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Bachelor Thesis

Evaluating Alternatives to Park and Ride: A data-centric analysis of Bicycle Infrastructure and Public Transport Accessibility at P+R Stations in Austria

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Abstract

This thesis examines the surrounding bicycle infrastructure and public transportation service quality of 28 core Park and Ride facilities and two Bike and Ride stations across Austria. While the original goal of Park and Ride is to reduce city center traffic and promote public transportation use, evidence from multiple studies shows that this is not always achieved. The aim of this thesis is to highlight areas for improvement in bicycle infrastructure and public transportation quality by comparing the different Park and Ride and Bike and Ride locations. The results indicate that, particularly in rural areas and smaller cities, there remains significant potential to enhance alternative modes of transport to the car.

1 Introduction

Park and Ride is an intermodal transport facility located near public transport nodes, where a private vehicle, in most cases a personal car, is parked and the customer continues the journey by public transportation modes, most often trains. The reasons for the change of mode can originate from multiple factors.[1]
In 2017, the planning and construction of Park-and-Ride and Bike-and-Ride facilities were regulated uniformly for the first time in Austria. Between 2017 and today (2025), these regulations were adapted to the increasing demands for sustainability. The promotion of alternatives to the car has also become increasingly important. A core goal is the creation of bicycle parking infrastructure as well as guaranteeing a safe bicycle network to reach the station. [2] Climate protection campaigns such as *klimaaktiv mobil*, part of the *klimaaktiv* initiative, support these goals at the federal level.[3] In addition to the promotion of alternative modes, another core goal of Park-and-Ride and Bike-and-Ride facilities is the avoidance and reduction of land consumption and soil sealing. [2]

1.1 Problem Statement

A Data-Centric Approach to Park and Ride highlights the misuse of parking facilities and consistently high occupancy rates. Out of 22 facilities, 9 reached full capacity on weekdays, and an additional 3 exceeded 90% occupancy. These findings point to the need for more attractive alternatives to ensure compliance with goals and regulations. [4]
Further problems highlighted in survey studies from Mingardo [5] and Parkhurst [6] are that not all users of Park and Ride facilities use them as intended. They take advantage of the parking facility to continue their journey by foot. The third problem is that the

parking facilities changed the travel behaviors of people, that prior the facility used the public transportation network or the bicycle to reach the train station.

1.2 Goal of the Thesis

The aim of this bachelor thesis is to analyze existing park-and-ride and bike-and-ride stations throughout Austria based on two main criteria: How good is the bicycle infrastructure around the train station and how good is public transportation to the train station? This analysis provides us with data-driven insights into where action is needed and where the existing infrastructure is already well developed, with a view to potentially relieving the burden on the existing infrastructure and preventing the sealing of undeveloped areas in order to act in accordance with the guidelines.

We want to reduce the so called unintended usage, as it will be described in the literature review under the section Identified problems with Park and Ride usage, and enhance the comfort and safety for inhabitants, to make alternatives to the car more attractive.

> *RQ T.1: Are there significant differences between the biggest Park and Ride stations among Austria in terms of accessibility of the station by alternative modes (bike and bus)?*
> *RQ T.2: Can we see differences between solely Bike and Ride and Park and Ride facilities*
> *RQ T.3: Can we observe patterns in the usage behavior that get influenced by the surrounding circumstances*

2 Target group of Park and Ride

First of all, we need to identify the factors that motivate users to utilize the Park and Ride system. Surveys by Giuliano Mingardo and Graham Parkhurst, as well as the data-driven approach by Shahrom Sohi, suggest that the largest user group consists of commuters who use the intermodal platform to continue their journey to work by public transportation. A survey conducted in The Hague and Rotterdam further shows that a very large share of users are solo drivers. Other user groups, which make up a smaller share, include visitors particularly on weekends as well as people traveling for shopping, study, or leisure purposes. [4][5][7]

Where to locate a Park and Ride (P+R) station is a trade-off between distances: if the P+R is too far from the destination, it becomes unattractive, while if it is too close, it loses its purpose [8]. Other external factors, such as the quality of public transportation and costs, also influence the decision [9].

2.1 Identified Problems with Park and Ride

To delve deeper into the problem described above at a high level, we can look at several survey-based studies. One frequently cited survey in this context is that conducted by Graham Parkhurst in 1994. This publication highlights the issue that Park and Ride facilities do not always achieve the intended effect namely, that every car parked there should represent one less car in city centers. Instead, they often redistribute traffic rather than significantly reducing it [6].

