



EXPLORING THE FIRST AND LAST MILE CONNECTIONS FOR RAILWAY PASSENGER TRAVEL: EVIDENCE FROM ZAGREB

Ivan Balaš, Marjana Petrović, Martin Starčević, Denis Šipuš

University of Zagreb, Faculty of Transport and Traffic Sciences, Croatia

Abstract

Public transport, and railways in particular, often form the backbone of urban mobility. However, the effectiveness of railway systems depends heavily on the quality of first- and last-mile connections, which can significantly influence ridership levels. Limited or unreliable options for first- and last-mile connections can discourage public transport use, thereby increasing private car dependency and contributing to congestion and environmental pressures. Understanding passenger behavior in these travel segments is crucial for a high-quality, integrated, and multimodal transport system. This study examines the travel behavior of railway passengers in the city of Zagreb, focusing on how users access their origin station and continue their journey from the destination station. Using survey data collected from railway commuters in the wider Zagreb area, the analysis explores the relationship between the distance from home to the origin station and the selected mode of access, as well as the perceived importance of station features that support multimodal travel. The results show that most passengers reach their origin station on foot or in a private car, typically within 10 minutes. Most passengers are satisfied with public transport options in the Zagreb area, and similar results are observed for railway transport, with an average rating of good. Passengers also value a sufficient number of available parking spaces for private cars and good connections with other modes of transportation. The paper offers insights for enhancing multimodal accessibility and promoting more sustainable travel patterns to and from railway stations.

Keywords: railway transport, accessibility, multimodality, passenger behavior

1 Introduction

Public transport is important for moving people through the cities and is one of the most important alternatives to personal cars. Railway transport is usually the backbone of an urban transit system due to its ability to carry large numbers of people. Railway transport could be a safe, reliable, and affordable alternative to private cars, yet the researcher, along with local authorities, struggles to attract new riders and retain existing ones. Choosing the type and mode of transportation is a rather complex decision.

For many decades, researchers have been trying to understand what affects people's choices and how to incentivize them to choose more sustainable transport options. However, a universal approach to improving transportation modal share in today's cities has not been found. Many attributes can affect a potential user's decision-making process. Attributes related to transport systems, such as cost, journey duration, safety issues, environmental concerns, etc., can affect outcomes, with some even prevailing over others. The issue is that a specific attribute will not have the same or even a similar effect across different user types. Apart from transportation modes having certain characteristics, people also have their own characteristics, and the decision will be made based on both sides.

That decision depends on the specific context, and each city is creating its own by offering various mobility options.

Even though railway systems represent the backbone of sustainable urban mobility, their overall effectiveness depends not only on the quality of the transport service between stations but also on how the first- and last-mile segments are organized. The concept of first- and last-mile refers to the part of the journey between a passenger's actual origin or final destination and the nearest railway station. The quality of these segments influences overall travel time, comfort, and the perceived integration of the system, thereby affecting the decision to use railway transport. Importance is given to the station's access mode, parking availability, connections to other transport modes, and the passenger information system. In the context of developing an integrated, multimodal transport system, understanding these factors is an important prerequisite for increasing the attractiveness of railway transport.

The goal of this paper is to identify specific features of the first- and last-mile issues for existing railway users in the City of Zagreb. Once identified, those issues can be addressed, thereby increasing the attractiveness of railway transport. The rest of the paper is organized as follows. The introduction is followed by a literature review that covers contributions from other authors and researchers in this area. Section 3 explains the questionnaire design and methods for data collection and analysis. The focus of section 4 is on valid responses and the most important results, followed by the final sections, discussion and conclusion.

2 Literature review

The first- and last-mile transportation options have been the focus of many studies [1-7]. This is especially important in the case of railway transport since railway stations are not the final origins/destinations of the journey. Some authors claim that rail effectiveness is determined by the quality of passenger access to the station [3].

