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Who combines shared e-scooters and public transportation? Insights from Stockholm, Gothenburg, and Malmö, Sweden

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Abstract

Shared e-scooters have promising potential to solve the problem of first- and last-mile with public transportation. However, it remains unclear how often these modes are combined in practice and which users are most likely to make multimodal trips. We address this research gap by surveying 1269 shared e-scooter users in Stockholm, Gothenburg, and Malmö, Sweden. A binary logistic regression model is estimated to determine the characteristics of users who have made at least one combined trip in the last six months. In addition, an ordinal logistic regression model is estimated to understand the factors that determine whether users exhibit frequent multimodal usage. Similar to other studies, the typical shared e-scooter user in Sweden is a younger, highly educated, well-paid urban man who lives in the city center. Our results suggest, however, that multimodal users could be a contrasting subgroup. In Stockholm, frequent users had higher odds of making a combined trip. However, frequent e-scooter usage did not necessarily lead to more frequent multimodal travel. Users with lower incomes or those living outside the city center had higher odds of combined trips. Users living outside the central operational zone in Stockholm were more than three times as likely to have made a combined trip, while in Gothenburg, such users were more than five times as likely to do so. In contrast, Malmö's multimodal users aligned more with the typical shared e-scooter profile: users who had combined the modes were under the age of 30, had higher incomes, or were more frequent users. These findings have important policy implications for authorities aiming for better and more equitable multimodal integration of e-scooters and public transportation.

1 Introduction

Shared e-scooters, first launched in cities in the late 2010s, are now a common sight in many urban areas. Despite their prevalence, they continue to be viewed as a novel element in the streetscape, as their role within the urban transportation system is not fully defined. Shared e-scooters compete primarily with public transportation in terms of travel time (Aarhaug et al., 2023; Psarrou Kalakoni et al., 2024). Although shared e-scooters often replace walking and public transport (Laa & Leth, 2020; Reck et al., 2021; Wang et al., 2022; Weschke et al., 2022), studies also suggest that their negative impact on public transportation ridership is very small or even insignificant (Luo et al., 2021; Ziedan, Darling, et al., 2021; Ziedan, Shah, et al., 2021). In contrast, some studies suggest a significant impact on shared e-scooter trip demand and attraction when opening and closing public transportation stations (Tyndall, 2022; Weschke, 2023) and that arrivals of shared e-scooters match departures of ferries in Oslo, Norway (Fearnley et al., 2020). The potential of using shared e-scooters as a first- or last-mile mode with public transportation is often promoted by advocates. These potentials have been studied from the perspective of employment accessibility (Hu et al., 2025) and the reduction of car trips (Yan et al., 2023). Despite the growing focus on shared micromobility research in recent years, several aspects of multimodal trips integrating shared e-scooters with public transportation remain underexplored. This paper aims to shed light on multimodal trips, particularly examining the demographics and characteristics of the users involved.

A common approach to estimating multimodal trips with shared e-scooters and public transportation is to categorize shared e-scooter trips that start or end within a certain radius of public transportation as multimodal. Using this method and a radius of 50 meters, between 6% and 51% of shared e-scooter trips were estimated to be multimodal in 124 European cities (Li et al., 2024). Another approach to the spatial relationships between shared e-scooters and public transportation is to classify whether an e-scooter trip is complementary to or substitutes for public transportation. In Rome, Italy, 15% of e-scooter trips were found to be complementary, neither starting nor ending by public transportation (Vinagre Díaz et al., 2023). 49% of trips in Rome were classified as first- or last-mile, with the remaining 36% classified as substituting. When comparing complementary and competing e-scooter trips in Stockholm, Sweden, and Helsinki, Finland, (Guo et al., 2023) found that the majority of trips in Stockholm were complementary trips, and found the opposite for Helsinki. Furthermore, more areas in Stockholm were associated with complementary trips, whereas in Helsinki, more areas were associated with competing trips. In Indianapolis, Indiana, almost none of the trips were estimated to be first or last mile, while about 27% of trips were found to be complementary, predominantly outside of bus service time (Luo et al., 2021). In Melbourne, Australia, shared e-scooter trips were concentrated both spatially and temporally in areas with high levels of public transportation service, based on a comparison of shared e-scooter and GTFS data (Currie et al., 2025). The highest level of mode complementarity was observed at night, when public transportation service was limited. In Chicago, Illinois, areas with higher recorded proportions of women and high-income residents were less likely to see multimodal trips combining shared e-scooters with either bus or train when considering the spatial relation of start or end points (Javadinasr et al., 2023). Conversely, areas with higher public transportation usage rates and higher crime levels showed higher rates of shared e-scooter trips starting or ending by public transportation.

However, this method of inferring that all trips starting or ending at a public transportation stop are multimodal trips may be overly simplistic, especially in cities with high levels of transit-oriented development. By combining shared e-scooter trip data with a post-ride quick survey, Yin et al. (2023) could estimate a more accurate share of first- and last-mile trips. Randomly selected users were asked three short questions after ending their trips, and one of the questions was whether the trip was to or from a public transportation stop. By combining this survey data with the spatial data previously used by other studies, the authors concluded that the spatial method greatly overestimated the share of multimodal trips, and in the case of Washington, D.C., by more than two times. Apart from overestimation, the spatial association method does not provide any insights into the reasons for making a first- or last-mile trip or which individuals make them. Several studies have surveyed shared e-scooter users to determine who they are and have confirmed the image of a typical shared e-scooter user as a younger, highly educated, well-paid urban man (Christoforou et al., 2021; Laa & Leth, 2020; Reck & Axhausen, 2021). Additionally, students occasionally emerge as a distinct user group within these studies. However, only a few studies have explored the crossover of shared e-scooter users who have used the mode for first- and last-mile trips.

