Improving Communication Procedures to Foster Rail Cross-Border Accessibility: A Survey on Connections Between Italy and Slovenia

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Abstract. Border regions often introduce accessibility asymmetries that limit citizens' ability to access work and education opportunities. In this context, improving cross-border connections is not merely a logistical need, but a fundamental prerequisite for ensuring equality and inclusivity.

The study analyses cross-border accessibility through a survey conducted in Italy, with reference to its border with Slovenia. The survey explored two complementary dimensions. First, the perceived quality of local public transport, both via road and rail, in relation to daily commuting. Second, the perception of accessibility to cross-border connections with Slovenia.

The results reveal an overall satisfactory perception of local public transport services but, at the same time, cross-border connections with Slovenia are perceived as poorly accessible. Also, even in the event of service improvements, the propensity of respondents to use such connections remains moderate. This may suggest the presence of barriers beyond the mere characteristics of the offer, including limited familiarity with existing connections and consolidated mobility habits.

The study falls into the impact evaluation of a digital translation tool considered in the European project T4Rail (Translate for Rail) IT-SI, which aims at fostering cross-border railway services by facilitating communication procedures at the border between Italy and Slovenia. Notably, the importance attributed by respondents to travel time reduction as a driver to shift towards railway cross-border connections reinforces the relevance of the T4Rail tool. Future developments of the study consider the employment of econometric analyses to capture the relationship among the examined variables, in support of the elaboration of incentive policies.

Keywords: Cross-border connections · Accessibility survey · Digital communication tool

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1 Introduction

Cross-border transport connectivity is essential for territorial integration and equal access to opportunities for proximity territories. However, many border regions in the European Union (EU) still have fragmented and poorly coordinated transport systems (Medeiros, 2019). Instead of functioning as integrated mobility corridors, borders often act as barriers, exacerbating spatial inequalities and hindering the realisation of European integration objectives (Decoville and Durand, 2018; Wiesböck et al., 2016).

Yet infrastructure provision alone cannot guarantee effective mobility. Even where physical connections exist, cross-border transport remains underutilised when services are infrequent, poorly integrated, or simply unknown to potential users, leaving the mobility potential inherent in geographical proximity largely untapped (Medeiros et al., 2021; Svensson and Balogh, 2018). Moreover, especially for railway transport, additional barriers to seamless cross-border transport systems can be related to a lack of interoperability according to different aspects, which range from organizational and technological disparities to normative and language constraints (Walker et al., 2009). The consequences of all these issues extend beyond mere inconvenience. Indeed, limited cross-border accessibility restricts residents' ability to pursue educational and professional opportunities available across the border, thereby constraining individual development and reinforcing spatial inequalities (Edzes et al., 2022).

Addressing this gap is particularly urgent within the EU, where seamless cross-border mobility is a core objective of both transport and cohesion policy, most notably embodied in the Trans-European Transport Network (TEN-T) (Christodoulou and Christidis, 2019; Medeiros, 2019). Bridging the gap between infrastructure availability and actual accessibility is therefore not merely a logistical challenge, but a fundamental prerequisite for territorial equality and inclusive regional development.

The Friuli-Venezia Giulia (FVG) region in north-eastern Italy offers a compelling case study of these dynamics. Strategically positioned at the intersection of three TEN-T corridors and bordering both Austria to the north and Slovenia to the east, FVG is a frontier region where the integration of national transport systems for both freight and passenger mobility remains an open challenge.

Building on these considerations, the present study was developed. Through a survey administered to a sample living within the FVG region ($n = 397$), the study explores two complementary dimensions. Firstly, it examines the perceived quality of local public transport by road and rail in relation to daily commuting patterns. Secondly, it examines the perceived accessibility of cross-border connections with Slovenia.

This study was conducted as part of the activities considered in the European project called T4Rail (Translate for Rail) IT-SI. The project aims to promote cross-border rail services by streamlining communication procedures at the Italy–Slovenia border using a dedicated digital translation tool. This latter consists of an application to automatically translate a set of predefined messages related to railway operations, contributing to reduce the duration of train stops at the border station and thus to increase the attractiveness of the rail mode. Indeed, shorter idle times at the Italian-Slovenian border would potentially improve railway service quality, enhancing accessibility and thus fostering territorial cohesion between the two countries. A discussion on the challenges and opportunities arising from technological improvements in cross-border rail transport is provided in

(Sinatra et al., 2026), with respect to operational, economic, environmental, employment and territorial aspects. In such a context, the performed study focuses on evaluating the broader societal impact of the T4Rail project, complementing the analysis carried out at the mentioned levels of investigation. To the best of author's knowledge, no comparable study has been previously conducted in the region.