Public transport in general is multimodal. Users need to access/egress the public transport station using other modes of transportation, such as walking, cycling, a private car, or other public transport. The researchers are trying to figure out which incentives would motivate users to choose specific modes of transport and to what extent the characteristics of transport modes and user affect users' decision-making. The reasoning is rather complex; it depends on users' characteristics, transportation modes characteristics, and the contextual features. A study conducted in Japan found that students occasionally choose to walk to campus rather than take a bus to meet friends and colleagues who also walk [1]. More common reasons include journey time, trip length, cost, vehicle ownership, safety issues, income level, etc. [5, 8]. For example, in a study conducted in Shanghai, there is a clear connection between income level and chosen transport mode. Higher income is associated with a higher probability of choosing a private car and a lower probability of choosing public transport, such as buses or rail [9]. The built environment plays a significant role in access and egress modal share, with key factors including bike lanes, public transportation stops, and parking facilities [2]. The quality of access paths, along with the environment around the railway station, such as distance to platforms, parking, and connections to other public transport, significantly affects users' access and egress mode choice [10]. Sometimes users don't have an alternative when choosing a transportation mode, so the highest-ranking factor is the lack of an alternative, followed by convenience, as found in a study conducted in Ghana [7]. The users choose various modes to access/egress the station. It mainly depends on the available modes of transport, but characteristics are also important. Rail passengers primarily access stations by walking, bicycling, riding feeder transit, or driving (or being dropped off) [3]. A study conducted in Japan found that students usually walk or take the bus to campus. For the second-most-used option, the one that takes the bus, reported walking, and vice versa [1].

Another study from the Netherlands found that users choose walking, bicycling, and public transport to get to/from the railway station, and the availability of private cars doesn't strongly affect the choice of access mode [2]. The same study reported that access and egress parts of the journey differ in many things, including the transportation modes used. A study from the same country, but with different authors, confirmed the finding regarding access modes: bicycles were the most used and cars the least [5]. In Žilina, for example, only 20% of users use a bicycle as a regular mode of transportation to work [6].

A study conducted in Australia found that many railway agencies don't do much to measure and analyze access/egress mode data [3]. This is surprising since access plays a key role in attracting passengers and generating ridership. Zagreb is not different in that sense. Another study from Malaysia suggests that the influencing factor can be context-specific. The researchers conducted a t-test on the access/egress group of factors and found that only travel distance showed a significant impact, while more obvious factors, such as travel time and travel cost, did not [11]. In Zagreb, railway passenger transport lacks clear indications on barriers to be avoided and on the types of measures that would increase railway usage. For that reason, the authors believe that these results will help clarify the mentioned issues and be relevant to decision-makers.

Although previous studies have extensively examined access and egress behavior in different geographical and socio-economic contexts, empirical evidence from medium-sized Central and Eastern European cities remains limited. Moreover, while many studies focus primarily on modal shares or influencing factors, fewer combine behavioral patterns with a structured evaluation of station attributes through a gap analysis approach. By integrating users' access and egress modal choices with their perception of station performance and importance, this paper contributes to a more comprehensive understanding of first- and last-mile issues in the context of Zagreb. In doing so, it provides both empirical insights and practical implications for improving multimodal integration in railway transport systems.

3 Data and methodology

For this research, a questionnaire was developed and administered online. The aim of the questionnaire was to gain insights into the characteristics of railway transport users and non-users. The questionnaire consists of three parts. The first part is common to all respondents and includes general questions such as sex, age, trip purpose, rail usage frequency, and ratings of factors that affect public transport usage. In the seventh question, the survey is divided into two additional parts: one includes actual railway users, and the other includes people who do not use the railway in their everyday commutes. 56% of respondents stated that they never or rarely use railway transport, and 44% stated that they do. For railway users, the authors obtained OD data, access and egress modal shares, time required to reach the station, and the importance of various station attributes. The third and final part was meant for people who do not use the rail in their everyday commute. The questions were directed at the reasons behind this, and at potential measures that could change their mind. The focus of this paper is on the second part of the questionnaire.

The questionnaire was administered online and was active for several months. During that period, the authors employed mostly convenient sampling and the snowball sampling method to maximize the number of respondents. The authors aimed for the users and non-users of the Zagreb railway transit. The main reason for choosing Zagreb is obvious: the presence of rail-based urban transit, along with other transport options, provides a solid foundation for multimodal urban trips. The total number of valid responses was 402, but only those from actual railway users (44%) were included in this research.

4 Survey results

In this section, the features of the sample are presented, along with the reported passenger opinion about different elements and attributes of the railway transport.

4.1 Sample characteristics

The sample characteristics are shown in table 1. The results in table 1 describe all valid responses (402) received for the purpose of this study.

