# Beyond Tracks: Modeling Intermodal Travel Behavior at Swiss Train Stations

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## SHORT SUMMARY

This paper investigates the interplay of various transportation modes at Switzerland's railway stations, focusing on the intricate dynamics between trains, bikes and cars. Through an analysis of empirical data from the Swiss Mobility and Transport Microcensus (MTMC), the study provides insights into intermodal travel behavior. In the next step, the integration of this data into an agent- and activity-based transport model is described.
The research reveals significant variations in transportation preferences across urban, suburban, and rural areas. Notably, accessing train stations by car is more prevalent in rural regions, while walking and local public transport are favored in urban and suburban settings.
The calibrated model showcases a close alignment with real-world modal shares. This integrated approach provides a robust foundation for optimizing station facilities, bike parking, and bus stops. As transportation systems evolve, the insights from this study are an important step towards designing an efficient and future-ready public transport system that caters to the dynamic needs of public transport users.

**Keywords:** Intermodal travel, Multimodal travel, agent-based modeling, MATSim, railway planning

## 1. INTRODUCTION

Switzerland's railway stations represent critical nodes in the country's transportation network, acting as gateways for diverse modes of travel. This paper focuses on the interplay between trains, bikes and cars at these key transit hubs. The goal is to dissect the intricacies of intermodal connections, examining how train users navigate and choose between various modes of transportation for a cohesive and efficient travel experience. Understanding this behavior is important in the present in order to improve a seamless intermodal connection at train station, e.g., by providing sufficient bicycle parking. When forecasting into the future, where, in the context of automated vehicles, on-demand modes may play a more significant role, anticipating intermodal behavior becomes crucial for designing station access and parking.
Intermodal travel behavior can be examined from travel diaries reported in the Swiss Mobility and Transport Microcensus (MTMC, FSO/ARE 2017). However, its sample size of roughly 0.5 per cent of the population is too small for detailed spatial analysis. Thus, for planning purposes, it is important to mirror intermodal travel behavior also into a transport model.
In this paper, we firstly give a brief overview of the available empirical data. In a second step, we demonstrate the inclusion of intermodal travel chains into SBB’s activity- and agent-based transport model SIMBA MOBi.

## 2. METHODOLOGY

### *Analysis of Empirical Data*

The selection of empirical data for intermodal travel behavior is rather small. Specifically, the MTMC is the only nationwide available data source that provides some information on travel chains that include a journey by rail in combination with some form of private transport. However, given that the number of people traveling in such chains is very limited, the sample in the MTMC is rather small. As such, a disaggregation into specific regions or stations is only useful for larger stations such as Bern or Zürich (e.g., Danalet 2022). Hence, an aggregation into stations in similar regions is a meaningful way for an aggregated analysis. In this case, the official Swiss typology into urban, suburban and rural communities is used (FSO 2012). In Table 1, the modal share of train users boarding or alighting is depicted according to the MTMC 2015[1], where a total of 7'788 domestic train trips have been reported.

**Table 1: Share of railway station access in different area categories.**

| Access / egress mode | Total | Urban Areas | Suburban areas | Rural areas |
|---|---|---|---|---|
| Walk | 60 % | 61 % | 61 % | 41% |
| Local public transport | 30 % | 30 % | 23 % | 27 % |
| Bicycle | 5 % | 5 % | 6 % | 5 % |
| Car (parked at station) | 3 % | 1 % | 5 % | 20 % |
| Car (pick-up / drop-off / taxi) | 3 % | 5 % | 5 % | 7 % |

Quite notably, accessing a train station by car, either as a driver or passenger, is far more popular at stations in rural areas, where it accounts for more than a quarter of all occasions and is just as important as taking a local bus. In contrary, walking is less popular or useful in rural areas. Accessing the station by bicycle is roughly of the same popularity across all land area categories.

In total, intermodal changes to and from private transport modes make up for just 10 per cent of all train trips. However, there are also considerable differences where persons consider an intermodal change. Notably, the first or last leg of a trip between a person's home location and a train station is far more likely to be performed using a private transport mode, than at any other activity location, as the figures in Table 2 show. This can to some extend be expected, as a car is usually available only for trips originating at home and transporting a bike on a train constitutes a certain additional burden.

