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Users' preferences on bike-train intermodality: what can induce travelers to use this type of intermodal transport?

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Abstract

Making railway stations accessible to all kinds of cyclists to improve bike-train intermodality is a challenge that must be met. This challenge is part of the European Community' objectives set out in Agenda 2030, as the transition from the use of private vehicles to the use of bicycles contributes to reducing emissions to air. One of the reasons why bicycles are still underused is the lack of security of the infrastructure and the absence of essential services. That is why it is necessary to know what the most urgent interventions are. This study aims to determine the types of action needed to improve bicycle-train intermodality according to people's preferences. A survey was carried out on a sample of the Italian population who use bicycles, regardless of age or gender, to understand what would lead travelers to choose that type of intermodal travel. The research found that the bike-train intermodality is influenced above all by the risk of theft of bicycles inside the railway station, the possibility or not to carry the bicycle on the train, and finally enjoy an easy access to the train station by bicycle.

Keywords: Intermodality; survey; bike train preferences

1. Introduction

Transportation has a significant impact on air pollution. Between 1990 and 2021 transport emissions of ammonia (NH3) increased by 109% and nitrous oxide (N2O) increased by 28% (European Environment Agency, 2023). Road

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travel accounts for three-quarters of transport emissions, of which the 45.1% come from passenger vehicles (Ritchie, 2020). However, one of the solutions to reduce the impact of road passenger transport, is the upgrading of intermodality (Bennaya & Kilani, 2023). Intermodality is the combination of two or more means of transport to reach one destination (Laplace et al., 2005; Stoilova & Kunchev, 2017). In this case, bike-train intermodality refers to the intermodal transport involving the use of bike and train to reach a destination. The benefits of an integrated bike-train transportation system include the depletion of energy use as there is a reduction in motor vehicles replaced with bicycles (Belloni & Maggi, 2022). In addition, cycling has the potential to make railway transport more flexible as it is the most efficient means of driving the "last mile" (Oeschger, Carrol, & Caulfield, 2020). This characteristic certainly also increases the attractiveness of the trip (Pazzini, et al., 2022). Despite the potential advantages of a multimodal transportation system, research into user perspectives is limited. To date, research has found that a person's bike modal choice can be explained by different factors, but no research has been done on bike-train intermodal choice. Giansoldati et al. (2021) highlights that in Italy the primary mode of transport to reach the railway station is the private car. Bell (2019) defined general user needs at intermodal hubs without providing a specific focus on the different means of transport. Hansson et al. (2019) developed research to analyze passenger preferences on public transport services, however, without focusing on the possibility of bike-train intermodality. Heinen et al. (2013) developed a survey throughout the Netherlands to understand the work-related factors on bicycle commuting, excluding infrastructural factors. In studying bike-train intermodality, limited research has been done on the preferences of travelers, although it seems very likely that many factors affect the modal choice (Kager, Bertolini, Te Brömmelstroet, 2016; Zuo et al. 2020; van Kuijk et al, 2022). To address this gap, this paper examines the factors that can influence all types of travelers to choose a trip that involves the combined use of bicycle and train. The research methodology develops a widespread survey of the Italian population taken on voluntary adhesion. The survey investigates the general attitude of the respondent to cycle and undertake a bike-train intermodal journey. In particular, the last part of the survey asks all the respondents to identify themselves as an intermodal user of bike-train who first takes the bike on the train and then leaves the bicycle at the railway station. In summary, this survey tests a large number of people, regardless of the usual modal choices, on the preferences towards infrastructure and services dedicated to cyclability and bike-train intermodality. The results of preferences on cyclability show similarities between people who regularly use their bicycle and individuals who do not use it. The most important factor is the necessity to have low interaction with motorized vehicles, while the results of the bike-train intermodality preferences show that the most important characteristic in that case is the presence of bike parking spots. This paper shows how, through a survey, bike-train intermodality can be improved efficiently. The current study is a follow up investigation to an earlier analysis on accessibility of bicycles inside railway stations (Pazzini, et al., 2023). The paper identified five categories that had to be evaluated when quantifying accessibility: the quality of the cycle track, the visibility and signs of the cycle track, the services provided by the railway station, the bike deposit and the bike sharing service. This paper explores these topics in a more representative manner, with the point of view of the regular user and the non-user. The present work is the first step of the creation of an accessibility indicator that can be useful for policymakers and railway managers to help in the decision-making process. The survey-based indicator is more accurate than a hard-data based indicator (Claveria, Monte, & Torra, 2016; Lehmann, 2015). For instance, the number of people who travel intermodally, or that currently use bike deposits, and bike sharing, or the trend during the years of the use of these services, may not be significant to the study as the aim of the indicator is to improve the service based on the features (investigated through surveying) that would actually induce travelers to switch the modal choice to bike and train. In particular, the indicator will be weighted through the analysis of the survey results (Gan, et al., 2017). The paper is structured as follows. The second chapter includes the research design and process of data collection. The following chapter illustrates the results and finally there is the discussion.