Table 1 Sample characteristics

Question	Possible answers	Results
Sex distribution		
	Male	55%
	Female	45%
Age distribution		
	≤24	27%
	25 - 64	69%
	≥65	4%
Transport user category		
	Employed	67%
	Pensioner	3%
	Student	27%
	Unemployed, tourists, and part-time employed	3%
Trip purpose		
	Education	19%
	Work	45%
	Personal needs	13%
	Entertainment	15%
	Visiting relatives/friends	5%
	Other	3%
Frequency of rail usage		
	Every working day	17%
	Several times a week	8%
	Once a week	2%
	Several times a month	17%
	Rarely or never	56%

4.2 Users' responses

The railway stops, and stations where the users start their trips are distributed along the Zagreb railway junctions. However, more than 50% of users ended their trip at Zagreb Main Station, followed by Trnava, which is the destination for most students because the student campus is nearby. Most users arrive at the station by walking (41%) and by private car (40%). The public transport options, such as buses and trams, are represented at 9% and 7%, respectively. For the two most dominant access modes majority of users are working people whose main trip purpose is going to work. Surprisingly, almost 21% of female users arrive at the station by private car, while almost 24% of male users walk to the railway station.

For egress modes, walking remains the dominant mode of transport at 59%. The second most represented category is public transport, which is not surprising, since the destination station is in the city center and connected to other public transport options. However, almost 30% of users stated they use public transport, but the timetables are not coordinated. Only 9% of the users' state that they use public transport and the timetables are coordinated. This indicates that timetable coordination among different modes of public transport is more coincidental than the result of careful transport planning. For access time, most users require 6 to 10 minutes to get from home to the stations. For the two most dominant access modes (walking and private car), people usually need 6 to 10 minutes, followed by the categories 2 to 5 minutes and 11 to 20 minutes. For the 3 most dominant access time categories, most users are employed, male, and the primary trip purpose is going to work.

To address various station attributes, the authors sought insights into how important these attributes are to passengers and the status of these attributes at their departure stops and stations. The attributes in question are listed in table 2. along with the results of a gap analysis. The authors compared perceived importance and actual performance for the station attributes. The perceived importance and actual performance of station attributes were measured through two separate questions. In the first question, passengers were asked to indicate how important specific station attributes are to them. Their responses were recorded using a Likert scale from 1 ("not important") to 5 ("very important"), representing the perceived importance of each attribute. In the second question, passengers were asked to evaluate the same station attributes at their departure station, thereby assessing the actual performance of those attributes. For example, passengers were asked to rate their level of agreement with statements such as: "Please rate the extent to which you agree with the following statement regarding your departure station or stop: "It has a quality passenger information system." Responses were again collected using a Likert scale, where 1 corresponds to "I strongly disagree" and 5 to "I strongly agree." The problem is that all attributes have negative gap values, indicating that passengers are dissatisfied with them. The biggest discrepancy is -1.55 for the attribute passenger information system, indicating that the passenger rate for that attribute is considered highly important, but the actual situation at the stations is not in line with that. The second-largest discrepancy is in connections with other transport modes, indicating a need to improve multimodality at railway stations. The smallest gap is for the places where users could safely leave their bikes. Given the small number of users who arrive by bike, this is not surprising.

Table 2 Mean importance and mean performance scores for station attributes

Attribute	Mean value (the real situation)	Mean value (perceived importance)	Gap
Station cleanness	3.18	3.92	-0.74
Parking spaces	2.69	3.48	-0.80
Bike racks	2.44	3.06	-0.62
Accessibility for PRM	2.69	3.44	-0.75
Passenger information system	2.53	4.08	-1.55
Connection with other transport modes	3.15	4.07	-0.92
Sufficient covered spaces	3.09	3.95	-0.86
Additional services	2.71	3.38	-0.66

The attribute describing whether stations are neat and clean is more important to females, but when asked to rate their station, most marked 3 on the Likert scale. Regarding the number of parking spaces, the current situation is not satisfactory. Both males and females chose grades 1, 2, or 3, indicating that many users can't leave their car near the station. However, that attribute is perceived as important by users and is a step toward attracting personal car users to more sustainable public transport options. Another useful analysis for decision-makers is shown in table 3. The table shows how passengers actually rate their departure station according to previously defined attributes. From table 3, it is possible to see which stops and stations require improvement and which attributes should be prioritized.

