A Stated Preference Survey to Forecast Microtransit Choice in Suburban Areas with Low Public Transport Ridership

Alessandro Emilio Capodici[1]; Gabriele D'Orso[2]; Marco Migliore[3]; and Martina Vittorietti[4]

Abstract: Public transport services with fixed schedules and fixed routes are often unreliable and economically unsustainable in suburban areas having a low transport demand that is spatially and temporally dispersed. Therefore, suburban areas become car-oriented and have transportation gaps, increasing the risk of social exclusion for the most vulnerable groups. Microtransit services aim to fill these gaps, offering greater flexibility in routes and schedules for noncommuting trips and operating more efficiently, with shorter walking distances to stops and waiting times. This paper aims to investigate the microtransit choice and the factors that influence it using a stated preference (SP) survey. Some suburban neighborhoods with underutilized public transport services in Palermo, Italy, were chosen as study areas. Conducting face-to-face interviews, revealed preference data were collected to assess residents' mobility habits. SP experiments were proposed to respondents to calibrate a mode choice model. A hybrid microtransit was proposed, operating as a conventional fixed-route and fixed-schedule public transport service in peak hours and as an on-demand service in off-peak hours. A scenario analysis was performed to understand which type of customers would be easier to attract and how in-vehicle, waiting, and walking times affect the microtransit choice. This study found that the choice probability for microtransit is higher for young people than for older people, increasing with the increase in the level of education and the introduction of travel demand management policies that discourage the use of private cars, such as parking pricing or the introduction of restricted traffic areas. **DOI: 10.1061/JUPDDM.UPENG-5100**.

Introduction

The conventional public transport system faces multiple challenges when trying to meet the different needs of users in suburban areas because while people have different reasons to travel, live in different and distant places, have different destinations, and want to travel at different times of the day, the system is inflexible (Poltimae et al. 2022). Suburban areas are often characterized by a travel demand that is not high and is spatially and temporally dispersed (Terry and Bachmann 2023). Therefore, operators of fixed-route and fixed-schedule public transport services are unable to meet the travel demand effectively. Moreover, having limited funds, they allocate them to denser areas, typically the central areas of the city, which are full of activities and points of interest (POIs), and have greater demand and high-capacity and high-frequency services. Therefore, the inhabitants of suburban areas often have access to poor-quality public transport services that are infrequent and not very regular.

Therefore, private transport is the dominant mobility option in suburbs with poor-quality public transport services. In particular, older people and families with children often rely on private cars in suburban areas (Poltimae et al. 2022). However, this also means that especially those who do not own a car or cannot buy one have to endure long and unpredictable waits at stops or long walking distances to reach them. Consequently, sometimes older adults and low-income people may be at risk of social exclusion.

In the last decade, new on-demand public transport services and shared mobility options have been developed to overcome these problems and optimize public transport services in low-density areas. Microtransit services, also called demand-responsive transport (DRT) services, represent one of these solutions, based on a fleet of vehicles smaller than conventional buses (minibuses or vans), on-demand schedules, and flexible routes, allowing detours to satisfy the users' requests (Shaheen et al. 2017). A user can book a ride in real time or in advance using a mobile application, and then access the service by walking to the nearest pick-up/drop-off (PUDO) point in the service area.

In suburban areas, a hybrid microtransit service could be a solution to meet the different needs that operators and users have. It could operate as a conventional public transportation service with fixed routes and fixed schedules during peak hours when students and workers make their trips, and as an on-demand service with flexible routes and schedules during off-peak hours to handle noncommuting trips. On the one hand, users need to have a service with fixed schedules during peak hours to reach schools and workplaces by business start times. An on-demand and shared-ride service such as microtransit does not effectively serve commuting trips because the travel time experienced by a user can be affected by the ride requests made by others. In off-peak hours, on the other hand, users mostly make noncommuting trips for purposes such as shopping, recreation, or visiting friends. These trips generally benefit from flexibility in schedules. Therefore, given the temporal dispersion in demand during off-peak hours in suburban areas, users

[1]National Sustainable Mobility Center, Dept. of Engineering, Univ. of Palermo, Viale delle Scienze, Building 8, 90128 Palermo, Italy. ORCID: https://orcid.org/0000-0002-2871-3796. Email: alessandro.capodici@unipa.it

[2]Dept. of Engineering, Univ. of Palermo, Viale delle Scienze, Building 8, 90128 Palermo, Italy (corresponding author). ORCID: https://orcid.org/0000-0002-8363-0993. Email: gabriele.dorso@unipa.it

[3]National Sustainable Mobility Center, Dept. of Engineering, Univ. of Palermo, Viale delle Scienze, Building 8, 90128 Palermo, Italy. ORCID: https://orcid.org/0000-0002-1494-5887. Email: marco.migliore@unipa.it

[4]Dept. of Applied Mathematics, Delft Univ. of Technology, Mekelweg 4, 2628 CD Delft, The Netherlands. ORCID: https://orcid.org/0000-0002-7695-3209. Email: m.vittorietti@tudelft.nl

Note. This manuscript was submitted on November 30, 2023; approved on August 2, 2024; published online on December 19, 2024. Discussion period open until May 19, 2025; separate discussions must be submitted for individual papers. This paper is part of the ***Journal of Urban Planning and Development***, © ASCE, ISSN 0733-9488.

could use microtransit service during these hours, benefiting from predictable and reduced waits at stops. From the operator's perspective, operating on-demand services means optimizing trips and routes and avoiding the travel of empty buses by making smaller vehicle travels only when users request rides.

This paper aims to investigate the demand potentially attracted by a hybrid microtransit service in a suburban area using stated preference (SP) surveys to evaluate microtransit choice in the hypothetical scenario of introducing this service. A suburban area of Palermo, Italy, was chosen as a case study to demonstrate the effectiveness of the methodology. The SP survey was an opportunity to collect revealed preference (RP) data to assess the mobility habits of the residents in the area and understand which of these might change. The results of the SP survey made it possible to develop and calibrate a mode choice model, deriving the choice probabilities of microtransit by different categories of users as service characteristics varied. In addition, this survey provided an opportunity to assess the elasticity of demand by considering different travel distances and travel demand management policies that local authorities can implement. This approach will make it possible to verify the economic sustainability of the future introduction of a microtransit service in the study area, determining how demand behaves according to the type of trip to be made, the socioeconomic profile of the user, the cost, and the characteristics of the service.

The remainder of the paper is structured as follows. The Background section gives a brief overview of the studies on the use of discrete choice experiments (DCEs) for understanding preferences toward innovative mobility solutions and the influence of sociodemographics in becoming a microtransit user. We describe the study area and the survey in the third section. In the fourth section, the discrete choice model is described. Then, the results are discussed in the Results section presenting some scenario analyses. In the Discussion section, we discussed whether our findings are in line with the literature and the limitations of our study. Our conclusions are drawn in the final section.

Background

Choice Experiment Studies on Innovative Mobility Services

In the literature, there are several examples of using DCEs to assess choice preferences toward innovative mobility solutions. DCEs are usually based on random utility theory, according to which the user is a rational decision maker who, among various choice alternatives, chooses the one that maximizes his perceived utility. New mobility solutions can be compared to others already in operation, considering attributes such as time and cost in the choice experiment. In this way, the respondents' potential inclination toward innovative solutions can be appreciated. For example, Yan et al. (2019) ran an RP/SP survey campaign on the University of Michigan campus to analyze users' propensity toward an integrated ridesourcing service, comparing it with existing modal alternatives such as car, bike, and walking. The authors were able to assess the variation in choice preferences as a function of socioeconomic and demographic characteristics such as gender, income, and car availability. Monchambert (2020) evaluated the attractiveness of an innovative carpooling service by comparing it with modal alternatives such as bus, train, and car, identifying, measuring, and evaluating the attributes of these modes by considering both a trip conducted as a driver and one as a passenger. Stated choice experiments were also employed by Tian et al. (2021) to assess the possible inclination of people to purchase an autonomous vehicle or use shared autonomous cars according to the socioeconomic profiles of the individuals and the characteristics of the choice alternatives. A stated choice analysis was performed by Ho et al. (2020) to understand the willingness-to-pay for different mobility packages in the framework of Mobility as a Service. The potential of the innovative solution of integrating passenger and freight transport is investigated by the SP survey conducted by Cavallaro et al. (2023).

Some choice experiment-based studies involved microtransit. Combining RP and SP surveys, Rossetti et al. (2023) applied DCEs to determine the propensity of residents of four US cities toward a first-mile/last-mile microtransit service as a replacement for their usual mode of transport. By varying departure and arrival times, waiting time, walking time, in-vehicle time, and cost, the authors were able to assess how these attributes affect residents' interests, preferences, and willingness-to-pay for microtransit. An SP survey was used by Frei et al. (2017) to identify potential users of flexible transit service and inform the service design, using the Chicago region as an example. Kang et al. (2021) used SP data to understand factors affecting pooled ride-hailing services. Finally, Alonso-Gonzales et al. (2020) designed SP surveys to assess the value of time (VOT) for different trip stages of a microtransit trip (waiting stage, in-vehicle stage, and transfer stage) in Netherlands. The main aim of our paper is to estimate the microtransit demand in a suburban area in the Italian context. To the best of the authors' knowledge, this is one of the few papers to estimate the microtransit demand in a suburban area of a European city using stated preference data.

However, although stated choice experiments are necessary to assess the impact of new services introduced to the market on the population's choices, they present an essential drawback: there are frequent discrepancies between the respondents' stated choices and their effective future behavior (Yan et al. 2019). These differences could be dependent on the complex structure of the SP survey, on scenarios that may appear unrealistic to the respondent, the lack of some attributes relevant to the decision maker, or possible biases, such as the justification bias whereby the user tries to justify their current choice behavior (Ben-Akiva et al. 1994; Cascetta 2006; Kroes and Sheldon 1988; Wardman 1988). Therefore, the results could be misleading since the respondents are not aware of the characteristics of the proposed new service. Using only RP data, conversely, would present limitations such as strong correlations between variables of interest (especially travel time and cost), a high risk of multicollinearity between attributes, the impossibility of assessing choice alternatives that do not yet exist, and difficulty in evaluating changes in secondary travel variables (such as travel comfort or vehicle design) (Brownstone et al. 2000; Kroes and Sheldon 1988). Hence, combining RP and SP data would improve the validity of the SP data, enhance the accuracy of parameter estimates, increase the efficiency of the demand model due to the joint estimation of preference parameters (or attribute importance), and fix possible bias (Ben-Akiva et al. 1994; Cascetta 2006; Wardman 1988).

