended *not* to replace cars
- If *PT didn't go where respondents were going*, there was a larger probability of replacing a car trip when selecting an e-scooter

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