Train-feeder modes in Italy. Is there a role for active mobility?

Marco Giansoldati *, Romeo Danielis, Lucia Rotaris

Dipartimento di Scienze Economiche, Aziendali, Matematiche e Statistiche "Bruno de Finetti", Università degli Studi di Trieste, Via dell'Università, 1, 34123, Trieste, Italy

A R T I C L E I N F O

JEL classification:
R41
R42
R48

Keywords:
Active mobility
Walking
Cycling
Train feeder modes
Commuters
Gender
Revealed preferences
Stated preferences

A B S T R A C T

The transport mode used to reach a train station is an important determinant of the urban traffic and rail transport attractiveness. In this paper, we have investigated train-feeder mode choice on the basis of 185 interviews with Italian train users living in cities of different size. We analyzed their current choice and their stated choices under hypothetical scenarios using various discrete choice model specifications. Their current train-feeder mode choice is mainly car-based: 63.2% of the respondents use the car, as either drivers or passengers. The active modes cycling and walking are chosen by 18.4% and 9.7% of the respondents, respectively; the remaining using either the bus or the scooter. Our estimates confirm that travel time and travel cost play a relevant role with two covariates, commuter and gender, explaining the large heterogeneity of the active mobility travel time variable. However, the performed scenario analysis suggests that, in many instances, it is extremely difficult to alter the existing train-feeder mode choice in favor of the active modes and that promoting active mobility in Italy requires a coordinated effort at many levels, including territorial planning, infrastructural investment and traffic regulations.

1. Introduction

Together with many benefits, mass motorization causes numerous problems such as air and noise pollution. Many authors emphasized these aspects (e.g. Banister, 2008; Cervero, 2013) and highlighted the importance of a shift of the transport planning paradigm towards sustainable and active mobility. The latter can be broadly defined as encompassing a wide variety of human-powered modes, including but not limited to walking and cycling (Metrolinx, 2018).

In the context of the Italian built environment, characterized by a network of small-medium cities connected by railway lines, rail transport represents an environmentally friendly alternative to the use of the car for intercity travel. However, its attractiveness depends on the efficiency on the total transport chain from the place of residence to the place of activity. The trip to and from the train station plays a crucial role in determining the railways' competitiveness for intercity commuting (Button & Rietveld, 1999; Rietveld, 2000). In fact, accessing\egressing a railway station is often the weakest part of the transport chain, hence contributing to travel time increases and travel discomfort. The modal choice to access/egress railway stations include both motorized and active transport modes.

In this paper, the focus is on rail transport users and their choice among the various train feeder modes, with a special attention to the active one (walking and cycling). In Italy, in 2018 passive passenger modes (auto and motorcycle) accounted for 71.3% of the travelled distance (measured in passenger-km), public transportation for 23.5%, while the active modes lagged behind with a mere 5.2% (Isfort , 2019). The picture was not particularly different when considering the time spent on mobility in a given day of the week. Private passive mobility dominated the scene with 58.2%, followed by active mobility with 22.5%, and public transportation with 19.3%. The use of active modes was particularly weak within suburban areas where merely 1.4% and 1% of the trips were made on foot or by bicycle, respectively. The percentage were much higher in urban areas, amounting to 31.3% for walking and 5.6% for cycling. The percentage of trips made by car was 53.8% in urban areas and 85.8% in suburban ones (Isfort, 2019).

We investigate the determinants of train users' selection of their feeder mode. As we will discuss more in detail in the Related literature section, the choice process is very complex. It starts with the decision to use the train to reach a given destination and the selection of the train station. Such a decision is intertwined with the selection of the mode to access\egress the station at the point of departure and at the point of destination (Frei et al., 2017; Zheng et al., 2016). The train-feeder mode choice is made among the available alternatives considering a large number of factors such as: the characteristics of the trip in terms of length, time of the day, and route availability (e.g., reserved lanes); the

* Corresponding author.
E-mail addresses: mgiansoldati@units.it (M. Giansoldati), ROMEO.DANIELIS@deams.units.it (R. Danielis), lucia.rotaris@deams.units.it (L. Rotaris).

Accepted 8 October 2020

characteristics of the train station, including parking conditions and facilities (e.g., parking restrictions, parking fees, guarded facilities for bicycles); and the characteristics of the train (e.g., frequency, bicycle carrying capacity). Moreover, one should take into account the observed and unobserved (attitudes and perceptions) characteristics of the train user.

To the best of our knowledge, the choice between active and passive modes of transport to reach the railway stations has not been studied with reference to Italy, while it has been researched for countries like the Netherlands, Denmark, France, United Kingdom, United States, Canada and China. Frequently, the train-feeder mode choice has been studied with reference to urban mobility (access to transit\metro stations) or intercity rail mobility in large urban areas. The number of studies regarding extra-urban areas is more limited (Chan & Farber, 2019; Midenet et al., 2018). In our paper, since Italy is quite densely populated but lacks large metropolitan areas (apart from Rome and Milan), we collected information regarding all types of railways station: located in large, medium and small cities to be as representative as possible of the differing urban and station environments. During the period March–August 2020, we collected information from 185 train users living in a number of Italian Regions (Friuli Venezia Giulia, Emilia Romagna, Lombardy, Piedmont, Tuscany, Liguria, Lazio, and Campania). More than half of the train stations used by our respondents are located in cities smaller than 50 thousand inhabitants, while only 10% are located in cities larger than 200 thousand inhabitants.

From a technical point of view, we collected both revealed preference (RP) and stated preference (SP) data. Hence, we were able to estimate several models including: a RP multinomial logit (MNL) model, an SP MNL model, a joint RP-SP MNL model and a joint RP-SP mixed logit (MXL) model. We aimed at understanding the motivations of the respondents' current choices and the potential for switching to active mobility provided that suitable infrastructural, economic and policy measures are undertaken. Hence, the estimated models are used to estimate the impact of an increase in the time needed to reach the train station and an increase in the share of cycling lanes or pedestrian lanes on the respondents' utility and on their train feeder mode choice. The performed simulations lead us to conclude that there is some room for increasing active mobility among Italian train users but it is quite limited: a large part of the respondents appear to be car-captive for several reasons connected to time, cost, personal needs and, not last, the distance between the place of residence and the train station. Extending the network of cycling and pedestrian lanes or discouraging car use might provide some results, but more importantly what is needed is a coordinated effort at many levels, including territorial planning, infrastructural investment and traffic regulation. With specific regards to bicycle use, improving the bicycle-sheltering infrastructure at the train stations has been suggested by many respondents as well as the increase of the bicycle carrying capacity on the main commuting trains.

The paper is organized as follows. Section 2 presents a review of the literature on active train feeder modes. Section 3 describes the interview and the current train-feeder mode choices. Section 4 presents the econometric model, whilst Section 5 outlines the results of the estimation of the RP MNL, SP MNL, joint RP-SP MNL and MXL logit models. Section 6 illustrates the model application. Section 7 provides a discussion and draws some policy conclusions.

2. Related literature

The issue of how people get to the railway station has been studied by the Dutch transport economist Rietveld and colleagues, with reference to the Netherland, in a series of pioneering papers (Givoni & Rietveld, 2007; Keijer & Rietveld, 2000; Rietveld, 2000). Rietveld (2000) underlined that the market potential of railway services depends on the quality of the total chain from residence to place of activity. He also observed that in the Netherlands the flat nature of the country and an abundant cycling infrastructure are conducive to a high market potential. He estimated that at the home end the bicycle as an access mode might have a 35% modal share, less so at the activity end. Givoni and Rietveld (2007) examined how the availability of car affects the mode choice on journeys to the station in the Netherlands, finding that it does not play a decisive role. Secondly, they studied the impact of passengers' perception of the station and of the journey to the station on travelling by rail, finding that the quality of the station and the access/egress facilities have an important effect on the general perception of travelling by rail.