Influence of Sociodemographics on Microtransit Use

We used SP data to understand what kind of customer would be easier to attract in low-density areas in the Italian context, and how in-vehicle travel, waiting, and walking times affect the choice of microtransit. Flexible transport services such as microtransit have been receiving increasing attention in recent years due to the growing interest in modes of transport that can be alternative or complementary to traditional fixed-line public transport services, especially in rural and suburban areas. From an analysis of various studies considering SP surveys or customer surveys, it is possible to observe how microtransit services may attract different categories of users, depending on the context. A customer survey involving Telebus users in Melbourne (Jain et al. 2017) revealed that people aged 15–24 years and older than 55 years are more likely to use the service. Conducting an online customer survey in Hanover, Germany, Gilibert et al. (2019) found that users are mainly between 18 and 29 years, and there is a gradual decrease in microtransit adoption as age increases. Conversely, according to Kim et al. (2017), the propensity toward a microtransit service—replacing the inefficient conventional public transport service in a rural area in Korea—increases as age increases. These conflicting results could be explained by the findings of Knierim and Schlüter (2021) who found that the influence of age on microtransit adoption depends on the city size and that age positively predicts DRT use in small localities with limited public services. Indeed, residents of bigger urban centers with considerable supply facilities and accessibility are considerably less willing to use microtransit with increasing age. Hence, it is no wonder that several studies reporting data from customer surveys (Mageean and Nelson 2003; Nelson and Phonphitakchai 2012; Wang et al. 2015) pointed out that the elderly and pensioners are more inclined toward a microtransit service operating in rural areas. A greater predisposition toward a microtransit service among the elderly and pensioners is also supported by Knierim and Schlüter (2021) and Thao et al. (2023). Mageean and Nelson (2003), as well as Gilibert et al. (2019), also identified students as a social group potentially attracted to a microtransit service. Being female positively influences the willingness to use microtransit according to several studies (Jain et al. 2017; Mageean and Nelson 2003; Nelson and Phonphitakchai 2012). Wang et al. (2015) noted that this higher predisposition among women holds at least until retirement age, upon which there is no substantial gender difference in microtransit adoption in rural areas. However, Gilibert et al. (2019) found that the users who would most frequently use the microtransit service in Hanover, Germany, are men. Thao et al. (2023) found that gender, as well as occupation, does not have a significant impact on users' modal choices. Jain et al. (2017) identified not being in the workforce, not having a driver's licence, belonging to low-income households with at most one car owned, and the absence of train stations nearby as other parameters that positively influence the willingness to use the DRT. In the same way, Nelson and Phonphitakchai (2012) observed that the most frequent users of the LinkUp service operating in a metropolitan area of England are predominantly low-income and less-educated people, in other words, people who belong to socially disadvantaged groups. Conversely, Thao et al. (2023) found that the propensity toward microtransit increases with users' educational level.

Access to a private car (Knierim and Schlüter 2021) and the presence of public transport services within peri-urban areas and toward neighboring cities (Thao et al. 2023) are deterrents to adopting microtransit. Factors such as cost, vehicle capacity, total travel time, and the flexibility and reliability of the service (Gunay et al. 2016) are of paramount importance in the decision to switch to microtransit services; moreover, technological aspects and the level of service generate a modal shift from the more conventional fixed-line and scheduled public transport services. High waiting and walking times are also factors pushing people to switch to microtransit services (Jain et al. 2017). However, the observation made by Thao et al. (2023) is intriguing, namely, that users of microtransit services are more tolerant of waiting time than of time loss due to detours. Furthermore, they point out that in suburban areas, it can be potentially profitable to integrate a demand-responsive service with the conventional public transport service, increasing accessibility, generating stable demand, and reducing the risk of competing between the two modes of transport. However, attention must be paid not to replace these flexible DRT services with other sustainable modes such as walking and cycling, whose users, according to the authors' survey, do not prefer a switch to a microtransit service. König and Grippenkoven (2020) contributed to strengthening the importance of the reliability of the microtransit service perceived by potential users. Conducting a household survey in two rural areas of Germany, they observed that among the predictors of behavioral intentions to use microtransit services, the Performance Expectancy (consisting of believing in the usefulness and improvement of personal mobility) has the strongest impact on choosing microtransit, suggesting practitioners to appropriately design and manage a microtransit service that meets the specific needs of users, possibly integrated with local public transport services. Furthermore, Gilibert et al. (2019) point out that factors such as availability and reliability, price competitiveness, short waiting times, travel times, and short walking distances to reach both the pick-up point and the final destination from the drop-off point are of crucial importance. Enoch et al. (2004) likewise draw attention to the relevance of certainty of the arrival time— especially for door-to-door services—and price, as well as several other factors such as reliability, frequency, cleanliness, vehicle heating and cooling, and, in general, vehicle comfort. However, according to the authors, the importance of these factors varies depending on the socioeconomic category of the users and the purpose of use. For example, according to Enoch et al. (2004), users with access to a car prefer a door-to-door service and a comfortable vehicle, while those without a car prioritize the cost of the service.

Survey Design and Administration

The following subsections describe the survey design process and its administration. We report the main characteristics of the sample, the mobility habits of the respondents, and the DCEs we presented to them.

Study Area

We designed a survey to understand people's propensity to use a microtransit service in a suburban area of Palermo, Italy. The study area encompasses the neighborhoods of Tommaso Natale and Partanna Mondello, located in the northern part of the city, and the small seaside villages of Mondello and Addaura (Fig. 1). The study area covers about 10.5 km^2 and is characterized by poor-quality public transport services and a discontinuous urban fabric. Indeed, the study area is not a transit desert; some bus routes are present but, having low frequency and low reliability, they are underperforming and underutilized. A railway station is located in Tommaso Natale, representing a high-capacity transport node.

As can be seen from Table 1, which reports the census data, the total population in the study area in 2021 is 29,109 inhabitants. About 29% of the residents belong to the over-60 age group. The study area is predominantly residential and characterized by low social housing blocks and villas, although some parts are commercial. There is, in fact, a large shopping mall in the southern part of the study area, as well as hotels, bars, and restaurants along the coastal strip. Low-income families live in the more densely populated areas of Tommaso Natale and Partanna Mondello, whereas high-income families live in the numerous villas in the study area.

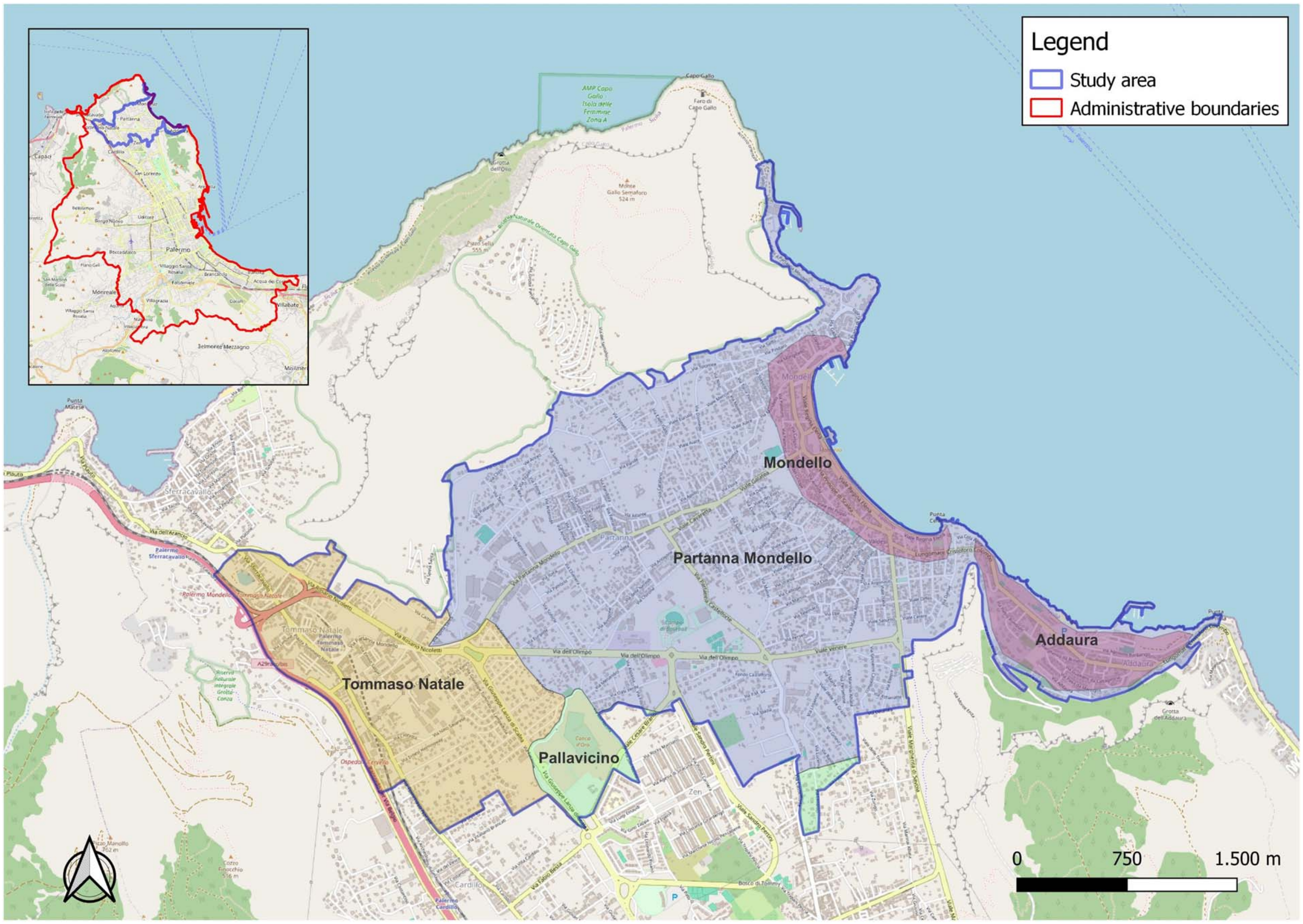


Fig. 1. The study area. (Map data © OpenStreetMap and the GIS User Community.)

Table 1. Population by age group

Age group (years)	Total	Percentage
0–14	3,801	13.0
15–29	4,689	16.1
30–44	5,272	18.1
45–59	6,921	23.8
60–74	5,667	19.5
Over 74	2,759	9.5

Source: Data from ISTAT (2021).

The discontinuity of the urban fabric and the unreliability of public transport services make these neighborhoods car-dependent; indeed, the modal share of public transportation is only 9% (Città di Palermo 2019). There is a transportation equity problem: high-income families, having the possibility to buy one or more cars, can access services and points of interest with ease and lower travel time; conversely, having difficulty owning a car, low-income people are forced to use unreliable public transport services, facing longer waiting times at stops or longer walking distances to reach their destinations. Moreover, many elders, who retired from work, belong to low-income families. The presence of poor-quality public transport services increases their risk of social exclusion since elderly people cannot face long waiting or walking times. Hence, they are limited in their mobility and must be accompanied by relatives to access essential public services, such as healthcare facilities.

Survey Design

A combination of RP and SP surveys was used, conducting the surveys simultaneously and administering a single questionnaire. The RP survey aimed to record the mobility behavior that users currently adopt. Conversely, the SP survey collected the mode choice decisions of the respondents under future scenarios; thus, this combination can be used to predict the behavior of the users when a service does not yet operate in the study area. Conducting RP and SP surveys simultaneously allowed for assessing the mobility habits of people living in the study area and their propensity to use microtransit in the future. Therefore, we could estimate if a change in mobility habits could occur and if the modal switch toward microtransit is from private vehicles, conventional public transport services, or walking.

