The Role of Perceived Station Accessibility in Mode Choice

Jonas Meli*[1], Lea Stapper[2], Alessio Levis[2], Katja Schimohr[1], Thomas Bernauer[2], Eva Heinen[1]

[1] *Institute for Transport Planning and Systems (IVT), ETH Zurich, Stefano-Franscini-Platz 5, 8093 Zurich, Switzerland*

[2] *Center for Comparative and International Studies, ETH Zurich, Haldeneggsteig 4, 8092 Zurich, Switzerland*

SHORT SUMMARY

Access to railway stations plays a crucial role in people's decision to travel by train . In this study, we investigated the relation between perceived station accessibility and people's likelihood to travel by train.
We use stated-preference mode choice data from the Swiss Mobility Panel, which collects data from a representative sample of Swiss residents. An integrated choice latent variable model was used to estimate the influence of perceived station accessibility on the utility of taking the train.
Our results show that perceived station accessibility significantly influences people's likelihood to prefer the train over the car. Additionally, perceived station accessibility also partially moderates the effect of calculated station accessibility on mode choice, namely the effect of walking time to the station.
These findings support the idea that improving station accessibility can be an alternative way to increase train ridership instead of focusing solely on improving the train network.

Keywords: Discrete choice modeling, first mile, ICLV, multimodal transport, perceived accessibility

1. INTRODUCTION

Investments in public transport often involve substantial sums of money. The Swiss Rail Infrastructure Fund, for example, has around four to five billion Swiss francs per year, which are allocated to investments in the construction and maintenance of railway infrastructure (UVEK, 2025). Even though this is a considerable sum, investments in rail infrastructure alone are unlikely to be sufficient to achieve the planned increase in public transport users (BAV, 2023). Next to investments into the public transport network, improving station accessibility can play a key role in increasing public transport ridership (Brons et al., 2009).
Station accessibility is usually expressed in terms of access/egress time or distance. However, research indicates that the distance people are willing to walk to public transport stops varies according to social (Chia et al., 2016) and spatial (Hillnhütter, 2025) contexts, suggesting that station accessibility comprises more than time or distance (Jehle et al., 2022). In fact, studies show that what people perceive as accessible can differ substantially from accessibility calculated based on geospatial and transport data (J. Ryan & Pereira, 2021; M. Ryan et al., 2016).
This discrepancy between perceived and calculated accessibility is highly relevant, as it is likely that perceived, rather than calculated, accessibility is the basis of behavior (Morris et al., 1979). Moreover, perceived accessibility has been found to moderate the effect of calculated accessibility on travel behavior (Negm et al., 2025). It is therefore paramount to examine the effect of station accessibility on mode choice in the context of perceived accessibility.

While several studies examine the role of perception in access mode choice (e.g., Gan et al. (2021); Gupta et al. (2022); Ryan et al. (2016)), the role of perceived station accessibility in people choosing to travel by train, and whether perceived station accessibility moderates the influence of calculated station accessibility, remains underexplored.
Therefore, this study addresses the following research question: *To what extent does perceived station accessibility influence people's preference for train travel and moderate the influence of calculated station accessibility?*

2. METHODOLOGY

Data

We use data from the Swiss Mobility Panel (SMP). The SMP conducts two to three survey waves per year in Switzerland using a representative sample of individuals aged 18 to 80 living in Switzerland (Levis et al., 2024; Lichtin et al., 2024). Each wave has a different focus, and we conducted an SP mode choice experiment in Winter 2024-2025.

In December 2024 and January 2025, the SMP conducted a stated-preference mode choice experiment with two alternatives per scenario and 4 to 8 scenarios per person. In the scenarios, one alternative is always the train combined with an access mode, while the other is either the car or the train with a different access mode. The choice experiment led to 10,564 valid choice observations from 2,003 individuals. For our analysis, we use a subset of this data, with the car as one alternative and the train as the other, and either walking or public transportation (PT), in the form of buses and trams, as access modes. This resulted in 2,179 choice situations from 1,118 individuals.

There are 1,167 choice situations with car vs walk&train. In these situations, the car was chosen 66.2% and walk&train 33.8%. In the other 1,013 choice situations, the car was chosen 80.3% and PT&train 19.7%.