The study therefore aims to provide a comprehensive picture of transport accessibility in the FVG region, with a particular focus on local public transport mobility and on cross-border rail connections between Italy and Slovenia.

The paper is organized as follows. Section 2 describes the methodology adopted for data collection and the characteristics of the sample. Section 3 presents and discusses the results. Section 4 offers concluding remarks and policy implications.

2 Methodology

As mentioned, the FVG region is located in north-eastern Italy, in a strategic position for freight and passengers flows towards both central-eastern Europe and the Mediterranean basin, thanks to the major ports situated within its territory. FVG is also located at the intersection of three TEN-T Corridors, i.e., the Baltic-Adriatic Corridor, the Mediterranean Corridor, and the newly introduced Western Balkans-Eastern Mediterranean Corridor (Fig. 1). In this context, the railway sector plays a key role by supporting cross-border freight and passenger transport – particularly with Austria and Slovenia – while also representing a significant source of regional employment.

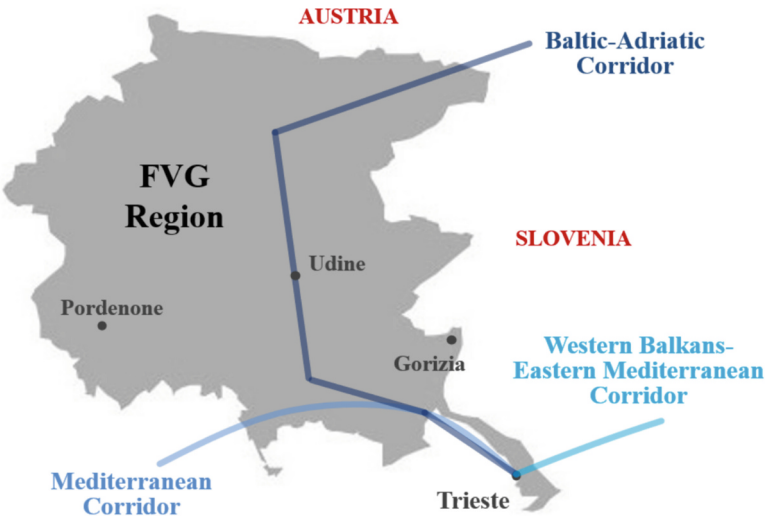


Fig. 1. Friuli Venezia Giulia Region and related TEN-T Corridors. Source: Authors' elaboration

To collect data aimed at assessing accessibility to local public transport and the propensity to use cross-border rail connections to Slovenia, a questionnaire was administered targeting dwellers in the FVG region. Data collection took place between December 2025 and February 2026, both in person and online (i.e., Computer-Aided Web Interviewing).

Prior to official administration, a pre-test was carried out with approximately ten respondents to verify that the questions were clearly formulated and that the branching logic had been implemented correctly.

The questionnaire consisted of three sections. The first section collected respondents' demographic data, including gender, age, and education level. The question on the net monthly income of interviewees was made optional – this was the only exception in the questionnaire – given its sensitive nature. Nonetheless, such a question was functional to the subsequent branching question, which investigated the monthly income share allocated to transport expenses.

The second section gathered data on accessibility to public transport services using two five-point Likert scale rating questions (1 = very poor; 5 = very good). The first question asked respondents to rate the accessibility of different categories of destinations in or near their municipality of residence using public transport (e.g. urban buses, regional buses or trains). The second question asked respondents to evaluate the characteristics of the urban public transport service in terms of the number of available lines, service frequency and stop proximity. For this question, the same Likert scale was used as for the first question, with the addition of a "I don't know" option for respondents who felt they did not have enough information to answer.

The third section explored accessibility concerning cross-border mobility between Italy and Slovenia through two rating questions. The first question investigated how respondents evaluate the accessibility of cross-border connections on a five-point Likert scale (1 = very poor; 5 = very good). Then, the second question examined their willingness to use cross-border rail connections should improvements be made, i.e., either in terms of reduced travel times or increased service frequency, also measured on a five-point Likert scale (1 = not at all willing; 5 = very willing).

