# An Ordered Logit Model for Predicting the Willingness of Renting Micro Mobility in Urban Shared Streets: A Case Study in Palermo, Italy

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**Abstract.** Sustainable transport modes, particularly micro-mobility, allows to reduce possible congestion phenomena in urban traffic. In this study, the aim is to make a contribution to increase micro-mobility use by exploring the impacts of socio-demographic, vehicle ownership (car, bicycle and micro mobility), level of infrastructure service and road users' perception in safety, comfort and chaotic environment on renting micro-mobility in a shared urban street. The study area is a historical center called Via Maqueda in Palermo, Italy, which is rich in commercial and cultural activities. A survey with 200 individuals is carried out for the data collection regarding the aim of the study.

The analysis starts with a descriptive statistics in order to illustrate the characteristics of the predictor variables. This is followed by relaxing p-value method for selecting the statistically significant predictor variables with 90% confidence level. These selected predictor variables are applied into an ordinal logit model. The results suggest that one unit increase in car ownership decrease the willingness of renting a micro mobility by log odds of −0.74, given all the other predictors are held constant. One unit increase in age group decrease the willingness of renting micro-mobility in shared urban streets. The outcomes will guide decision makers to understand who the average road users are and what are their needs in terms of further developments of the micro-mobility system in urban shared streets. The originality of this paper consists the perceptions of road users, such as safety and comfort, on micro-mobility that can encourage to use this sustainable urban travel mode in restricted traffic areas.

**Keywords:** Micro-mobility · New mobility users · Relaxing p-value method · Ordered logit model

## 1 Introduction

Transport in today's cities have been dominated by private cars, which generally have only one passenger on board. Decision makers have been aware of the environmental and social impacts of high amount of private car on the traffic and constantly have been

© Springer Nature Switzerland AG 2020
O. Gervasi et al. (Eds.): ICCSA 2020, LNCS 12250, pp. 796–808, 2020.
https://doi.org/10.1007/978-3-030-58802-1_57

looking for solutions to eliminate these influences by providing advanced accessibility and livability in urban [1, 2]. Currently there is a growing understanding of the benefits of new sustainable travel modes, particularly micro mobility, in special situations such as pandemic. It is believed that individual non-motorized means of transport with low economic and environmental impact can be an optimal solution [3–7].

Micro mobility vehicles, including electric scooter, hover-board, segway, mono-wheel and electric bike [8] offer a chance to achieve this aim by reducing travel time for short distances and waiting time on congested roads. In heavy traffic congestion, micro-mobility compared to private car provides faster means of travel in urban cities [9]. Micromobility are very light to carry and do not require the use of ad hoc parking. In addition, micro-mobility vehicles have several more advantages such as not requiring any certificate/license, allowing rapid movements from door to door, reducing crowds in public transport, which is essential for disable and elder road users, focusing routes that are in limited traffic areas.

In recent years, there has been a growing tendency to consider sharing, rather than owning vehicles [10, 11]; similarly, sharing micro-mobility has been spreading rapidly, particularly in the western countries. Sharing micro-mobility vehicles is very suitable for large cities where the traffic congestion is a vital issue [12]. Majority of European governments are in favor of spreading shared micro-mobility [13]. Most particularly, shared e-scooter is one of the most promising new micro-mobility solutions in urban. Sharing service offers people an opportunity to rent a micro-mobility vehicle by booking and paying for it through the mobile app.

Despite all these advantages, the studies [14–19] suggested that there have been some barriers to increase the use of micro-mobility in urban. It was showed that travel choices of means of transport were influenced by sociodemographic characteristics. Majority the users of both bicycles and e-scooters have been male. This result may depend on difference in comfort perception of women and men, road users' social and cultural heritage, the perception of the risk that is higher in women. In addition, women may not prefer to use micro-mobility as a means of moving from home to office because office clothing makes handling difficult. Tendency of the use of micro-mobility also was influenced by age of road user, because there was a requirement of elasticity of the spine in posture and good reflexes for sudden braking. Therefore, it was suggested that further relevant studies should consider sociodemographic parameters.

Micro-mobility vehicles compared to other transportation modes occupy the least amount of area on road space and they do not need area for parking. Road users often do not need to move at great speed because they tend to move for short journeys. Therefore, micro-mobility is an outstanding mode in shared urban spaces by its efficient use of the area.