Latent Variables

We used the Perceived Accessibility Scale proposed by Lättman et al. (2016) to measure perceived station accessibility. We adapted it for two access modes: walking and public transportation (bus, tram, or metro) (Table 1). Cronbach's alpha is 0.89 for Perceived Station Accessibility by Walk (PA-Station-Walk) and 0.87 for Perceived Station Accessibility by PT. This indicates that the internal consistency is good.

Table 1: Descriptive statistics for the perceived accessibility indices

	α if item deleted	Mean	Std. Deviation
Perceived Station Accessibility by Walking (PA-Station-Walk)	**0.89**	**3.37**	**1.31**
It is easy to get to the train station on foot.	0.82	3.38	1.58
If I could only walk to the train station, I would still be able to continue living the way I want.	0.90	3.07	1.48
It is possible to walk to the train station I want to go to.	0.87	3.73	1.45
Access to the train station is satisfying on foot.	0.82	3.3	1.54
Perceived Station Accessibility by Public Transportation (PA-Station-PT)	**0.87**	**3.38**	**1.21**
It is easy to get to the train station by public transport.	0.80	3.5	1.47
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.	0.87	3.03	1.40
It is possible to get to the train station I want to by public transport (bus, tram, or metro).	0.84	3.70	1.43
Access to the train station is satisfying with public transport (bus, tram, or metro).	0.81	3.35	1.44

Exogenous Variables

To calculate realistic travel times, we used Google API for the routing and travel times, based on the trip destinations participants indicated in wave 6. Walking was only considered for distances below 2.5km, and public transportation for distances above 300m.
We used the Public Transport Connection Quality (PTCQ) (ARE, 2022) to assess the calculated public transportation accessibility at the residential location and at the train station. We label the calculated public transportation accessibility at the station as *Station Class*, and at the residential location as *PTCQ Class*.

Modeling Framework

To model direct and indirect effects and account for the latent nature of perceived station accessibility, we use an integrated choice latent variable (ICLV) model (Ben-Akiva et al., 2002). We use 1,000 Sobol draws (Sobol, 1967) to simulate the random components.

The latent variable model can be divided into two parts: the structural model and the measurement model. For an individual n, the equation for the structural model is as follows:

$$LV_n = g\left(\gamma, X_n, \varphi_n\right) + \nu_n \quad (1)$$

Where LV_n, the latent variable is a function of X_n the observed variables, γ the estimated coefficients for the observed variables, and ν_n is the error term. φ_n denotes a random individual- and latent-variable-specific component with $\varphi_n \sim N(0, \sigma_n^2)$. For the model to be identifiable, we fixed the variances of the two latent variables to 1: $\sigma_n^2 = 1$. For an individual n, the measurement model is as follows:

$$I_n = h\left(\lambda, LV_n\right) + \eta_n \quad (2)$$

Where the indicator I_n is a function of the latent variable LV_n, λ is the corresponding factor loading, and η_n the error term. For each latent variable, we fixed the factor loading of the first item to 1.

We use ordered logit with four thresholds to estimate the measurement models. An indicator I for item i of access mode m, is identified as follows:

$$I_{i,m} = \begin{cases} j \text{ if } I^*_{i,m} < \tau_{tim} \\ 5 \text{ if } I^*_{i,m} > \tau_{4im} \end{cases} \quad (3)$$

Where τ_{tim} denotes the thresholds for $t \in [1,4]$.

For the choice model, we used a mixed logit model (Train, 2009) with an individual- and mode-specific random component $\omega_{ln} \sim N(0, \sigma^2_{ln})$. The utility of mode l for individual n is denoted as:

$$U_{\ln} = V(\beta, Z_n, \omega_{ln}, \delta, LV_n) + \varepsilon_{\ln} \quad (4)$$

Where V is a function of the observed utility, consisting of the observed variables Z_n, the estimated coefficients for these variables, β, the latent variable LV_n and the estimated coefficients for the latent variable, δ. ε_{ln} is the unobserved error term.

3. RESULTS AND DISCUSSION

Table 2 shows the model fits for the estimated ICLV, which is an improvement over the model with observed shares.