Another pioneering contribution was made by Wardman and Tyler (2000) on the effect of changes in accessibility to the rail network on the demand for inter-urban rail travel, a topic which was relatively little researched. They pointed out the importance of studying the choice set composition, distinguishing between travelers with different choice sets related to personal characteristics or factors specific to transport supply. More recently, several studies investigated the parallel issue of accessing the transit\metro stations.[1] Crowley et al. (2009) examined how variations in walking distance to rapid transit and auto ownership affect mode choice with reference to Toronto, Canada. They also investigated how temporal changes in the built environment associated with transit-oriented development in close proximity to rapid transit (subway) service encourage residents to use transit. Pan et al. (2010) discussed the challenges and opportunities for improving the bicycle–rail connection by using Shanghai as a case study, finding that the access and egress phase have a strong influence on the use of rail transit together with travel distance and cost. Cervero (2013) analyzed the possibility of converting park-and-ride trips to bike-and-ride trips. The study area includes several rail stations of the Bay Area Rapid Transit (BART) system of San Francisco, California. He found that on-site factors, such as the number of secure and protected bicycle parking racks, and off-site factors, such as the lineal miles of separated bike-paths and bike boulevards, explain growing use of bicycles for accessing rail stations. He concluded that the adage "build it and they will come" holds for bicycle improvements as much as for other forms of urban transportation infrastructure. Consequently, he argued that pro-active partnerships between transit agencies, local municipalities, and bicycle advocacy organizations are critical to promote active mobility to urban rail stations.

Chakour and Eluru (2014) developed one of the first modeling studies to investigate the role of socio-demographic variables, level-of-service parameters, trip characteristics, land-use and built environment factors, and station characteristics on commuter train user behavior. They tackle the research question of whether user choose first the station or the access mode with reference to the Montreal region, Canada. They found that individuals are more likely to select a station first as the distance from the station increases. Young persons, females, car owners, and individuals leaving before 7:30 a.m. have an increased propensity to drive to the commuter train station. Travel time has a significant negative impact on station choice, whereas, presence of parking and increased train frequency encourages use of the stations. Hochmair (2015) used responses from on-board travel surveys in three U.S. metropolitan areas to assess the median bicycle access distances to transit stations. He finds that they are within the buffer radii of 1 mile for local bus-only service hubs to 2 miles for regional train service hubs.

More recently, La Paix and Geurs (2015, 2016a, 2016b) and La Paix et al. (2020) developed an interesting series of studies on cycling to the railway station with reference to the Netherlands. La Paix and Geurs (2015) and La Paix et al. (2020) modelled both observed (distances greater than 3.6 km, trip purpose, travel time, car availability) and unobserved determinants (perception of connectivity, attitude towards station environment and perceived quality of bicycle facilities). To do so, in addition to a traditional binary logit model they used a hybrid choice

[1] For a comparison among alternative forms of public transport, see Tirachini et al. (2010).

model, including the train users' perception of connectivity, attitude towards station environment and perceived quality of bicycle facilities. They found that both attitudes and observable travel-related elements are important in the decision to cycle to a railway station. They concluded that important policies to promote cycling are the availability of parking facilities especially during rush hours and improvements in unguarded bicycle parking facilities. Moreover, they claimed that transport strategies encouraging bicycle-train use must be implemented by station type. La Paix and Geurs (2016b) studied railway station accessibility combining RP and SP data. As we will discuss more in depth in the methodological section, RP data are based on actual behavior and real world situations and have therefore been often used in the feeder modes literature. However, RP data do not allow testing the effect of improved service to access the train station. Furthermore, in the RP surveys variables such as cost and time are often correlated (Cherchi & Ortúzar, 2002). The SP data, on the contrary, take into account the hypothetical users' response to diverse attribute combinations that are not observed in the market, but suffer from the limitation that hypothetical scenarios might be unrealistic or inconsistent. The joint estimations of RP–SP data are advocated to overcome these issues, combining the properties of the two data sets (Bradley & Daly, 1997; Hensher, 1994).

Halldórsdóttir et al. (2017) made also use of joint RP and SP data. They collected information on both home-end and activity-end trips retrieved from the travel diaries collected through the survey managed by the Technical University of Denmark. Focusing on travelers who have chosen train as their main travel mode, they analyzed the choices between five transport modes (i.e., walk, bicycle, car driver, car passenger, bus). They found that bicycle parking (number of spaces, number of covered places, possibility to leave a bicycle during the night, etc.) plays a decisive role. They also claimed that not only travel time and trip characteristics, but also traveler characteristics, occupation, and purpose are relevant factors.

Ji et al. (2017) conducted a study on rail transit users near rail stations in Nanjing, China. They analyzed the choice among five feeder modes: car, bus, walk, private bike, and public bike. They found that female, older, and low-income rail commuters are less likely to use public bicycle to access rail transit. Rail commuters with bicycle theft experience and making school- or work-related trips are more likely to use public bicycle to access rail transit. Land use variables are largely insignificant in this study except that density shows a positive relationship with walking to rail transit. de Souza et al. (2017) modelled the potential for cycling in access trips to bus, train and metro in Rio de Janeiro. They found that the main barriers to cycling are personal constraints, living too close to the public transport boarding point, current parking conditions and public safety, while the main motivators are changing home location, owning a bicycle, implementation of cycle ways and improvement in parking conditions.

Midenet et al. (2018) is one of the few studies to focus on train stations in exurban areas. They studied the Val d'Amboise, a French exurban territory with good quality train services and room for growth for cycle access to the station. They found that under a bicycle-friendly scenario the car and the bicycle achieve similar modal shares, including a high level of pedelec (pedal electric cycle) use. They claimed that car parking access control at the station is a key factor to achieve such a modal shift. Chan and Farber (2019) observed that park-and-ride facilities at stations are at capacity and this may pose a limitation on future ridership growth. Active transportation with transit is thus increasingly being pursued as a strategy to boost alternative means to access transit services. Investigating the Greater Toronto and Hamilton Area (Canada), they found that population density, proportion of residential land, population age, low automobile ownership and median income are positively associated with the integration of active transportation and transit. On the contrary, the proportion of commercial/institutional land, street density, and the amount of car parking at stations are negatively associated with access by active transport.

To summarize, the reviewed studies have demonstrated that several factors play a role in determining the choice among alternative train feeder modes (Table 1). It is commonly recognized that access distance and travel time determine the catchment areas within which the active modes are possible. The threshold for walking is, of course, lower than that for cycling (about 3.6 km in the Netherlands; 1 to 2 miles in the US depending on the hub type), but the overall street network conditions are also important (e.g., less intersections increase the cycling speed). More generally, the quality of the built environment nearby transit\train stations have an influence on accessibility and on the train users' perception. Many papers have stressed the importance of the cycling infrastructure, the existence of separated bike-paths or bike boulevards and of the quality of the pedestrian paths. Almost all contributions have also underlined the importance of providing proper bicycle parking facilities at the train stations, including protected parking racks, covered places, and the possibility to leave the bicycle during the night. Midenet et al. (2018) have also pointed out the need to regulate and control car parking nearby the train stations. Finally, several studies have investigated the impact of the socio-economic characteristics of the decision maker (age, gender, occupation), of the trip purpose and assigned great importance to car ownership.

As it can be seen from Table 1, most of the studies were conducted with reference to large conurbations and almost half of them concerned mode choice to access\egress transit (metro) stations. A lower number of studies investigated the access to intercity train stations or train stations in exurban areas. None of the reviewed papers has been carried out in Italy. Building on the previous literature, we developed a study considering various types of railways stations located in large, medium and small Italian cities.