However, it is considered that there should be a banning of the micro-mobility in shared spaces. The studies [20–22] showed that the rapid increase of micro-mobility use at shared spaces without specific rules reduced safety for pedestrians, particularly for elder and young road users. Micro-mobility has been used on shared sidewalks with approximately 17 km/h [23]. The risk for pedestrians to be hit increases while sharing roads with micro-mobility vehicles. Therefore, decision makers have been considering adapting strict regulations for existence of micro-mobility. For instance, Italy and

Germany have been showing an effort to integrate micro-mobility into the shared spaces; however, France and Spain have been considering the banning option [24].

In Italy, which was the case study country in this paper, a limitation of micro-mobility use was established considering some age groups, possession of a license for rental and use of devices in different time of the day. In addition, the places where you can use the micro-mobility vehicles and travel speed are regulated by rules. However, with respect to the suggested [8, 9, 11] barriers for micro-mobility use, an optimum solution still has been a research gap in the literature. Regarding the state-of-the-art review, this paper aimed to understand the relationship between road user perceptions, sociodemographic, infrastructure, vehicle ownership and shared micro-mobility in shared urban spaces. Following section presented the developed methodology considering the relevant state of the art review. Section 3 showed the details of data collection and this was followed by Sect. 4 which illustrated the results. Finally, discussions based on the results and limitations of the study were presented in Sect. 5.

## 2 Methodology

The overall aim of this study was to gain a fundamental understanding of how the socio-demographic characteristics, vehicle ownership (car, bicycle and micro mobility), level of service and road perception impact the attitude of renting micro mobility in shared urban streets. A series of analytical steps were carried out including descriptive statistics, relaxing p-value and ordered logit model. Regarding the suggestion in the state of art review [25], analysis needs to start with a descriptive statistics in order to illustrate the description of the data. In addition, descriptive statistics also guides to gain a better understanding of the results in the further applied models. With respect to exploring the relationship between considered variables, correlation analysis or Pearson's chi square test should be applied instead of fitting a regression model [26–28]. However, these statistical techniques cannot explain to what extent do the independent predictors has influence on dependent variable. Therefore, regression models should be considered if the aim is to gain a deeper understanding about the interaction between the variables [29]. Regression analysis predicts an outcome variable from one or several independent variables [30]. If only one independent variable is used in the prediction, the model is called simple regression; and if more than one independent variable is applied to the analysis, the model is called multiple regression. There are several types of regression models and the difference comes from the characteristics of the dependent variable [31]. For investigating the impacts of independent predictors on a dependent continuous variable, linear regression should be applied [32]. The formula of linear regression is as follows [33]:

$$Y = \beta_0 + \beta_1 X_1 + \ldots \beta_n X_n$$

where $Y$ is the response variable; $\beta_0$ is the coefficient of the unknowns; $X_1, \ldots X_n$ are the predictor variables; and $\beta_1, \ldots, \beta_n$ are the coefficients of the predictor variables.

In some datasets, the dependent variable is a categorical response. Considering the assumption of the linear regression, which states that there is a linear relationship

between dependent and independent variables, a categorical dependent variable cannot fit to the calculations. Therefore, logit models should be used for categorical dependent variables. Logit model predicts the increase of probability of occurrence for dependent variable when there is one unit increase in predictor variable. If the number of categories is only two such as yes or no (1, 0), it is suggested that binary logit model should be used [31]. The formula of logit model is as follows [30]:

$$(p) = \log(Odds) = \beta_0 + \beta_1 X_1 + \ldots \beta_n X_n$$

When the ordinal scale presents interval/ratio scale, such as the categories "Very high, High, Medium, Low, Very low)", ordered logit model should be applied [31]. The dependent variable in ordered logit model, which is also known as proportional odds model, is in a meaningful sequential order. In such case, there is a confusion for whether a linear regression should be applied or not. Previous studies suggested that there are several inconveniences when a linear regression was applied for sequential ordered dependent data [32, 33]. The formula of ordered logit model is given as follows:

$$logit(p_1) = log\frac{p_1}{1-p_1} = \alpha_1 + \beta_1 X_1 + \ldots + \beta_n X_n$$