2. Methodology

A sample survey was proposed to the Italian population, regardless of age, gender, race, disability, economic status and other diverse background. It was distributed online via email and LinkedIn. The survey was taken by 1125 people and was accessible online for a period of 1 month. The average investigation time was 10 minutes. The survey was pretested through 20 interviews to identify questions that respondents may have difficulty understanding or interpreting (Collins, 2003). Pazzini et al. (2023) defined a methodology to measure the accessibility of bicycles inside

railway stations. The research set out some indicators on a checklist that characterize bike-train intermodality. The survey was designed based on those indicators. The survey consists of a total of 21 questions and includes 9 multiple choice questions, 1 true or false question, 5 open questions and 6 questions in 5-points Likert scale questions.

The 21 questions can be identified in four parts:

- The first part concerns the socio-economic information of the user. Here the user is asked about gender, age, place of residence, level of education and profession.
- The second part of the survey goes in depth into the travel modes used to reach the workplace or school and deepens the reasons for each choice.
- The third part explores, first the propensity of the respondents to undertake a bike-train intermodal trip and then their propensity to use the bicycle as the daily modal choice.
- The fourth part investigates the preferences of the respondents when making a bike-train intermodal trip.

The third part consists of two different cases based on the attitude of the respondent to cycle. In case the respondent is not a regular cycler, a 5-points Likert scale question comes up to identify what characteristics would invert this habit (1- not increasing the propensity to cycle; 5- would increase propensity to cycle); in case the respondent regularly cycles, but does not feel confident while doing so, he/she is asked to answer a 5-points Likert scale question to identify the features that would give him/her more security (1- not increasing perception of safety; 5-would increase the perception of safety). The characteristics assessed in both cases are listed in Table 1.

Table 1. Part 3 Likert scale indicators in case the respondent does not use the bicycle as the first modal choice and in case the respondent cycles but does not feel safe.

		Respondent doesn't cycle (How would this feature increase your tendency to cycle?)	Respondent cycles but doesn't feel safe (How would this feature increase your perception of safety?)
1	Cycle paths protected with kerb	X	X
2	Direct and fast cycle paths even if they mean the use of a cycle lane	X	X
3	Safe, free parking spots	X	X
4	Bike sharing availability	X	
5	Good signs dedicated to cyclists	X	X
6	Presence of bike deposits	X	X
7	Low conflict with vehicular traffic	X	X
8	A better outfit (I do not use the bike because I have to be dressed in a specific way)	X	
9	Bike parking spots not overcrowded	X	
10	Availability of dressing rooms and showers at destination place	X	
11	A good cycle path lighting	X	X
12	Lower slope of the street	X	X
13	Closeness to points of interest	X	
14	Lower probability of theft	X	
15	Owning a low cost bike	X	
16	Reduced physical effort	X	
17	Lower air pollution	X	
18	Weather (warm, cold, rain)	X	
19	Cycle paths at raised level	X	X

The fourth part of the survey is made of four differentiated 5-points Likert scale questions, rating scales from 1 "less important" to 5 "most important", in which the respondent must assume he/she has to perform a bike-train intermodal trip. The topics identified for the four questions, specific to bike-train intermodality, are listed in Table 2. The questions proposed to the respondents are showed in the first line of Table 2. Indicators 13, 7 and 4 from Table 1 are also present in Part 4.