2.1 The Sample

The initial sample consisted of 397 respondents residing in the FVG region, specifically across the provinces of a few main cities, i.e., Trieste, Udine, and Gorizia. The province of Pordenone, which is another main regional city, was excluded from the survey, because its geographical distance from the Slovenian border makes it fall outside the scope of the research (Fig. 1). On the contrary, among the cities involved in the survey, Trieste and Gorizia are the ones lying the closest to Slovenia, although many villages belonging to the province of Udine are not far from it. As far as the demographic composition of the sample, attention was paid to the active layer of the population, i.e., from 15 years and over, in line with the objective of the survey of evaluating local and cross-border transport service accessibility for work and study purposes. In this sense, the survey also targeted students attending regional high schools and universities, who represent a suitable sample for the mentioned goal.

Given the fact that, to the best of authors' knowledge, no comparable study has been previously conducted in the FVG region, the sample characteristics were benchmarked against regional-level figures provided by the Italian National Institute of Statistics (ISTAT) to provide contextual reference.

The sample showed a slight female majority (53%), which is broadly consistent with the regional figure of 51.1%.[1] The sample was also relatively young, with the 15–18 age group being the most represented (25%), followed by the 25–34 age group (14%) and the 18–24 age group (11%). Additionally, over half of the sample (53%) held an upper secondary school diploma, which is above the regional proportion of 40.1%. Furthermore, 39% of the sample held a bachelor's or master's degree, or a higher qualification such as a postgraduate master's or PhD, compared to a regional proportion of 15.4%.[2] The residence of the sample was concentrated mostly in the provinces of Trieste (45%) and Udine (33%).

With respect to income, 36% of respondents reported no monthly earnings, consistently with the large student component of the sample. Among those with an income, approximately 37% earned between €1,200 and €2,400 per month, while 7% earned between €2,400 and €3,000.

The monthly transport expenditure is relatively modest for most respondents: 27% spent up to €50, 29% spent between €51 and €100, and 18% spent between 101 and €150.

The predominant mode of transport of respondents was private cars (50%), followed by public transport, encompassing urban and regional buses and trains, which was used by 43% of respondents. Commuting patterns further highlighted the mobility intensity of the sample: 32% of respondents travelled outside their municipality of residence on a daily basis, and an additional 20% did so several times a week.

Table 1 presents the full socio-economic profile of the sample.

Table 1. Socio-economic profile of the sample (n = 397). Source: Authors' elaboration.

	No.	%
Total sample	397	100
Gender		
Female	209	53%
Male	184	46%
I prefer not to answer	4	1%
Age groups		
15–18	100	25%
18–24	43	11%
25–34	56	14%
35–44	53	13%

(*continued*)

[1] https://www.istat.it/wp-content/uploads/2025/04/Censimento-permanente-popolazione_Anno-2023_FVG.pdf

Table 1. (*continued*)

	No.	%
45–54	52	13%
55–64	46	12%
65+	47	12%
Province of residence		
Gorizia	83	21%
Trieste	181	45,5%
Udine	133	33,5%
Level of education		
Bachelor's or Master's degree or higher university qualification (e.g. Master's/PhD)	156	39%
Primary level (primary school/lower secondary school)	31	8%
Upper secondary school (e.g. sixth form college, vocational college)	210	53%
Occupation		
Housewife	9	2%
Employee	153	38%
Unemployed	19	5%
Self-employed	23	6%
Retired	36	9%
Student	157	40%
Net monthly income		
Up to 1,200€	44	11%
From 1,200€ to 1,800€	86	22%
From 1,800€ to 2,400€	62	16%
From 2,400€ to 3,000€	26	7%
Over 3,000€	13	3%
I do not receive any monthly income	142	36%
Missing data (those who preferred not to answer the question)	24	6%
Monthly transport budget		
Up to 50€	109	27%
From 51€ to 100€	117	29%
From 101€ to 150€	71	18%
From 151€ to 200€	28	7%
Over 200€	14	4%
I would not know how to quantify it	58	15%

(*continued*)

Table 1. (*continued*)

	No.	%
Means of transport to which the largest share of the monthly budget is allocated		
Private car	199	50%
Bicycle	1	0.3%
Car sharing	1	0.3%
Bike sharing	1	0.3%
Public transport (city buses, regional buses, trains, …)	173	43.5%
Scooter or motorbike	17	4.3%
Taxi	5	1.3%
Journeys outside one's municipality of residence		
Daily	126	32%
Several times a week	81	20%
Once a week	60	15%
Several times a month	48	12%
Once a month	33	9%
Rarely	49	12%

3 Results

The data analysis yielded a nuanced picture of transport accessibility, examined through descriptive statistics across three areas: local public transport accessibility, the assessment of urban public transport services and cross-border connections between Italy and Slovenia. At this phase of the study, the analysis has been intentionally limited to descriptive statistics to capture the main insights of the survey, in line with the most common approach used in the majority of previous contributions on the topic, as reported in the literature review performed by (Tsiopa et al., 2024). However, additional detailed results could be derived in the future using more articulated econometric techniques.