Existing studies present a fragmented picture of the typical shared e-scooter users who combine their rides with public transportation. In Oslo, Norway, men and students were more likely to have made a combined trip in a descriptive analysis of survey results of 549 shared e-scooter users (Fearnley et al., 2020). In Washington, D.C., and Los Angeles, individuals without a college degree and non-white users showed a higher likelihood of making combined trips (Huang et al., 2023). The perceived safety of e-scooters and a high usage frequency of public transportation also increased the odds of having made a multimodal trip. Males and frequent users of shared e-scooters expressed the intent to make combined trips that, however, were not realized. In the Chicago metropolitan area, the likelihood of integrating shared e-scooters with public transportation was higher for male users, users living in households without access to personal vehicles, and those holding at least a master's degree (Javadinasr et al., 2025). Furthermore, users with access times of less than 5 minutes to shared e-scooters were also associated with a greater propensity for multimodal travel. In a stated preference survey in Seoul, South Korea, high income and previous experience with shared e-scooters increased the choice probability of the mode as a last-mile option (Baek et al., 2020). A stated preference survey in Florida found that students and low-income individuals were more likely to prefer combining e-scooters with public transportation, while environmentally concerned and time-sensitive travelers were less inclined to do so (Sarker et al., 2024). In a stated preference survey among university students in Portland, Oregon, female and Black students were less likely to choose the combination of shared e-scooter and light rail over a private car (McQueen & Clifton, 2022). These mixed findings indicate a need for further research to understand the demographics and characteristics of shared e-scooter users who combined the mode with public transportation.

While one prior study has examined multimodal travel in two North American cities, we provide the first multi-city empirical analysis in a European context, based on reported usage rather than stated preference data. Using robust regression methods, we analyze the frequency of shared e-scooter and public transport integration and identify key sociodemographic factors for such behavior, including living location, a characteristic not previously addressed in this research area.

- Who makes multimodal trips combining shared e-scooters and public transportation, and what are their defining characteristics?
- What influences shared e-scooter users to have a high share of combined trips?

The rest of the paper is structured as follows. In Section 2, we present the current research about multimodal trips combining shared e-scooter and public transportation. In Section 3, we present the data and methodology. Descriptive results are presented in Section 4, and the result from the binary and ordinal logistic regression model is presented in Section 5. In Section 6, the result is discussed and compared to other similar studies. Finally, in Section 7, we present the conclusion of the study.

2 Data and methodology

A web-based survey was distributed in the three largest cities in Sweden: Stockholm, Gothenburg, and Malmö. All three cities have robust and extensive public transportation systems and were early markets for shared e-scooter companies in Sweden. Respondents to the survey were recruited in November 2022. During this month, the city of Stockholm had a fleet size cap of 12,000 vehicles evenly distributed over seven private shared e-scooter companies (Voi, Lime, Tier, Bolt, Link/Superpedestrian, Dott, and Qick), and the city of Gothenburg had a fleet size cap of 4,400 vehicles evenly distributed over four private shared e-scooter companies (Bolt, Lime, Tier, and Voi). Malmö had an estimated 5000 vehicles operated by four private companies (Tier, Voi, Lime, and Bolt). All cities had, at the time, some type of public bike-sharing service. However, none of these were integrated into the public transportation tickets.

The survey was originally distributed to investigate attitudes and perceptions of a new national parking policy for e-scooters introduced on September 1, 2022 (Berg Wincent et al., 2025). Apart from questions regarding the design features of shared e-scooter parking and changes in travel behavior and perception, the respondents were also asked if and how frequently they had combined trips with shared e-scooters and public transportation in the last six months. Additionally, we collected information on the demographic and socioeconomic characteristics of the shared e-scooter users.

Table 1. List of independent variables used in the models

Variable code	Type	Value and description
Usage Frequency	Ordinal	Frequency of riding shared e-scooters in the last six months 1 = Less than monthly 2 = Once or more times per month 3 = Once or more times per week 4 = Once or more times per day
Living Location	Dummy	0 = Living inside of the Stockholm, Gothenburg, or Malmö operating zone as defined in Figure 1 1 = Living outside of the central operating zone
Living Location Stockholm	Categorical	1 = Living inside the Stockholm central operating zone as defined in Figure 1 2 = Living inside the operating zone in Nacka, Solna, or Sundbyberg 3 = Living outside of the operating zone
Income	Ordinal	Yearly income SEK 1 = Less than 200,000 2 = 200,000 – 400,000 3 = 401,000 – 600,000 4 = 601,000 – 800,000 5 = More than 800,000
Age over 30	Dummy	1 = Age over 30 years old 0 = Age less than 30

The survey was distributed with the help of shared e-scooter company Voi to all their users who had taken at least one trip before and after the enforcement of the new parking policy on September 1, 2022, in Stockholm, Gothenburg, or Malmö. A total of 77,270 users received the survey via email: 48,865 in Stockholm, 16,011 in Gothenburg, and 12,394 in Malmö. Users who had not opened the email after a week received a reminder to answer the survey. No cash incentive or promo code was offered to survey respondents.

In the end, we obtained 1082 complete responses from users in Stockholm, 163 from users in Gothenburg, and 177 from users in Malmö. The data cleaning process was based on four control questions: riding shared e-scooters before September 1, 2022; riding after September 1, 2022; usually riding in the indicated city (Stockholm, Gothenburg, or Malmö); and having taken at least one trip in the last 6 months. After the data cleaning process, there were 965 responses for Stockholm, 145 for Gothenburg, and 159 for Malmö.