The questionnaire consisted of three sections: in the first section, the socioeconomic characteristics of the respondents were recorded; in the second section, the mobility habits of the respondents were assessed; the last section was the SP survey, including sets of discrete choice experiments. Hence, the survey collected household and personal socioeconomic attributes such as gender, age, occupation, educational attainment, driving license ownership, number of family members, number of cars per household, car availability, ownership of a public transport pass, and membership of shared mobility services. The survey administrators recorded every travel outside the home by asking respondents to recall what trips they made during the day before the survey (recall technique). To reduce the chance that major trips will be forgotten, they asked respondents to think in the framework of activities and places where they did these activities. Hence, they recorded the first five trips made by the respondent during the day, making notes of the origin, the destination, the mode of transport used, and the trip purpose.

To prime respondents on the discrete choice experiments, a description (Fig. 2) of the microtransit service was presented to them beforehand. It was described as a first-mile/last-mile shuttle, with PUDO stops within a 10-min walk from the houses, connecting to a high-capacity or high-regularity transit node, and with a fare similar to a bus. It was specified that the service would operate as an on-demand service during off-peak hours, while the vehicles would operate as a conventional bus service during the hours in which trips to workplaces and schools are made. To make the DCEs as real as possible, we decided to design scenarios where respondents had to choose between private cars, motorcycles, walking, and microtransit for traveling within the study area or from the study area to other parts of the city, considering different parking costs and on-street parking search times and, in the latter case, the need to access a restricted traffic area and to combine the use of microtransit with the railway service or some bus lines to reach a destination located in the city center. Since we were interested in microtransit as a first/last-mile connector, this alternative's label was microtransit + conventional public transport service in the scenarios representing trips beyond the study area. Moreover, walking was removed from the options in these scenarios, since it is not a convenient transport mode for long trips.

Cycling was not considered an alternative in the choice set. In fact, in this suburban context, creating safe and convenient infrastructures for bicycles is difficult, and this is also evident from the limited use that residents make of them, as highlighted by the results of the RP survey. At the same time, carsharing and bikesharing services were not included either as very few interviewees declared they had a subscription to these services.

To construct the scenarios to be submitted to the respondents, the attributes associated with each mode of transportation and likely to be determinants of choice were determined, and a lower level and an upper level were established for each of these. To set the upper and lower levels of the attributes, some significant Origin/Destination (O/D) pairs were selected and simulations were carried out, assessing the possible travel times and monetary costs incurred by the user. Different levels were set for the attributes for scenarios representing trips inside the study area and for scenarios representing trips from the study area to the outside (Tables 2 and 3).

In the scenarios representing trips within the study area, travel time by car was considered to be composed of two attributes: in-vehicle time and parking search time; for walking, it is assumed that in-vehicle time equals travel time; for motorcycles, total travel time was considered to be equal to in-vehicle time only; and for microtransit, travel time was considered to be composed of three components: the walking time to access a pick-up location, the waiting time at the pick-up location due not only to the time the vehicle takes to arrive but also to the possibility of trip requests occurring that could cause a time loss, and the in-vehicle time. Regarding costs, we considered the cost of fuel (fixed) and the cost of parking (varying between two levels) for the car mode; the cost of fuel (fixed) for the motorcycle mode; and a cost varying between two levels (€ 1.5 or € 2.5) for the microtransit mode.

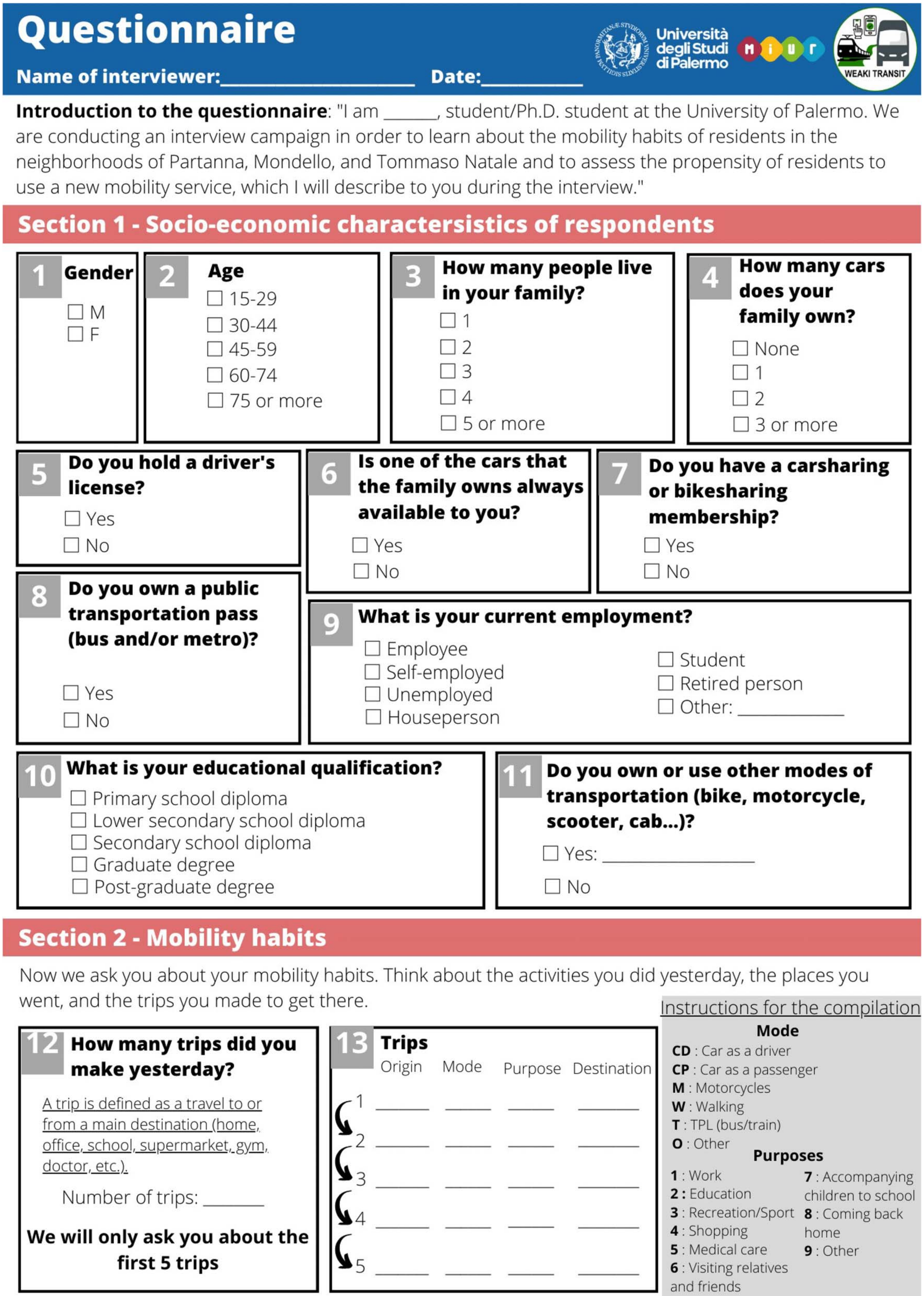
In the scenarios representing trips to locations outside of the study area, we considered two aliquots for the in-vehicle time with two levels, to make this time vary over a wider range, allowing us to subject the respondents to scenarios with medium-range trips to neighborhoods not far from the study area but also scenarios with long-range trips with a downtown destination. In-vehicle time for the microtransit + conventional public transport service mode also considers the time spent on board the mass transit service. The waiting time was not increased compared to scenarios representing shorter trips because it was assumed that microtransit works in a coordinated manner with the schedules of the mass transit service and that users book the ride on the microtransit service considering the connection. In terms of costs, the possibility of having to access the restricted traffic zone was also considered for the car mode, so an additional two-level attribute was added.

We wanted each respondent to perform four DCEs described mainly by cost, waiting times, walking times, and in-vehicle times. Scenarios were constructed developing full factorial designs. Considering six attributes with two levels, we found 64 scenarios representing trips inside the study area. Conversely, considering one attribute with four levels and six attributes with two levels, we found 256 scenarios representing trips beyond the study area. We made a partition of the full factorial designs using blocking: we separated the scenarios into blocks so that the full choice set is completed by groups of respondents and each group responds to a different subset of scenarios. Using two-factor interactions as blocking variables, we divided the full factorial design for trips inside the study area into 16 blocks, while we divided the full factorial design considering trips outside the study area into 64 blocks using three-factor interactions as blocking variables. We divided scenarios into blocks so that each block consisting of four scenarios satisfied the balance and orthogonality properties. The choice to submit only four scenarios stems from the desire to limit the interview time to a few minutes and not make the choice exercise too burdensome for the respondents, given the choice to conduct the survey through personal interviews while the respondents were conducting trips. This prevented respondents from giving hasty and inconsistent answers to finish the interview as soon as possible and return to their activities. An example of scenarios considering trips within the study area presented in the experiments is shown in Fig. 3.

Survey Administration

The survey was administered between November and December 2021. We selected and trained some students from the University of Palermo as survey administrators. Personal interviews were conducted during off-peak hours stopping respondents near the main points of interest in the study area. We considered as respondents only people older than 14 years. The potential participants, randomly selected among residents who were making their trips, were approached and asked if they would be willing to complete a survey that would take approximately 5 min about the introduction of a new transport mode in the area. If willing to participate, the surveyor would read the questions to the participants and record their responses in the survey form.

We attempted to reduce response bias by tracking and varying the day of the week and the time of the day, despite considering working days and off-peak hours. Monday was excluded since the day before the interview would be Sunday. Between 2 and 4 h were spent at each site daily. Thirteen people were interviewed near the POIs in Mondello, 66 in Partanna Mondello, and 65 in Tommaso Natale. Typically, between 50% and 75% of those approached would participate; however, at one location (Mondello), less than half of those asked agreed to answer the questions. We chose to conduct intercept surveys to be able to better explain the characteristics of the microtransit service, which is unknown to most of the population. This allowed for consistent responses. However, this method resulted in a low response rate as many



Questionnaire

Name of interviewer:____________________ **Date:**__________

Introduction to the questionnaire: "I am ______, student/Ph.D. student at the University of Palermo. We are conducting an interview campaign in order to learn about the mobility habits of residents in the neighborhoods of Partanna, Mondello, and Tommaso Natale and to assess the propensity of residents to use a new mobility service, which I will describe to you during the interview."