3.1 Local Public Transport Accessibility

The assessment of local public transport accessibility – by urban buses, regional buses, or trains – revealed a differentiated picture depending on the considered destination. Regarding accessibility to the workplace, 35% of respondents expressed a positive judgement (ratings 4 and 5), while 31% a negative one (ratings 1 and 2). 34% of interviewees took a neutral position. This broadly balanced distribution suggests that a significant portion of the sample reaches their workplace by other means of transport, consistent with the finding that 50% of respondents primarily use a private car for their own trips.

The accessibility of educational institutions was perceived more positively, with 52% of respondents expressing a positive opinion, compared to 19% who expressed a negative opinion. The remaining 29% were neutral. This finding is consistent with the high proportion of students in the sample, reflecting the widespread coverage of public transport networks serving schools and universities.

Regarding access to shops and commercial services, 46% of respondents gave a positive assessment, 30% a neutral one and 24% a negative one. Access to recreational activities was viewed somewhat more critically, with 37% of respondents giving a positive response, 33% a neutral response and 29% a negative response. In this regard, a study concerning students' leisure transfers is reported in (Caramuta et al., 2025), which describes the planning of a bus demand responsive transport service implemented in the main city of the FVG region to address the mobility needs of such users. A similar pattern emerged for healthcare services, where 39% of respondents gave a positive rating, 35% a neutral rating and 25% a negative rating.

Table 2 provides a detailed overview of responses concerning accessibility to activities and services through local public transport.

Table 2. Judgements on accessibility to activities and services through local public transport. Source: Authors' elaboration.

	1 = Very poor	2 = Poor	3 = Neutral	4 = Good	5 = Very good
Work activity	15%	16%	34%	26%	10%
Education (school, university)	8%	11%	29%	38%	14%
Shops/commercial services	10%	14%	30%	34%	12%
Recreational activities/leisure	12%	18%	33%	30%	8%
Health services	10%	15%	35%	29%	10%

Educational institutions were perceived as the most accessible destination by public transport, while uncertainty was greatest regarding the workplace, with responses distributed almost equally across the three positions. Leisure destinations and healthcare services occupy an intermediate position, with a comparatively higher proportion of neutral responses, which may reflect more sporadic and less organized mobility patterns compared to regular commuting.

3.2 Assessment of Urban Public Transport Services

With regard to the characteristics of urban public transport services, the sample expressed an overall favourable judgement across all three examined aspects. The number of available lines received positive ratings from 55% of respondents, compared to 24% of negative ones. Service frequency also achieved a predominantly positive rating (48%), albeit with 28% and 22% of negative and neutral responses, respectively. The best-rated aspect

was the distance of stops from places of residence, with 60% of respondents giving a positive rating and only 14% giving a negative rating. A marginal 2% of interviewed people were unable to express a judgement. These results indicate a generally satisfactory perception of the urban public transport provision, with stop proximity being perceived as a key strength, while service frequency was attributed to the greatest dissatisfaction. This could discourage people from using public transport.

Table 3 illustrates the judgements expressed by respondents with respect to the characteristics of urban public transport services, for each level of the rating scale.

Table 3. Judgements on the characteristics of urban public transport services. Source: Authors' elaboration.

	1 = Very poor	2 = Poor	3 = Neutral	4 = Good	5 = Very good	I don't know
Number of available lines	10%	14%	20%	33%	22%	2%
Frequency of services	12%	16%	22%	32%	16%	2%
Distance between stops	7%	7%	24%	38%	22%	2%

In terms of the proximity of their house from the nearest railway station, the survey proved that 32% of respondents lived more than 2 km away but had a good local public transport connection. On the contrary, 19% of interviewed people lived at the same distance, but without adequate transport services. Besides, it turned out that 15% of respondents lived within a walking distance of up to 400 m from the nearest railway station and another 13% of them lived within a reasonable walking or cycling distance (400 m to 2 km) from it, under good pedestrian and cycling infrastructure conditions.