[1] In this paper the MTMC 2015 was used as a reference, even though the MTMC 2020/2021 is available. This is to avoid depicting behavior related to pandemic-related changes in travel behavior.

**Table 2: Share of railway station access at each activity.**

| Access / egress mode | Home to/from station | Work to/from station |
|---|---|---|
| Walk | 49 % | 65 % |
| Local public transport | 32 % | 32 % |
| Bicycle | 9 % | 2 % |
| Car (parked at station) | 5 % | 0 % |
| Car (pick-up / drop-off / taxi) | 5 % | 1 % |

### *Integration into an agent-based transport model*

SIMBA MOBi (Scherr et al., 2020), the activity and agent-based transport model available for Switzerland at the Swiss Federal Railways (SBB), uses MATSim (Horni et al., 2016) as the simulation framework. The public transport router in MATSim is based on the Raptor algorithm proposed by Delling et al. (2015). The MATSim implementation by Rieser et al. (2018) provides a pluggable framework that allows, in principle, to add any available transport mode in MATSim as a feeder mode to or from a public transport stop. When a routing request is made for a specific route, all stops reachable by a certain mode within a mode-specific distance are considered for least cost routing. For example, a maximum distance for walking could be set to 1’000 meters, whereas bicycle access to a station could be 3’000 meters. The costs associated with the travel time and distance to access the stop are considered into the total cost when performing a least cost path calculation for a trip by public transport. Additionally, constraints on the allowed access and egress modes can be defined for each public transport stop. By these means, e.g., park-and-rail access can be limited to stations where such service is available.

In its current release 4.0, representing the reference year 2017, the transit schedule used in SIMBA MOBi consists of 25’037 stop points and 1879 transit lines extending across Switzerland and its neighboring countries. Depending on a route’s start point, several hundred possible stops could fall within a 5’000-meter radius. Access route calculations need to be performed for all of these, additionally to all raptor calculations from each of the stops. This leads to a considerable increase in computation times if intermodal routing is being used for all stops.

The maximum distances for each access or egress mode defined are noted in Table 3.

**Table 3: Maximum distances for intermodal access modes**

| Access / egress mode | Maximum distance (m) |
|---|---|
| Walk | 2’500 |
| Bicycle | 4’000 |
| Car (parked at station) | 15’000 |
| Car (pick-up / drop-off / taxi) | 15’000 |

To circumvent this, in a first step, we have limited the number of stops for intermodal access to only those where there is either a railway station or a designated park and ride facility available. This is backed by MTMC data, where intermodal transfers are almost exclusively being performed at railway stations. In a second step, travel times and distances for car- and bicycle modes from each station are pre-cached using the tree calculation functionality of MATSim's Speedy ALT network routing. These caches are pre-calculated at the beginning of a simulation for each of the 1940 stops where intermodal access is available. As this calculation can be parallelized, the whole process takes just a few minutes.

The strong differentiation between different spatial typologies can be reproduced by applying an agent-specific constant for each intermodal mode depending on the residence location of each agent. A similar principle can be applied to each activity type.

## 3. RESULTS AND DISCUSSION

With the model modifications and setup, a calibration of access and egress modes in the model can be performed by modifying constants and cost parameters of feeder modes. As such, feeder modes for station access and egress are scored differently in MATSim than their corresponding main modes, for which scoring parameters have been obtained from Weis et al. (2021). There are some reasons that justify a different behavioral scoring of feeder modes: Firstly, car trips to a station require an additional time buffer to plan for unexpected travel time delays. Secondly, parking a car or a bike can be challenging at larger stations. Thus, using car (both drive and passenger) or bicycle as a feeder mode is scored at a higher cost compared to using the mode from point to point. As an example, the mode parameters for "car" and "car as a station feeder mode" and their differences are shown in Table 4.

