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Jonas Meli
Katja Schimohr
Lea Stapper
Alessio Levis
Florian Lichtin
Stefan Wehrli
Thomas Bernauer
Eva Heinen

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Jonas Meli
IVT ETH Zurich
jonas.meli@ivt.baug.ethz.ch

Katja Schimohr
IVT ETH Zurich
katja.schimohr@ivt.baug.ethz.ch

Lea Stapper
IPEEP ETH Zurich
lea.stapper@istp.ethz.ch

Alessio Levis
IPEEP ETH Zurich
alessio.levis@ir.gess.ethz.ch

Florian Lichtin
ISTP ETH Zurich
florian.lichtin@gess.ethz.ch

Stefan Wehrli
DSL ETH Zurich
wherlist@ethz.ch

Thomas Bernauer
CIS ETH Zurich
thbe0520@ethz.ch

Eva Heinen
IVT ETH Zurich
eva.heinen@ivt.baug.ethz.ch

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Abstract

Railway supply is often planned based on calculated accessibility, which can differ substantially from perceived accessibility. Little is known about the perceived accessibility of railway stations and how it differs for different spatial and societal groups. However, in order to promote rail as a means of transportation, it is important to better understand the perceived accessibility of train stations and to incorporate this into planning. We show that having access to cars, bikes, and a public transportation subscription significantly affect perceived station accessibility by foot and public transportation. Overall, measuring railway station accessibility solely based on the station connection quality and the walking distance will lead to an inaccurate measure of the station accessibility.

Keywords

Perceived accessibility; Railway station; Switzerland; Socioeconomic; Walking Access; Transit Access

Preferred citation

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1 Introduction

Railways are central to the Swiss transport system and a cornerstone of the federal government's transport and climate strategy. To achieve the climate targets and improve the transport system’s sustainability, the government wants the railway system and public transport as a whole to handle a larger share of the traffic volume (BAV, 2023).

One way to increase the attractiveness of rail travel without incurring the expense of building new lines or upgrading existing ones is to improve railway station accessibility. Improving railway station accessibility can increase train ridership and seems particularly effective for infrequent rail users (Brons et al., 2009).

Railway station accessibility is often described as the first and last mile (FLM). This refers to the leg(s) from the home end of the trip to the station (access, or first mile) and the leg(s) from the station to the activity end of the trip (egress, or last mile). A sizable body of literature has already been dedicated to this topic (Lu et al., 2024). However, most of the research has been dedicated to measuring railway station accessibility in terms of spatial data, such as distance (Chia et al., 2016; Daniels & Mulley, 2013), walkability scores (Park et al., 2015; van Soest et al., 2020), and greenery (Ha et al., 2023). However, studies show that measures of accessibility, which are only based on observable data, can substantially differ from how people perceive their accessibility. Planning a transportation system based on calculated accessibility can thus lead to unmet needs, and specific population groups can hardly benefit from improvements (Lättman et al., 2018).

While the topic of perceived accessibility has been receiving more attention in recent years (Negm et al., 2025), investigating railway station accessibility based on perceived accessibility has met only limited attention. To our knowledge, current studies that investigate railway station accessibility in the context of perception do so solely for (frequent) rail users, e.g., Jehle et al. (2022) and Ryan et al. (2016). However, studies show that travel behavior and perceived accessibility are linked (Mehdizadeh & Kroesen, 2025). Thus, only including frequent users already leads to bias in results.

This study aims to investigate the extent to which perceived railway station accessibility by foot and public transport (PT) differs across different spatial and societal structures in Switzerland.

2 Literature Review

2.1 Factors Influencing Railway Station Accessibility

According to Ryan et al. (2016), the factors influencing railway station accessibility can be grouped into user-specific, station-specific, and travel-specific variables.

2.1.1 User Characteristics

These include characteristics of individual users, such as individual needs, abilities, and available resources. They are what Geurs and van Wee call the "individual component" of accessibility (Geurs & Van Wee, 2004) and reflect available resources (e.g., which modes are available), needs, preferences, and abilities (e.g., which distances people walk to public transport stops (Chia et al., 2016)). This component determines how other aspects of (railway station) accessibility are perceived (Pot et al., 2021).