2.1.1 Abstraction Problem

We speak of abstraction when people who previously traveled by bicycle or by local public transportation to their final destination or to the train station (in our case, since all Park and Ride facilities analyzed are located near train stations), now use the car to park at the Park and Ride facility and continue their journey by train.

Evidence for this phenomenon is provided by a survey-based study from Giuliano Mingardo in the Netherlands. In Rotterdam, 30.6% of users and in The Hague 37.0% stated that they would use public transportation in the absence of a Park and Ride facility. For bicycles, 3.7% in Rotterdam and 5.3% in The Hague would make the trip entirely by bike, while a further 16.9% in The Hague would cycle to reach the public transportation terminal [5].

This behavior also diminishes the environmental benefits that Park and Ride would otherwise provide if used as intended. The paper *"A meta-analysis of the effectiveness of Park and Ride facilities"* shows, based on 40 studies including 180 evaluated Park and Ride sites, that satellite-type facilities (rail-based and origin facilities) have limited impact on reducing car traffic in city centers, but do contribute to a small reduction in vehicle kilometers traveled (VKT). Fringe-type facilities, on the other hand, are expected to increase VKT [10].

2.1.2 Reasons for Abstraction

The most prominent reasons for abstraction from public transportation are comfort and speed. An interesting observation in Rotterdam was that, in addition to these two factors, the cost of public transportation was also mentioned. Similar reasons are cited for abstraction from cycling: the combination of the car being faster and more comfortable motivated users to switch [5].

2.1.3 Additional Problems

Two additional problems identified by Sohi et al. are, on the one hand, overnight parking, several parking lots never reached 0% occupancy, and, on the other hand, the misuse of charging infrastructure [4]. Field observations have also shown the unintended effect of "Park and Walk", meaning that the parking lot is used as the final destination. Employees of large companies were observed in Mairahoeve and Voorburg (NL) using the Park and Ride facility as a regular company parking lot [5].

3 Data Sources

All the data used, with the exception of the occupancy dataset, is publicly available. The download links and further description are provided in the Appendix, as well as in the README of our GitHub repository. [1]

3.1 ÖBB Data

s

The data used for gathering information about Park and Ride facilities across Austria is provided on the Open Data portal from ÖBB [11]. The dataset used is `NETEX 2025`, which, at the time of the thesis, is the most recent update of the data. The compressed `.zip` directory contains two `.xml` files and one documentation `.pdf`. We are interested in the `SiteFrame .xml`, which contains, in the `parking` node, the relevant information about the P+R facilities. Relevant information for our analysis is:

- `id` – an identifier number for the facility
- `Name` – self-explanatory
- `Covered` – a boolean value that describes whether the facility is covered
- `ParkingVehicleTypes` – describes the type of the parking spots; there are three different types (`car`, `motorcycle`, `bicycle`)

[1] Link: `https://github.com/DanielZipp/bachelor_thesis_ST_2025`

- `TotalCapacity` – describes the capacity of the parking spots
- `RechargingAvailable` – a boolean value that describes the availability of recharging stations [12]

3.1.1 Park and Ride Occupancy Data

The occupancy data was provided directly by ÖBB Infrastruktur AG and contains hourly aggregated occupancy data from 22 Park and Ride facilities in Austria. Key variables we need are:

- `Timestamp` – the exact date and hour of the record
- `Label` – the name of the facility
- `OccupancyTotal` – the occupancy at this specific time
- `CountTotal` – the total capacity of the station

We were only interested in the data during our defined working hours; therefore, we filtered for the hours and ignored weekends and holidays. We ended up with a dataframe with the following attributes:

- `Label` – as explained above
- `Occupancy` – the minimum, mean, and maximum occupancy during working hours
- `HoursBeyondThreshold` – we calculated the total hours beyond 75%, 80%, 90%, and 95% occupancy rate

3.2 Mobilitätsverbünde Österreich

The public transportation data used throughout the analysis were retrieved from the data platform of `Mobilitätsverbünde Österreich (MVÖ)`. `MVÖ` is an association of the seven transport authorities in Austria, which aims to create an Austria-wide multi- and intermodal journey planner. The data for this scope derives from public transport providers:

1. Public Transport Authority Eastern Region (`Verkehrsverbund Ost-Region`)
2. Public Transport Authority of Upper Austria (`Oberösterreichischer Verkehrsverbund`)
3. Public Transport Authority of Salzburg (`Salzburger Verkehrsverbund`)
4. Public Transport Authority of Tyrol (`Verkehrsverbund Tirol`)
5. Public Transport Authority of Vorarlberg (`Verkehrsverbund Vorarlberg`)
6. Public Transport Authority of Styria (`Steirischer Verkehrsverbund`)
7. Public Transport Authority of Carinthia (`Verkehrsverbund Kärntner Linien`) [13]