3 Descriptive results

3.1 Socioeconomic profile of survey samples

The socioeconomic profile of the survey sample is presented in Table 2. The gender distribution of users was predominantly male in all three cities. In Gothenburg and Stockholm, over 70 % of respondents were male. In Malmö, the proportion of female respondents was slightly higher, which could mean that slightly more women ride electric scooters in the city. This gender disparity among shared e-scooter users is consistently reported in research (Wang et al., 2022). For example, studies show that in Paris, 68% of e-scooter users are male (Christoforou et al., 2021). In Vienna, this figure reaches 74% (Laa & Leth, 2020), and 68% in Zurich (Reck & Axhausen, 2021).

The age of users in Gothenburg and Stockholm was higher than in Malmö. Almost half of the respondents in the two cities, over 47%, were 40 years or older. The age category with the most responses in Malmö was 30–39 years, where 38% of respondents were included. This stands in stark contrast to Vienna, where 42% of users were below the age of 25 (Laa & Leth, 2020), Paris, where the figure is 38% (Christoforou et al., 2021), and Zurich, where 42% were younger than 30 (Reck & Axhausen, 2021).

Annual income among users was the highest in Stockholm. Almost half, 47%, had a yearly income above 600,000 SEK, and 77% had an income above 400,000 SEK. This places them well above the median income of 412,300 SEK recorded in Stockholm for 2022 (Statistics Sweden, 2025). In Gothenburg, 58% of users earned more than 400,000 SEK, surpassing the city's median of 369,100 SEK. Similarly, in Malmö, where the median income was 336,400 SEK in 2022, 55% of e-scooter users reported incomes above 400,000 SEK. These findings indicate that most shared e-scooter users in Sweden earn above the national median (371,500 SEK in 2022), a trend consistent with observations from other cities such as Paris, where shared e-scooter users tend to be wealthier (Christoforou et al., 2021), and Zurich, where the users' incomes exceed the average (Reck & Axhausen, 2021).

The level of education among users was high; 65% of users in Stockholm, 48% of users in Gothenburg, and 56% of users in Malmö had at least a bachelor's degree. In addition, 16%, 20%, and 21% in each city respectively had a post-secondary education not from a college or university. By contrast, in 2022, 33% of the general population, ages 25–64, in Sweden had completed three or more years of post-secondary education, with higher proportions in Stockholm (48%), Gothenburg (41%), and Malmö (39%) (Statistics Sweden, 2025). This reinforces the perception of shared e-scooter users as highly educated, as noted in earlier studies (Christoforou et al., 2021; Laa & Leth, 2020; Reck & Axhausen, 2021). Most users were employed full-time, at least 69% in each city. In Stockholm, 14% of users were self-employed, and 8% were students. In both Gothenburg and Malmö, the proportion of students was higher (17% and 10% respectively), and the proportion of self-employed was lower (9% and 4% respectively) among users. Although previous research has identified students as a significant portion of users (15%–30%) (Christoforou et al., 2021; Laa & Leth, 2020; Reck & Axhausen, 2021), this trend does not hold in Stockholm and Malmö. However, it does hold for users in Gothenburg.

Table 2. Characteristics of e-scooter users

		Stockholm		Gothenburg		Malmö	
		n	%	n	%	n	%
Gender	Man	703	73	104	72	101	64
	Woman	253	26	40	28	57	36
	Other	4	0	0	0	0	0
	Prefer not to say	5	1	1	1	1	1
Age	20 years or younger	24	2	14	10	7	4
	21–29 years	221	23	26	18	39	25
	30–39 years	263	27	36	25	60	38
	40–49 years	244	25	29	20	37	23
	50 years or older	213	22	40	28	16	10
Annual income (SEK)	Under 200,000	53	5	22	15	17	11
	200,000 -- 400,000	116	12	29	20	43	27
	401,000 -- 600,000	287	30	49	34	50	31
	601,000 -- 800,000	218	23	21	15	27	17
	Above 800,000	236	24	16	11	11	7
	Prefer not to say	55	6	8	6	11	7
Education	Primary	21	2	12	8	1	1
	Secondary	168	17	35	24	35	22
	Post-school	151	16	29	20	33	21
	Bachelor's	271	28	39	27	53	33
	Master's	334	35	29	20	30	19
	Doctoral	20	2	1	1	7	4
Occupation	Full-time employed	719	75	100	69	123	77
	Part-time employed	15	2	1	1	8	5
	Student	72	7	25	17	16	10
	Retired	8	1	1	1	1	1
	Self-employed	135	14	13	9	7	4
	Unemployed	7	1	0	0	3	2
	Other	9	1	5	3	1	1
Living location	Within operating zone	673	70	109	75	130	82
	Within operating zone (not Stockholm)	50	5				
	Outside operating zone	220	23	31	21	24	15
	Unknown	22	2	5	3	5	3
Usage frequency (last six months)	Less than monthly	71	7	9	6	16	10
	Monthly	327	34	49	34	63	40
	Weekly	434	45	68	47	59	37
	Daily	133	14	19	13	21	13
Total		965	100	145	100	159	100