2.1.2 Station Characteristics

These variables reflect the land-use component (Geurs & Van Wee, 2004), i.e., the attributes of the railway station, such as station location, service quality, and facility qualities.

Service and facility quality may be related to railway station accessibility. However, they are more indicators of railway accessibility (Debrezion et al., 2009) than station accessibility, as they do not directly influence how accessible a station is. However, access facilities, such as bike parking spaces or local transport access, are important for station accessibility (Halldórsdóttir et al., 2017).

2.1.3 Travel Characteristics

These variables reflect the transport component of accessibility: travel time, network connectivity distance, cost, greenery, etc. This includes the route from home to the station. Numerous studies examine the attractiveness of footpaths, also known as walkability.

2.2 Perceived Accessibility

Perceived accessibility was first mentioned by Morris et al. (1979). However, the topic has not received much attention until approximately ten years ago (Pot et al., 2021). Since then, the number of studies focusing on perceived accessibility has been steadily increasing (Negm et al., 2025).

Calculated accessibility indicators assume that individuals are fully aware of their surroundings, know the various destinations and routes to get there, and make decisions based on complete information. However, it has been established that decisions are based on perceptions of the environment and not on complete information, meaning that calculated accessibility does not necessarily match perceived accessibility (Pot et al., 2021).

This discrepancy has consequences that go far beyond inaccurately calculated accessibility. Transport policy decisions are made, and infrastructure is planned based on this inaccurately calculated accessibility. This can lead to accessibility poverty (Lucas et al., 2016), with certain groups in society having little or no access to various destinations.

Perceived accessibility has been defined by different authors in different ways, focusing on different aspects. In this study, we use the definition from Pot et al. (2021) for perceived accessibility: “the perceived potential to participate in spatially dispersed opportunities.” However, we are adjusting the definition as the focus here is on railway stations. We therefore define perceived accessibility of railway stations as follows: “The perceived potential to access railway stations.”

2.2.1 Perceived Accessibility Index

Lättman et al. (2016, 2018) developed an index to quantify perceived accessibility. They use four different items to measure the four different aspects of accessibility: the land-use component, the transportation component, the individual component, and the temporal component (Lättman et al., 2016). The items can be adapted to capture perceived accessibility for specific modes of transportation, such as public transportation. This index has been used in different studies, for example, Pot et al. (2023) and Olsson et al. (2021).

3 Methods

3.1 Data

We use data gathered by the Swiss Mobility Panel (SMP) in several waves. The SMP conducts regular panel studies in Switzerland, exploring different aspects of mobility and how they vary across Switzerland (*Swiss Mobility Panel*, 2025). The participants were drawn from a representative sample of people aged between 18 and 80 living in Switzerland (Lichtin et al., 2024). The current baseline data (wave 4) is from 2022, while data regarding reported travel behavior (wave 6), stated access mode preferences, and perceived accessibility (both wave 6 follow-up) are from two waves conducted in 2024. Furthermore, we use spatial data provided by swisstopo (2025).

3.1.1 Sample

Our analysis is based on data from 1,984 individuals across Switzerland. Table 2 shows the summary statistics and how they compare to the Swiss population.

The table shows that women are underrepresented in our sample. People with high education, as well as people between 40 and 64 are overrepresented in our sample.

For the modelling process, we imputed the missing incomes based on the data from wave 4.

3.2 Variables

Our models incorporate different spatial characteristics to reflect travel-specific characteristics (distance to the station, route directness, municipality type, inhabitant density) and station-specific characteristics (station connection quality).

3.2.1 Perceived Railway Station Accessibility

To measure perceived railway station accessibility, we use the PAC from Lättman et al. (2016), which we adapted to capture how individuals perceive railway station accessibility. We asked participants about their perceived accessibility using walking and public transportation.

Table 4 shows the items used, descriptive statistics, factor loadings, and Cronbach's alpha for PSAC by foot. Table 5 shows the items used, descriptive statistics, factor loadings, and Cronbach's alpha for PSAC by PT. The overall item correlation for both PSAC by foot and PT is satisfying ($\alpha_{foot} = 0.90, \alpha_{PT} = 0.88$).

As a measure of perceived station accessibility, we take the average over all four items for each mode.