Table 2: Model fits

Goodness-of-Fit Parameter	
Number of estimated parameters	127
Log Likelihood at observed shares (whole model)	-15,206.988
Final Log Likelihood (whole model)	-12,056.621
Initial Log Likelihood (choice model)	-1,511.061
Final Log Likelihood (choice model)	-877.0113

Perceived Station Accessibility and Mode Choice

There is a positive relationship between perceived station accessibility and people's preference for choosing the train over the car (Table 3). This implies that with increasing perceived station accessibility, the utility of the train also increases. Meanwhile, the access time has no significant direct effect on the mode choice.

Several other trip characteristics, such as the travel time and cost, are also significant and have the expected sign. From the spatial variables, only the PTCQ class has a direct effect. With the decreasing PTCQ class at the residential location, the utility of PT&train increases. This means that PT&train is more attractive.

From the sociodemographic variables, only education has a direct effect on mode choice. People with a higher education are more likely to use PT&train than care compared.

Table 3: Modeling results of the choice model, standard errors in parentheses

Estimate	Car (ref. Mode)	Walk&Train	PT&Train
ASC		-3.697*** (1.104)	-4.093* (1.824)
PA-Station		1.668*** (0.246)	1.502*** (0.341)
Random Term	-2.514*** (0.336)	0.608 (0.372)	1.312 (1.255)
Trip Characteristics			
Travel Time Train	-2.398*** (0.421)	-2.564*** (0.517)	-2.564*** (0.517)
Access Time [h]		-2.418 (1.326)	-0.796 (0.997)
Cost [CHF]	-0.046** (0.017)	-0.046** (0.017)	-0.046** (0.017)
Parking Costs	-0.068*** (0.013)		
Park Search Time	-3.879* (1.575)		
Access Costs PT [CHF]			-0.051 (0.204)
Trains per Hour		0.012 (0.015)	0.012 (0.015)
Number of Transfers		-0.111 (0.111)	-0.111 (0.111)
Waiting Time PT			-3.697*** (1.003)
Train Occupancy (ref. High)			
Medium Occupancy Train		0.111 (0.245)	0.111 (0.245)
Low Occupancy Train		-0.790** (0.251)	-0.790** (0.251)
PT Occupancy (ref. High)			
Medium Occupancy PT			-0.475 (0.428)
Low Occupancy PT			-0.062 (0.396)
Leisure Trip		-0.331 (0.358)	0.477 (0.458)
Spatial Variables			
Inhabitant Density		4.864 (3.404)	1.290 (3.429)
Station Class (ref. Class A)			
Station Class B			-0.920 (0.572)
Station Class C			-0.692 (0.533)
Station Class D			-0.511 (0.795)
PTCQ Class (ref. Class A)			
PTCQ Class B			1.848* (0.863)
PTCQ Class C			1.625* (0.799)
PTCQ Class D			2.534** (0.927)
PTCQ Class None			2.035 (1.109)
Sociodemographic Variables			
Female		0.037 (0.341)	0.455 (0.427)
Age (ref: 20-35)			
Age 36-45		0.106 (0.644)	-0.649 (0.819)
Age 46-55		-0.124 (0.606)	-0.422 (0.779)
Age 56-65		0.599 (0.628)	0.453 (0.771)
Age 66 and older		0.700 (0.700)	0.755 (0.887)
High Education		-0.134 (0.346)	1.113* (0.515)
Mobility Resources			
PT Subscription (ref. None)			
GA		2.623*** (0.665)	2.002 (1.298)
Half-Fare Card		1.577*** (0.457)	1.419* (0.707)
Other Form of PT Card		3.124*** (0.653)	1.713 (0.966)
Private Car available		-1.016 (0.561)	-1.348 (0.776)
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$			

The access time has no direct effect on mode choice, but the results from the latent variable model (Table 4) show that there is an indirect effect of the access time on walk&train. With increasing

access time, PA-Station-Walk decreases, and thereby also the utility of walk&train. Similarly, the station class has an indirect effect on mode choice through its effect on PA-Station-PT. As station class decreases, PA-Station-PT decreases, thereby reducing the utility of PT&train.
A lower PTCQ Class is also associated with lower PA-Station-PT levels. This means that the indirect effects of PTCQ class via PA-Station-PT reduce the overall effect of PTCQ class on the utility of PT&train.
Our results show that the access time significantly affects perceived station accessibility for access on foot but not access by PT. In addition, the results show that using access time alone as a measure of station accessibility does not reflect people's perception of it. In denser residential areas, for example, higher levels of perceived station accessibility are reported, and people with higher education also report higher levels of it. Similarly, people who commute by train or use it for leisure trips also report higher levels of perceived station accessibility.