3. The interview and the current access trips

In order to reach the largest possible number of respondents we prepared an online questionnaire, developed via Google Form and posted on the Facebook pages of the commuter committees of a number of Italian regions, including Friuli Venezia Giulia, Emilia Romagna, Piedmont, Tuscany, Lombardy, Liguria Lazio, and Campania. We collected information from 185 respondents during the period March–August 2020. The questionnaire consisted into five webpages. The first webpage described the research project to the interviewee. The second and the third webpage collected information on:

- socio-demographics, such gender, age, place of residence, occupation (student or non-student), car ownership, driving license, ownership of a bike in the place of residence, ownership of an electric bike in the place of residence, frequency of bus runs able to take the respondent to the train station, distance between the place of residence and the railway station (in km), frequency of train use per week;
- current train feeder mode choice including car as a passenger, car as a driver, bus, walking cycling, scooter;
- train-feeder mode characteristics (travel time, travel cost, time to reach the station from the parking place, bus frequency);
- alternative available train-feeder mode choices, including car as a passenger, car as a driver, bus, walking cycling, scooter, with the respondent able to choose more than one option[2];
- existence of a bike-sharing system in the place of residence;
- existence of bicycle lane and pedestrian lane as a percentage of the total feeder trip.

[2] De Luca and Di Pace (2015) suggested that carsharing could be a complementary alternative to the transit system when the service is not guaranteed or efficient. We have not included it since it was not mentioned by our respondents.

Table 1
Summary of recent studies on train feeder modes.

Authors	Study area	Station type	Key factors
Rietveld (2000)	Netherlands	Intercity train	Cycling infrastructure, distance, supply of services to use the bike at the activity end
Wardman and Tyler (2000)	United Kingdom	Intercity train	Accessibility to the rail network
Givoni and Rietveld (2007)	Netherlands	Intercity train	Quality of the station, access/egress facilities, car availability does not matter
Crowley et al. (2009)	Toronto, Canada	Transit	Walk-access distances, built environment associated transit-oriented development, lifestyle
Pan et al. (2010)	Shanghai, China	Transit	Access/egress facilities, travel distance and cost
Cervero (2013)	BART system of San Francisco, California	Transit	Number of secure and protected bicycle parking racks, separated bike-paths and bike boulevards
Chakour and Eluru (2014)	Montreal region, Canada	Intercity train	Socio-demographic variables, levels-of-service parameters, trip characteristics, land-use and built environment factors, and station characteristics
Hochmair (2015)	3 U.S. metropolitan areas	Transit	Access distances to transit stations
La Paix and Geurs (2015, 2016a, 2016b)	Rotterdam – The Hague area, Netherlands	Local train	Observed (distances greater than 3.6 km, trip purpose, travel time, car availability) and unobserved determinants (perception of connectivity, attitude towards station environment and perceived quality of bicycle facilities)
Ji et al. (2017)	Nanjing, China	Transit	Female, older, and low-income rail commuters are less likely to use public bicycles
Halldórsdóttir et al. (2017)	Copenhagen; Denmark	Suburban train	Travel time, car ownership, bicycle parking (number of spaces, number of covered places, possibility to leave a bicycle during the night, etc.), traveler characteristics, occupation, and trip purpose, urban density affect walking
de Souza et al. (2017)	Rio de Janeiro, Brazil	Transit	Access distance, bicycle parking conditions
Midenet et al. (2018)	train stations in exurban areas in France	Intercity train	Car parking access control at the station
Chan and Farber (2019)	Greater Toronto and Hamilton Area, Canada	Transit	Population density, proportion of residential land, population age, low automobile ownership, median income

The fourth webpage asked the respondent to leave her/his contact details, i.e. email and phone number so we could customize the questionnaire and ask the interviewee under which conditions s/he would switched from the actual train feeder mode (i.e. the revealed preference) to the hypothetical ones (i.e. the stated preferences). The fifth webpage asked the respondent to provide further information on her/his access to the train station that the questionnaire did not address.

Table 2 reports selected descriptive statistics. The sample is almost balanced between men and women, distributed over all age groups but with a prevalence of younger respondents. More than half of respondents are students, while the remaining 48% are workers. 87% of respondents are commuters. The share of trips shorter than 2 km is limited (38%), the remaining involve much longer distances. Cycling lanes are to some extent available to 72% of the respondents but with various degrees. Only 9% states that the bicycle lane covers their entire trip. Pedestrian lanes have also differing degrees of availability: they are not available to 29% of the respondents, while 16% of respondents can make the entire trip using a pedestrian lane. Bike-sharing is available only to 28% of the respondents. The largest number of railway stations used by our respondents are in Emilia-Romagna and in Friuli Venezia Giulia, both with 27%, followed by Lombardy and Veneto, both with a 13%, whilst Tuscany, Campania and Piedmont are at the bottom of the frequency with a mere 1%. In terms of city size, almost half of the railway stations are located in cities with less than 50 thousand inhabitants. Only 10% are located in cities with more than 200 thousand inhabitants.

In Fig. 1 we represent the distance of the trip from home to the train station associated to the mode actually chosen as stated by the respondents. As expected, the active modes are the ones with the lowest average distances: on average equal to 1.3 km for walking and to 2.1 km for cycling. The maximum distance for walking is 3 km and 4 km for cycling, suggesting a catchment area of up to 4 km. It is interesting to note that all motorized modes are used also for quite short trips, suggesting an area of overlapping and substitutability between the motorized and the non-motorized ones. Beyond the catchment area, travelers are sometimes car-captive or they choose between the car and the bus. In only one case (a non-commuter), the scooter is used for quite a long distance.

Our findings compare with the literature as follows. For the access mode walking, it is well known that its share declines with distance (Crowley et al., 2009; Cervero, 2001) and it is lower for urban rapid transit than for railways. El-Geneidy et al. (2014) stated that in the public transit industry buffers at 400 meters around bus stops and 800 meters around rail stations are commonly used to identify the area from which most transit users access the system by foot. In their study for Montreal, Canada, El-Geneidy et al. (2014) found that the 85th

Table 2
Summary of sample statistics.

Gender: Males: 54%; Females: 46%.
Age: 19–24: 51%; 25–29: 3%; 30–34: 7%; 35–49: 11%; 40–44: 11%; 45–49: 4%; 50–54: 7%; 55–59: 2%; 60 or more: 3%.
Occupation: students: 52%; non-students: 48%.
Travelling habits: commuters: 87%; non-commuters: 13%.
Distance between the place of residence and the railway station: up to 1 km: 11%; 1–2 km: 27%; 2–3 km: 13%; 3–4 km: 14%; 4–5 km: 9%; 5–6 km: 5%; 6–7 km: 3%; 7–8 km: 1%; 8–10 km: 5%; more than 10 km: 13%.
Percentage of cycling lanes: 0%: 28%; 1–24%: 9%; 25–49%: 28%; 50–74%: 18%; 75–99%: 16%; 100%: 9%.
Percentage of pedestrian lanes: 0%: 29%; 1–24%: 9%; 25–49%: 20%; 50–74%: 18%; 75–99%: 8%; 100%: 16%.
Bike-sharing availability: Yes: 28%; No: 72%.
Distribution of railway stations per Region: Emilia-Romagna: 27%; Friuli Venezia Giulia: 27%; Lombardy: 13%; Veneto: 13%; Lazio: 9%; Liguria: 6%; Piedmont: 1%; Tuscany: 1%; Campania: 1%.
Distribution of railway stations per city size: less than 10 thousand inhabitants: 9%; 10–25 th. inhab.: 19%; 25–50 th. inhab.: 17%; 50–100 th. inhab.: 31%; 100–200 th. inhab.: 14%; more than 200 th. inhab.: 10%.