**Table 4: Cost parameters for car and car feeder mode**

| | **Car** | **Car feeder** | **Difference** |
|---|---|---|---|
| Constant | -0.15 | -0.45 | -0.3 |
| Marginal Utility of Travel time (utils / hour) | -1.25 | -1.75 | -0.5 |
| Monetary Distance Rate (CHF / km) | 0.22 | 0.22 | 0.0 |

### *Global Modal Share in Station Access and Egress*

In Table 5, the obtained calibration result for the modal shares is shown and compared to the values obtained from MTMC. The calibration fits the census data very well globally and in urban areas with its large train stations. However, especially the differentiation between car and car as a passenger is complicated in rural areas and thus, not very well calibrated.

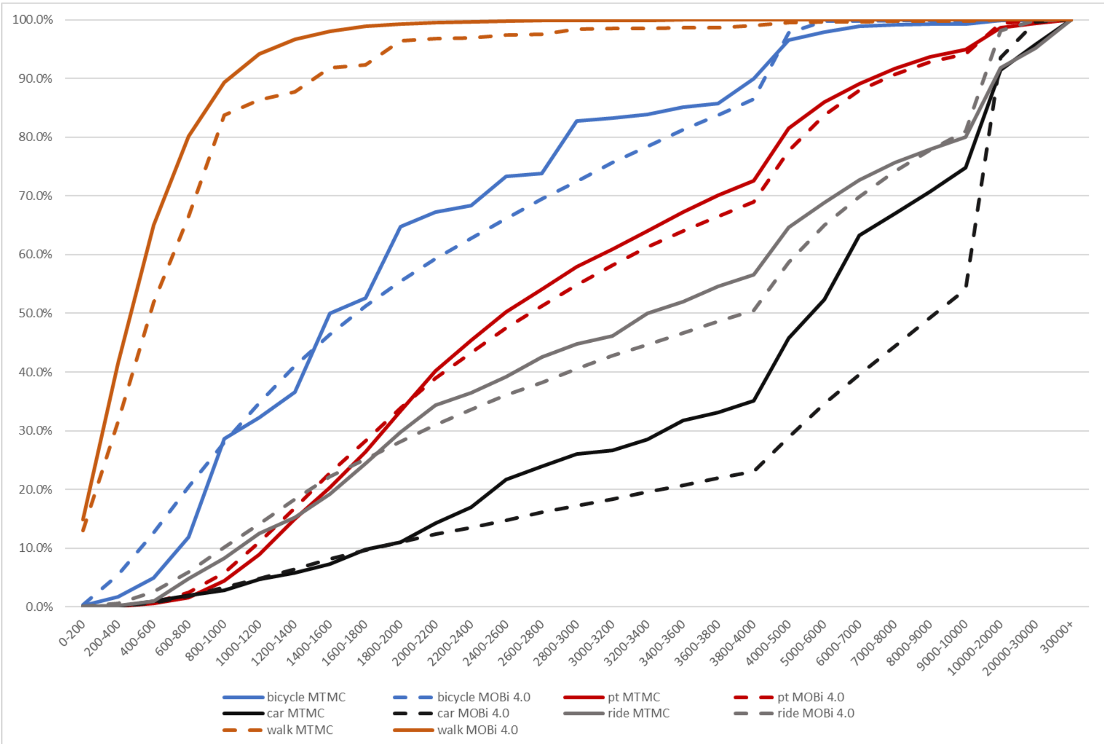
**Table 5: Modal share of simulated access modes to and from train stations per spatial area category and their difference to the empirical measure**

| Access / egress mode | Total | Urban Areas | Suburban areas | Rural areas |
|---|---|---|---|---|
| Walk | 58% (-2) | 60% (-1) | 55% (-6) | 39% (-2) |
| Local public transport | 31% (+1) | 32% (+1) | 27% (+4) | 34% (+7) |
| Bicycle | 5% (0) | 4% (0) | 6% (0) | 5% (0) |
| Car (parked at station) | 3% (0) | 2% (1) | 6% (1) | 11% (-9) |
| Car (pick-up / drop-off / taxi) | 3% (0) | 2% (0) | 7% (2) | 11% (+4) |

### *Distance distribution of feeder modes*

Depending on the distance from a station, different access or egress modes are chosen by the agents. In Figure 1, the shares per access mode is plotted per distance class for both the simulation and the empirical value from the MTMC. Overall, the calibration of the distance distribution in the simulation shows a very good match with the census data. Walk is predominant for short distances, with over 90% of all walk trips being shorter than one kilometer. Bicycle trips are somewhat longer, with a median of around 2000 meters and some trips of up to 4000 meters. Access by local public transport and car have slightly higher median access distances.