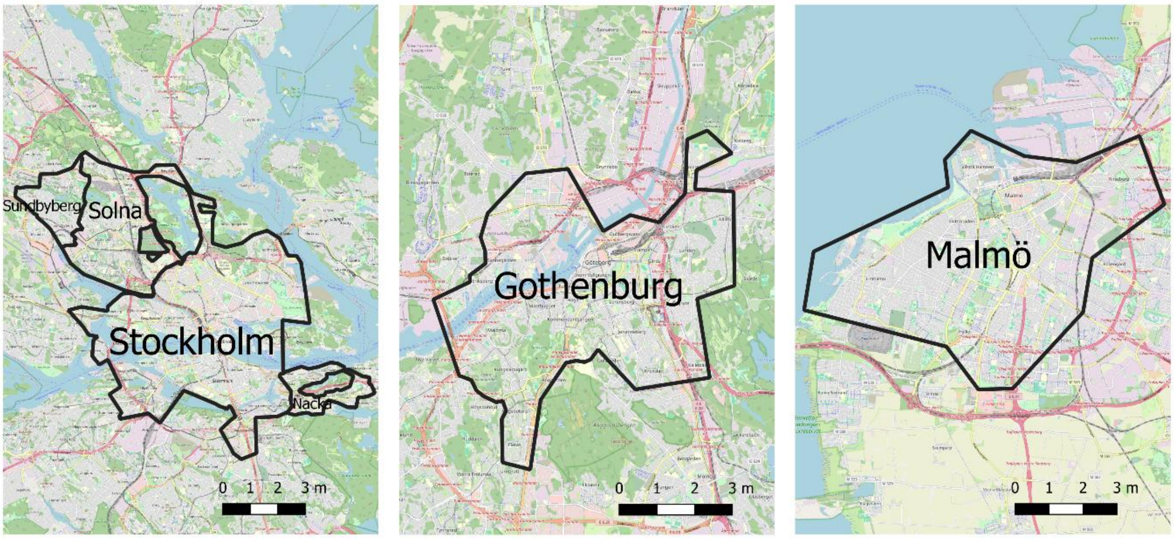

Figure 1. The Voi operation zone during fall 2022

To understand where users lived, we asked each respondent to enter their postal code. Each postal code was then matched to the centroid of a polygon corresponding to each postcode in Sweden. Some users provided invalid postal codes that could not be matched. Based on the centroid location, it was determined whether the respondent lived inside or outside the Voi operating zone in the respective city. During the fall, Voi also had operations in the Stockholm region municipalities of Nacka, Solna, and Sundbyberg, all of which were part of Voi's contiguous Stockholm area. Users who lived within the operating zones of the surrounding municipalities were given a special category in Table 1. Over 70% of users in all cities live within the operational zone. This finding aligns with results from the Chicago metropolitan area, where the majority of users also lived within the operational zone, with higher concentrations observed in the downtown area and northern neighborhoods (Askari et al., 2025; Javadinasr et al., 2025).

3.2 *Public transportation and shared e-scooter integration*

To understand the extent of multimodal trips combining shared e-scooters and public transportation, the respondents were asked if they had used a shared e-scooter to connect to or from a public transport journey in the last six months. Malmö had the highest proportion of users who had made at least one combined trip in the last six months, 63%, followed by Stockholm, 58%, and last Gothenburg, 51%.

Users who had made at least one combined trip in the last six months were asked about the share of their shared e-scooter trips that were made in combination with public transportation (see Figure 3). In Stockholm, 16% said that more than half of their trips with shared e-scooters were combined with public transportation, and 17% said it was about half. The remainder, 66%, said that less than half of their trips were combined. In Gothenburg, 20% said that more than half of their trips with shared e-scooters were combined with public transportation, and 22% said it was about half. In Malmö, 31% said that more than half of their trips were combined with public transportation, and 26% said it was about half.

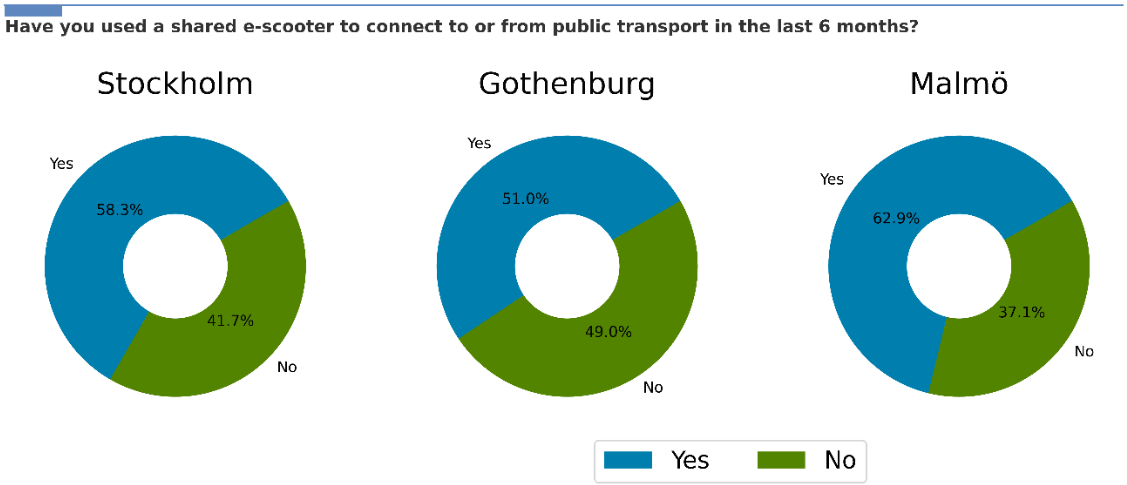

Figure 2. Share of users who have taken at least one multimodal trip

4 Statistical analysis

In this section, we explore the factors contributing to shared e-scooter and public transportation trips. First, we apply binary logistic regression to examine the user characteristics and demographics of those who used shared e-scooters and public transportation in combination at least once in the last six months. We first run a pooled model with city-specific interactive dummy variables and then run city-specific models to validate and detail the findings of the pooled model. Second, we use ordinal logistic regression to analyze the factors influencing a high or low rate of combined trips.

4.1 Combining public transportation and shared e-scooter

4.1.1. Pooled model for all cities

Table 3 presents the binary logistic regression analysis results investigating the factors that influence the likelihood of having made at least one combined trip in the past six months across the three cities. The dependent variable is binary, indicating whether a combined trip was made (Yes = 1 and No = 0). The model includes the independent variables defined in Table 1 with two city-specific interactive dummy variables for Gothenburg and Malmö, with Stockholm serving as the reference category. The interactive variables capture city-specific effects on the likelihood of multimodal trips. A positive and significant coefficient of the interactive dummy variable suggests a higher effect from the predictor on the likelihood of combined trips in that city compared to the reference city.