Table 2. Part 4 Likert scale indicators with relative questions

How important is the following characteristic of the cycle path that reaches the railway station?	How important is the presence of the following characteristic, or service, in the proximity of the railway station?	How important is the presence of the following characteristic, or service, assuming you are taking the bike on the train?	How important is the presence of the following characteristic, or service, assuming you are not taking the bike on the train?
13. Closeness (less than 75m) to the railway station	29. The lighting at the entrance of the railway station	34. Signs direct to lifts/ramps/ cycle paths	36. The visibility of bike racks entering/exiting the railway station
20. Direction of the cycle path	30. The absence of interference with pedestrians in the entrance of the railway station	35. The presence of ramps/lifts to reach platforms	37. The presence of bike racks
21. The absence of fixed obstacles	31. The absence of interference with vehicles in the entrance of the railway station		38. The possibility to tie up the bike frame and the wheel
22. The absence of interference with pedestrians	4. The presence of bike sharing		39. The distance of the bike deposit from the railway station
7. The absence of interference with vehicles	32. The presence of bike sharing without obligation to return in specific areas		40. The cost of the bike deposit
23. The maintenance of the cycle path	33. The presence of pumping column		41. The presence of services for the cyclist inside the bike deposit
24. The colouring of the cycle path compared to the external asphalt			42. The possibility to book in advance a slot inside the bike deposit
25. The presence of a one lane cycle path rather than two lanes two ways cycle path			43. The opening hours of the bike deposit
26. The absence of vehicles parked by the cycle path			44. The method to access the bike deposit
27. The absence of lateral conflict due to driveways			
28. The presence of signs dedicated to the points of interest			

3. Results

Among the 1125 submitted responses, a total of 1124 respondents logged usable responses on the core section of the survey (questions of part four). Of these, 44 (4%) did not specify the usual mode of transport; of these 39 (98.8%) were pensioners. Of the valid responses, among the people who specified the primary mode of transport, 465 (43.06%) reported the bicycle as their main travel mode to reach work (or school), 51 (4.72%) reported using the train, 145 (13.43%) reported using the train combined with another mode, where the “other mode” is the bicycle for 107 (9.5%) users. 81 (7.5%) walked, 2 (0.28%) used car sharing, 171 (15.83%) used their own car, 4 (0.28%) shared the car with another person, 19 (1.76%) used a motorbike, 28 (2.59%) used multiple means of transport (excluded train), 24 (2.22%) used the bus, 91 (8.3%) used different modes depending on the weather conditions.

3.1. Cycling preferences

Results from respondents are studied to define preferences on infrastructure dedicated to cycling and service for cyclists, by different types of bicycle users or non-users. Respondents who do not cycle are 15.9% with 55% male ratio. Among regular bicycle users (84.1%, with 63% male ratio) can be distinguished users who feel safe pedaling (15%, with 61.3% male ratio), and users who do not feel safe pedaling (85%, with 55% male ratio). Average (M) and standard deviation (SD) of characteristics from Table 1 are calculated and reported in Table 3 by non-cycler

respondents (which include people who never use the bicycle or use it only once or twice a month) and by regular cyclers who do not feel safe (which include people who use their bicycle every day or one to three times per week).

Table 3. Mean and Standard Deviation of infrastructural/service availability preferences based on regular cyclists who don't feel safe and non-cyclers.