These data are downloadable in different file formats. Furthermore, the platform provides timetable data for the railway, including the following rail associations:

1. `ÖBB - Personenverkehr AG`
2. `Raaberbahn/GYSEV`
3. `Montafonerbahn`
4. `WESTbahn`
5. `Austrian Society for Railway History (ÖGEG)` [14]

We decided to use the `General Transit Feed Specification (GTFS)` format for ease of use.

3.2.1 General Transit Feed Specification

`General Transit Feed Specification (GTFS)` is an open data standard for transit passenger information. It provides a structure for public transit agencies to describe the details of their services [15].

The standard originates from a collaboration between `TriMet` in Portland, Oregon, and `Google` in 2006. In 2019, the non-profit `MobilityData` was established in Montreal, Canada [16].

`GTFS` data needs to include at least four text files, each formatted as comma-separated values (`CSV`), and three conditionally required files:

1. `agency.txt`
2. `routes.txt`
3. `trips.txt`
4. `stops.txt` (conditionally)
5. `stop_times.txt`
6. `calendar.txt` (conditionally)
7. `calendar_dates.txt` (conditionally)

The conditionally required files listed above can only be excluded under the following conditions:

1. `stops.txt`, if demand-responsive zones are defined in `locations.geojson`; otherwise, it is required
2. `calendar.txt`, if all dates of service are defined in `calendar_dates.txt`
3. `calendar_dates.txt` is optional unless `calendar.txt` is omitted [17]

3.3 AustriaTech

The bicycle and road infrastructure data were provided by AustriaTech, a non-profit organization and subsidiary of the Austrian Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK). For more than 15 years, AustriaTech has been working to place people at the center of new mobility solutions and to facilitate the implementation of technological innovations in the field of mobility [18].
The organization provides a geodatabase based on the OGD export of the Graphen Integrations Platform (GIP) from February 2024. From this database, we used two different layers, called Netz_Basis_Radverkehrsnetz_GIP and Netz_Sicheres_Radverkehrsnetz_GIP, which translate to base bicycle network and safe bicycle network [19].

3.3.1 Base Bicycle Network

This layer represents all links in the GIP OGD 2024/02 with the following attributes:

- Regcode beginning with AT: the link is in Austria
- ONEWAY_BK greater than −1: there is no cycling ban
- BAUSTATUS = 5: the link is active
- FRC not in the following set: 12, 105, 106, 200, 300, meaning that the link does not fall under the following categories:
  - 12: Sonstiger Weg
  - 105: Almaufschließungsweg
  - 106: Forstaufschließungsweg
  - 200: Singletrail (MTB)
  - 300: Wanderweg

If a link fulfills all these attributes, it is categorized as base bicycle infrastructure. The majority of features of these links are the geometries, which are projected in the `ETRS89 / LAEA Europe (EPSG:3035)` system. This projection uses meters and is standard for countries in the European Union and EU candidate countries [19].

3.3.2 Safe Bicycle Network

This layer represents all links in the `GIP OGD 2024/02` which are considered safe for bicycle usage. To be considered `Safe Bicycle Infrastructure`, the links need to have one of the following attributes:

1. Begegnungszonen
2. Fahrradstraße
3. Radfahren in Fußgängerzonen
4. Geh- und Radwege gemischt
5. Geh- und Radwege getrennt
6. Mehrzweckstreifen
7. Radfahrerüberfahrten
8. Radfahrstreifen
9. Radwege
10. Wohnstraßen

If none of these attributes is present, links may still be considered suitable for cycling under the following conditions:

1. The maximum permitted speed does not exceed 30 km/h, or

2. Motor vehicle access is restricted but cycling is explicitly allowed, in combination with a maximum permitted speed of $\leq$ 50 km/h.

3.4 WorldPop

The population data is provided by the `WorldPop` project, based in the `School of Geography and Environmental Sciences` at the `University of Southampton`. The data estimates the number of people per grid cell, at a resolution of 3 arc-seconds, which is approximately 100 meters at the equator [20]. The top-down constrained estimation method of `WorldPop` uses building footprints derived from satellite images, together with settlement maps from the `Global Human Settlement Layer (GHSL)` and `World Settlement Footprint (WSF)`. The gathered information about the population is then disaggregated only to grid cells containing residential buildings. The classification of residential buildings is obtained from `GHSL` and `OpenStreetMap (OSM)` [21].