Users residing within the central operational zone for shared e-scooters have a lower likelihood of having made a multimodal trip compared to those living outside. Specifically, the odds ratio (Exp(B)) for users residing outside the central operational zone making a combined trip is 3.176, indicating that these users have over three times higher odds of making such a trip compared to those residing inside the central operational zone. This finding is robust, as indicated by a p-value lower than 0.001. The city-specific variables do not show significant deviations from the overall pattern. Thus, there is no statistical evidence to suggest that the effect of living location on the likelihood of engaging in multimodal trips differs between Gothenburg and Malmö compared to Stockholm.

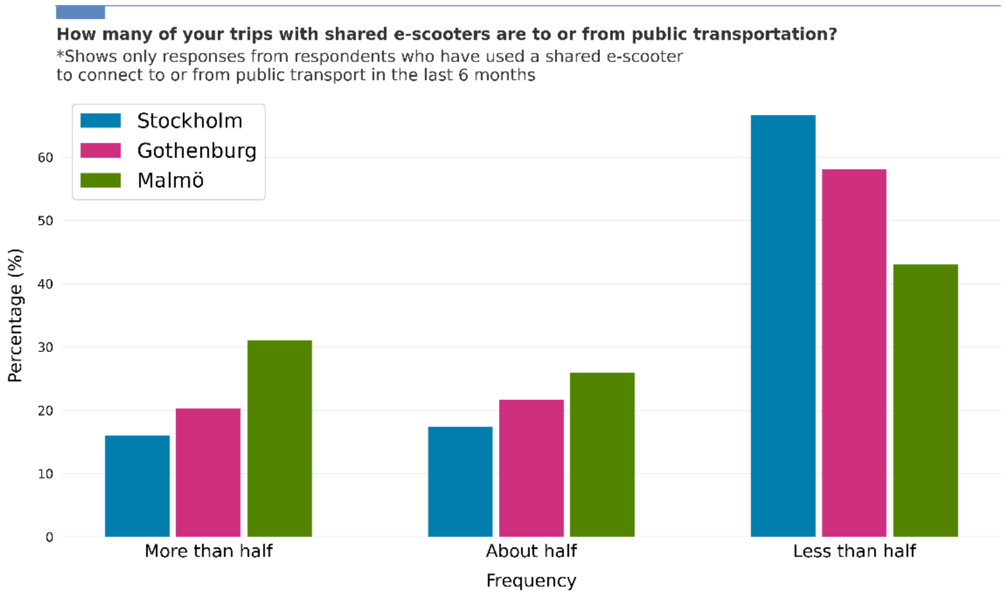

Figure 3. Share of multimodal trips

The estimated coefficient (B) for the income variable is negative and significant, indicating that users with higher incomes are less likely to have made a combined trip. Specifically, for each increase in the income group a user belongs to, as defined in Table 1, the odds of a user making a combined trip decrease by approximately 16% (Exp(B) = 0.841). The income effect is not statistically significant in Gothenburg. However, in Malmö, the pattern is reversed: the higher the income, the higher the likelihood of having made a combined trip.

Our results show that frequent users of shared e-scooters have higher odds of engaging in multimodal trips in Stockholm, while the effect is slightly smaller for Gothenburg. This result might not be unexpected since the survey question asked about the usage of shared e-scooters to connect to or from public transportation at least once in the last six months. Taking more trips should increase the probability of more diverse trip purposes. Users who use e-scooters monthly already show a significant increase in the likelihood of multimodal trips compared to users who travel less frequently than monthly (the baseline category). This trend is even more pronounced for those who use e-scooters weekly and daily, emphasizing the relationship between frequent usage and multimodal trips. A one-unit increase in usage frequency increases the odds of having made a multimodal trip by 66%.

The effect of age is nearly significant ($p = 0.061$) in Malmö, where users over the age of 30 have a lower likelihood of combining shared e-scooters with public transportation. Neither having a university degree, being a student, nor gender has any significant effect on multimodal trips in any of the cities.

The model shows a significant improvement from the null model to the full model, and the data fit the model. R^2 values are moderate (Nagelkerke = 0.114 and McFadden = 0.085), which is common for individual travel behavior models.

A Pearson correlation analysis highlights that users living in central operational zones tend to use e-scooters more frequently ($r = .223$, $p < .001$), and users over the age of 30 generally report higher incomes ($r = .440$, $p < .001$). City-specific variables confirm these trends ($r > .85$) but also indicate potential multicollinearity and the importance of city-level modeling. This is further supported by high VIF values (VIF 6–9) for several city-specific variables (Usage frequency and Income), which is, however, not unexpected with interactive dummy variables.

Table 3. Binary logistic regression on multimodal trips for all cities

Variable	Interactive dummy variable	B	S.E.	Sig.	Exp(B)
Living location		**1.156**	**0.173**	**<.001**	**3.176**
Living location	Gothenburg	0.550	0.556	0.322	1.733
Living location	Malmö	-0.817	0.535	0.127	0.442
Income		**-0.173**	**0.067**	**0.010**	**0.841**
Income	Gothenburg	0.110	0.191	0.566	1.116
Income	**Malmö**	**0.480**	**0.172**	**0.005**	**1.617**
User frequency		**0.511**	**0.089**	**<.001**	**1.666**
User frequency	**Gothenburg**	**-0.329**	**0.164**	**0.045**	**0.720**
User frequency	Malmö	-0.080	0.164	0.627	0.924
Age over 30		-0.240	0.184	0.190	0.786
Age over 30	Gothenburg	0.143	0.520	0.783	1.154
Age over 30	Malmö	-0.937	0.500	0.061	0.392
Constant		-0.535	0.287	0.062	0.585
Observations in analysis		1167			
Model fit	-2 Log Likelihood (null model)	1588.353			
	-2 Log Likelihood (final model)	1484.806			
	Likelihood ratio $\chi 2$ stat	103.548		<.001	
Pseudo R^2	Nagelkerke	0.114			
	McFadden	0.085			

4.1.2. City-level models

Within the Stockholm region, Voi and other e-scooter companies also operated within the surrounding municipalities of Nacka, Sundbyberg, and Solna. Users who resided within these operational zones were considered to live outside the *central* operating zone in the model presented in Table 3 for comparability with Malmö and Gothenburg. To further explore how the users' living (home) location affected multimodal travel, we added a specific variable for these zones to evaluate whether living in the inner city or merely having access to shared e-scooters influences multimodal travel.