Section 1 - Socio-economic charactersistics of respondents

1 Gender
☐ M
☐ F

2 Age
☐ 15-29
☐ 30-44
☐ 45-59
☐ 60-74
☐ 75 or more

3 How many people live in your family?
☐ 1
☐ 2
☐ 3
☐ 4
☐ 5 or more

4 How many cars does your family own?
☐ None
☐ 1
☐ 2
☐ 3 or more

5 Do you hold a driver's license?
☐ Yes
☐ No

6 Is one of the cars that the family owns always available to you?
☐ Yes
☐ No

7 Do you have a carsharing or bikesharing membership?
☐ Yes
☐ No

8 Do you own a public transportation pass (bus and/or metro)?
☐ Yes
☐ No

9 What is your current employment?
☐ Employee
☐ Self-employed
☐ Unemployed
☐ Houseperson
☐ Student
☐ Retired person
☐ Other: ____________

10 What is your educational qualification?
☐ Primary school diploma
☐ Lower secondary school diploma
☐ Secondary school diploma
☐ Graduate degree
☐ Post-graduate degree

11 Do you own or use other modes of transportation (bike, motorcycle, scooter, cab...)?
☐ Yes: _________________
☐ No

Section 2 - Mobility habits

Now we ask you about your mobility habits. Think about the activities you did yesterday, the places you went, and the trips you made to get there.

12 How many trips did you make yesterday?

A trip is defined as a travel to or from a main destination (home, office, school, supermarket, gym, doctor, etc.).

Number of trips: _______

We will only ask you about the first 5 trips

13 Trips

	Origin	Mode	Purpose	Destination
1	______	_____	_____	_______
2	______	_____	_____	_______
3	______	_____	_____	_______
4	______	_____	_____	_______
5	______	_____	_____	_______

Instructions for the compilation

Mode
CD : Car as a driver
CP : Car as a passenger
M : Motorcycles
W : Walking
T : TPL (bus/train)
O : Other

Purposes
1 : Work
2 : Education
3 : Recreation/Sport
4 : Shopping
5 : Medical care
6 : Visiting relatives and friends
7 : Accompanying children to school
8 : Coming back home
9 : Other

Fig. 2. Sections 1 and 2 of the questionnaire.

Table 2. Levels used in the design of discrete choice experiments for scenarios representing trips inside the study area

Mode	Attribute	Levels
Walking, motorcycles, private car, microtransit	in-vehicle time	(15, 2.5, 5, 5 min), (30, 5, 10, 10 min)
Microtransit	Waiting time	5, 10 min
Microtransit	Walking time	5, 10 min
Private car	On-street parking search rime	5, 10 min
Private car	Parking fee	€ 0, € 3
Microtransit	Cost	€ 1.5, € 2.5

approached people did not want to participate in the survey as they were interrupted during their activities.

In total, 145 respondents were surveyed. During data cleaning, one respondent was flagged due to inconsistencies in the responses and removed from further analysis. Moreover, five respondents did not choose any of the four options proposed in one or more scenarios, therefore those scenarios were excluded. Hence, the final data set used for analysis had 144 respondents and 565 scenarios.

Sample Characteristics

Table 4 shows the sample's sociodemographic characteristics. The 2011 Population and Housing census data disseminated by the Italian National Institute of Statistics (ISTAT) are also reported to compare the characteristics of the sample to those of the population older than 14 years living in the study area. The population size (people aged more than 14 years living in the study area) is equal to 24,140. We considered 2011 ISTAT data as they are more complete than those of later years, including data on the level of education, household size, and occupation. Three respondents reported being members of the carsharing service while 16 respondents had a public transportation pass. It is also worth noting that no respondents had ever heard of on-demand services such as microtransit.

Mobility Habits

The mobility habits of residents in the study area were investigated by asking them to recall the trips they made the day before the interview. The interviewers noted the total number of trips made by the respondent and for the first five trips recorded the trip purpose and the mode used. The respondents made a total of 349 trips, of which 343 were recorded by the interviewers. While 13.9% of respondents made no trips during the day before the interview, 52.8% made two trips. Only 4.2% made more than five trips. Breaking down the sample by age group, we find that respondents aged 15–29 years made an average of 2.6 trips on the day before the interview, respondents aged 30–44 years made 2.8 trips, respondents aged 45–59 years made 2.5 trips, respondents aged 60–69 years made 2 trips, and finally, respondents over 74 years made an average of 1.8 trips.

Fig. 4 shows the number of recorded trips by purpose and mode of transport; 138 of the 343 recorded trips were commuting trips while 205 were noncommuting trips. Indeed, we conducted the surveys during off-peak hours, when the future on-demand service will be active, and when more noncommuting trips than commuting trips are made. Moreover, retired people, housepeople, and unemployed people are 22.2%, 16%, and 13.9% of the respondents, respectively, and these social groups do not make commuting trips. Conversely, the proposed service, operating during off-peak hours and allowing for route deviations causing extra travel time, may better satisfy noncommuting trips without time constraints rather than commuting trips with time constraints.

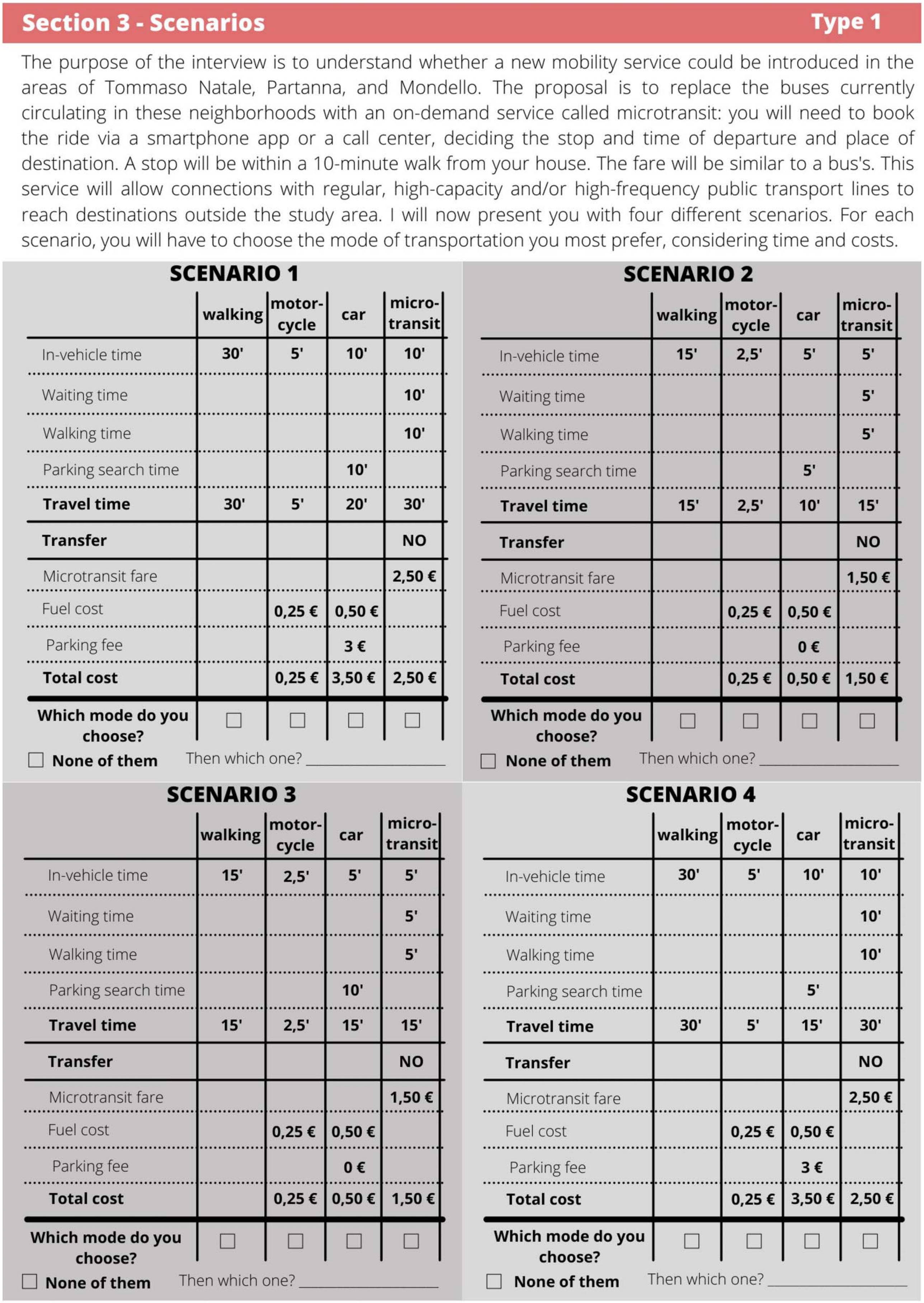
Excluding trips for coming back home, the most frequent trip purposes were recreation and sport (46 of 343 trips, 13.4%), shopping (44 of 343 trips, 12.8%), and going to work (42 of 343 trips, 12.2%). Regarding commuting trips, car as a driver is the most used mode of transportation for going to work (61.9%), while students mostly use public transport services to go to school/university (47.4%). Parents accompany children to school by walking or driving in equal measure (50%).

Considering noncommuting trips, the car is the predominant mode for recreation/sport (47.8%), going shopping (38.6%), and other noncommuting purposes (27.3%). However, public transport is the most used mode (62.5%) for visiting relatives and friends, while car as a driver and car as a passenger are used in equal measure (40%) for going to healthcare facilities. Furthermore, the noncommuting trips (205) recorded in the interviews represent slightly more than 1% of the potential noncommuting trips that the population in the study area makes over a day. This percentage was deduced from the data that ISFORT indicated for the population aged between 14 and 80 years in its last report of 2022 on the mobility of the Italian population (ISFORT 2022). The research institute found that Italians aged 14–80 years made an average of two trips per day. Therefore, considering the 2011 census data by ISTAT, we estimated that the residents of the study area aged over 14 years make 48,280 commuting and noncommuting trips. Furthermore, with reference to urban trips in 2021, ISFORT found that 39.2% of these trips are noncommuting in nature; therefore, we inferred that the potential noncommuting trips of the population aged over 14 years residing within the study area amount to 18,926. Hence, in the survey campaigns, we interviewed a number of users who make up about 1% of the daily noncommuting trips in the study area.

Fig. 5 shows the difference in the number of trips between men and women by trip purpose. Precisely, 178 of the total 343 trips

Table 3. Levels used in the design of discrete choice experiments for scenarios representing trips beyond the study area

Mode	Attribute	Levels
Walking, motorcycles, private car, Microtransit + conventional PT service	in-vehicle time	(10, 20, 25 min), (20, 25, 35 min), (20, 35, 50 min), (30, 40, 60 min)
Microtransit + conventional PT service	Waiting time	5, 10 min
Microtransit + conventional PT service	Walking time	5, 10 min
Private car	On-street parking search time	10, 20 min
Private car	Parking Fee	€ 0, € 3
Private car	Cost for entering restricted traffic area	€ 0, € 4
Microtransit + conventional PT service	Cost	€ 2.5, € 3.5



Section 3 - Scenarios

Type 1

The purpose of the interview is to understand whether a new mobility service could be introduced in the areas of Tommaso Natale, Partanna, and Mondello. The proposal is to replace the buses currently circulating in these neighborhoods with an on-demand service called microtransit: you will need to book the ride via a smartphone app or a call center, deciding the stop and time of departure and place of destination. A stop will be within a 10-minute walk from your house. The fare will be similar to a bus's. This service will allow connections with regular, high-capacity and/or high-frequency public transport lines to reach destinations outside the study area. I will now present you with four different scenarios. For each scenario, you will have to choose the mode of transportation you most prefer, considering time and costs.