		Respondent does not cycle		Respondent cycles but does not feel safe	
n.		M	SD	M	SD
1	Cycle paths protected with kerb	4.19	1.17	4.36	1.07
2	Direct and fast cycle paths even if they mean the use of a cycle lane	3.54	1.40	3.74	1.15
3	Safe, free parking spots	4.13	1.26	3.82	1.35
4	Bike sharing availability	2.89	1.50		
5	Good signs dedicated to cyclists	3.66	1.41	3.92	1.14
6	Presence of bike deposits	3.87	1.27	3.90	1.21
7	Low conflict with vehicular traffic	4.48	1.10	4.47	0.91
8	A better outfit (I do not use the bike because I have to be dressed in a specific way)	2.54	1.43		
9	Bike parking spots not overcrowded	2.96	1.40		
10	Availability of dressing rooms and showers at destination place	2.82	1.55		
11	A good cycle path lighting	4.12	1.19	4.09	1.07
12	Lower slope of the street	2.91	1.45	2.15	1.14
13	Closeness to points of interest	3.37	1.43		
14	Lower probability of theft	4.36	1.21		
15	Owning a low-cost bike	2.68	1.37		
16	Reduced physical effort	2.53	1.42		
17	Lower air pollution	3.69	1.42		
18	Weather (warm, cold, rain)	3.67	1.34		
19	Cycle paths at raised level	3.28	1.61	3.25	1.44

Results from respondents who do not cycle show that, the most significant factors to improve cycling is to have a low conflict with vehicular traffic (M=4.48 and SD=1.10), and a lower probability of theft (M=4.36 and SD=1.21). Closely related to traffic interference and the risk of theft are the presence of cycle paths protected with kerb (M=4.19; SD=1.17) and the availability of safe and free parking spots (M=4.13; SD=1.26). The characteristics that least affect the use of bike are a reduced physical effort (M=2.53; SD=1.42), the outfit of the cyclist (M=2.54; SD=1.43) and the possess of a low-cost bicycle (M=2.68; SD=1.37). Results from respondents who do not feel safe cycling show that the cardinal factor to improve in cyclability is the low conflict with vehicular traffic (M=4.47; SD=0.91), leading to the second major factor being the cycle paths protected with kerb (M=4.36; SD=1.07). Lighting of the cycle path is also one of the most important factors (M=4.09; SD=1.07). The least important elements that affect the improvement of safety for the cyclers who do not feel safe are the slope of the street (M=2.15; SD=1.14) and the cycle path at raised level (M=3.25; SD=1.44).

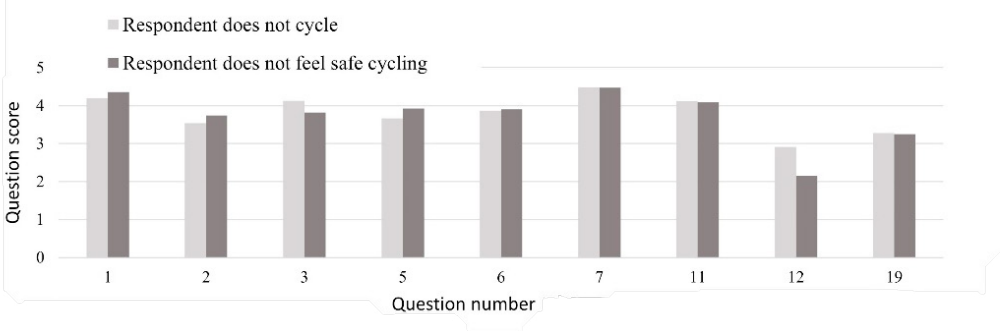

Fig. 1. Average preferences to improve cyclability

A comparison between users who regularly cycle and users who don't cycle (Fig.1) shows similarities among most of the infrastructural characteristics. The main discrepancies are shown in factors Question n.3 and Question n.12 with a difference of 0.31 and 0.76 between respondents who do not cycle and cyclists who do not feel safe. In general, the order of preferences for the results of the two groups is the same except for Question n.3 which stands in the sixth position for people who do not feel safe to pedal, against the third position for the people who do not cycle. In both cases, the highest importance is given to the low conflict with vehicular traffic (Question n.7), followed by cycle paths protected with kerb (Question n.1), and the least importance is given to a lower slope of the street (Question n.12). The trend of a higher SD for the least important factors in case of non-cycling respondents is not confirmed with the second type of respondents. The most significant example is shown by Question n.12 where the SD in a case is 1.45 and, in case the respondent is a cycler who does not feel safe, is 0.90.