As for the nearest regional bus stop, 23% of interviewees lived within the same walking distance from it, whereas 21% lived more than 2 km away, although with a good local public transport connection. In contrast, the survey also revealed that 16% of respondents lived more than 2 km away from such a stop without a proper public transport connection and 13% of them lived within walking or cycling distance under good infrastructure conditions. Accordingly, the majority of the sample could reach transport nodes relatively easily, although approximately one fifth of respondents face limited accessibility to the rail network.

3.3 Accessibility to Cross-Border Connections

With reference to mobility generated by work or study purposes, the findings on the existing cross-border connections between Italy and Slovenia revealed an overall critical perception of accessibility. Regarding rail connections, 44% of respondents rated them as poor (scale points 1 and 2) and only 17% attributed a positive judgement (scale points

4 and 5). A noteworthy finding is the 39% of interviewees having neutral position, which is a result likely attributable to limited familiarity with the existing offer.

A similar picture emerged for cross-border accessibility by regional buses, where the largest share of respondents (44%) expressed a neutral position and 35% provided a negative assessment (scale points 1 and 2), with an even smaller positive share.

Table 4 contains a precise indication of judgements collected on the use of the existing cross-border connections between Italy and Slovenia for work or study purposes.

Table 4. Judgements on accessibility to existing cross-border connections between Italy and Slovenia for work or study purposes. Source: Authors' elaboration.

	1 = Very poor	2 = Poor	3 = Neutral	4 = Good	5 = Very good
Via train	19%	25%	39%	15%	2%
Via regional bus	13%	22%	44%	18%	3%

In terms of willingness to use cross-border rail connections following service improvements, the results showed a balanced distribution. Regarding reduced travel times, 37% of respondents said they would use such connections, while 30% said they would not. The results for the scenario of increased service frequency were similar, with 36% of people willing to use rail cross-border connections and 29% unwilling to do so. These findings suggest that even when faced with the prospect of potential service improvements, a significant proportion of respondents remain sceptical about using cross-border rail connections. This may reflect additional barriers, such as ticketing fragmentation, limited awareness of available services or deep-rooted mobility habits, which extend beyond the characteristics of the service itself.

Table 5 includes the exact data gathered on the willingness of using cross-border rail connections between Italy and Slovenia, in case of the realization of service improvements.

Table 5. Judgements on the willingness of using cross-border rail connections between Italy and Slovenia after service improvements. Source: Authors' elaboration.

	1 = Not at all willing	2 = Not very willing	3 = Neutral	4 = Quite willing	5 = Very willing
Reduction of travel time	14%	17%	33%	28%	9%
Increase of service frequency	13%	16%	35%	26%	11%

4 Discussion

As highlighted in (Tsiopa et al., 2024), even if most papers on cross-border mobility have been developed according to a transport perspective, heterogeneity can be observed in a variety of investigation features, like employed techniques, variables, data types, and application scope. Moreover, given the greater stress posed on specificities rather than on commonalities, comparability among research studies on the topic considered is difficult to fulfill. Based on those findings, the present contribution differs from previous scientific papers at least for one of the following reasons: the approach used to collect mobility data, the examined geographical area, the transport modes considered, and the investigation goal. Regarding this latter aspect, of course, differences in the objective of the analysis partially motivate methodological discrepancies with respect to existing contributions.

For instance, considering papers which take into account both rail and road modes, public transport accessibility of cross-border commuters has been analyzed in (Cavallaro and Dianin, 2020) referring to Central Europe, more specifically to the boundary between Hungary and Austria. The analysis consisted in estimating cross-border commuting public transport accessibility through a network efficiency indicator along the main connections, comparing the resulting values with those related to domestic commuting public transport accessibility. The study proved a quite significant difference between the cross-border and domestic public transport attractiveness, mainly because of long travel times, fragmentation of multimodal solutions and uncompetitive fares. Besides, the investigation pointed out a more limited cross-border accessibility in rural areas, advocating a stronger collaboration among transport companies operating in different territories. Another effort to evaluate cross-border accessibility using a quantitative approach has been made in (Bertram et al., 2024), which proposes a cartographic visualization of spatial accessibility while focusing on German borders. Nevertheless, in this case, attention was paid only to public transfers by rail, other than to private car connections, thus overlooking possible bus services. The "space-time-line" maps provided in such a study showed once again relevant differences between cross-border and domestic connections when using either the road or rail mode, with the latter one being generally slower than the former one in most connections. In addition, rural border areas demonstrated poor mobility conditions in both the considered modes and cross-border links with border regions turned out slower than cross-border links between major cities.