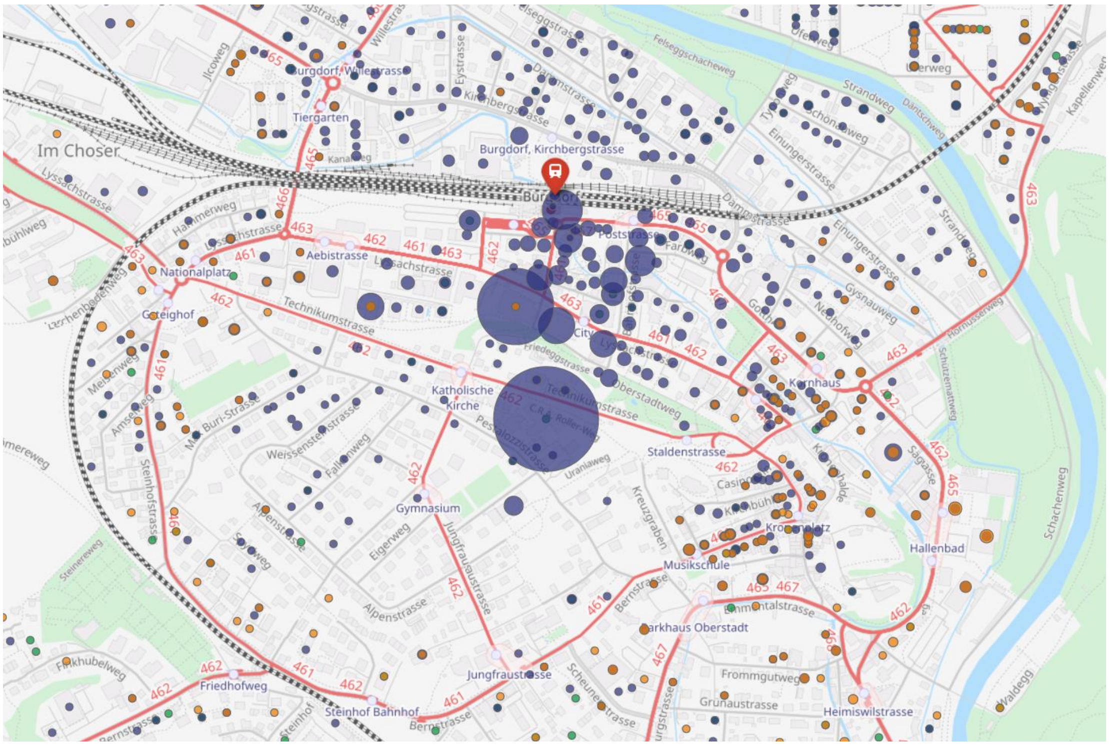
**Figure 1: Share for train Station access per distance class.**