3.2.2 Public Transport Connection Quality

The Public Transport Connection Quality by the Federal Office for Spatial Development measures public transportation accessibility, incorporating service attributes by categorizing public transport stops into five different stop categories based on the public transportation mode and the service frequency (ARE, 2022). There are two categories for railway stations: stations offering connections to multiple directions and stations offering connections along a specific corridor. The stop categories and the distance as the aerial distance to the station are then used to classify public transport stops into different classes, from A (very good) to D (poor) or no category (None). Areas further than 1000m from any stop have no classification.

The station connection quality is the public transport connection quality of the first railway station a person accesses. Because the quality is measured right at the station, the distance does not matter, and the station connection quality reflects the stop category. Thus, it measures the railway offer at the station itself in terms of frequency and directions served at the station. Although it is primarily a measure of rail accessibility, we nevertheless include it in our model as it serves as an approximation for the connection of local public transport to the station and could therefore influence the PSAC by PT.

3.2.3 Distance to Railway Station

The distance to the railway station is the walking distance to the station. We used routing to determine the shortest walking distance to the station, which may not reflect the distance people walk when accessing the railway station. We use a log-transformation on the distances to reduce the effect of outliers.

3.2.4 Directness Factor

The directness factor is the ratio between the walking distance to the station and the distance as the aerial distance. Values above 1 indicate that people have to take detours.

3.2.5 Municipality Type

The residential communities were divided into urban, peri-urban, and rural groups. The definitions are from the Federal Statistical Office BFS (2024). We aggregated the municipalities into three instead of nine categories to keep the models parsimonious and because several categories had very few observations.

3.2.6 Inhabitant Density

The inhabitant density is measured in people per hectare. Both the inhabitant density and the municipality type are indirect measures of the built environment. We assume that higher inhabitant density and an urban setting reflect a denser environment. If no density could be assigned, we assumed the lowest density that occurred at the assignable locations.

3.3 Modelling Approach

We used ordinary least squares (OLS) regression to model the relationship between the outcome variable, mean perceived station accessibility by foot or PT, and the independent variables. All analyses are conducted using the open-source software R (R Core Team, 2025).

4 Results

The estimation results for PSAC by foot and PT are presented in Table 1. The effect of age is only significant ($p<0.05$) for people between 46 and 65. On average, their perceived station accessibility is 0.217 lower than that of those aged between 20 and 35.

On average, people with a tertiary degree have a 0.164 higher PSAC by foot than people with a secondary degree. In comparison, people with no secondary degree have a 0.376 higher PSAC by PT. Changes in income have no significant effect on the perception of station accessibility.

The ownership of different transportation resources significantly affects PSAC by foot and PT. On average, access to a car reduces PSAC by foot by 0.519 and PT by 0.301.

In general, people using PT to get to connection quality classes A and B stations have higher PSAC than people accessing class D stations. People walking to stations of class A also have significantly higher PSAC than those walking to class D stations.

The public transport connection quality at the residential location are highly significant for PSAC by PT. People living in areas with connect quality A have a significantly lower PSAC by foot.

Walking distance to the station has a highly significant effect on PSAC. While every log meter decreases perceived accessibility by foot, it increases the PSAC by PT. The route's directness has no significant effect on either PSAC.

Living in an urban municipality also significantly increases the PSAC for both access modes relative to living in a rural municipality. People living in peri-urban municipalities have a significantly higher PSAC by PT than their counterparts in rural municipalities.

The inhabitant density significantly increases the PSAC by foot.

Table 1: Model results for PSAC by foot and PT

	PSAC by Foot		**PSAC by PT**	
	Estimate	Std. Error	Estimate	Std. Error
Socioeconomic Characteristics				
Age (ref: 20-35 years old)				
36 - 45 years old	-0.192*	-0.101	-0.191*	-0.100
46 - 65 years old	-0.217**	-0.091	-0.168*	-0.090
66 or older	-0.190	-0.120	-0.074	-0.119
Gender (ref: Male)				
Female	-0.027	-0.050	0.051	-0.050
Education (ref: education on secondary level)				
High Education	0.164***	-0.055	0.0430	-0.054
Low Education	-0.110	-0.179	0.376**	-0.178
Monthly Household Income (ref: Income under 4,000 CHF)				
4,000 - 8,000 CHF	0.112	-0.108	0.004	-0.108
8,000 - 12,000 CHF	0.169	-0.112	0.023	-0.112
> 12,000 CHF	0.040	-0.118	0.028	-0.117
Employment status (ref: Not in the workforce)				
Employed	-0.159*	-0.081	-0.108	-0.081
Self Employed	-0.157*	-0.093	-0.066	-0.092
Student	0.143	-0.135	0.112	-0.134