3.2. Preferences regarding bike-train intermodality

Part 4 (Table 2) of the questionnaire, shows the characteristics of the infrastructure and services provided to users that are most important for an intermodal trip. The results shown in Fig. 2 represent the differences to the responses of the survey between people who make a bike-train intermodal trip every day or at least once a week (18% of total respondents, 70.6% males) and people who do not make intermodal travel but use their bike every day or at least once a week (63.1% of total respondents, 61.3% males).

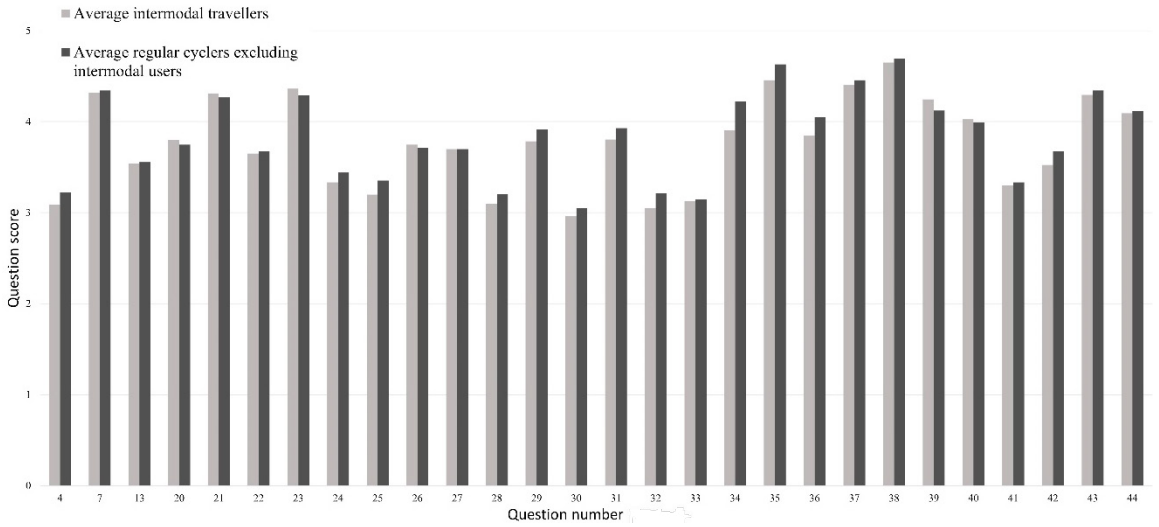

Fig. 2. Average preferences to improve bike-train intermodality

The main discrepancy is represented by indications for lifts/ramps/cycle paths (Question n. 34) with a mean of 4.22 (SD=1.00) for people who cycle and do not travel intermodally and an average of 3.91 (SD=1.12) for regular intermodal travelers. A difference of 0.20 between the two types of respondents is calculated for the visibility of bike racks entering/exiting the railway station (Question n. 36) that has an average of 4.05 (SD= 0.96) for non-intermodal travelers and 3.85 (SD=1.06) for intermodal travelers. The same average is obtained for the absence of lateral conflict due to driveways (Question n.27, M=3.70). Both types of users agree on the three most important characteristics that are: the possibility to tie up the bike frame and the wheel (Question n.38), the presence of ramps/lifts to reach platforms (Question n.35), and the presence of bike racks (Question n.37). Results also match on the least important factor that results to be the absence of interference with pedestrians at the entrance of the railway station (Question n.30). This characteristic is the only one that has average scores and importance below 3 (intermodal users, M=2.93; SD=1.17). In general, results from intermodal users show lower values than non-intermodal users.