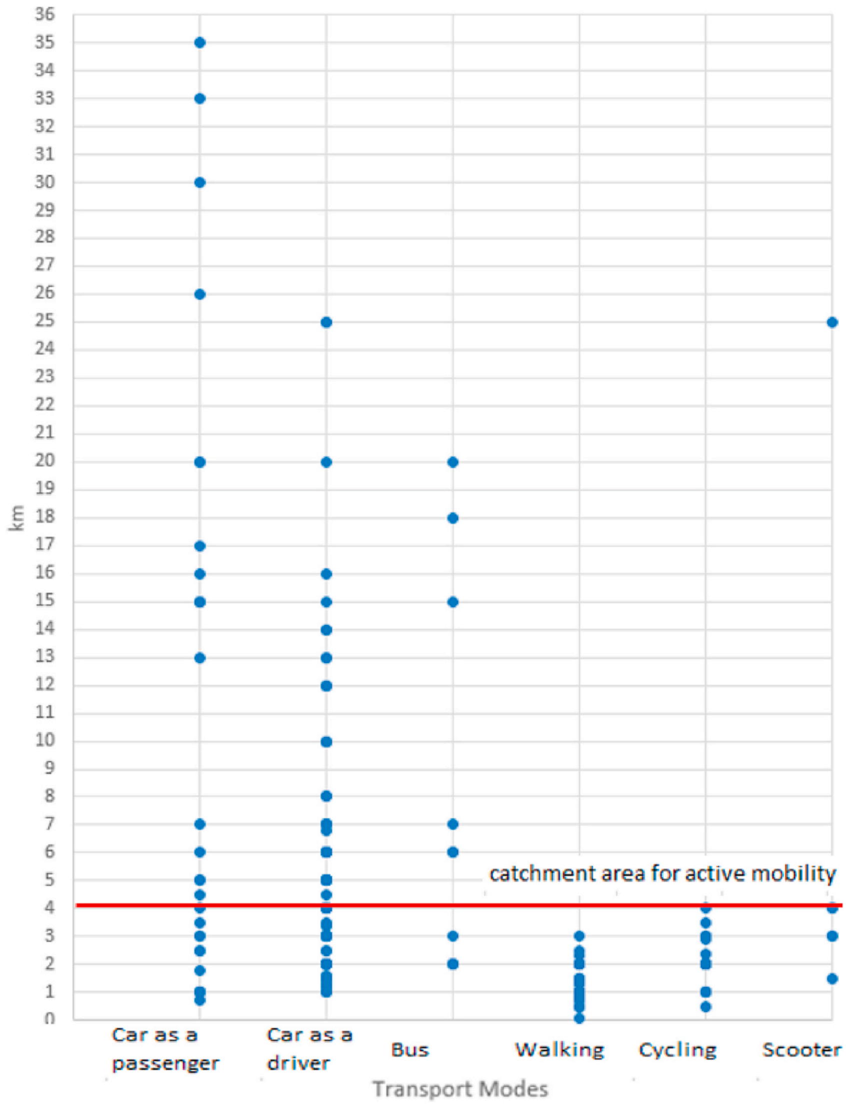

Fig. 1. Distance of the trip from home to the train station.

percentile walking distance to bus transit service is 524 meters for home-based trip origins, and 1,259 meters for home-based commuter rail trip origins. Hence, the catchment area for walking in our sample is relatively higher than that reported in the literature.

With regards to cycling, in their study on the Shanghai metropolitan area Pan et al. (2010) estimated a catchment area for bike-and-ride ranging from 800 to 1500 meters. For the case of subway commuters of both Seoul and Daejeon metropolitan cities in South Korea, Lee et al. (2016) estimated an average cycling distance of 1960 m. Martens (2004), reviewing cases in the Netherlands, Germany and the UK, found that metro stations have the most local orientation, with the vast majority of bike-and-ride users not cycling further than 2 km. The catchment area of bus stops is substantially larger: more than half of all the bike-and-bus users cycles more than 2 km to their bus stop, and about 20% cycles even more than 4 km. Train stations attract cyclists from the largest distance, with about two thirds of all bike-and-train users cycling more than 2 km to their train station. Hochmair (2015) estimates median values between 1 and 2 miles for three metropolitan areas (Los Angeles, Atlanta, Minneapolis and Saint Paul) in the United Stated. Hence, the catchment area for the cycling in our sample, considering the high share of small-to-medium sized cities in the sample, can be considered in line with the literature.

4. Modeling framework

The modeling framework draws from Bhat and Castelar (2002) and Lavasani et al. (2017). We separately estimated a multinomial logit model (MNL) for each data type j (RP or SP). The utility function for each proposed alternative i (car as a passenger, car as a driver, bus, walking, cycling and scooter) is described by Equation (1). It is assumed to be a linear function of the alternative specific constant ASC_{ij}, of the k alternative-specific attributes X_{ki}, and of the r socio-economic characteristics SE_{rq} of the respondents and an i.i.d. error term ε_{iqj} with extreme value type 1 distribution.

$$U_{iqj} = ASC_{ij} + \sum_k \beta_{kij} X_{ki} + \sum_r \phi_{rkj} X_{ki} SE_{rq} + \varepsilon_{iqj} \tag{1}$$

Then we merged the two datasets and we estimated a joint RP-SP MNL choice model. To this aim, we took into account that in pooled estimations the variance of the error term may differ according to the dataset type j. Indeed, the scale parameter λ_j is related to the inverse of the variance of the error term of each dataset, as shown in Equation (2):

$$\lambda_j = \frac{\pi^2}{6\sigma_j^2} \tag{2}$$

where σ_j^2 stands for the variance of the error term of each dataset and λ_j

has an extreme value type I distribution over the alternatives i of each dataset. For identification purposes, we normalized the scale parameter of the RP dataset to one and we specified the scale parameter for the SP dataset as described in Equation (3):

$$\lambda_{SP} = [(1-\delta)\lambda_{SP}] + \delta \tag{3}$$

where $\delta = 1$ for the RP data and 0 for the SP data. When the estimated scale parameter for SP data is smaller than 1, the variance of SP data is larger than the RP data, and vice versa.

Taking into account also the dataset-specific scale parameter λ_j, the utility function of the joint scaled MNL model can be described as in Equation (4):

$$U_{iqj} = \lambda_j ASC_i + \sum_k \lambda_j \beta_{ki} X_{ki} + \sum_r \lambda_j \phi_{rk} X_{ki} SE_{rq} + \varepsilon_{iqj} \tag{4}$$

Next, we allowed for random taste variation, unrestricted substitution patterns, and correlation in unobserved factors over time or individuals (Train, 2009). To this aim, we specified a mixed logit model (MXL) as described in Equation (5):

$$U_{iqj} = \lambda_j ASC_i + \sum_k \lambda_j \beta_{kiq} X_{ki} + \sum_r \lambda_j \phi_{rk} X_{ki} SE_{rq} + \varepsilon_{iqj} \tag{5}$$

where β_{kiq} is the coefficient of each attribute k of the alternative i for individual q. The value of each β_{kiq} varies over respondents according to a density function $f(\beta|\Delta)$, where Δ describes the parameter distribution (mean and covariance).

5. Results

Let us first discuss the actual and stated choices made by the respondents during the interview. Table 3 illustrates the actual choices made by the 185 respondents. The first row indicates the mode availability. "Car as a driver" is the most often available mode (103 out of 185) and the most frequently chosen (47%). When available, such a mode is chosen 84.5% of the times. "Car as a passenger" is available for less than half of the sample (mostly students). It is the chosen mode 16.2% of the times (44.1% when available). Overall, hence, car is the chosen mode 63.2% of the times. Among the remaining modes, the active modes walking and cycling are chosen 18.4% and 9.7% of the times, respectively, although their availability is much higher. For instance, the bicycle is available to 94 respondents but it is used only by 18 of them (9.7% of the times). The bus plays a minor role: although available to 82 respondents, it is chosen only by 10 of the respondents. Similarly, for the scooter.

Differently from the RP choices, the SP choices depend on the proposed hypothetical scenarios described in Section 3. Table 4 illustrates the choices made. The respondents confirmed their strong preference for car: "car as a driver" is the preferred mode 46.4% of the times (similarly to the RP choices) and "car as a passenger" 8.4% of the times (lower than the RP choices). The active modes slightly decrease their overall share (27% of the SP choices vs. 28.1% of the RP choices), with cycling increasing its appeal relative to walking. The number of people stating to choose the bus increases by almost 10 point, mostly at the expense of the "car as a passenger" mode.