SCENARIO 1

	walking	motor-cycle	car	micro-transit
In-vehicle time	30'	5'	10'	10'
Waiting time				10'
Walking time				10'
Parking search time			10'	
Travel time	30'	5'	20'	30'
Transfer				NO
Microtransit fare				2,50 €
Fuel cost		0,25 €	0,50 €	
Parking fee			3 €	
Total cost		0,25 €	3,50 €	2,50 €
Which mode do you choose?	☐	☐	☐	☐

☐ **None of them** Then which one? ____________

SCENARIO 2

	walking	motor-cycle	car	micro-transit
In-vehicle time	15'	2,5'	5'	5'
Waiting time				5'
Walking time				5'
Parking search time			5'	
Travel time	15'	2,5'	10'	15'
Transfer				NO
Microtransit fare				1,50 €
Fuel cost		0,25 €	0,50 €	
Parking fee			0 €	
Total cost		0,25 €	0,50 €	1,50 €
Which mode do you choose?	☐	☐	☐	☐

☐ **None of them** Then which one? ____________

SCENARIO 3

	walking	motor-cycle	car	micro-transit
In-vehicle time	15'	2,5'	5'	5'
Waiting time				5'
Walking time				5'
Parking search time			10'	
Travel time	15'	2,5'	15'	15'
Transfer				NO
Microtransit fare				1,50 €
Fuel cost		0,25 €	0,50 €	
Parking fee			0 €	
Total cost		0,25 €	0,50 €	1,50 €
Which mode do you choose?	☐	☐	☐	☐

☐ **None of them** Then which one? ____________

SCENARIO 4

	walking	motor-cycle	car	micro-transit
In-vehicle time	30'	5'	10'	10'
Waiting time				10'
Walking time				10'
Parking search time			5'	
Travel time	30'	5'	15'	30'
Transfer				NO
Microtransit fare				2,50 €
Fuel cost		0,25 €	0,50 €	
Parking fee			3 €	
Total cost		0,25 €	3,50 €	2,50 €
Which mode do you choose?	☐	☐	☐	☐

☐ **None of them** Then which one? ____________

Fig. 3. Section 3 of the questionnaire.

(52%) are made by females. On average, women made 2.4 trips the day before the interview, while men made 2.3 trips. Approximately 66.7% of the recorded trips for going to work and 67.4% of the recorded trips for recreation/sport were made by men. Most of the trips to school/university (63.2%) were made by women. Moreover, women were more willing to accompany their children to school than men (85.7% of the recorded trips are made by females) and went more frequently to shopping and grocery stores (59.1%), to healthcare facilities (60%), and to visit relatives and friends (56.3%).

Fig. 6 shows the difference in the use of modes of transport between men and women by trip purpose. It can be noted that women did not use motorcycles as a mode of transport for any of their recorded trips. The private car is the most used mode of transportation to get to work for both women and men; in addition, while women used public transportation more, men used carpooling and motorcycles. Regarding travel to school/university, women tended to use public transportation more, while men made greater use of carpooling. Men accompanied their children to school exclusively by car, while women made greater use of walking. While

Table 4. Sociodemographic characteristics of the sample

Sociodemographic variable	Sample ($N = 144$)	Census (2011)
Female	50.7%	52%
Age		
15–29	27.0%	21.8%
30–44	23.6%	25.3%
45–59	18.1%	27.0%
60–74	27.8%	18.2%
Over 74	3.5%	7.6%
Educational attainment		
Primary school diploma	13.9%	—
Lower secondary school diploma	35.4%	—
Secondary school diploma	44.4%	36.2%
Graduate degree	6.3%	15.6%
Occupation		
Employee (1)	20.8%	(1) + (2) 37.7%
Self-employed (2)	9.7%	
Unemployed	13.9%	6.1%
Student	17.4%	9.3%
Houseperson	16.0%	17.4%
Retired person	22.2%	—
Household size		
One person	15.3%	24.5%
Two people	22.2%	24.9%
Three people	16.7%	21.8%
Four people	25.7%	21.2%
Five people or more	20.1%	7.6%
Cars per household		
None	18.8%	—
One	50.7%	—
Two	25.0%	—
Three or more	5.5%	—

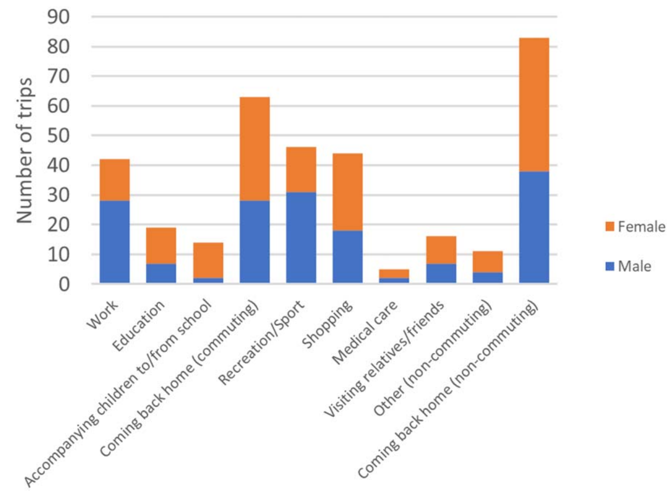


Fig. 5. Number of trips by gender and trip purpose.

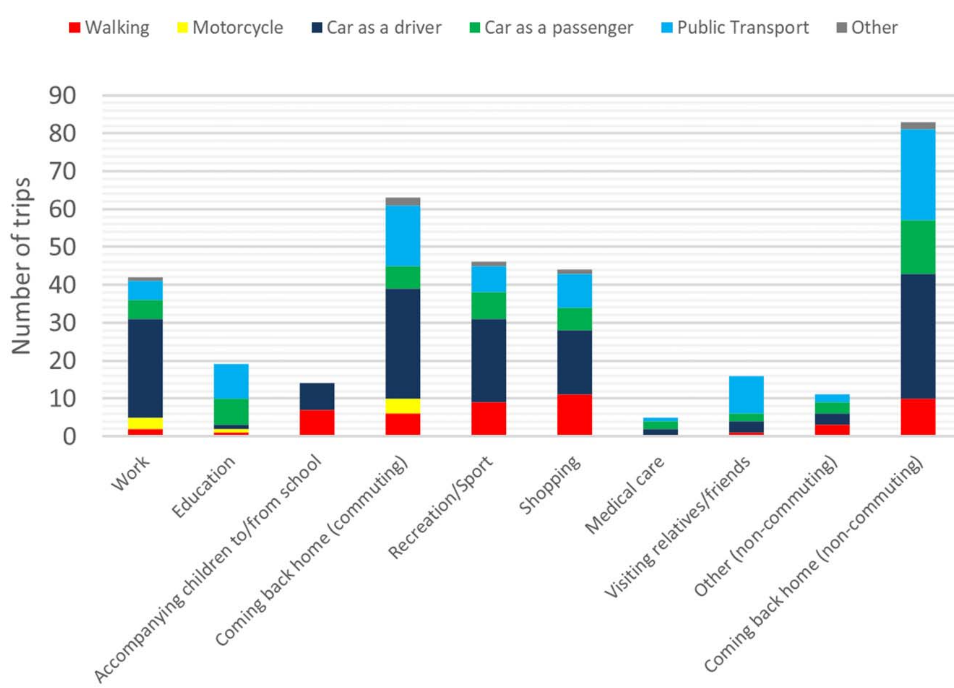


Fig. 4. Number of commuting and noncommuting trips by purpose and mode of transport.

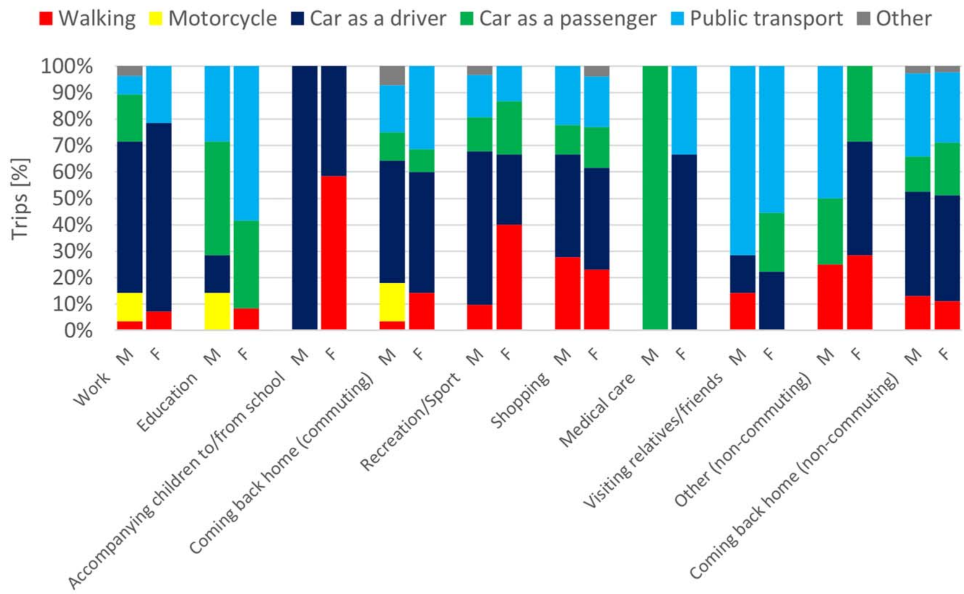


Fig. 6. Percentage of trips by gender, trip purpose, and mode of transport.

men made more trips for recreational or sports activities by driving a car, women preferred to walk to make trips for this purpose. For both men and women, the main mode of transportation for going shopping was the private car. Public transportation is the main mode for visiting relatives and friends for both men and women.