Table 4: Latent Variable Modeling Results, standard errors in parentheses

Estimate	**PA-Station-Walk**	**PA-Station-PT**
Random Term	1 .000	1 .000
Spatial Variables		
Inhabitant Density	2.748*** (0.499)	1.690* (0.657)
Access Time [h]	-0.034*** (0.002)	0.586 (0.333)
Access Time Squared [h^2]		-0.156 (0.181)
Station Class (ref. Class A)		
Station Class B		-0.197 (0.114)
Station Class C		-0.602*** (0.120)
Station Class D		-0.476* (0.186)
PTCQ Class (ref. A)		
PTCQ Class B		-0.185 (0.142)
PTCQ Class C		-0.002 (0.151)
PTCQ Class D		-0.351* (0.165)
PTCQ Class None		-0.792*** (0.197)
Sociodemographic Variables		
Female (ref. Male)	-0.059 (0.078)	-0.016 (0.084)
Age (ref. 20-35)		
Age 36-45	-0.058 (0.164)	-0.132 (0.159)
Age 46-55	-0.340* (0.154)	-0.169 (0.149)
Age 56-65	-0.210 (0.153)	-0.089 (0.146)
Age 66 and older	-0.128 (0.168)	0.075 (0.158)
High Education	0.285*** (0.079)	-0.061 (0.080)
Mobility Resources		
PT Subscription (ref. None)		
GA	0.594*** (0.177)	0.131 (0.190)
Half-Fare Card	0.366*** (0.088)	0.292** (0.092)
Other Form of PT Card	0.241 (0.152)	0.390* (0.167)
Private Car Available	0.000 (0.130)	-0.291* (0.136)
Past Travel Behavior		
RP Train Commute	0.502*** (0.138)	0.508*** (0.141)
RP Train Leisure	0.244* (0.111)	0.269* (0.122)
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$		

4. CONCLUSIONS

We investigated the extent to which perceived station accessibility influences people's preference for the train over the car, using stated-preference data from the Swiss Mobility Panel and an integrated choice latent variable model. Our results suggest that perceived station accessibility positively influences people's likelihood to choose the train over the car. This is the case for both walking and taking public transportation to the station. Additionally, perceived station accessibility partially moderates the effects of calculated station accessibility on mode choice. The access time has an indirect effect on mode choice through perceived station accessibility. Moreover, our results show that using access time to reflect station accessibility would not adequately represent people's perception of station accessibility. Especially in less densely populated areas and among people who do not commute by train, perceived accessibility may be lower than one would expect based on travel time. Therefore, it is important to consider the local context when using calculated measures of accessibility.

ACKNOWLEDGEMENTS

This work was partially supported by the ETH Mobility Initiative program under the ALIGN project.

REFERENCES

ARE, B. für R. (2022). *ÖV-Güteklassen Berechnungsmethodik ARE*. Bundesamt für Raumentwicklung ARE.

BAV. (2023). *Perspektive BAHN 2050: Hintergrundbericht, Vision, Ziele und Stossrichtung*. Bundesamt für Verkehr.

Ben-Akiva, M., Walker, J., Bernardino, A., Gopinath, D., Morikawa, T., & Polydoropoulou, A. (2002). Integration of Choice and Latent Variable Models. *Perpetual Motion: Travel Behaviour Research Opportunities and Application Challenges*.

Brons, M., Givoni, M., & Rietveld, P. (2009). Access to railway stations and its potential in increasing rail use. *Transportation Research Part A: Policy and Practice*, *43*(2), 136–149.

Chia, J., Lee, J. (Brian), & Kamruzzaman, M. (2016). Walking to public transit: Exploring variations by socioeconomic status. *International Journal of Sustainable Transportation*, *10*(9), 805–814.