$$logit(p_1 + p_2) = log\frac{p_1 + p_2}{1-p_1-p_2} = \alpha_2 + \beta_1 X_1 + \ldots + \beta_n X_n$$

$$logit(p_1 + p_2 + \ldots + p_n) = log\frac{p_1 + p_2 + \ldots + p_n}{1-p_1-p_2-\ldots-p_n} = \alpha_n + \beta_1 X_1 + \ldots + \beta_n X_n$$

$$p_1 + p_2 + \ldots + p_{n+1} = 1$$

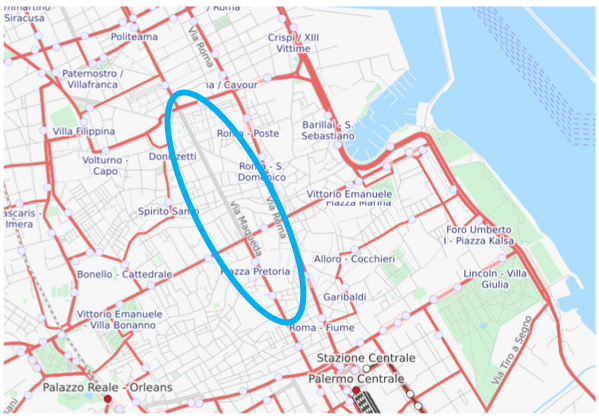
where $p_n$ is the probability of one unit change in dependent variable.

While more predictor variables in a regression model increase the accuracy of the results, adding too many causes inefficiency and overfitting. On the other hand, biased results may occur if fewer variables are added into a regression model. Therefore, the model should be simple but avoid any biased outcomes. The number of predictors needs to be determined carefully [34]. It is suggested that relaxing p-value should be applied in order to carry out a statistically accurate selection method. In relaxing p-value method, both simple ordinal logit model for each individual predictor variables and a full multiple ordinal logit model should be applied [29]. From the outcomes, the predictor variable, which are statistically significant above 90% level of confidence, should be selected and applied in a final model. In this paper, after the descriptive statistics, relaxing p value method was applied to select the predictor variables. This was followed by a final full model of ordered logit. The following section will describe the undertaken research including the study area and data collection survey.

## 3 Description of the Undertaken Research

Palermo is a metropolitan city, which is in the north-western Sicily. There are 660.00 inhabitants (52% women and 48% men). The investigated area is called via Maqueda which is located 1.5 km from the historic center of the city of Palermo. The area of the historic center is characterized by a low slope which encourages the use of micro-mobility. The traffic limitation (named ZTL) has reduced the number of private cars in the different streets of Palermo; therefore, many inhabitants recently have been using micro-mobility, particularly scooters, vehicles for less than a year. As shown in Table 1, the data used in this paper was recorded by using CCTV cameras in March 2019. The four CCTV cameras were placed at the access points of the Via Maqueda and used by Local Police. This system allowed to estimate the peak value of the micro-mobility flow along the road.

**Table 1.** Investigated area (blue color) located in the historical city center of Palermo; road geometry and flow details. Source: Map data copyrighted OpenStreetMap contributors and available from https://www.openstreetmap.org

| Variables | Measures | Geo-localization |
|---|---|---|
| Length [m] | 1380 |  |
| Effective width [m] | 10-11 (sidewalk about 1.5) | |
| Pedestrian flow [ped/h] | Max flow: 1000peds/h, Average flow: 640peds/h | |
| Micro-mobility flow [unit/h] | Max flow 490 u/h Average flow 330 u/h | |



A questionnaire with 200 individuals was carried out in December 2019. The data was processed statistically using the Likert scales which was adopted to express judgments and/or the individual's answers given to each question. This technique is widely used in psychometrics to measure attitudes and opinions through the administration of questionnaires. In the first part of the questionnaire, five possible alternatives for each item were recorded as follows: completely agree, agree, uncertain, disagree, completely disagree. The second and third parts of the questionnaire data related to the aptitude for using the micro-mobility vehicles and the perception of road users on the level of infrastructure service was collected. In the last part of the dataset,

the propensity to rent micro-mobility vehicle and the frequency of movement along the examined area was asked to the individuals (See Table 2).