Table 3 Average attribute rating per stops/stations

Stop/Station	Čulinec	Dugo Selo	Gajnice	Kustošija	Maksimir	Podsused	Remetinec	Savski Marof	Sesvete	Sesv. Kraljevec	Vrapče	Zagreb GK	Zagreb ZK	Zaprešić
Number of respondents	6	8	8	5	6	27	6	5	9	5	10	24	6	6
1. Station cleanness	2.83	2.63	3.63	2.80	3.00	3.30	3.17	2.60	4.11	3.20	3.30	3.17	3.17	4.50
2. Parking spaces	1.67	2.00	1.88	2.20	3.00	3.37	2.00	3.20	3.44	3.20	2.70	2.50	1.83	3.33
3. Bike racks	1.83	1.75	1.63	1.80	2.67	2.41	2.00	2.40	3.00	3.00	3.20	2.29	2.17	3.33
4. Accessibility for PRM	2.17	2.00	3.13	2.40	2.83	2.63	2.67	2.20	3.33	3.00	3.40	2.42	1.50	4.00
5. Passenger information system	2.00	2.50	2.25	2.00	2.33	2.41	1.83	2.60	3.22	2.00	2.50	3.17	2.83	4.00
6. Connection with other transport	2.83	2.13	3.38	2.00	3.00	3.67	3.33	2.40	4.44	1.80	3.80	3.71	2.83	4.00
7. Sufficient covered spaces	3.50	2.13	4.25	1.80	3.33	2.63	2.83	2.60	2.67	2.80	4.20	3.67	4.50	3.33
8. Additional services	2.00	2.25	2.25	1.60	3.50	3.22	3.00	1.60	4.22	1.40	2.20	3.42	3.00	3.17

For the last question, passengers are asked to rate the departing stops/stations. 38% of respondents reported a good rating, followed by 25% for very good and 24% for sufficient.

5 Discussion

The findings of this study can be interpreted within the broader theoretical framework of multimodal integration and perceived service quality. The results confirm that access and egress segments play a decisive role in shaping overall user satisfaction and system attractiveness. In line with previous research, physical accessibility, the availability of complementary infrastructure, and information provision emerge as critical factors influencing passengers' perceptions of railway transport quality. The consistently negative gap values indicate that perceived importance systematically exceeds actual performance, suggesting structural shortcomings in integrating railway services with other transport modes.

HAKOM, the national regulatory agency, is conducting surveys on passenger satisfaction with the railway transport in Croatia. The data we obtain for the City of Zagreb differ in certain areas from the reports HAKOM publishes. For example, modal share for the access part of the journey is similar for walking, but it differs for public transport and private cars. In the HAKOM report, users were not asked about the information system itself, but they did report that 70% of passengers are not satisfied with pre-trip and trip information [12]. This is also in line with another survey conducted in Zagreb, which found that passengers reported shortcomings in the passenger information system, especially during delays [13].

Another connection to the HAKOM report concerns the station's cleanliness, for which passengers reported that it looks neglected and that they don't feel safe near it. The gap analysis that we conducted shows dissatisfaction with that aspect of the railway stations.

The main improvements from this research are outlined in the gap analysis (table 2). All attributes show negative gap values, indicating they all need improvement. The largest discrepancy between the attribute's importance and its actual state is in the passenger information system. The shortcomings of the information system are outlined in other studies, so this is not surprising. Another attribute that requires attention is better integration with other transport modes, especially in timetable coordination. Table 3 is especially helpful for decision-makers, as it clearly shows which station needs improvement and which attributes should be prioritized.

There is significant potential to attract private car users to railway transport, as 40% of respondents reported using a private car to reach the station. The issue is that they also report an insufficient number of parking spaces available. Based on this, the railway operator could benefit from introducing a P&R system, thereby increasing the number of potential passengers. To increase the number of potential passengers, it is also possible to introduce places where users can safely leave their bicycles, thereby attracting people seeking sustainable transport modes but not sufficiently incentivized.