Table 3
Overview of RP choices.

	Car as a passenger	Car as a driver	Bus	Walking	Cycling	Scooter
Times available	68	103	82	68	94	40
Times chosen	30	87	10	34	18	6
% chosen overall	16.2	47.0	5.4	18.4	9.7	3.2
% chosen when available	44.1	84.5	12.2	50.0	19.2	15.0

Table 4
Overview of SP choices.

	Car as a passenger	Car as a driver	Bus	Walking	Cycling	Scooter
Times available	358	1147	724	531	866	222
Times chosen	139	763	249	240	204	51
% chosen overall	8.4	46.4	15.1	14.6	12.4	3.1
% chosen when available	38.8	66.5	34.4	45.2	23.6	23.0

Next, we use the RP and SP data to estimate four, increasingly sophisticated discrete choice models: 1) an MNL model on RP data only, 2) a MNL model on SP data only, 3) a joint RP-SP MNL model using both RP and SP data and 4) a joint RP-SP MXL model, including socio-economic covariates. Table 4 reports the results.

Starting with the MNL model based on RP data, one can observe that, ceteris paribus "car as a driver" is preferred (as expected, given the above discussion) to "car as a passenger", while bus is less preferred. The alternative specific constant (ASC) of walking has also a positive and statistically significant sign, implying that this mode is preferred to the reference one (car as a passenger). The ASC of cycling and scooter are not statistically significant. Among the remaining tested variables, the only significant one is "active mobility travel time", indicating that the time needed to walk or cycle to the train station plays a negative role on the respondents mode choice. On the contrary, "motorized travel time" (i.e., the time spent using the motorized modes: car, bus or scooter) and travel cost are not statistically significant. Such a result is not uncommon with RP data because the data often lack the necessary variability to be able to statistically detect their impact in the choice decision process (Bhat & Castelar, 2002). This is one of the reasons that motivates the combination of RP and SP data, the latter providing the necessary variability for statistical analysis.

Turning to the second model illustrated in Table 5, the MNL model estimated with SP data only, the results change, reflecting the fact that under alternative scenarios the respondents might alter their current choice revealing their preference structure. As far as the ASCs are concerned, "car as a driver" and walking are still preferred (although less strongly) to "car as a passenger". The ASC of cycling and scooter have a negative and statistically significant sign, indicating that, ceteris paribus, they provide less utility than "car as a passenger". The ASC bus is weakly significant. Thanks to the higher SP data variability, some other variables carry a statistically significant sign. Both motorized and activity mobility travel time show the expected negative sign, the latter being higher than the former signaling that respondents attribute a larger disutility to the time spent for cycling or walking than to the time spent for being in the car, on the bus or riding a scooter. This finding is confirmed, when not further reinforced in the other model specifications. Our interpretation is that this result is related to four specific features of our research question: the trip to the station is performed out of necessity and not of pleasure; it takes place either early in the morning (going to work\school) or late in the afternoon\evening (returning from work\school); the surroundings of the train station are often unpleasant; and the traveler often carries a luggage that adds to the burden of the trip. The relative importance of this motivations would require a specific, in-depth research.

Furthermore, we have tested whether the percentage of walking and cycling lane in the home-to-train station trip plays a role in shaping the mode choice decisions. In the SP MNL specification, both variables play a role but only the latter has a statistically significant one.

Merging the two data sets (Joint RP-SP MNL) one obtains the joint

Table 5
RP MNL, SP MNL, joint RP-SP MNL and MXL models.

Variables *(omitted ASC: car as a passenger)*[a]	RP MNL		SP MNL		Joint RP-SP MNL		Joint RP-SP MXL	
	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.	Coeff.	S.E.
Mode attributes								
ASC car as a driver	1.691***	−0.389	0.923***	−0.131	1.522***	−0.267	4.868***	−1.073
ASC cycling	0.634	−0.657	−0.793***	−0.242	−0.821**	−0.346	−4.567***	−1.603
ASC scooter	−0.782	−0.579	−0.487**	−0.211	−0.833***	−0.317	−3.776***	−0.912
ASC bus	−1.599***	−0.563	0.278*	−0.154	0.051	−0.227	0.693	−0.894
S.D. of ASC bus							7.595***	−0.575
ASC walking	2.153**	−0.855	0.788***	−0.251	1.421***	−0.418	17.86***	−2.186
S.D. of ASC walking							−20.26***	−1
Motorized travel time	0.018	−0.03	−0.023***	−0.006	−0.026***	−0.009	−0.541***	−0.03
S.D. of Motorized travel time							−1.062***	−0.054
Active mobility travel time	−0.071**	−0.033	−0.039***	−0.008	−0.064***	−0.015	−2.268***	−0.028
S.D. of Active mobility travel time							0.706***	−0.039
Total travel cost	0.086	−0.151	−0.045	−0.034	−0.029	−0.049	−0.478***	−0.124
Infrastructural attributes								
Percentage of walking lane	0	−0.007	0.005*	−0.003	0.007*	−0.004	0.057***	−0.012
Percentage of cycling lane	0.004	−0.008	0.018***	−0.003	0.023***	−0.004	0.212***	−0.019
Socio-demographic interactions								
Active mobility travel time * Commuter							1.413***	−0.033
Active mobility travel time * Male							0.577***	−0.054
mu_SP					0.583***[b]	−0.091	0.742**[b]	−0.111
Number of inter-person draws							500	
Number of individuals	185		185		185		185	
Number of observations	185		1657		1842		1842	
LL (start)	−158.8		−1349.6		−1508.4		−1508.4	
LL (0)	−158.8		−1349.6		−1508.4		−1508.4	
LL (final, whole model)	−99.0		−1167.7		−1284.6		−782.3	
LL (RP)					−112.6		−126.9	
LL (SP)					−1172		−744.6	
Rho-square (0)	0.37		0.13		0.14		0.48	
Adj.Rho-square (0)	0.31		0.13		0.14		0.47	
AIC	218		2355		2591		1598	
BIC	250		2409		2652		1692	
Estimated parameters	10		10		11		17	
Iterations	18		18		27		73	

***, **, * indicate significance at 1%, 5% and 10% respectively.
Notes: [a]ASC is an acronym that stands for Alternative Specific Constant. [b] The p-value of the scale factor is computed with respect to a value of 1 and the reported stars indicate the corresponding level of significance.

preference structure underlying the respondents' train-feeder mode choice, taking advantage of the characteristics of both data sets. The results are similar to the SP ones in terms of signs and level of significance, while the absolute values reflect both the RP and SP data. As expected, the scale factor mu_SP is lower than one. Tested again the null hypothesis that it is equal to 1, leads to the conclusion that the variance of the SP data is much higher than that of the RP data. Although this result is reasonable, its extent signals that the two data sets underline quite different preference structures, meaning that the results of the joint RP-SP model should be interpreted with caution.

Finally, we tested whether there is preference heterogeneity in the model's parameters and which covariates might explain it. All parameters were assumed to be normally distributed with the standard deviation indicating the degree of heterogeneity. The available socio-demographic data were used as covariates. After testing several specifications, we found that the one reported in the last column of Table 5 best fits the data. As expected, the joint RP-SP MXL model, allowing for parameters distribution, improves over the joint RP-SP MNL model (the Adjusted Rho-square improves drastically as well as the AIC and BIC indicators). The results are in line with those provided by the joint RP-SP MNL but the absolute values of the coefficients are larger. Some of the parameters that were not previously statistically significant, gain significance and have the expected sign. This is the case of the "total travel cost" and of the "percentage of walking lane" parameters. The scale factor mu_SP tested against the null hypothesis that it is equal to 1 is less statistically significant, indicating a lower difference in the variance of the two datasets. As for the covariates, we find that commuters and men derive a lower disutility from the time spent cycling or walking to the train station.