**Table 2.** Monitored variables of survey

| | Variables | Option provided |
|---|---|---|
| A Socio-demographic | A.1 Gender | □Male □ Female |
| | A.2 Age | □18-24 □25-39 □ 40-54 □ 55-64 □ ≥65 |
| | A.3 Job | □student □worker □ retiree □ other |
| | A.4 car ownership | □YES □ NO |
| | A.5 bike ownership | |
| | A.6 Micro-mobility ownership | |
| B Transport attitude | B.1 Rent attitude | **Likert scale** □1= disagree □2= partially disagree □3=I cannot evaluate □4=partially agree □5= agree |
| | B.2 walking attitude | **Temporal scale** □ Every day □ 4 times per week □ 2-3 times per week □ Once per week □ More rarely |
| | B.3 Road usability | |
| | B.4 LOS value | □ A □ B □ C □ D □ E □ F |
| C Travel perception | C.1 Safe | **Likert scale** □1= disagree □2= partially disagree □3= I cannot evaluate □4=partially agree □5= agree |
| | C.2 Comfort | |
| | C.3 Chaos | |

## 4 Data Analysis

Results of each analysis step, namely descriptive statistics, relaxing p-value and ordered logit model, are detailed in the following sections

### 4.1 Descriptive Statistics

A descriptive statistics was carried out in order to explore the details of each considered variable namely, gender, age group, owning a car, owning a bike, having a micro mobility, profession, road use, level of infrastructure service, road user's perception on safety, comfort and chaotic condition in a shared urban street (See Table 3). The investigated sample size consisted of 200 individuals which corresponds to approximately 60% of the average flow recorded at the entrance of Via Maqueda during the daily time slot.

Gender distribution was homogeneous with 53% of men and 47% of women. This numerical balance avoided biased results in further modelling steps. 36% of the participants were ranged in age group 40–54. This was followed by 26.5% for 55–65 and 21.5% for 25–39. Car ownership was 85.5% among the participants, however bike

**Table 3.** Statistical results related to monitored variables

| Variable | Units and frequency |
|---|---|
| A.1 | Female = 106 (47%); Male = 94(54%) |
| A.2 | (18–24) = 21 (10,5%); (25–39) = 43 (21,5%); (40–54) = 72 (36%); (55–65) = 53 (26,5%); (65 $\leq$ ) = 11 (5,5%) |
| A.3 | Student = 29 (14,5%); worker = 112 (56,0%); retiree = 51(25,5%); other = 8 (4%) |
| A.4 | Yes = 171 (85,5%); No = 29 (14,5%) |
| A.5 | Yes = 67 (33,5%); No = 133(66,5%) |
| A.6 | Yes = 87(43,5%); No = 113 (56,5%) |
| B.3 | (every day) = 4(2%); (four times per week) = 12(6%); (two-three times per week) = 29(14,5%); (once per week) = 74(37%); (more rarely) = 81 (40,5%) |
| B.4 | A = 1(0,5%); B = 5(5,5%); C = 28(14%); D = 67(33,5%); E = 86(43%); F = 13 (6,5%) |
| C.1 | 1 = 7(3,5%); 2 = 68(34%); 3 = 97(48,5%); 4 = 26(13%); 5 = 2(1%) |
| C.2 | 1 = 18(9%); 2 = 47(23,5%); 3 = 80(40%); 4 = 49(24,5%); 5 = 6(3%) |
| C.3 | 1 = 2(1%); 2 = 19;(9,5%); 3 = 52(26%); 4 = 76(38%); 5 = 51(25,5%) |

ownership was far less by 33.5%. Having a micro-mobility was approximately 44% in the explored sample. This showed that at least approximately half of the participants had an experience of using micro-mobility. 59.5% of the sample was familiar to the considered street by using the road at least one per week. 83% of the participants founded the infrastructure less than Level C. This was a significant low percentage and needed a further investigation in the following model.

### 4.2 Ordered Logit Model with Relaxing P-Value

The relaxing p-value method was carried out in order to select the statistically significant predictors at 90% confidence level. In this method, both simple and multiple ordered logit model were applied (See Table 4). The results showed that the variables, namely age group, car ownership and profession, were statistically significant at 90% of level of confidence.