6 Conclusion

The goal of this study was to explore first- and last-mile issues faced by passengers using railway transport in their daily commutes in the City of Zagreb. Zagreb is chosen because its public transport offers railway, tram, and bus services, along with various private and shared options, making it a good starting point for multimodality. For this research, a questionnaire was developed, and the results indicate that the majority of railway users walk and use private cars to reach railway stops and stations. Access time ranges from 2 to 20 minutes, but most users require 6 to 10 minutes to reach the station. The significant contribution lies in the gap analysis, which identifies which station attributes require improvement. For railway stops and stations in Zagreb, the priority should be improving the passenger information system, followed by better connections with other transport modes and increasing comfort in the station area (covered spaces). A railway operator would benefit from implementing Park-and-Ride (P&R) and Bike-and-Ride (B&R) systems, together with additional measures consistent with an integrated passenger transport system.

Despite the valuable insights obtained, this research has certain limitations. The results are based on self-reported data and a non-probability sample, which may affect generalizability. Future research could include larger representative samples, apply inferential statistical methods to test the significance of observed relationships, and developing predictive models of access mode choice. Additionally, comparative studies with other cities could provide a broader understanding of first- and last-mile dynamics in different urban contexts.

References

- [1] Nobuhiro, S.: Activity-end access/egress modal choices between stations and campuses located on a hillside, *Research in Transportation Economics*, 83 (2020)
- [2] Givoni, M., Rietveld, P.: The access journey to the railway station and its role in passengers' satisfaction with rail travel, *Transport Policy* 14 (2007), pp. 357–365
- [3] Semler, C., Hale, C.: Rail Station Access – an assessment of options, 33rd Australasian Transport Research Forum Conference, 2010.
- [4] Yang, H., Feng, J., Dijst, M., Ettema, D.: Mode choice in access and egress stages of high-speed railway travelers in China, *The Journal of Transport and Land Use*, 12 (2019) 1, pp 701-721
- [5] Waerden, P., Waerden, J.: The Relation between Train Access Mode Attributes and Travelers' Transport Mode-Choice Decisions in the Context of Medium- and Long-Distance Trips in the Netherlands, *Transportation Research Board*, 2672 (2018) 6, DOI: 10.1177/0361198118801346
- [6] Kalašová, A., Čulík, K., Poliak, M.: The Importance of Connecting the First/Last Mile to Public Transport, *Communications*, 24 (2022) 2, DOI: 10.26552/com.C.2022.2.A66-A78
- [7] Sogbe, E., Susilawati, S., Currie, G., Pin Tan, C.: Exploring factors influencing first-mile and last-mile connections to public transport from car users' perspective: Evidence from Greater Accra, Ghana, *Journal of Transport Geography*, 126 (2025), DOI: <https://doi.org/10.1016/j.jtrangeo.2025.104240>
- [8] Venter, C.: Measuring the quality of the first/last mile connection to public transport, *Research in Transportation Economics*, 83 (2020), DOI: <https://doi.org/10.1016/j.retrec.2020.100949>
- [9] Le, J., Teng, J.: Understanding Influencing Factors of Travel Mode Choice in Urban-Suburban Travel: A Case Study in Shanghai, *Urban Rail Transit*, 9 (2023), pp 127–146, DOI: <https://doi.org/10.1007/s40864-023-00190-5>
- [10] Irawan, M.Z., Putri, M.K., Belgiawan, P.F., Dwitasari, R.: Analyzing Commuters' Behavior on Egress Trip from Railway Stations in Yogyakarta, Indonesia, *The Open Transportation Journal*, 11 (2017) 1, DOI: 10.2174/1874447801711010053
- [11] Sukor, A., Jarani, N., Fisal, M.: Analysis Of Passengers' Access And Egress Characteristics to the Train Station, *Engineering Heritage Journal*, Zibeline International Publishing, 1 (2017) 2, pp. 1-4
- [12] HAKOM, Analiza savjetovanja s predstavnicima korisnika usluga željezničkog prijevoza putnika, 2025., https://www.hakom.hr/UserDocsImages/2025/zeljeznica/S%C5%BDU-AN-INTS-analiza%20savjetovanja_putnicki-2025_02_25_V_1.2.pdf?vel=1052417
- [13] Beljak, M., Petrović, M., Živičnjak, M., Starčević, M.: Identification of passenger interests for passenger-oriented rescheduling during disturbances in Croatia, *TRANSCODE 2025*, Zagreb, Croatia, 11-12 December 2025.