Fig. 7 shows the number of commuting and noncommuting trips by age group and mode of transport. For both types of trips, it is evident that the predominant mode of transportation is the car as a driver (63 commuting and 80 noncommuting trips, for a total of 143 trips), followed by public transport (30 commuting and 53 noncommuting trips, for a total of 83 trips). Analyzing commuting trips, the age group making most trips is 15–29 years (56 trips). It is also interesting to highlight how public transport is predominantly used by people aged 15–29 years (22 trips recorded in the interviews), as well as how these people are also those who declare walking (8 trips) more than the other age groups considered. Conversely, driving a car is dominant for the remaining age groups. Regarding noncommuting travel, the majority of these are made by individuals between the ages of 60 and 74 (69 trips). The significant difference compared to commuting travel conducted by the same age group (10 trips) could be related to reaching retirement age, thus not making trips for work-related reasons. This age group also accounts for the highest number of trips made by walking (14 out of the 34 noncommuting trips made on foot by all age groups combined). Conversely, most noncommuting trips made by driving a car are carried out by respondents aged 30–44 years (31 trips out of the 51 noncommuting trips they made in total). This age group also showed the highest percentage of trips made by walking (21.6%) compared to the noncommuting trips revealed in the RP survey. Moreover, it could be noted that people aged over 74 years made only noncommuting trips and were mostly accompanied by car by relatives (77.8%). This supports the fact that elderly people living in the study area are at risk of social exclusion and limited in their independence in travel. It is also pointed out that

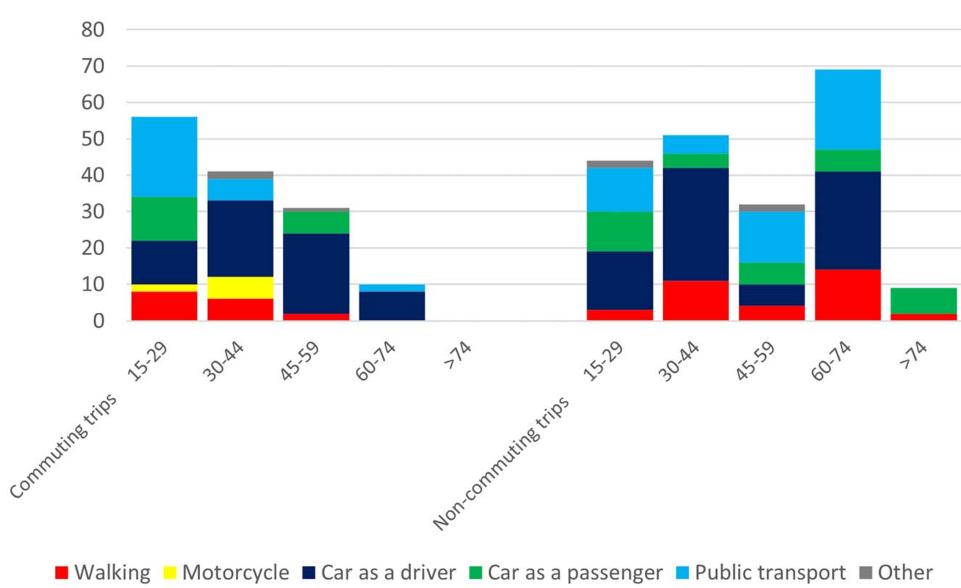


Fig. 7. Number of commuting and noncommuting trips by age group and mode of transport.

this group of users did not make any noncommuting trips using public transportation; this is a direct consequence of the poor quality of the public transportation services in the study area involving long waiting times at stops or long walking distances, which are difficult for older people to face.

Mode Choice Model

We used the multinomial logit model to develop a mode choice model based on the responses to the discrete choice experiments. This model is based on the random utility maximization theory, which posits that decision makers face a choice set of alternatives with random utilities and choose the alternative with the highest utility based on their individual choice preferences. We used the results of the survey to calibrate a mode choice model, with the help of the statistical software *R* and, in particular, the library mlogit. We used the multinomial logit model to estimate the choice probability for microtransit for different user groups (considering age, gender, and level of education as explanatory variables). The considered attributes are reported in Table 5. A stepwise regression method with backward elimination was adopted to drop all the variables having no statistical significance. Therefore, this allows for having a calibration not affected by nonsignificant variables. The significant attributes and the results of the model calibration are reported in Table 6. The VOT for motorized vehicles is 3.63 €/h $(=[\beta_{t_{\text{motorizedvehicles}}}/\beta_{C_{\text{tot}}}] \times 60)$.

This value is lower than the one found by Rossetti et al. (2023) and Kang et al. (2021). However, VOT is contextual and may depend on different factors. This discrepancy is due to the different contexts in which the surveys were conducted, the characteristics of the respondents and also the trip purpose that was mainly investigated. Many low-income families and unemployed people live in the study area and they give a lower VOT to motorized vehicles. Moreover, we considered an on-demand service operating during the off-peak hours in which mainly noncommuting trips such as leisure and shopping trips are made. Hence, the trip purpose also led to this lower value. Indeed, our values are closer to the ones found by Alonso-Gonzales et al. (2020), considering Dutch individuals and leisure trips, or the ones estimated by Wardman et al. (2016) for cars making noncommuting trips in Italy and by Migliore et al. (2021).

The value of the McFadden R^2 of approximately 0.2 suggests a good model fit (Hensher and Stopher 2021). Coefficients related to travel time, total cost, and transfer are negative: indeed, increasing cost, transfers, or travel times means having a decrease in utility. Age is significant for the choice of motorcycle, car, and microtransit, and the negative sign means that younger people are more willing to use these modes rather than walk. The number of cars per person is significant for car and microtransit, and positive coefficients imply the higher the number of cars per person, the more likely people are to choose cars or microtransit compared to walking. The possession of driving license is significant only for microtransit, and the negative coefficient implies that people are more inclined to use microtransit than a car if they do not have a driving license. The level of education is significant for all the transport modes, and the negative coefficient means that the higher the level of education, the lower the utility perceived for these modes

Table 5. Attributes of the mode choice model

Attribute	Symbol	Description
Walking time	t_{walking}	Travel time for walking as a transport mode.
Travel time for motorized vehicles	$t_{\text{motorized vehicles}}$	Time that motorized vehicles (motorcycle, car, and microtransit) spend to complete the trip. Motorcycle: in-vehicle time; car: in-vehicle time and parking time; microtransit: in-vehicle time, waiting time, and walking time to the nearest microtransit stop. Waiting time and walking time to the nearest stop were multiplied by 3 considering the different perception of these times rather than the in-vehicle time by users, which was found by analyzing the results of the SP survey.
Travel cost	C_{tot}	Motorcycle: fuel cost; car: fuel cost and parking rate; microtransit: cost of the ticket for microtransit plus the cost of the ticket for conventional public transport service, if any.
Transfer	Transfer	Binary variable. 0: no transfers toward other conventional public transport services; 1: otherwise.
Alternative specific constant	$ASC_{\text{motorcycle}}$, ASC_{car}, ASC_{DRT}	Alternative specific constants for motorbike, car, and microtransit, respectively.
Age	$Age_{\text{motorcycle}}$, Age_{car}, Age_{DRT}	Middle value of the age groups considered in the questionnaire (22 for age between 15 and 29; 37 for age between 30 and 44; 52 for age between 45 and 59; 67 for age between 60 and 74; 82 if the respondent is older than 74).
Gender	$Gender_{\text{motorcycle}}$, $Gender_{\text{car}}$, $Gender_{\text{DRT}}$	Binary variable for the gender of the respondents (0 for males and 1 for females).
Cars per person	Number $car_{\text{motorcycles}}$, Number car_{car}, Number car_{DRT}	Number of cars owned per person per household. This variable is obtained from the ratio of the number of cars owned to the number of members in the household, as recorded in the RP survey.
Driving license possession	Driving $license_{\text{motorcycles}}$, Driving $license_{\text{car}}$, Driving $license_{\text{DRT}}$	Binary variable, which is equal to 1 in case of driving licence possession and 0 otherwise.
Level of education	$Education_{\text{motorcycles}}$, $Education_{\text{car}}$, $Education_{\text{DRT}}$,	Number of years needed to obtain a specific qualification (5 for primary school certificate, 8 for junior high school diploma, 13 for high school diploma, and 17 for degree).

Table 6. Significant attributes

Attribute	Coeff β	Std. error	z	$p > z$
t_{walking}	−0.0886945	0.0148455	−5.97	0.000 (***)
$t_{\text{motorized vehicles}}$	−0.0120287	0.0070721	−1.70	(.)
C_{tot}	−0.1987762	0.0448350	−4.43	0.000 (***)
Transfer	−0.7227308	0.2664712	−2.71	0.007 (**)
$\text{ASA}_{\text{motorcycle}}$	9.7808605	2.6472395	3.69	0.000 (***)
ASA_{car}	8.0833144	2.5087600	3.22	0.001 (**)
ASA_{DRT}	10.7439860	2.5182978	4.27	0.000 (***)
$\text{Age}_{\text{motorcycle}}$	−0.1790616	0.0321480	−5.57	0.000 (***)
$\text{Gender}_{\text{motorcycle}}$	−2.4914474	0.7297172	−3.41	0.001 (***)
Level of $\text{education}_{\text{motorcycle}}$	−0.3999587	0.1131814	−3.53	0.000 (***)
Age_{car}	−0.1262652	0.0302785	−4.17	0.000 (***)
Cars per $\text{person}_{\text{car}}$	4.7736104	1.2125511	3.94	0.000 (***)
Level of $\text{education}_{\text{car}}$	−0.3357910	0.0977002	−3.44	0.001 (***)
Age_{DRT}	−0.1320482	0.0301695	−4.38	0.000 (***)
Cars per $\text{person}_{\text{DRT}}$	3.3907248	1.2030916	2.82	0.005 (**)
Driving license $\text{possession}_{\text{DRT}}$	−1.5824563	0.7650447	−2.07	0.039 (*)
Level of $\text{education}_{\text{DRT}}$	−0.3049811	0.0962529	−3.17	0.002 (**)

Log-likelihood: −469.31;
Likelihood ratio test: chi-square = 233.52 (p-value $\leq 2.22 \times 10^{-16}$);
McFadden R^2: 0.19923;
Significance: 0 (***); 0.001 (**); 0.01 (*); 0.05 (.); 0.1 (,).

compared to walking. Moreover, an increase in the level of education implies an increase in the utility associated with microtransit. Gender was not significant in the choice of microtransit service. It is highly significant for motorcycles, and the attribute sign shows that men are more likely to use this mode of transportation than women. Based on the results of the calibrations and the significant attributes shown in Table 6, the following formulas express the utility associated with the four modes of transport:

$$V_{\text{walking}} = \beta_{t_w} \times t_{\text{walking}} \tag{1}$$

$$\begin{aligned} V_{\text{motorcycle}} = {} & \beta_{t_{\text{motorized vehicles}}} \times t_{\text{motorcycle}} + \beta_{C_{\text{tot}}} \times C_{\text{tot}_{\text{motorcycle}}} \\ & + \text{ASC}_{\text{motorcycle}} + \beta_{\text{Gender}_{\text{motorcycle}}} \times \text{Gender} \\ & + \beta_{\text{Age}_{\text{motorcycle}}} \times \text{Age} + \beta_{\text{Education}_{\text{motorcycle}}} \times \text{Education} \end{aligned} \tag{2}$$

$$\begin{aligned} V_{\text{car}} = {} & \beta_{t_{\text{motorized vehicles}}} \times t_{\text{car}} + \beta_c \times C_{\text{tot}_{\text{car}}} + \text{ASC}_{\text{car}} + \beta_{\text{Number car}_{\text{car}}} \\ & \times \text{Number car} + \beta_{\text{Age}_{\text{car}}} \times \text{Age} + \beta_{\text{Education}_{\text{car}}} \times \text{Education} \end{aligned} \tag{3}$$

$$\begin{aligned} V_{\text{DRT}} = {} & \beta_{t_{\text{motorized vehicles}}} \times t_{\text{DRT}} + \beta_c \times C_{\text{tot}_{\text{DRT}}} + \text{ASC}_{\text{DRT}} + \beta_{\text{Number car}_{\text{DRT}}} \\ & \times \text{Number car} + \beta_{\text{Driving license}_{\text{DRT}}} \times \text{Driving license} + \beta_{\text{Age}_{\text{DRT}}} \\ & \times \text{Age} + \beta_{\text{Education}_{\text{DRT}}} \times \text{Education} \end{aligned} \tag{4}$$

Once the utilities are estimated, the probability of choosing each mode of transport can be determined.