These three selected variables were applied in a last full model of ordered logit (See Table 5). The results suggested that one unit increase in car ownership decreased the willingness of renting a micro mobility by log odds of −0.74, given all the other predictors were held constant. Regarding to the reference category of age group 18–24, one-unit increase reduced the probability of willingness of renting micro-mobility in shared urban streets for participant aged between 25 and 54 with statistically significance at 95% confidence level. Conversely, the participants aged over 65 were 3.98 times more likely to rent a micro mobility with statistically significance at 95% confidence level. However, with respect to the descriptive statistics, the number of participants aged over 65 were only 5.5% of the sample. Therefore, there was a wide range of 95% confidence interval for odds ratio between 1.00 and 15.95. The results for

**Table 4.** Relaxing P-value method

| | Simple ordered logit | | | | Multiple ordered logit[b] | | | |
|---|---|---|---|---|---|---|---|---|
| Variables[a] | Coefficient | P-Value | Odds Ratio | 95% confidence interval for odds ratio | Coefficient | P-Value | Odds Ratio | 95% confidence interval for odds ratio |
| A.1 | (reference category = male) | | | | | | | |
| Female | 0.20 | 0.45 | 1.22 | L 0.73<br>U 2.03 | 0.41 | 0.15 | 1.51 | L0.86<br>U 2.64 |
| A.2 | (reference category = 18-24) | | | | | | | |
| 25–39 | −0.74 | 0.12 | 0.48 | L 0.19<br>U 1.22 | −1.23 | **0.03** | 0.29 | L 0.10<br>U 0.87 |
| 40–54 | −0.55 | 0.21 | 0.58 | L 0.24<br>U 1.37 | −1.00 | **0.05** | 0.37 | L 0.14<br>U 0.98 |
| 55–65 | −0.02 | 0.96 | 0.98 | L 0.40<br>U 2.40 | −0.52 | 0.32 | 0.59 | L 0.21<br>U 1.65 |
| 65 ≤ | 0.79 | 0.23 | 2.20 | L 0.61<br>U 7.93 | 1.16 | 0.11 | 3.20 | L 0.76<br>U13.57 |
| A.4 | −0.53 | 0.15 | 0.59 | L 0.28<br>U 1.21 | −0.68 | **0.10** | 0.51 | L 0.22<br>U 1.15 |
| A.5 | −0.42 | 0.14 | 0.66 | L0.38<br>U1.14 | −0.37 | 0.23 | 0.69 | L0.37<br>U 1.27 |
| A.6 | 0.09 | 0.73 | 1.09 | L0.65<br>U1.83 | 0.38 | 0.18 | 1.46 | L 0.84<br>U 2.53 |
| A.3 | (reference category = worker) | | | | | | | |
| Student | −0.19 | 0.62 | 0.82 | L0.39<br>U1.76 | −1.11 | **0.02** | 0.33 | L0.13<br>U0.85 |
| Retiree | 0.11 | 0.73 | 1.11 | L0.61<br>U2.01 | 0.14 | 0.68 | 1.15 | L0.60<br>U 2.20 |
| Other | −2.17 | **0.00** | 0.11 | L0.03<br>U0.46 | −2.62 | **0.00** | 0.07 | L 0.12<br>U 0.30 |

[a]The reference category for each variable, namely owning a car, owning a bike, having a micro mobility vehicle, road use, infrastructure level, bike safe, bike comfort and bike chaos, is NO
[b]Cut 1 = −5.11; Cut 2 = −3.30; Cut 3 = −1.26; Cut 4 = 1.13

profession showed that compared to workers as taken the reference category students were less likely to rent a micro-mobility (odds ratio 0.31) at 95% confidence level. The same influence was observed for participants who were recorded as others; however, participants with other profession were 4% of the sample regarding to the descriptive statistics.