Table 4 shows the model output for combined trips in Stockholm. The results largely confirm the findings of the analysis presented in Table 3. Living location, income, and usage frequency significantly affect the odds of making multimodal trips. Likewise, gender, age, occupation, and level of education are not found to be significant predictors of multimodal trip behavior in Stockholm. The Stockholm analysis provides more detail on how the living location affects multimodal trips. Shared e-scooter users who reside within the operating zone in the surrounding municipalities of Solna, Sundbyberg, and Nacka have the highest odds of having made a combined trip; they are 3.8 times as likely to have made a multimodal trip as users living within the operating zone in the city of Stockholm. Users residing outside the operating zone altogether have 3.1 times higher odds of having made a multimodal trip compared to users living within the operating zone in Stockholm. This result suggests that it is not the mere availability of shared e-scooter services that influences multimodal travel, but rather where users live in relation to the city center. Furthermore, living in the surrounding municipalities with access to shared e-scooters appears to encourage more first- and last-mile trips.

The second part of Table 4 shows the model output for multimodal trips in Gothenburg. Only one variable, living location, is statistically significant. Similar to Stockholm, residents living outside the operating zone have 5.5 times higher odds of having made a multimodal trip compared to those living within the central city. In other words, users living outside the operating zone are approximately 5.5 times more likely to have done so. These results suggest that living location had a stronger effect in Gothenburg than in Stockholm.

The last part of Table 4 shows the model output for users who have made combined trips with public transportation and shared e-scooters in Malmö. As concluded in Table 3, users over the age of 30 have a lower probability of having made a multimodal trip compared to users under the age of 30. Same as Stockholm, users traveling more frequently with shared e-scooters have higher odds of having made multimodal trips. A one-unit increase in usage frequency, as defined in Table 1, increases the odds of having made a multimodal trip by 65%. As indicated by the model output in Table 3, the relation between income and multimodal trips is reversed in Malmö compared to Stockholm. Specifically, for each increase in the income group a user belongs to, the odds of a user making a combined trip increase by approximately 47% (Exp(B) = 1.468).

Table 4. City-level binary logistic regression on multimodal trips

Stockholm					
Variable		B	S.E.	Sig.	Exp(B)
Usage frequency		**0.522**	**0.095**	**<.001**	**1.685**
Income		**-0.225**	**0.062**	**<.001**	**0.798**
Living location	Stockholm OP zone				
	not Stockholm OP zone	**1.356**	**0.388**	**<.001**	**3.879**
	outside OP zone	**1.125**	**0.182**	**<.001**	**3.08**
Constant		-0.554	0.328	0.092	0.575
Observations in analysis		965			
Model fit	-2 Log Likelihood (null model)	1234.652			
	-2 Log Likelihood (final model)	1155.304			
	Likelihood ratio $\chi 2$ stat	79.348		<.001	
Pseudo R^2	Nagelkerke	0.112			
	McFadden	0.084			
Gothenburg					
Variable		B	S.E.	Sig.	Exp(B)
Living location	Gothenburg OP zone				
	outside OP zone	**1.704**	**0.494**	**<.001**	**5.496**
Constant		-0.277	0.193	0.152	0.785
Observations in analysis		140			
Model fit	-2 Log Likelihood (null model)	193.967			
	-2 Log Likelihood (final model)	179.498			
	Likelihood ratio $\chi 2$ stat	14.469		<.001	
Pseudo R^2	Nagelkerke	0.131			
	McFadden	0.098			
Malmö					
Variable		B	S.E.	Sig.	Exp(B)
Income		**0.384**	**0.186**	**0.039**	**1.468**
Age over 30		**-1.112**	**0.468**	**0.017**	**0.329**
Usage frequency		**0.499**	**0.223**	**0.025**	**1.648**
Constant		-0.418	0.635	0.511	0.65
Observations in analysis		148			
Model fit	-2 Log Likelihood (null model)	194.225			
	-2 Log Likelihood (final model)	181.402			
	Likelihood ratio $\chi 2$ stat	12.823		0.005	
Pseudo R^2	Nagelkerke	0.114			
	McFadden	0.083			

The explanatory power of the models was evaluated using pseudo R-squared measures that provide an indication of improvement in fit compared to the null model. The Nagelkerke R^2 was lowest for the Stockholm model (0.112), slightly higher for Malmö (0.114), and highest for Gothenburg (0.131), all indicating modest fits, which are not uncommon in transport behavior modeling using logistic regression. These values suggest that the included predictors explain between 11.2% and 13.1% of the variance in the likelihood of making a multimodal trip. For reference, the corresponding McFadden R^2 values ranged from 0.083 to 0.098.

4.2 *Frequency of combined trips*

To better understand the factors influencing the frequency of multimodal trips with shared e-scooters and public transportation, we estimate an ordinal logistic regression model using survey responses shown in Figure 2. Only respondents who stated that they had used shared e-scooters in combination with public transportation in the last six months are included. The dependent variable captures the frequency of multimodal use, measured as the share of a respondent's shared e-scooter trips that are combined with public transportation. It is treated as an ordinal variable where higher values indicate a greater share of combined trips, coded as: less than half (1), about half (2), and more than half (3). A positive coefficient in the model indicates increased odds of being in a higher share category of multimodal trips, while a negative coefficient indicates decreased odds. The test of the proportional odds assumption holds, indicating that a relationship between the predictors and the log odds of being in a higher category of the outcome variable is consistent across all threshold points.