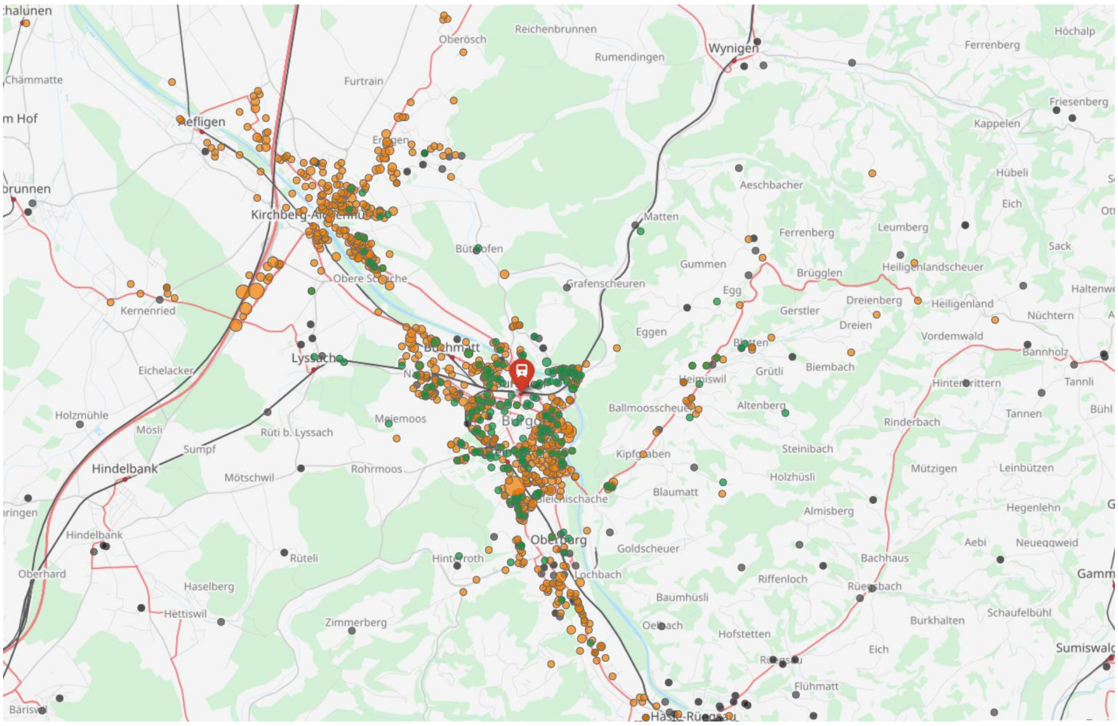
### *A typical use case*

The integration of intermodal access and egress is often being used for a report that collects all trips to and from any Swiss train station. This report provides an analysis of a train station, for planning purposes. Especially at small and midsize stations, planning of station exits, bike parking facilities and bus stops can be facilitated.
As an example, Figure 2 shows access and egress locations of agents using the train station in Burgdorf. Burgdorf is a mid-size station near Berne with a workday-average patronage of 15’900 (2022). It is served both by local services and inter regional trains going directly to Zürich and Bern.
Each bubble in the figure shows a location where an agent has traveled to or from the train station. Bigger bubbles stand for more persons using this facility, e.g., at schools or shopping centers. In Figure 2 (a), the vicinity of the station is displayed, where walk mode (blue) clearly dominates, with some people arriving by bike (green) and bus (orange). Figure 2 (b) shows the outskirts of the city, where bike mode is still of importance, but people arriving by bus are in the majority. Car (black dots) is being used especially for people arriving from locations that are otherwise difficult to access.

**Figure 2: Access and egress locations per mode in Burgdorf station**



(a)



(b)

## 4. CONCLUSIONS

In summary, this paper underscores the vital role of Switzerland's railway stations as hubs for diverse transportation modes and investigates commuters' intermodal behavior. This study integrates empirical data from the Swiss Microcensus into our agent-based transport model, providing a powerful tool for understanding and simulating commuter choices.

The calibrated model demonstrates a close alignment with real-world modal shares, especially in urban areas. Notably, it reveals the complexity of behavioral modeling in diverse contexts, such as accurately differentiating between car and car as a passenger in rural areas. The distance distribution analysis enhances our understanding of how access modes vary with proximity to the station.

This research emphasizes that an integrated model holds significant potential to enhance the planning process for train stations. By providing realistic simulations of commuter behavior, including first and list mile, it enables a nuanced analysis of station access, aiding in the optimization of facilities, bike parking, and bus stops. Enabling intermodal access/egress also improves modelling of rail journeys, especially in rural areas where local public transport is often not available within walking distance and thus improves the overall quality of the mode. As transportation systems evolve, the insights from this study become increasingly crucial for designing efficient, future-ready train stations that cater to the dynamic needs of commuters.

Future research could investigate how people choose the bus stop where they get on and off from/to the train station in larger railway stations. Count data at bus stops show that it is not always clear. Depending on data availability, a choice model could be estimated, with the dependent variable being the bus stops and the choice attributes being the distance, the type of path (with or without stairs, e.g.), the slope, the lighting, etc.

## ACKNOWLEDGEMENTS

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