4. Discussion and conclusion

This paper used a large-scale survey of people travelling using several different travel modes to compare five main areas of interest identified from an earlier work: quality of the cycle path, visibility and signs of the cycle path, services for cyclists, bike deposit and bike sharing. Different mode users were compared. Although different research has shown that private cars remain the most widely used mode of transport among Europe and in the Italian population, the survey may not be representative of the national population since the majority of respondents use the bike as the main modal choice (41.3%) (Gonzalo, Gomez, & Christidis, 2023; Gonzalo, Christidis, & Gomez, 2023; Sottile et al., 2021). The cause of this unbalance in the respondents may be due to the fact that who currently uses the bike is more inclined to respond to a survey that could possibly lead to improvements. The responses to the survey provided significant results. The results from users who do not usually cycle show a low SD, which increases for the factors that least affect the use of bicycles. This means that the factors that mostly affect cyclability are also the stronger ones compared to the other factors. The four most impacting factors to respondents who do not use a bicycle represent two main issues with their solutions. In fact, the low conflict with vehicular traffic (Table 3, question n.7), finds an acknowledgment into cycle tracks protected with kerbs (Table 3, question n.1). Similarly, the lower probability of theft (Table 3, question n.14) finds an acknowledgment in safe, free parking spots (Table 3, question n.3). The results also show that the choice of not using a bicycle is not affected by the physical effort (Table 3, question n.16), or by the availability of dressing rooms in the destination place. Question n.16 is however the feature with the highest SD (1.55). The comparison between people who cycle and don't feel safe, and people who do not cycle provides interesting results. For both types of respondents, the safety of the user expressed as a low interaction with vehicles, the type of protection and lighting of the cycle paths, are the factors that mostly influence the use of this mean of transport. Many studies have underlined the effect of some elements present in the route that discourage cyclists to choose this mode of transport. One of these are interceptions, sidewalks and different elements of infrastructure (Buehler & Dill, 2016; Aultman-Hall & F. Adams, 1998; Akar & Clifton, 2009). What links all these elements is the perception of safety. The responses on part four are deeply useful to induce all types of travelers to make an intermodal trip. This section finds most homogeneous responses with $0{,}73<SD<1{,}40$, compared to the third part of the survey which has $0{,}90<SD<1{,}60$. The characteristics with $SD<0{,}97$ for both cyclers and intermodal travelers are the possibility to tie the frame of the bike (question n.38), the presence of bike racks (n. 37), the maintenance of the cycle path (question n.23), the presence of ramps/lifts to reach platforms (question n.35), the distance of the bike deposit (question n.39), the time openings of bike deposit (question n.43). The reason for such a low SD is probably due to the fact that in this part of the survey all users are asked to put themselves at the same level, which could lead to unprecise results. In fact, here, the user expresses himself as someone who he may not be (Kalton & Schuman, 1982).

The strongest factor that is analyzed in both part three and part four is the interaction with vehicles which has the highest priority when analyzing cyclability for both cyclers who don't feel safe and non-cyclers ($M=4{,}48$). Acerra et al. (2023) demonstrated, through sperimentation, that cyclists give much attention to motorized vehicles on the road when riding. Also, they tend to drive through a less congested road when possible (Gardner, 1998). However, when asking specific questions on bike-train intermodality, the interaction with motorized vehicles is not considered as the priority, but gets behind the quality of the bike parking spots. This means that when undertaking a bike-train intermodal trip the priority is no longer the safety of the cyclist, but the one of the bicycles. The findings are of potential significance to policymakers and railway management systems. Policymakers could benefit in a number of ways from encouraging people to travel through the combination of bike and train: reduced pollution from private vehicles, reduced demand for parking, reduced commuting costs, healthier population. Railway management systems, meanwhile, could efficiently allocate resources, and encourage people to abandon the private vehicle in favor of the use of trains. Further research will investigate the specific needs of the population to encourage the use of train to develop bike- train intermodality so that the people who use the bike but do not yet use the train as a modal choice, will be facilitated to do so.

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