Transportation Resources				
Car (dummy)	-0.519***	-0.086	-0.301***	-0.086
PT subscription (dummy)	0.490***	-0.059	0.409***	-0.059
Standard Bike (dummy)	0.204***	-0.063	0.098	-0.062
E-Bike (dummy)	0.057	-0.074	0.057	-0.073
Spatial Characteristics				
Station Connection Quality (ref: Class D)				
Class A	0.317**	-0.130	0.370***	-0.129
Class B	0.191	-0.127	0.253**	-0.126
Class C	0.226*	-0.120	-0.011	-0.119
PT Connection Quality (ref: None)				
PT Class A	-0.477***	-0.121	0.880***	-0.121
PT Class B	-0.142	-0.11	0.691***	-0.109
PT Class C	-0.147	-0.094	0.715***	-0.093
PT Class D	-0.143*	-0.085	0.446***	-0.085
Distance to Station as log(m)				
Distance	-0.584***	-0.024	0.177***	-0.024
Directness factor				
Route directness	-0.002	-0.003	0.000	-0.003
Municipality type (ref: Rural Municipality)				
Urban Municipality	0.206**	-0.088	0.438***	-0.087
Peri-Urban Municipality	-0.036	-0.084	0.213**	-0.084
Inhabitant Density [1,000 People per ha] at Residential Location				
Inhabitant Density	1.246**	-0.495	0.742	-0.492
Constant	7.382***	-0.293	1.144***	-0.291
N	1,984		1,984	
R2	0.367		0.242	
Adjusted R2	0.358		0.231	
F Statistic	40.554***		22.263***	

*p<0.1; **p<0.05; ***p<0.01

5 Discussion and Conclusion

This study aimed to investigate the extent to which socioeconomic and spatial characteristics influence perceived station accessibility. We find that while both socioeconomic and spatial variables significantly affect PSAC, the effects of spatial characteristics are, on average, larger.

The finding that people between the ages of 36 and 65 have, on average, lower perceived station accessibility contradicts the findings of Pot et al. (2023), who have the opposite direction of effects. However, while they study general perceived accessibility, which does not focus on a specific mode, we look at perceived station accessibility by foot, which is mode-specific.

While several studies show that gender impacts perceived accessibility (Negm et al., 2025), our models show no significant impact of gender on perceived station accessibility. Although education has a significant effect in our models, it has to be kept in mind that our sample is biased regarding the distribution of education levels.

Furthermore, the model results show the high significance of transportation resources on perceived station accessibility. The negative effect of car access on PSAC, for example, is in line with the findings of other studies that car ownership negatively affects perceived accessibility by PT (Olsson et al., 2021; Vafeiadis & Elldér, 2024), which may very well be related to perceived station accessibility. We assume that the ownership of transportation resources is affected by socioeconomic variables and residential location choice. Literature shows that, for example, car ownership is affected by socioeconomic variables and the built environment (Ding et al., 2017; Schimohr et al., 2025). Therefore, we suggest using structural equation modelling (SEM) to model the direct and indirect effects of the built environment socioeconomic characteristics on PSAC.

Regarding the spatial characteristics, the highly significant effects of station and PT connection quality on PSAC by PT show that good PT connections at both the residential and station end are important for PSAC by PT. While the PT connection quality effects on PSAC by PT are as expected, the negative effect of PT class A on PSAC by foot is surprising. PT connection quality class A is most often found in urban municipalities. It could be that people living in areas with PT class A more often take PT to travel to train stations and thus perceive their accessibility by foot as lower. In addition, the contrasting effect of walking distance to the station may be attributed to public transport stops usually having a certain spacing. Therefore, it is possible that people who live close to a railway station do not have the same quality of connection with public transportation to railway stations as people who live further away. In addition, since the directness factor is not significant, longer routes appear to influence the PSAC only in terms of absolute distance. Living in more urban municipalities positively impacts PSAC by PT, potentially reflecting better PT network quality. The higher PSAC by foot of urban municipalities relative to rural municipalities could reflect shorter distances to train stations.