Results

The results of the model calibration can be better illustrated through a scenario analysis. Some scenario analyses were carried out between different O/D pairs to understand how the characteristics of the decision maker and the modal alternatives affect the choice probability of microtransit service. Via Iandolino, located in the most densely populated part of Partanna Mondello and in the center of the study area, was chosen as the origin of trips for all the scenario analyses (Fig. 8).

A first scenario analysis considered an O/D pair within the study area. Therefore, a shopping mall located in the southern part of the study area was chosen as the destination. This is one of the main points of interest in the study area. The distance between Via Iandolino and Conca D'Oro shopping mall is 2.8 km. We used a cost for microtransit equal to € 1.50, a walking time to the nearest microtransit stop equal to 5 min, and a waiting time equal to 10 min as input data. Fig. 9 shows the choice probability for microtransit by level of education and age group. The choice probabilities shown in the figure are the mean between the choice probabilities for microtransit for males and females. Young people with a higher level of education are more willing to choose microtransit (44%), while the propensity to choose microtransit decreases with the increase in age and the decrease in level of education. People aged over 74 years holding a primary school diploma belong to the group having the lowest probability of choosing microtransit (28%).

The second scenario analysis was carried out considering an O/D pair with a destination in an external commercial area about 6 km away and often frequented by residents of the study area due to the presence of numerous stores, restaurants, and a cinema. The cinema was chosen as the destination point and it is 5.7 km from Via Iandolino. We used a cost for the combination of microtransit and railway service equal to € 3.40, a walking time to the nearest microtransit stop equal to 5 min, and a waiting time equal to 10 min as input data. Fig. 10 shows that young people with a higher level of education are more willing to choose microtransit (23%), while the model assesses the lowest probability to choose microtransit (13%) for people aged over 74 years with the lowest education level.

For the third scenario analysis (Fig. 11), an O/D pair was chosen for which the choice of mode of transportation may be influenced by travel demand management policies that disincentivize the use of the private car (parking pricing and restricted traffic areas), especially with respect to occasional trips. Hence, a theater located within a restricted traffic area in downtown Palermo, Italy, was considered the destination. The theater is 10 km away from Via Iandolino. We used a cost for the combination of microtransit and the bus service equal to € 2.90, a walking time to the nearest microtransit

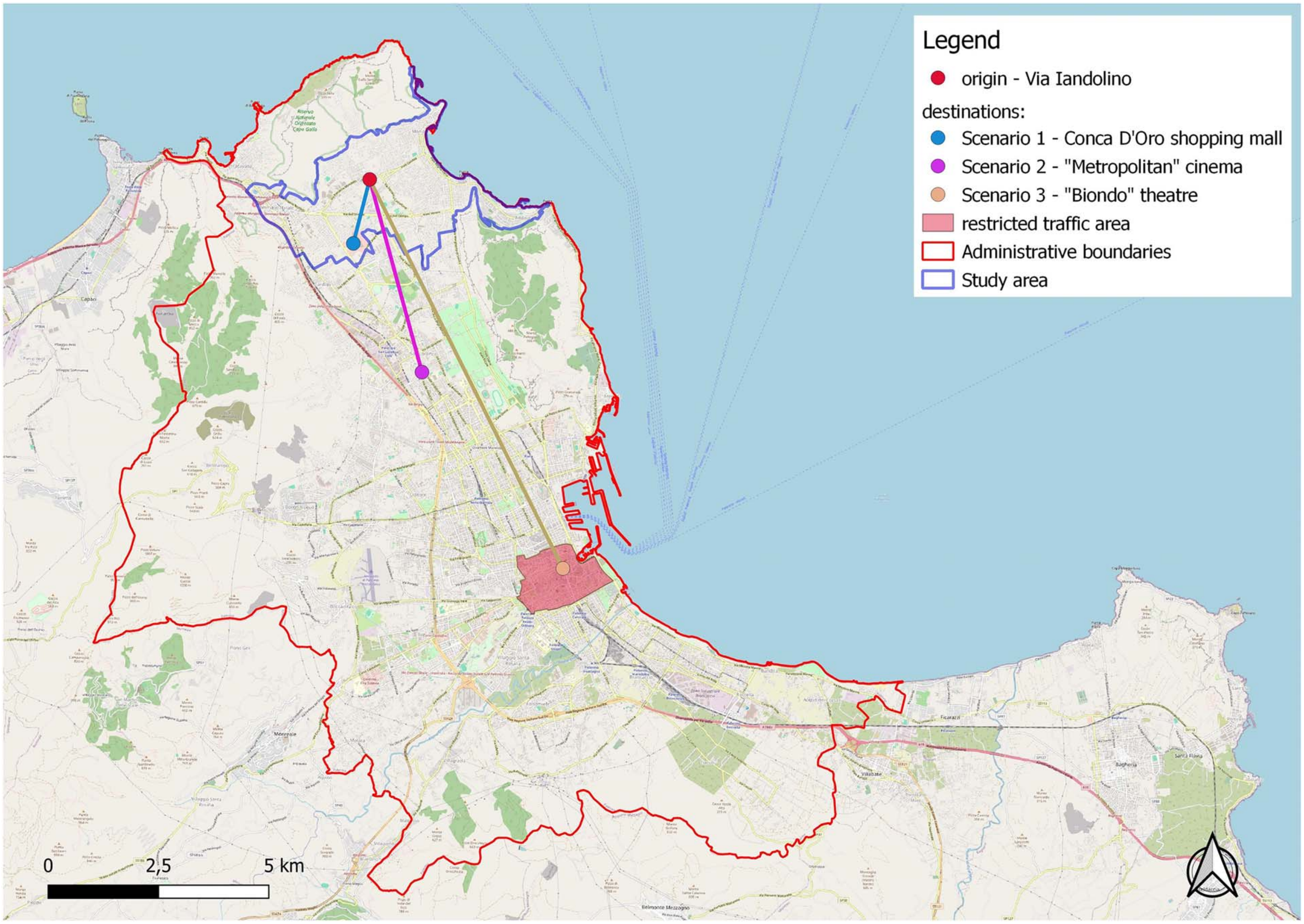


Fig. 8. O/D pairs in the scenario analyses. (Map data © OpenStreetMap and the GIS User Community.)

stop equal to 5 min, and a waiting time equal to 10 min as input data. The increase in the cost of the use of the private car due to the presence of parking pricing and the restricted traffic area generates higher probabilities of choosing microtransit. Also in this case, people aged 15–29 years with a higher level of education are more willing to choose microtransit (61%), while the propensity to choose microtransit decreases with the increase in age and the decrease in level of education. People aged over 74 years holding a primary school diploma have the lowest probability to choose microtransit (45%). In any case, 61% is the modal share for microtransit for a particular O/D pair where travel demand management policies based on disincentives to switch from car to public transport are implemented. However, considering the possible O/D pairs between which users travel most frequently, the probability

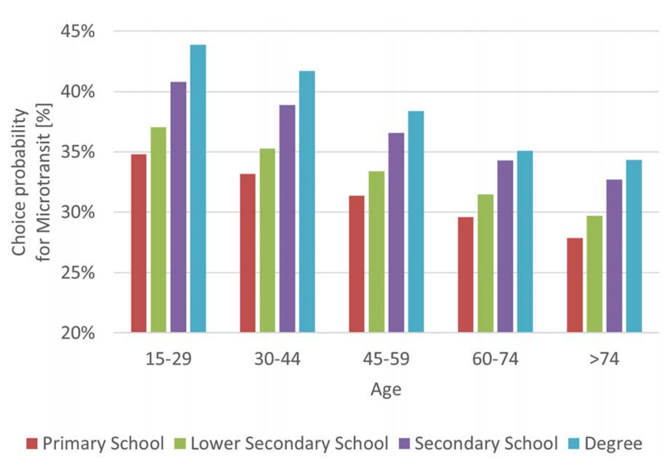


Fig. 9. Variation in choice probability for microtransit by education level and age group: Scenario analysis no. 1.

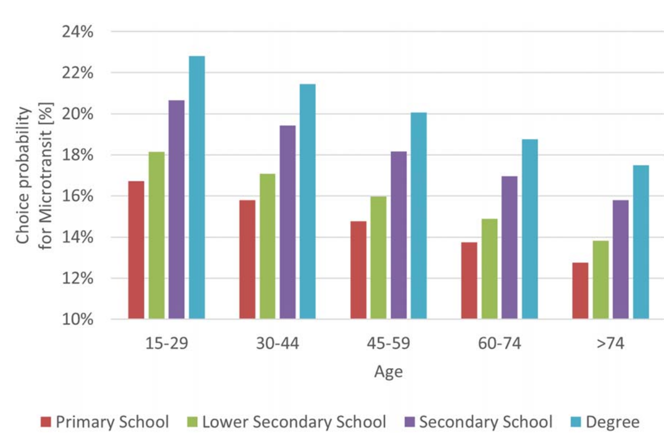


Fig. 10. Variation in choice probability for microtransit by education level and age group: Scenario analysis no. 2.

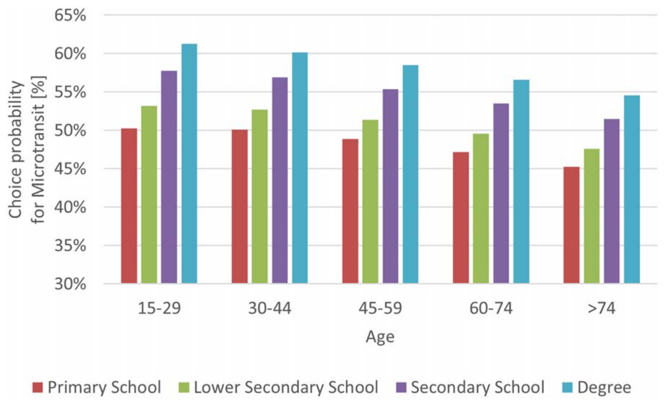


Fig. 11. Variation in choice probability for microtransit by education level and age group: Scenario analysis no. 3.

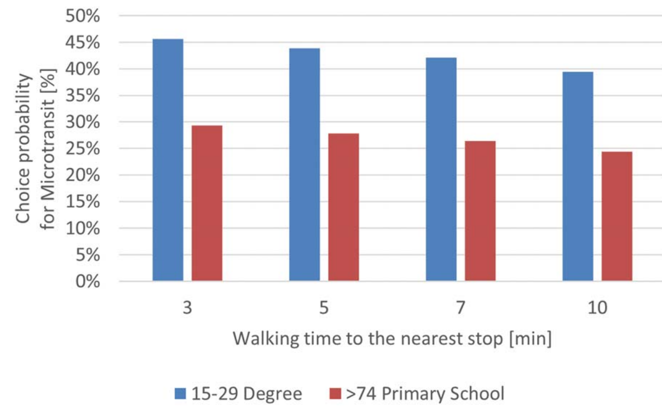


Fig. 13. Variation in choice probability for microtransit by walking time to the nearest stop.

of choosing microtransit on average is closer to that resulting in the second scenario analysis (between 13% and 23%, 18% on average).