On the basis of the results obtained with the joint RP-SP MXL model, we estimated the monetary value of the time spent travelling to reach the train station. We used the delta method since the number of individuals we interviewed is well above the threshold depicted by Gatta et al. (2015) to obtain robust estimates. According to our analysis, 5 min spent travelling by car, scooter or bus are valued €5.7, while 5 min cycling or walking are valued €8.9 and €23.7 by non-commuters and commuters, respectively. As a further robustness check, we also estimated the joint RP-SP MXL model in the willingness-to-pay space obtaining slightly lower results: € 4.8 if travelling by car, scooter or bus, and €11 and €19.4 if cycling or walking for non-commuters and for commuters, respectively.

6. Model application

In order to test the impact of policy changes on the choice of active mobility as feeder mode, we performed a simulation analysis on the basis of the estimated joint RP-SP MXL model under the following 3 scenarios:

- Scenario 1: 30% increase of the travel time by car.
- Scenario 2: 50% increase of the share of cycling lanes.
- Scenario 3: 50% increase of the share of pedestrian lanes.

Scenario 1 is motivated as follows. In our model, the variable travel time summarizes all components of the time needed to reach the vehicle (car or bus) from the residential location, the in-vehicle travel time, the time needed to search for a parking space (for car, scooter and bicycle drivers), the walking time from the vehicle (bus, car, scooter and bicycle) to the train station. All these time components were collected from the respondents in the face-to-face or on-line interviews. In Scenario 1, we assumed that in the case of car users, the total travel time increases by 30%. Several motivations are possible, but the one that is mostly related to our experiment is that the area outside the station becomes more bicycle-friendly and less car-friendly. A possible explanation is that finding a parking space near the train station might become more difficult (because of car access restrictions, reserved or toll parking areas, construction of sheltered cycling parking infrastructures in the vicinity of the station, etc.) so that car users might be required to walk longer distances to reach the station. On the basis of the information that car users have provided us, this might mean an increase in the travel time from the average value of 10 min to about 13 min.

The last two scenarios assume that city authorities drastically modify the existing road infrastructure extending the network of the cycling and pedestrian lanes to accommodate a larger use of active mobility. As a result, it would be possible for active mobility passengers to make use of the lanes during the train feeder trips for a 50% larger amount than that currently possible. Such an assumption is not unrealistic since it is currently taking place in many Italian cities as a consequence of the COVID-19 crisis and the associated fear to use public transport modes.

The two main effects of a 30% car travel time increase (Scenario 1) are: a 11.7% decrease in the predicted demand of RP model estimates for the use of the car as a passenger and a 48.8% increase in preference for the scooter (Fig. 2). In the SP framework the variations are smaller: car as a passenger decreases by 6.5%, whilst scooter use increases by 38.2%. A 50% increase in the share of cycling lanes (Scenario 2) results in a 27.2% increase in the RP-based predicted demand for cycling and a decline in the predicted demand for all transport modes by 2%–6%. The SP-based predictions confirm such results, slightly increasing the ranges. A 50% increase in the share of pedestrian lanes (Scenario 3) in the RP framework leads to a mere 3.5% increase in the predicted demand for walking, whilst the predicted demand for the remaining transport modes remains almost unchanged, with the largest drop (−2.7%) shown by cycling. The SP results confirm the RP ones.

The impact of such variations on the modal share is summarized in Table 6. The increase in the predicted demand for active train feeder

Table 6
Modal share variations.

	Base case		30% increase in car travel time		50% increase of the share of cycling lanes		50% increase of the share of pedestrian lanes	
	RP	SP	RP	SP	RP	SP	RP	SP
Car as a passenger	11%	8%	10%	7%	11%	8%	11%	8%
Car as a driver	37%	39%	36%	37%	35%	36%	36%	39%
Bus	15%	13%	15%	14%	14%	13%	15%	13%
Walking	22%	20%	22%	20%	21%	18%	23%	21%
Cycling	13%	18%	14%	19%	17%	24%	13%	18%
Scooter	2%	2%	3%	2%	2%	2%	2%	2%
Active modes	35%	38%	36%	39%	38%	42%	36%	39%

modes (i.e. cycling and walking) resulting from the assumed Scenarios is rather limited. In the base case scenario (no policies undertaken), active train feeder modes are estimated to be 35% and 38% depending on the model used (RP or SP). Walking is 22–20% and cycling 13–18%. Under the assumption of Scenario 1, active mobility increases by 1%, to 36–39%. In Scenario 2, its share increases to 38–42% and in Scenario 3 to 36–39%. The overall conclusion, hence, is that none of the policy assumed in the scenarios alters significantly the active mobility share. The 30% car travel time increase reduces only modestly the car modal share (by 1–2%), reflecting the fact the most respondents are car-captive. A 50% increase of the share of cycling lanes increases cycle use by 4%, but some of it (1–2%) comes at the expense of walking. The 50% increase of the share of pedestrian lanes would only modestly increase walking by 1%.

7. Discussion and policy implications

The transport mode used to reach a train station is an important determinant of the urban traffic (especially nearby railway stations) and rail transport attractiveness. In this paper, we have investigated train-feeder mode choice in Italy on the basis of face-to-face and on-line interviews to 185 Italian train users living in different Italian regions. We analyzed their current choice and their stated choices under

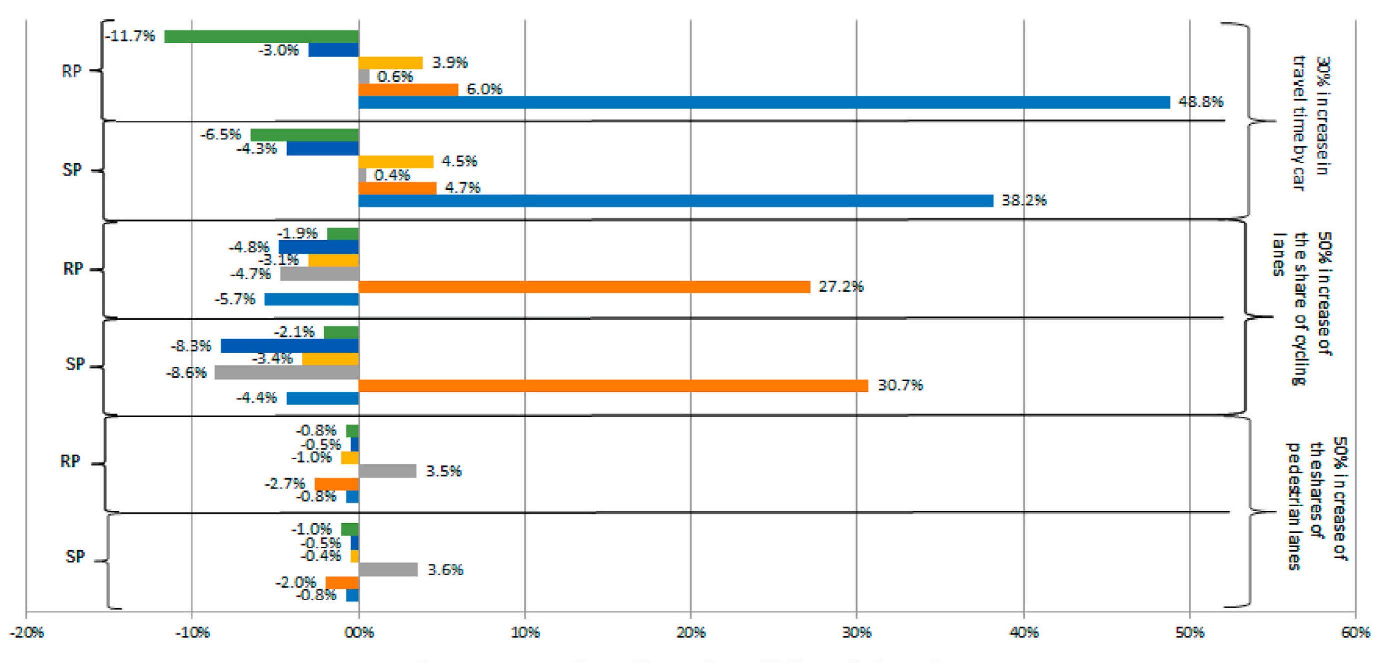

Fig. 2. Variation in the predicted demand.

hypothetical scenarios. Their current train-feeder mode choice is mainly car-based: 63.2% of the respondents use the car, as either drivers or passengers. The active modes cycling and walking are chosen by 18.4% and 9.7% of the respondents, respectively. Only, 5.4% use the bus and 3.2% the scooter.