In conclusion, while distance is a standard method of measuring the accessibility of train stations, our models show that distance is also important for the perceived accessibility of railway stations. However, limiting ourselves to distance (and PT connection quality) alone would not be accurate when measuring railway station accessibility. The type of municipality and access to various transport resources are also significant factors in perceived accessibility. Moreover, while our modelling results suggest that socioeconomic characteristics have limited direct influences on PSAC, they may influence PSAC indirectly through the ownership of transportation resources.

Finally, perceived accessibility relates to other topics, such as residential location choice, travel attitudes, and travel behavior (Negm et al., 2025). While the direction of effects remains unclear, this has to be kept in mind when interpreting our results. In our models, transportation resources could reflect current travel behavior. Moreover, it is unclear if and how the frequency of access with a certain mode influences perceived station accessibility.

A Appendix

A.1 Sample Population

Table 2: Descriptive statistics of the sample population

Variable	Sample	Swiss Population
Gender		
Female	42.1%	50.31%
Male	57.9%	49.69%
Age		
20 – 39	17.5%	32.5%
40 – 64	61.1%	43.6%
65 – 79	19.7%	17.1%
80 and older	1.7%	6.9%
Education[1]		
Low	1.5%	17%
Middle (Secondary)	33.7%	42%
High (Tertiary)	62.9%	41%
Other	1.5%	-
Employment Status		

[1] The data for education on a national level is only available for people 25 years or older

Employed	68.80%	51.38%
Self-Employed	7.67%	10.43%
Student	2.21%	6.76%
Not in the workforce (e.g., voluntary work, retired, housework, etc.)	21.31%	31.43%
Car available in the Household		
No	10.6%	22%
Yes	89.4%	88%
Public Transportation Subscription		
No Subscription	25.5%	47%
Subscription	74.5%	53%

Data Sources: BFS (2023, 2025). We used data from 2021 and 2022 to match the time when wave 4 was conducted.

Table 3: Spatial data

Characteristic	In the Sample Population
Station Connection Quality	

A	44.20%
B	22.60%
C	28.10%
D	4.56%
None	0.55%
Walking Distance to Station	
Mean Distance	2402
Median Distance	1178
SD Distance	5727
Min	0
Max	179137
Skewness	19.1
Directness	
Mean Directness	1.59
Median	1.22
SD Directness	9.32
Min	0
Max	416
Skewness	44.2

Municipality Type	
Urban	62.2%
Peri-Urban	25.2%
Rural	12.4%
Missing	0.2%
Inhabitant Density	
Mean Inhabitant Density	55.3
Median Inhabitant Density	42
SD Inhabitant Density	55.3
Min	3
Max	615
Skewness	2.71

A.2 Perceived Station Indices

Table 4: Descriptive statistics, factor loadings, and Cronbach's alpha for PSAC by foot (N = 1,984, overall mean = 3.4, overall std. dev = 1.3, alpha = 0.90)

Item	Mean	Std. Dev	Skewness	Factor loading	α if item deleted
It is easy to get to the train station on foot	3.35	1.60	-0.34	0.93	0.84
If I could only walk to the train station, I would still be able to continue living the way I want	3.21	1.49	-0.21	0.69	0.91
It is possible to walk to the train station I want to go to.	3.71	1.48	-0.81	0.79	0.88
Access to the train station is satisfying on foot.	3.32	1.55	-0.34	0.93	0.84

Table 5: Descriptive statistics, factor loadings, and Cronbach's alpha for PSAC by PT (N = 1,984, overall mean = 3.5, overall std. dev = 1.2, alpha = 0.88)

Item	Mean	Std. Dev	Skewness	Factor loading	α if item deleted
It is easy to get to the train station by public transport (bus, tram, or metro).	3.58	1.46	-0.62	0.90	0.82
If public transport (bus, tram, or metro) were my only mode to access the train station, I would still be able to continue living the way I want.	3.22	1.42	-0.21	0.68	0.89
It is possible to get to the train station I want to by public transport (bus, tram, or metro).	3.85	1.39	-1.01	0.79	0.85
Access to the train station is satisfying with public transport (bus, tram, or metro).	3.49	1.43	-0.53	0.86	0.83

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