Moreover, considering the first O/D pair and the user groups with the highest and the lowest probability to choose microtransit (highly educated people aged between 15 and 29 years and less-educated people aged over 74 years, respectively), other scenario analyses were conducted. First, the variation in the choice probability of microtransit by waiting time has been assessed. From Fig. 12, it can be noted that the choice probability of microtransit decreases as the waiting time at the pick-up location increases. The decrease in choice probability is slightly greater for highly educated young people: a decrease of 3% in choice probability happens when the waiting time goes from 7 to 10 min. Moreover, we also evaluated the variation in the choice probability of microtransit by walking time to the nearest pick-up location. From Fig. 13, it can be noted that the choice probability of microtransit decreases as walking time to the nearest pick-up point increases. The decrease in choice probability is slightly greater for highly educated young people: a decrease of 3% in choice probability happens when walking time to the nearest pick-up point goes from 7 to 10 min. Finally, we also evaluated the variation in the choice probability of microtransit by the cost of the service. From Fig. 14, it can be noted that the choice probability of microtransit decreases as cost increases. For elderly people, an increase of € 0.50 in cost means a decrease of 2% in the probability of choosing microtransit, while the highest decrease in choice probability for young highly educated people (3%) is when the cost increases from € 1.50 to € 2.00.

Discussion

Gender was found to be nonsignificant in the choice of microtransit services, meaning that, other socioeconomic characteristics being equal, men and women are equally likely to choose microtransit. This result confirms the findings of Thao et al. (2023). A higher propensity to use microtransit services was found for young people with a high level of education. This result is also supported by the findings of Rossetti et al. (2023), Gilibert et al. (2019), and Thao et al. (2023), according to which as age decreases and education level increases, the willingness to use microtransit services increases.

Indeed, the use of microtransit by older people seems more limited. This is not in line with some of the previous studies (Mageean and Nelson 2003; Nelson and Phonphitakchai 2012; Wang et al. 2015; Knierim and Schlüter 2021; Thao et al. 2023). The use of the service by older people is perhaps hindered by its innovation and technological barriers. Elders are generally less inclined to innovation and may find difficulties in using smartphone applications or booking rides in real time, not being used to services with flexible schedules and routes. This result suggests the need to implement targeted policies for this group of potential users, who are

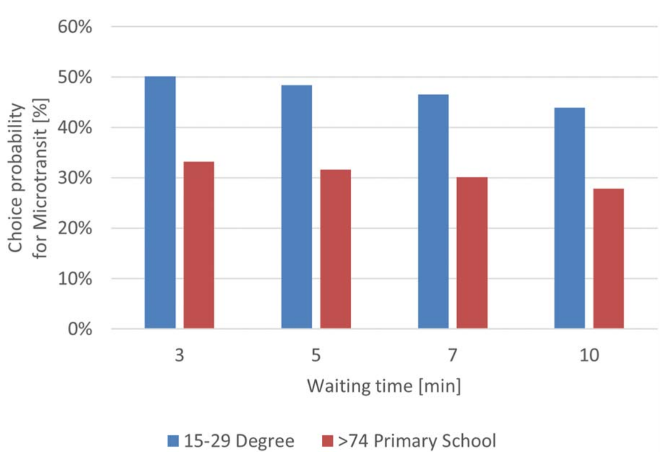


Fig. 12. Variation in choice probability for microtransit by waiting time.

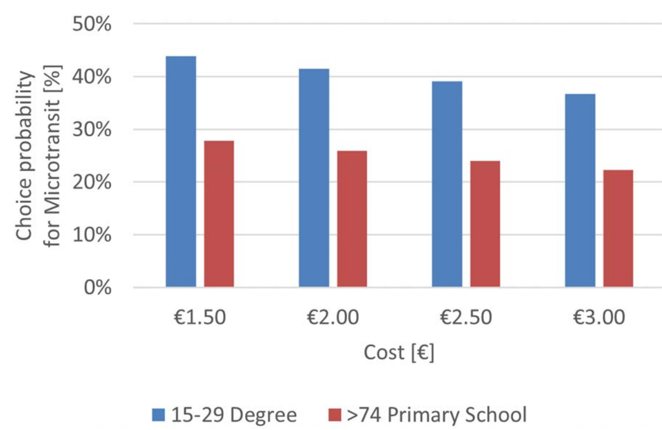


Fig. 14. Variation in choice probability for microtransit by cost of the service.

also those at greatest risk of social exclusion. There is a need not only to provide the ability to book rides in advance but to do so through a call center, to avoid the use of smartphones by the older population. In addition, publicity actions, such as meetings and free trial rides, should be put in place to familiarize the elderly with microtransit, as well as the introduction of discounts reserved for them to incentivize their use of the service. Another reason why older people are less inclined to choose microtransit in the DCEs is related to the levels of walking distance to reach the pick-up location, which we considered in the survey design. Considering walking distances of up to 10 min may have resulted in older people being less inclined to use this service than younger people. Indeed, older people are less inclined to walk long distances and a short walking distance to the pick-up point was found to be one of the features of on-demand services that are most important to the elderly (Jittrapirom et al. 2019). A door-to-door service would better suit their needs.

A limitation of this study should be noted. Our findings could be affected by the effects of the Coronavirus disease 2019 (COVID-19) pandemic on transport mode preferences. As several studies have found, the COVID-19 pandemic led to a reduction in public transport ridership, which has not yet fully recovered (Rothengatter et al. 2021). Furthermore, travelers shifted from public and shared modes to private vehicles as a consequence of the pandemic (Das et al. 2021). The survey was conducted at the end of 2021 after the lockdown imposed by the Italian government and the closure of commercial activities occurred in 2020. Daily life had returned almost to normal, apart from the mandatory use of face masks, even on buses and trains. The state of emergency for COVID-19 in Italy was declared over on March 31, 2022, only a few months after the survey administration. The choices expressed during the interviews could be affected by a sense of insecurity in using a shared service, certainly greater in the case of older people, who are more fragile and more scared of the consequences of the infection. Therefore, also this aspect, together with the lower inclination to use technology and walk long distances, could have led to a lower propensity of older people to use microtransit.

However, the scenario analyses showed how the microtransit service can play a role in decreasing congestion and externalities even in denser areas of the city, due to its vocation as a feeder system to more reliable and high-capacity public transport services. It can also improve the travel experience within the study area, replacing some underutilized bus routes. However, the impacts of replacing fixed-route services with a demand-responsive transport system must be evaluated through pilot programs. Indeed, Coutinho et al. (2020) found a reduction in ridership after the introduction of microtransit in a low-demand area in Amsterdam, Netherlands, although the reduced mileage and operating time frame contributed to better overall efficiency and the on-demand service enjoyed a good perception by users due to its punctuality. Conversely, Yan et al. (2019) found that replacing low-ridership bus lines with ridesourcing services could slightly increase transit ridership while reducing operations costs.

The results of the scenario analyses also show that improving the efficiency of public transportation through the introduction of on-demand services with flexible schedules and routes, coupled with effective travel demand management policies in the central areas of the city, results in a significant increase in the demand for public transportation and therefore lower negative externalities. Therefore, microtransit makes public transport more effective and competitive for longer trips, especially when demand management policies discouraging the use of cars by increasing their costs are present in the core of the city; in this way, longer car trips can be reduced (i.e., those from the suburbs to the city center), with a reduction in traffic flows in the congested area and a reduction in negative externalities. This appears reasonable and is confirmed by other studies on the impact of low emission zones, road pricing, and parking restrictions on transit ridership (Gonzalez et al. 2022; Migliore et al. 2012). In fact, from the 9% recorded during the drafting of Palermo's Sustainable Urban Mobility Plan (SUMP) in 2019, the modal share for public transport would increase significantly reaching more than 50% for trips with destinations within the restricted traffic zone. In any case, for the average trips made by residents of the study area, there is a doubling of the percentage of public transportation use (from 9% to about 18%).

Conclusions

Microtransit services can be an option for increasing accessibility to services in areas with temporally and spatially dispersed demand that are served by inefficient public transportation services. Therefore, suburban areas seem to be one of the best fields to implement microtransit services, which can make public transit as relevant as possible in communities that just do not have the ability to access high-frequency fixed-route service.

The paper shows that SP surveys can be effectively used to assess the propensity to use microtransit services in suburban areas by different groups of users and evaluate the elasticity of demand considering different travel distances and the presence or absence of travel demand management policies that discourage car use. The case study of some suburban areas in Palermo, Italy, was presented. This is one of the few studies that uses the SP survey to predict microtransit choice and is the only one in the Italian context as far as we know.

Considering the specific context, we found that older people are less inclined than younger ones to use a stop-to-stop microtransit service. This is particularly notable for communities seeking to serve older people. Moreover, we found that there is potential for a hybrid microtransit service to replace some underutilized and underperforming bus routes, improving the travel experience and optimizing the transportation resources in the study area. However, this study represents the first step in the investigation of demand for microtransit in suburban areas. The sample needs to be expanded to overcome the limitation that the study currently shows, i.e., the low representativeness of the sample in relation to the population. However, conducting face-to-face interviews, we were able to interview those users who make up about 1% of the noncommuting trips in the study area during the day. In any case, the study proposes a valid methodology to investigate the demand attracted by microtransit services, which is replicable in other contexts; moreover, the results are in line with the scientific literature on the topic. However, these results cannot be generalized because they are highly dependent on the context; this underlines the need for public transport operators to conduct ad hoc surveys to understand which users to target under different conditions (lack of public transport services, introduction of door-to-door services, urban context, etc.).

Future studies will focus on the design of microtransit services in suburban areas: through the use of the model calibrated for the study area, a service design methodology can be developed, and a pilot can be developed to verify that the service improves the area's public transport performance in terms of waiting and travel time and to test whether the choice probabilities found in the SP survey are reflected in actual user behavior. Moreover, to further our research, we plan to apply the developed methodology to rural areas or small towns without local public transport services.

Data Availability Statement

All data, models, or codes that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments

This work was carried out within the research project "WEAKI TRANSIT: WEAK-demand areas Innovative TRANsport Shared services for Italian Towns" (No. 20174ARRHT), which is funded by the Programmi di Ricerca Scientifica di Rilevante Interesse Nazionale (PRIN) of the Italian Ministry of Education, University and Research. This work was also co-financed by the European Union —FESR or FSE, National Operational Programme (NOP) on Research and Innovation 2014-2020 (DM 1062/2021). This research has been partially supported by the European Union— Next-Generation EU (National Sustainable Mobility Center, CN00000023, MUR Decree No. 1033—17/06/2022, Spoke 2, CUP B73C22000760001).

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