The only contributions sharing a similar geographical context with the present paper are (Gabrovec, 2013; Gabrovec et al., 2021), which deal with cross-border mobility between Slovenia and, respectively, Italy and Austria. However, in the former study, the analysis was limited to two border provinces (i.e., Gorizia/Gorica and Muggia/Mulje) and to road mode, since no railway connections were available at the time in which the investigation was conducted. In addition, based on statistical data, field observations and interviews, such a paper examines the daily travel needs of the greatest share of public transport users in the considered area, which is constituted mainly by students and pensioners. Consequently, cross-border commuting for work purposes was overlooked by that analysis, which still enabled to formulate proposals for joint public transport planning on the Italian and Slovenian sides. Regarding the latter study, mobility between Slovenia and neighboring countries was investigated throughout three decades (from

1991 to 2019), in order to assess the effects of political changes on cross-border public transport. Then, attention was concentrated specifically on transfers between Slovenia and Austria in the Carinthia region, referring to rail mode, which was the only available option for cross-border public transport. In this case, mobility derived by both work and education reasons were examined, using questionnaires to assess users' trip frequency and satisfaction with the service provision.

Against these two contributions, other than focusing on an unexplored area, the study reported in the present paper examines a more comprehensive transport offer, the related perception of passengers and even their willingness to change mobility habits in face of service improvements. In this sense, the article exceeds the mere analysis of traffic data concerning cross-border flows with reference to the users' characteristics, suggesting recommendations for policy makers.

5 Conclusion

This study aimed to provide a comprehensive overview of transport accessibility in the FVG region, with a particular focus on local mobility within the region and on cross-border rail connections between Italy and Slovenia. To that end, a survey was administered in the context of the European project T4Rail, whose objective is to enhance border operations by improving communication procedures thanks to a digital translation tool. Such technological innovation is thus meant to enhance the attractiveness of rail cross-border transfer, positively impacting at economic, social, environmental and territorial level.

Regarding cross-border connections, the data reveal untapped potential. The majority of respondents rated the accessibility to Slovenia as poor, both by rail and regional buses. A significant proportion of neutral responses indicate widespread unfamiliarity with the existing services. Furthermore, willingness to use these connections in case of service improvements remains moderate.

The findings regarding local public transport suggest that this latter is generally considered satisfactory in terms of network coverage and the proximity of stops. However, there are significant issues regarding service frequency and accessibility to workplaces. The fact that many people still rely on private cars indicates that public transport remains an uncompetitive alternative for many people when dealing with work-related journeys.

In terms of policy implications, these findings highlight important considerations. Firstly, operational interventions on the supply side, such as reducing travel times and increasing service frequency, may not be sufficient to change deep-rooted mobility habits. Complementary demand-side measures are therefore necessary. These measures could include targeted communication and awareness campaigns to reduce limited familiarity with cross-border connections.

Secondly, increasing the frequency of local public transport appears to be a priority, particularly on routes with higher commuter demand, in order to make public transport a more competitive alternative to private cars. This is a necessary step, given that half of the sample still relies predominantly on such mobility alternative.

Finally, reducing travel times on cross-border connections between Italy and Slovenia is the most effective way to increase users' willingness to adopt those services. In

this respect, the digital tool proposed in the T4Rail project, which was developed to specifically facilitate communication procedures between Italian and Slovenian railway operators, aims to reduce the time spent at borders due to language barriers. This may stimulate demand for cross-border transport.

Future research could extend the analysis to the Slovenian side of the border, so as to obtain a broader framework of cross-border mobility patterns and attitudes. Incorporating the perspective of Slovenian residents and commuters would allow for a more systematic comparison of accessibility perceptions across the two national contexts, potentially revealing asymmetries in service quality, awareness, and travel behaviour. Furthermore, longitudinal data collection following the implementation of service improvements for cross-border connections would provide valuable evidence on the extent to which supply-side interventions are capable of translating into actual behavioural change. Finally, regression models are meant to be employed to capture the relationship among the examined variables and thus support the elaboration of incentive policies.

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