Table 5 shows the model output for the share of combined trips. Similar to the model output in Table 3, users in Stockholm serve as the reference category, and Gothenburg and Malmö each have an interactive dummy variable. Once again, the income and living location variables are significant predictors in the model. The negative and significant coefficient for income indicates that users with higher incomes have lower odds of being in a higher category of combined trip share. In contrast, the dummy variable for Malmö is significant ($p < .001$), indicating that a higher income is associated with a higher share of multimodal trips in Malmö.

The model shows a strong positive effect for users living outside of the central operational zone ($B = 1.498$, $p < .001$), indicating that these users have significantly higher odds of having a high share of combined trips. This suggests that users residing inside the central operational zone are less likely to combine shared e-scooters with public transportation more frequently. Neither of the interaction terms for Gothenburg nor Malmö is significant. This may indicate that users in all three cities follow similar multimodal trip patterns. Another explanation could be the smaller sample sizes in Gothenburg and Malmö.

Table 5. Ordinal logistic regression on the proportion of multimodal trips for all cities

Variable		Estimate	Std. Error	Sig.
Combined trips	Less than half	0.478	0.239	0.045
	About half	1.489	0.246	<.001
	More than half			
Income		**-0.247**	**0.069**	**<.001**
Income	Gothenburg	0.165	0.113	0.144
Income	**Malmö**	**0.443**	**0.08**	**<.001**
Living location		**1.498**	**0.191**	**<.001**
Living location	Gothenburg	-0.76	0.591	0.199
Living location	Malmö	-0.561	0.552	0.31
Observations in analysis		677		
Model fit	-2 Log Likelihood (null model)	277.998		
	-2 Log Likelihood (final model)	181.917		
	Likelihood ratio $\chi2$ stat	96.081		<.001
Pseudo R^2	Nagelkerke	0.158		
	McFadden	0.078		

The significant chi-square value, 96.081 ($p < .001$), indicates that the final model with predictors fits the data significantly better than the intercept-only model. The model fits the data well, as indicated by the non-significant Pearson and Deviance chi-square statistics, suggesting no major deviation between observed and expected values. Similar to the previous models presented, the pseudo- R^2 values (Nagelkerke = 0.158, McFadden = 0.078) indicate a modest explanatory power. While the predictors contribute meaningfully to the model and provide important insights, a substantial portion of variation remains unexplained.

5 Discussion

Our research reveals notable differences between the sociodemographic profile of shared e-scooter users in general and those who had taken at least one e-scooter trip in combination with public transportation in the past six months. Shared e-scooter riders in Stockholm, Gothenburg, and Malmö match the demographic profile found in earlier studies: they are mostly young, well-educated, well-paid urban men (Laa & Leth, 2020; Reck et al., 2021; Wang et al., 2022; Weschke et al., 2022). Additionally, we find that the average user lives in the inner city, which overlaps with the e-scooter operating zone.

In contrast, users residing outside the inner city had higher odds of making multimodal trips and doing so more frequently, especially in Stockholm and Gothenburg. This result suggests that shared e-scooters play a stronger complementary role for users living outside the inner city. This group does not use shared e-scooters for home-based trips but may instead take public transportation into the city and use e-scooters for the last mile, or the first mile when returning home. For the many users living in municipalities surrounding Stockholm, where shared e-scooters are also available, these trips can thus serve as first- or last-mile solutions, complementing the less dense public transport system in these areas.

Our regression analysis indicates that income is negatively associated with the likelihood of making a multimodal trip in Stockholm. This contrasts with the typical higher-income shared e-scooter user, suggesting that multimodal riders in Stockholm may represent a distinct subgroup living outside the city center and earning less. Although shared e-scooters are often associated with recreational use and described as a fun mode, our results suggest a different use case: for lower-income groups and outer-city residents, e-scooters might be an essential first- or last-mile option, providing equitable transportation. The effect was smaller but still significant for residents living outside of the city center of Gothenburg. Hu et al. (2025) found that combining shared e-scooters and public transportation could increase employment accessibility within a 30-minute travel time radius. Employment accessibility may explain why lower-income users have higher odds of engaging in multimodal trips despite the relatively high cost of shared e-scooters. These services primarily compete with public transportation on travel time, not cost (Aarhaug et al., 2023; Psarrou Kalakoni et al., 2024). In contrast, we found that income is positively associated with the likelihood of multimodal travel in Malmö. This result could reflect the specific urban and socioeconomic context of Malmö, including differences in the public transport system or the demographic composition of shared e-scooter users compared to Stockholm. It may also be related to the higher cost of combining shared e-scooters with public transportation compared to walking to a stop.

Unlike in Oslo (Aarhaug et al., 2023) and Portland (McQueen & Clifton, 2022), we did not find that students combined the modes significantly more than other groups. In fact, we did not find students to be a very large user group, which may indicate that the sample was too small to yield statistically significant results. While most users were men, gender was not a significant predictor of multimodal trips in our data, in contrast to findings from Oslo, Portland and Chicago (Javadinasr et al., 2025). In contrast to Los Angeles and Washington, D.C. (Huang et al., 2023), we found that frequent usage of shared e-scooters yielded multimodal trips, but not to a significantly higher rate.

These findings suggest that while exposure increases the likelihood, it does not necessarily reflect a structural dependence on multimodal travel.