**Table 5.** Final ordered logit model

| Variables[a] | Coefficient[b] | P-Value | Odds ratio | 95% confidence interval for odds ratio Lower Upper |
|---|---|---|---|---|
| A.2 (reference category = 18–24) | | | | |
| 25–39 | −1.01 | **0.05** | 0.36 | L0.13 U0.98 |
| 40–54 | −0.88 | **0.06** | 0.42 | L0.16 U1.05 |
| 55–65 | −0.44 | 0.36 | 0.64 | L0.25 U1.67 |
| 65 ≤ | 1.38 | **0.05** | 3.98 | L1.00 U15.95 |
| A.4 | −0.74 | **0.05** | 0.48 | L0.22 U1.04 |
| A.3 (reference category = worker) | | | | |
| Student | −1.17 | **0.01** | 0.31 | L0.13 U0.75 |
| Retiree | 0.11 | 0.73 | 1.12 | L0.60 U2.07 |
| Other | −2.29 | **0.00** | 0.10 | L0.03 U0.40 |

[a]The reference category for Owning a Car is NO
[b]Cut 1 = −4.26; Cut 2 = −2.48; Cut 3 = −0.53; Cut 4 = 1.81

## 5 Discussions and Limitations

Micro-mobility vehicles, including electric scooter, hover-board, segway, monowheel and electric bike [8], have been providing several advantages such as reducing traffic congestion [9], eliminating social and environmental effects [3, 4] and helping to keep social distance in extreme health conditions. Besides these positive influences, there were some barriers to increase the use of micro-mobility in urban streets [15–17]. In addition, a research gap in the state-of-the-art review was explored about the impacts on shared micro-mobility in shared urban streets. Therefore, this paper aimed to find out what were these impacts and to what extend did they influence willingness of renting micro-mobility. A questionnaire analysis with 200 individuals was conducted in the city of Palermo, Italy. The study area was selected based on availability for data collection. It is recommended to carry out a similar analysis in a different area with higher number of observations. This may help to generalize the results in a global perspective.

The results suggested that the willingness for renting micro-mobility statistically significantly was affected by age group. The propensity to rent a micro-mobility

decreased when the age of participant increased. This suggested that young people were more likely to rent a micro-mobility in shared urban streets. This outcome was consistent with the literature since there was a requirement of elasticity of the spine in posture and good reflexes for sudden braking.

Regarding gender, there was no difference in propensity for renting between female and male. The studies in the literature given in Sect. 1 suggested that males are more likely to use micro-mobility compared to females because of comfort and safety perception. However, the results in this paper suggested that the similar trend was not observed for renting micro-mobility in shared urban spaces. In addition, safety, comfort and chaotic situation on shared urban streets did not influence individuals' willingness of renting. The results suggested that students compared to working class were more likely to rent micro-mobility in shared streets. This was consistent with the results of age impact. In addition, individuals who owns a car were found to be less likely to rent micro-mobility in shared spaces.

In overall, results showed that renting micro-mobility in shared urban streets was fit with younger student class without owning a private car. Therefore, further studies should focus on figure out how to attract elder working class for willingness in renting micro-mobility in shared spaces or switch their travel mode from private car using to micro-mobility services. The results of this paper will guide decision makes to find out how to increase the use of micro mobility in urban shared spaces.

Regarding the limitations, this study was carried out with 200 participants and the number of individuals in the further studies should be increased for improving the accuracy of the results. In addition, the recent local legislation in the case study area has allowed the use of micro-mobility in shared spaces since few months ago; therefore an investigation over a longer period of time can be necessary in order to gain a better understanding. This also can confirm the results which were obtained in this study. The further step of this study will be enlarged in order to be able to evaluate the flow transiting not only on via Maqueda but also within the major streets that are essential part of the transport network.

**Acknowledgments.** This study was supported by the MIUR (Ministry of Education, Universities and Research [Italy]) through a project entitled WEAKI TRANSIT: WEAK-demand areas Innovative TRANsport Shared services for Italian Towns (Project code: 20174ARRHT/CUP Code: J74I19000320008), financed with the PRIN 2017 (Research Projects of National Relevance) programme. We authorize the MIUR to reproduce and distribute reprints for Governmental purposes, notwithstanding any copyright notations thereon. Any opinions, findings and conclusions or recommendations expressed in this material are those of the authors, and do not necessarily reflect the views of the MIUR.

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This paper is the result of the joint work of the authors. 'Abstract' 'Introduction' 'Methodology' and 'Results' were written jointly by the authors. TC and NA focused on the state of the art. TC designed the methodological approach and discussion. Supervision and research funding NA, TC and GT.

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