Next, we have analyzed their mode choice determinants on the basis of four discrete choice model specifications: the RP MNL, the SP MNL, the joint RP-SP MNL, and the joint RP-SP MXL models. In line with previous studies (Bhat & Sardesai, 2006; Chakour & Eluru, 2014; Dissanayake & Morikawa, 2010; Givoni & Rietveld, 2007; Krygsman et al., 2004), our estimates confirm that travel time and travel cost play a relevant role. Two covariates, commuter and gender, explained the heterogeneity of the active mobility travel time variable. An interesting finding is that the sensitivity to travel time is higher for active modes than for motorized modes. More research is needed to understand such a finding. Our tentative interpretation is associated with the quality (surroundings, infrastructure, traffic regulation, safety) and time of the trip to the station.

Based on the estimated models, we have performed some scenario analysis. The main results is that it is extremely difficult to alter the train-feeder mode choice in favor active modes. A large part of the respondents appears to be car-captive. The econometric analysis confirms the comments made by the respondents during the interviews. Some of them claimed that the distance between their place of residence and the train station does not allow them to consider modes of transport other than the car. We find that the catchment area for the active modes is at most 1–2 km (see Table 2 and Fig. 1). Respondents who walk to the train station live on average 1.3 km (up to 3 km) from it. This result is higher than that reported in the previous literature (e.g. Cervero, 2001; Crowley et al., 2009; El-Geneidy et al., 2014). Respondents who cycle to the train station live on average 2.1 km (up to 4 km) from it, in line with the literature (Martens, 2004). Others have motivated their car choice with family-related duties (shopping on the way back, taking children to school, etc.).

Our findings raise the question of what policies could be used to increase the share of active mobility as a train-feeder mode choice. Cycling and walking are part of the selecting modes but increasing their share is problematic. Previous literature suggests the possibility of extending the network of the bicycle and pedestrian lanes. Cervero et al. (2013) found that doubling the bike infrastructure (lineal km) led to a 69% increase in the number of bicycle trips made to the San Francisco Bay Area Rapid Transit (BART) stations between 1998 and 2008. Midenet et al. (2018) argued that the enactment of proactive policies favoring cycling would lead to an increase from 10.1% to 37.9%. On the contrary, Weliwitiya et al. (2019) found that bicycle network density does not influence bicycle use to the railway stations of the city of Melbourne. Our model simulations for the Italian train users suggest positive but modest results. Informal discussion with the respondents confirm the need for more cycling and pedestrian lanes, although only in some cases they would cause a definite switching point. Interestingly, the recent COVID-19 pandemic has deeply affected transport choices. Some Italian cities (e.g., Milan) have taken this opportunity to extend drastically the cycling lane network. It is quite likely that the change made in the city transport infrastructure might increase the number of train commuters switching from motorized to active mode of transport.

Another obstacle to the use of the active modes is the provision of sheltered bicycle parking in the rail stations. As emphasized by Cervero et al. (2013), Jonkeren et al. (2019) and Weliwitiya et al. (2019), this is a crucial determinant of bicycle use. Both measures were discussed and deemed important by our respondents. Many underlined that Italian railway stations still lack adequate bicycle parking places. Only very few stations, and very recently, have developed ad hoc shelters for bicycles, either for free (e.g. Modena) or with a fee for the service if the area is surveilled (e.g. Padova, Pordenone, Vicenza). The Italian main train operator, Ferrovie dello Stato Spa, manages the railway infrastructure including the railway stations and the surrounding areas and buildings. Two companies are specifically in charge of managing, modernizing and using the railways station areas: Grandi stazioni (with regards to the main stations in the larger metropolitan areas) and FS Sistemi Urbani (with regards to all other stations). In the last decades, some of the stations are unmanned, and managed via telecommunications systems. Especially in the latter cases, there is an opportunity for unused buildings and areas to be restored and adapted to the needs of the cycle community.

A further measure to promote the active modes as train feeders is the expansion of cycle-carrying capacity of the trains (Bachand-Marleau, Larsen, & El-Geneidy, 2011; Krizek and Stonebraker 2010, 2011; Ravensbergen et al., 2018). The main Italian train operator, Trenitalia, allows for such possibility in various international, national or regional routes,[3] but the service is not widely used.

Promoting active mobility in Italy, hence, requires a coordinated effort at many levels, including territorial planning, infrastructural investment and traffic regulations. In fact, on the basis of the interviews carried out for this paper, we believe that the piecemeal active mobility policies so far enacted in the Italian cities have been insufficient to convince even young respondents (the absolute majority in our sample) to abandon the motorized modes of transport in favor of active ones as train feeder modes.

An interesting addition to the present investigation would be to include in the model latent variables such as attitudes, beliefs and perceptions on active mobility and healthy life styles, which, in combination with the revealed and stated choices, could provide a richer understanding of the process of choosing how to access\egress train stations.

CRediT authorship contribution statement

Marco Giansoldati: Data curation, Software, Writing - original draft, Project administration, Writing - review & editing. **Romeo Danielis:** Conceptualization, Methodology, Investigation, Supervision, Software, Writing - review & editing. **Lucia Rotaris:** Methodology, Investigation, Supervision, Software, Writing - review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

Financial assistance by Department of Economics, Business, Mathematics and Statistics of the University of Trieste is kindly acknowledged.

References

Bachand-Marleau, J., Larsen, J., & El-Geneidy, A. M. (2011). Much-anticipated marriage of cycling and transit: How will it work? *Transportation Research Record, 2247*(1), 109–117.

Banister, D. (2008). The sustainable mobility paradigm. *Transport Policy, 15*(2), 73–80.

Bhat, C. R., & Castelar, S. (2002). A unified mixed logit framework for modeling revealed and stated preferences: Formulation and application to congestion pricing analysis in

[3] Trenitalia regulation states that "… on all regional trains – even those not marked with a special pictogram – it is allowed the free transport of a folding bicycle, suitably closed, for each traveler, even outside the appropriate bag, provided that the dimensions do not exceed 120 × 80 × 45 cm, and that does not cause danger or inconvenience to other travelers …". Moreover, the regulation states that "On regional trains marked with a special pictogram, limited to the available seats, each traveler can carry a mounted bicycle, purchasing the bike supplement…" (https://www.trenitalia.com/it/offerte_e_servizi/in_treno_con_la_bici.htm).