The data comes in `GeoTIFF` format and is projected in the `Geographic Coordinate System (WGS84)`.

4 Park and Ride in Austria

In the `2025 NETEX XML`, we can find a total of 819 different Park and Ride facilities throughout Austria. They contain a total of 69,867 parking spots for cars, of which 20.27% are covered; 48,980 bicycle parking spots, of which 3.82% are covered; and 3,848 motorcycle parking spots, of which 4.13% are covered.
The descriptive statistics below provide an overview and insight into the facilities in Austria.

Parking Type	**Mean**	**Median**	**Std Dev**
Car	85.31	29.0	192.96
Bicycle	59.80	26.0	107.25
Motorcycle	4.70	0.0	8.19

Table 1: Statistics of Park and Ride parking spots in Austria (`2025 NETEX XML`)

We can observe a highly skewed distribution (the mean is much larger than the median, confirmed by the high standard deviation) for all three vehicle types.
If we look at the facilities with recharging infrastructure, we can observe that they are significantly larger than facilities without it. We also observe a skewed distribution here, with a high difference between mean and median. The smallest P+R facilities with recharging infrastructure in our dataset are `Mittlern` in Carinthia and `Achau` in Lower Austria, with 35 car spots each.

Recharging Available	**Mean Capacity**	**Median Capacity**	**Std Dev**
False	53.33	23.5	91.55
True	341.14	192.0	443.01

Table 2: Descriptive statistics of Park and Ride facilities by recharging availability (`2025 NETEX XML`)

When examining the descriptive statistics of facilities that are fully covered, partially covered, or not covered at all, we observe that uncovered facilities are, on average, smaller than covered ones. The skewness in this aggregated data is relatively low for two reasons. First, the fully covered category contains only two facilities, and the partially covered category contains just 22. Second, the variance among covered sites is not very high because these facilities are all relatively large compared to the uncovered ones. It is important to mention in this context that "partially covered" means that at least one car parking spot is outside a building.

Coverage	Mean Capacity	Median Capacity	Std Dev
No	65.23	28.0	104.40
Partially	795.36	607.0	700.23
Fully	256.00	256.0	189.50

Table 3: Descriptive statistics of Park and Ride facilities by coverage (`2025 NETEX XML`)

The smallest at least partially covered facility we can find is `Eichgraben-Altlengbach`, with a total of 67 car parking spaces that are covered.

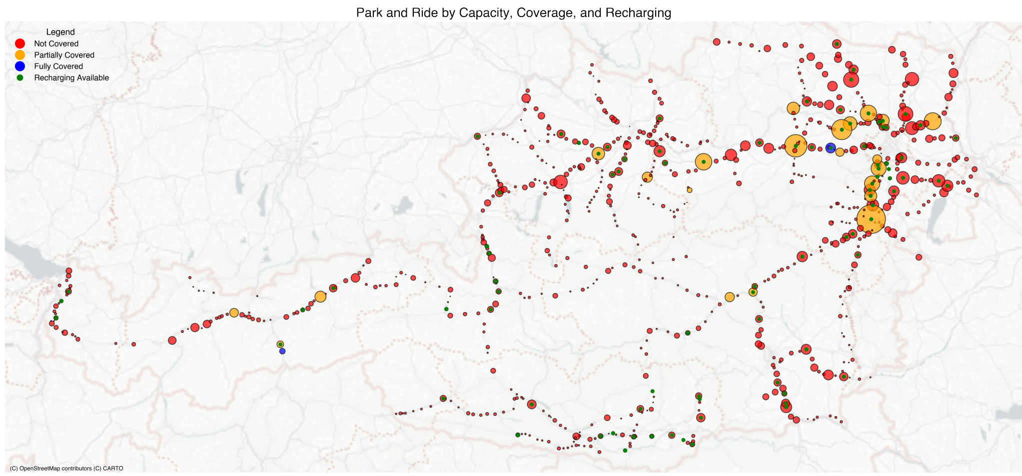


Figure 1: Park and Ride and Bike and Ride facilities all over Austria (`2025 NETEX XML`)

4.1 Federal State Analysis

Firstly, we were interested in the distribution of parking capacities across the three vehicle types. It is clear that `Lower Austria` has the largest total capacity, with 38,354 car parking spots, 19,389 bicycle parking spots, and 964 motorcycle parking spots, which is consistent with the fact that nine out of the ten largest facilities are located in this state.