De Vos, J., & Witlox, F. (2013). Transportation policy as spatial planning tool; reducing urban sprawl by increasing travel costs and clustering infrastructure and public transportation. *Journal of Transport Geography*, *33*, 117–125.

Gan, Z., Yang, M., Zeng, Q., & Timmermans, H. J. P. (2021). Associations between built environment, perceived walkability/bikeability and metro transfer patterns. *Transportation Research Part A: Policy and Practice*, *153*, 171–187.

Gupta, A., Bivina, G. R., & Parida, M. (2022). Does neighborhood design matter for walk access to metro stations? An integrated SEM-Hybrid discrete mode choice approach. *Transport Policy*, *121*, 61–77.

He, X., & Heinen, E. (2026). How are objective and perceived walkability associated with the health of older adults through walking behavior? *Transportation Research Part A: Policy and Practice*, *207*, 104942.

Hillnhütter, H. (2025). Walking environments for transit access: Travelers' perspectives. *Journal of Transport Geography*, *129*, 104414.

Jehle, U., Coetzee, C., Büttner, B., Pajares, E., & Wulfhorst, G. (2022). Connecting people and places: Analysis of perceived pedestrian accessibility to railway stations by Bavarian case studies. *Journal of Urban Mobility*, *2*, 100025.

Lättman, K., Olsson, L. E., & Friman, M. (2016). Development and test of the Perceived Accessibility Scale (PAC) in public transport. *Journal of Transport Geography*, *54*, 257–263.

Levis, A., Lichtin, F. M., Stapper, L., Smith, E. K., Wehrli, S., Wäger, P., Linder, J., Maissen, P., Pahls, H., Seidlmann, E., Walker, L., Paroz, M., Kaufmann, G.-L., Axhausen, K. W., & Bernauer, T. (with ETH Zurich). (2024). *Schweizer Mobilitätspanel. Vierte Erhebungswelle: Zweite Basisbefragung. Besitz von Mobilitätsmitteln, Mobilitätsverhalten und politische Präferenzen in der Schweiz.* [Application/pdf]. ETH Zürich, Institute of Science, Technology and Policy (ISTP).

Lichtin, F., Smith, E. K., Axhausen, K. W., & Bernauer, T. (2024). "How much should public transport services be expanded, and who should pay? Experimental evidence from Switzerland." *Transport Policy*, *158*, 64–74.

Morris, J. M., Dumble, P. L., & Wigan, M. R. (1979). Accessibility indicators for transport planning. *Transportation Research Part A: General*, *13*(2), 91–109.

Negm, H., De Vos, J., Pot, F., & El-Geneidy, A. (2025). Perceived accessibility: A literature review. *Journal of Transport Geography*, *125*, 104212.

Negm, H., & El-Geneidy, A. (2025). Subjectivity matters: Investigating the relationship between perceived accessibility and travel behaviour. *Transportation Research Part A: Policy and Practice*, *193*, 104399.

Ryan, J., & Pereira, R. H. M. (2021). What are we missing when we measure accessibility? Comparing calculated and self-reported accounts among older people. *Journal of Transport Geography*, *93*, 103086.

Ryan, M., Lin, T. (Grace), Xia, J. (Cecilia), & Robinson, T. (2016). Comparison of perceived and measured accessibility between different age groups and travel modes at Greenwood Station, Perth, Australia. *European Journal of Transport and Infrastructure Research*, *16*(2), Article 2.

Scheepers, C. E., Wendel-Vos, G. C. W., Van Kempen, E. E. M. M., De Hollander, E. L., Van Wijnen, H. J., Maas, J., Den Hertog, F. R. J., Staatsen, B. A. M., Stipdonk, H. L., Int Panis, L. L. R., Van Wesemael, P. J. V., & Schuit, A. J. (2016). Perceived accessibility is an important factor in transport choice—Results from the AVENUE project. *Journal of Transport & Health*, *3*(1), 96–106.

Sobol, I. M. (1967). On the distribution of points in a cube and the approximate evaluation of integrals. *USSR Computational Mathematics and Mathematical Physics*, *7*(4), 86–112.

Train, K. (2009). *Discrete Choice Methods with Simulation*. Cambridge University Press, Cambridge.

UVEK. (2025). *Investitionen ins Verkehrsnetz*.