the San Francisco Bay area. *Transportation Research Part B: Methodological, 36*(7), 593–616.
Bhat, C. R., & Sardesai, R. (2006). The impact of stop-making and travel time reliability on commute mode choice. *Transportation Research Part B: Methodological, 40*(9), 709–730.
Bradley, M. A., & Daly, A. J. (1997). Estimation of logit choice models using mixed stated- preference and revealed- preference information. In P. Stopher, & M. Lee-Gosselin (Eds.), *Understanding travel behaviour in an era of change*. Bingley: Emerald Group Publishing.
Button, K. J., & Rietveld, P. (1999). "Transport and the environment" chapters. In Jeroen C. J. M. van den Bergh (Ed.), *Handbook of environmental and resource economics, chapter 40*. Edward Elgar Publishing.
Cervero, R. (2013). *Transport infrastructure and the environment: Sustainable mobility and urbanism*. IURD, Institute of Urban and Regional Development, University of California.
Cervero, R., Caldwell, B., & Cuellar, J. (2013). Bike-and-ride: Build it and they will come. *Journal of Public Transportation, 16*(4), 5.
Cervero, R. (2001). Walk-and-ride: factors influencing pedestrian access to transit. *Journal of Public Transportation, 3*(4), 1.
Chakour, V., & Eluru, N. (2014). Analyzing commuter train user behavior: A decision framework for access mode and station choice. *Transportation, 41*(1), 211–228.
Chan, K., & Farber, S. (2019). *Factors underlying the connections between active transportation and public transit at commuter rail in the Greater Toronto and Hamilton Area*. Transportation.
Cherchi, E., & Ortúzar, J. (2002). Mixed RP/SP models incorporating interaction effects. *Transportation, 29*(4), 371–395.
Crowley, D. F., Shalaby, A. S., & Zarei, H. (2009). Access walking distance, transit use, and transit-oriented development in North York City Center, Toronto, Canada. *Transportation Research Record, 2110*(1), 96–105.
De Luca, S., & Di Pace, R. (2015). Modelling users' behaviour in inter-urban carsharing program: A stated preference approach. *Transportation Research Part A: Policy and Practice, 71*, 59–76.
Dissanayake, D., & Morikawa, T. (2010). Investigating household vehicle ownership, mode choice and trip sharing decisions using a combined revealed preference/stated preference nested logit model: Case study in Bangkok Metropolitan Region. *Journal of Transport Geography, 18*(3), 402–410.
El-Geneidy, A., Grimsrud, M., Wasfi, R., Tétreault, P., & Surprenant-Legault, J. (2014). New evidence on walking distances to transit stops: Identifying redundancies and gaps using variable service areas. *Transportation, 41*(1), 193–210.
Frei, C., Hyland, M., & Mahmassani, H. S. (2017). Flexing service schedules: Assessing the potential for demand-adaptive hybrid transit via a stated preference approach. *Transportation Research Part C: Emerging Technologies, 76*, 71–89.
Gatta, V., Marcucci, E., & Scaccia, L. (2015). On finite sample performance of confidence intervals methods for willingness to pay measures. *Transportation Research Part A: Policy and Practice, 82*, 169–192.
Givoni, M., & Rietvelt, P. (2007). The access journey to the railway station and its role in passengers' satisfaction with rail travel. *Transport Policy, 14*(5), 357–365.
Halldórsdóttir, K., Nielsen, O. A., & Prato, C. G. (2017). Home-end and activity-end preferences for access to and egress from train stations in the Copenhagen region. *International Journal of Sustainable Transportation, 11*(10), 776–786.
Hensher, D. A. (1994). Stated preference analysis of travel choices: The state of practice. *Transportation, 21*(2), 107–133.
Hochmair, H. H. (2015). Assessment of bicycle service areas around transit stations. *International Journal of Sustainable Transportation, 9*(1), 15–29.
ISFORT. (2019). *16° Rapporto sulla mobilità degli italiani*. Rome, Italy.
Ji, Y., Fan, Y., Ermagun, A., Cao, X., Wang, W., & Das, K. (2017). Public bicycle as a feeder mode to rail transit in China: The role of gender, age, income, trip purpose, and bicycle theft experience. *International Journal of Sustainable Transportation, 11*(4), 308–317.
Jonkeren, O., Kager, R., Harms, L., & te Brömmelstroet, M. (2019). *The bicycle-train travellers in The Netherlands: Personal profiles and travel choices*. Transportation.
Keijer, M. J. N., & Rietveld, P. (2000). How do people get to the railway station? The Dutch experience. *Transportation Planning and Technology, 23*(3), 215–235.
Krizek, K. J., & Stonebraker, E. W. (2010). Bicycling and transit: A marriage unrealized. *Transportation Research Record, 2144*(1), 161–167.
Krizek, K. J., & Stonebraker, E. W. (2011). Assessing options to enhance bicycle and transit integration. *Transportation Research Record, 2217*(1), 162–167.
Krygsman, S., Dijst, M., & Arentze, T. (2004). Multimodal public transport: An analysis of travel time elements and the interconnectivity ratio. *Transport Policy, 11*(3), 265–275.
La Paix, L., Cherchi, E., & Geurs, K. (2020). Role of perception of bicycle infrastructure on the choice of the bicycle as a train feeder mode. *International Journal of Sustainable Transportation*, 1–14.
La Paix, L., & Geurs, K. (2015). Modelling observed and unobserved factors in cycling to railway stations: Application to transit-oriented-developments in The Netherlands. *European Journal of Transport and Infrastructure Research, 15*(1).
La Paix, L., & Geurs, K. T. (2016a). Integration of unobserved effects in generalised transport access costs of cycling to railway stations. *European Journal of Transport and Infrastructure Research, 16*(2).
La Paix, L., & Geurs, K. T. (2016b). Train station access and train use: A joint stated and revealed preference choice modelling study. In *Accessibility, equity and efficiency*. Edward Elgar Publishing.
Lavasani, M., Hossan, M. S., Asgari, H., & Jin, X. (2017). Examining methodological issues on combined RP and SP data. *Transportation Research Procedia, 25*, 2330–2343.
Lee, J., Choi, K., & Leem, Y. (2016). Bicycle-based transit-oriented development as an alternative to overcome the criticisms of the conventional transit-oriented development. *International Journal of Sustainable Transportation, 10*(10), 975–984.
Martens, K. (2004). The bicycle as a feedering mode: Experiences from three European countries. *Transportation Research Part D: Transport and Environment, 9*(4), 281–294.
Metrolinx. (2018). *2041 regional transportation plan*. Toronto, ON. Retrieved from: http://www.metrolinx.com/en/regionalplanning/rtp/.
Midenet, S., Côme, E., & Papon, F. (2018). Modal shift potential of improvements in cycle access to exurban train stations. *Case Studies on Transport Policy, 6*(4), 743–752.
Pan, H., Shen, Q., & Xue, S. (2010). Intermodal transfer between bicycles and rail transit in Shanghai, China. *Transportation Research Record, 2144*(1), 181–188.
Ravensbergen, L., Buliung, R., Mendonca, M., & Garg, N. (2018). Biking to ride: Investigating the challenges and barriers of integrating cycling with regional rail transit. *Transportation Research Record, 2672*(8), 374–383.
Rietveld, P. (2000). The accessibility of railway stations: The role of the bicycle in The Netherlands. *Transportation Research Part D: Transport and Environment, 5*(1), 71–75.
de Souza, F., Puello, L. L. P., Brussel, M., Orrico, R., & Van Maarseveen, M. (2017). Modelling the potential for cycling in access trips to bus, train and metro in Rio de Janeiro. *Transportation Research Part D: Transport and Environment, 56*, 55–67.
Tirachini, A., Hensher, D. A., & Jara-Díaz, S. R. (2010). Comparing operator and users costs of light rail, heavy rail and bus rapid transit over a radial public transport network. *Research in Transportation Economics, 29*(1), 231–242.
Train, K. E. (2009). *Discrete choice methods with simulation*. Cambridge University Press.
Wardman, M., & Tyler, J. (2000). Rail network accessibility and the demand for inter-urban rail travel. *Transport Reviews, 20*(1), 3–24.
Weliwitiya, H., Rose, G., & Johnson, M. (2019). Bicycle train intermodality: Effects of demography, station characteristics and the built environment. *Journal of Transport Geography, 74*, 395–404.
Zheng, Z., Washington, S., Hyland, P., Sloan, K., & Liu, Y. (2016). Preference heterogeneity in mode choice based on a nationwide survey with a focus on urban rail. *Transportation Research Part A: Policy and Practice, 91*, 178–194.