Contrary to Los Angeles, Washington, D.C. (Huang et al., 2023) and Chicago (Javadinasr et al., 2025), we found no connection between higher education and multimodal trips, even though we found that shared e-scooter users in Stockholm, Gothenburg, and Malmö had generally higher levels of education than the rest of the population. Thus, a higher level of education does not seem to be a defining factor for those who combine the two modes in the Swedish context. A possible explanation for this could be that Swedish cities have more equitable public transport access and usage across demographic groups, compared to a North American context.

The survey targeted users who had taken at least one trip both before and after September 1, 2022, in each city. The operator made no distinction between users in central Stockholm and those in surrounding municipalities during the sampling process. However, one of the control questions was whether they usually traveled within the city's central operating zone. This question was intended to ensure that all respondents referred to the same parking system and were frequent users of shared e-scooters in that city, rather than occasional visitors. This filtering approach may have inflated the share of multimodal users from the surrounding municipalities. Nevertheless, users living outside the operating zone in both Stockholm and Gothenburg still had higher odds of making multimodal trips. In particular, Gothenburg users outside the operating zone had the highest odds of making multimodal trips.

Future research should aim for a more detailed understanding of why users combine modes, allowing for a clearer distinction between opportunistic usage and necessity-driven multimodality. Research could focus on the role of shared e-scooters outside of service hours, where Luo et al. (2021) and Currie et al. (2025) found complementary trips in Indianapolis and Melbourne. Further research should also include survey questions about public transportation use patterns, ticket purchasing patterns, driver's licenses, and access to cars in the household to deepen the analysis. However, the fact that the typical shared e-scooter users and multimodal users are different is important for policymakers to consider. Our findings suggest that policymakers should also account for users who live outside the immediate service area when regulating or changing the service, as they are often more likely to make multimodal trips. Furthermore, our study highlights which user groups could benefit the most from integrating shared e-scooters into public transportation fare systems, such as by including minutes in travel passes or discounts for pass holders. Future research should explore how, and in what form, shared e-scooters could be incorporated into public transport systems.

6 Conclusion

This study investigates the demographics and characteristics of shared e-scooter users who combine shared e-scooters and public transportation in Stockholm, Gothenburg, and Malmö, Sweden. By estimating binary and ordinal logistic regression models, we identify which user groups made first- and last-mile trips with shared e-scooters and which groups did so most frequently. In Stockholm, frequent users had significantly higher odds of making a combined trip in the past six months. However, frequent e-scooter usage did not translate into significantly more frequent multimodal trips. Additionally, users with lower incomes or those residing outside the city center in Stockholm were more likely to have made a combined trip and to use shared e-scooters for multimodal travel at a higher rate. In Gothenburg, similar to Stockholm, users living outside the central operational zone were more than five times as likely to have made a combined trip compared to users residing in the city center. In Malmö, users under the age of 30 who frequently used shared e-scooters or had higher incomes had higher odds of having made a multimodal trip.

In summary, the groups that make first- and last-mile trips vary across the three cities. Furthermore, multimodal users differ from the typical users of shared e-scooters, especially in Stockholm and Gothenburg. Our results suggest that shared e-scooters might serve different purposes for different user groups: For lower-income users residing outside the city center, shared e-scooters may play an important complementary role. Higher-income users may be more inclined to combine modes, where doing so offers a substantial travel time advantage. This result highlights the role of shared e-scooters within the urban transportation system and their potential as a complementary mode. As the urgency grows for sustainable alternatives to private cars, there is a need to further enhance and promote public transportation, and the findings from this study become increasingly relevant.

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Data Access Statement

The data that support the findings of this study are available from KTH Data Repository through https://doi.org/10.71775/kth.3g473-ypg92 upon request for academic research purposes, in accordance with GDPR requirements.

Author and Contributor Statement

Boel Berg Wincent: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Formal analysis, Data curation, Conceptualization; Erik Jenelius: Writing – review & editing, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Conceptualization; Wilco Burghout: Writing – review & editing, Writing – original draft, Supervision, Methodology, Funding acquisition, Formal analysis, Conceptualization.

Use of AI

During the preparation of this work, the authors used ChatGPT for final language editing and grammar improvement. After using this tool/service, the authors reviewed, edited, made the content their own and validated the outcome as needed, and take full responsibility for the content of the publication

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Conflict Of Interest (COI)

There is no conflict of interest.

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Appendix

Table 6. Survey questions and response options

Question	Response options
Demographics	
Which age group do you belong to?	17 or younger 18-20 21-29 30-39 40-49 50 or older
Gender	Male Female Prefer not to say Other
What is your postal code?	
What is your highest completed education?	Primary and Secondary Post-school Bachelor's Master's Doctoral
What is your main occupation?	Full-time employed Part-time employed Student Self-employed Retired Unemployed Other
What is your annual income before taxes? (SEK)	Under 200,000 200,000 - 400,000 401,000 - 600,000 601,000 - 800,000 Above 800,000
Background	
How often have you, on average, used shared e-scooters in the last six months?	Never Less than monthly Once or more times per month Once or more times per week Once or more times per day
Do you usually start or end your trips with shared e-scooters within the marked area on the map (Stockholm/Malmö/Gothenburg)?	Yes No
Which e-scooter operators have you used in the last six months?	Voi Tier Qick Ryde Link/Superpedestrian Lime Dott Bolt Bird Other (specify)

Are you aware of the new parking policy for e-scooters that came into effect on September 1, 2022?	Yes No
Have you used shared e-scooters before September 1, 2022?	Yes No
Have you used shared e-scooters after September 1, 2022?	Yes No
Public transportation	
In the last 6 months, have you used a shared e-scooter to connect to or from public transportation?	Yes No
How many of your trips with a shared e-scooter are to or from public transportation?	More than half About half Less than half
Is it easy to park at a public transportation station or stop?	Always or often Sometimes Rarely or never