When examining the mean capacities per federal state, the pattern for car parking spaces remains the same. Surprisingly, however, the mean number of bicycle parking spots per facility is higher in `Vienna` and `Vorarlberg` (also reflected by the median), suggesting a stronger focus on bicycle parking infrastructure in these states. The mean number of motorcycle parking spots also shows an interesting pattern, with `Lower Austria` ranking behind `Upper Austria`, `Tyrol`, `Salzburg`, `Styria`, and `Vorarlberg`.

Considering the bicycle-to-car ratio, we observe that `Vorarlberg`, `Salzburg`, `Vienna`, and `Tyrol` have ratios greater than 1, indicating that these states provide more bicycle parking spots than car parking spots in their P+R facilities.

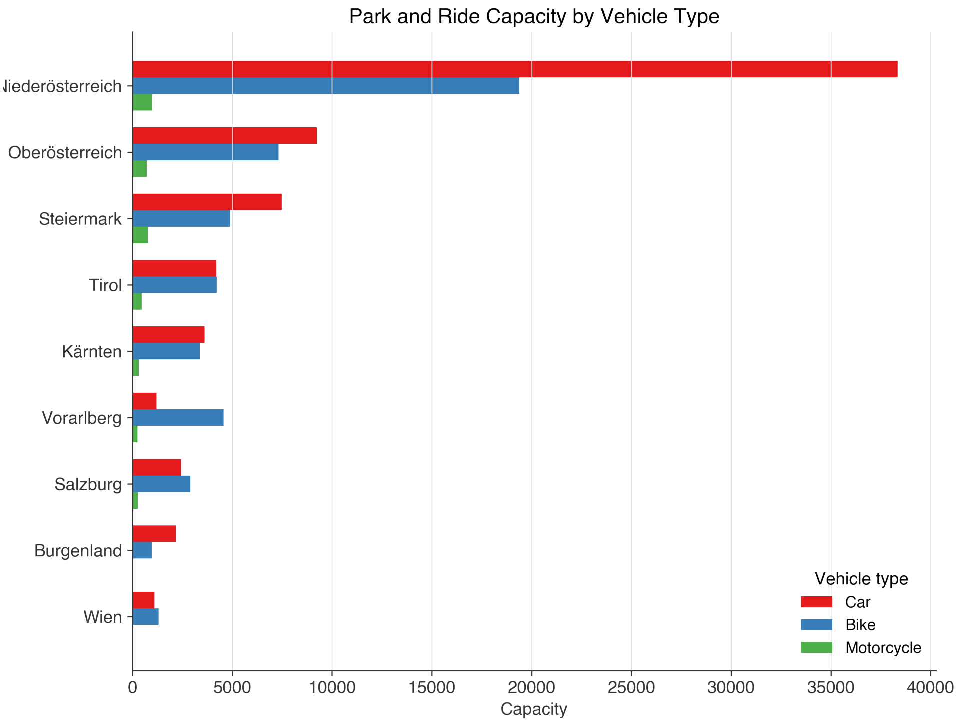


Figure 2: Capacity by vehicle type and federal state (`2025 NETEX XML`)

4.2 Facilities in the Spotlight

For our further analysis, we selected 30 Park and Ride facilities. In Table 3, these facilities are listed and sorted by total capacity (the sum of car, motorcycle, and bicycle spots). In the last column, we calculated the percentage of the capacity that is covered. The selection was performed in two steps: first, the largest facility from each of the nine federal states was included (indicated by underlined names in the table); second, an additional 16 of the largest Park and Ride facilities across the remaining facilities were chosen to complete the dataset. To reach a total of 30 facilities, we also included facilities described in the paper *"A data-centric approach to Park and Ride"*.

A `DataFrame` consisting of 30 rows with the following attributes therefore served as a starting point for further analyses:

Bundesland	Name	Covered	Car	Bike	Motorcycle	Data
Niederösterreich	Wiener Neustadt Hbf	partially	3167	1179	37	yes
Niederösterreich	St.Pölten Hbf	partially	1939	693	23	yes
Niederösterreich	Tullnerfeld	partially	1568	125	20	no
Niederösterreich	Mödling	partially	888	745	14	yes
Niederösterreich	Baden	partially	910	704	9	yes
Niederösterreich	Gänserndorf	partially	1128	328	21	no
Niederösterreich	Wolkersdorf	no	850	603	5	no
Niederösterreich	Amstetten	partially	1057	239	51	yes
Oberösterreich	Wels Hbf	partially	613	694	20	no
Niederösterreich	Tulln an der Donau	partially	737	566	18	no
Niederösterreich	Hollabrunn	no	900	392	22	yes
Niederösterreich	Stockerau	partially	1030	180	0	no
Niederösterreich	Bad Vöslau	no	503	508	28	no
Niederösterreich	Korneuburg	partially	640	376	2	yes
Steiermark	Leibnitz	no	483	414	80	no
Niederösterreich	Deutsch Wagram	no	660	283	20	no
Niederösterreich	Gramatneusiedl	no	624	318	16	no
Tirol	Innsbruck Hbf	no	0	931	0	no
Niederösterreich	Mistelbach	no	699	185	0	no
Niederösterreich	Leobersdorf	partially	573	276	15	yes
Vorarlberg	Dornbirn	no	139	559	45	no
Salzburg	Salzburg Hbf	no	0	668	13	no
Kärnten	Klagenfurt Hbf	no	87	483	10	no
Burgenland	Parndorf Ort	no	497	36	24	no
Wien	Wien Westbf	no	0	494	0	no
Niederösterreich	Melk	no	231	96	28	yes
Salzburg	Bischofshofen	no	113	106	36	yes
Tirol	Jenbach	partially	474	379	32	yes
Niederösterreich	St.Valentin	no	494	380	15	yes
Niederösterreich	Ennsdorf	no	52	60	0	yes
Wien	Wien Wolf in der Au	no	113	106	36	yes

Table 4: Selected 30 Park and Ride facilities in Austria with capacities and coverage (`2025 NETEX XML`)

4.2.1 Train Traffic at the Facilities

To get an overview of how much traffic there is at a facility, we counted the trains every weekday from 05:00 to 10:00 and from 15:00 to 20:00. The busiest station in the morning hours is Wiener Neustadt Hauptbahnhof, which unsurprisingly also results in the smallest headway between trains. The same holds true for the evening hours, followed by Salzburg, St. Pölten, and Innsbruck.

[1] `Wien Westbahnhof` and `Innsbruck Hauptbahnhof` have no car or motorcycle parking spots, only bicycle parking.

These facilities also offer the broadest range of destinations that can be reached by train.

The less active stations in our subset are Hollabrunn, Mistelbach, and Ennsdorf, each averaging fewer than 20 trains in the morning and evening hours per weekday. This results in an average headway of about a quarter of an hour, with Ennsdorf showing the largest mean difference between trains at 18 minutes.

Noteworthy is that Bad Vöslau has the largest difference in activity between morning and evening, with an average of 13 more trains in the morning. Ennsdorf again stands out with the largest headway difference, averaging 3.4 minutes longer between trains in the evening than in the morning

5 Methodology

Before beginning the calculations, we need to ensure that all geodata are projected in the same coordinate system. For our calculations, we decided to use `EPSG:3035`, whose unit is meters and which is used in Austria.

For the calculations, we used Python version 3.11.12 and the packages `numpy` 2.2.6 (for numerical computations and array operations), `pandas` 2.2.3 (for data manipulation and tabular data handling), `geopandas` 1.1.1 (for handling geospatial data and vector operations), `shapely` 2.1.1 (for geometric operations on shapes), and `rasterio` 1.4.3 (for reading and writing raster datasets). If you are interested in the Jupyter Notebooks, you can clone them from the GitHub repository.

5.1 Bicycle Potential Calculation

The goal of calculating the bicycle potential is to obtain a comparable parameter that allows for the assessment and comparison of bicycle infrastructure across different Park and Ride facilities.

This approach goes beyond only considering the ratio between safe and base bicycle infrastructure; it also takes into consideration population data to identify new areas where the development of safe cycling infrastructure would be most beneficial, in order to create an efficient strategy that maximizes the number of people with access to safe bicycle routes.

To calculate the bike potential in the surroundings of the different facilities, we used data from `AustriaTech` (as described in the chapter Data Sources), the information of the different Park and Ride facilities from the `ÖBB NETEX XML`, and the population data from `WorldPop`. We limited our calculation to a radius of 3 km, corresponding to an area of about 28.3 km^2, representing an average cycling time of approximately 10 to 15 minutes.
The following approach is based on the case study conducted by Laura Wysling and Ross S. Purves [22]. However, in contrast to their methodology, we did not include data from OpenStreetMap, as our dataset already provided a complete street network. Furthermore, slope data, which was incorporated in the original Paris case study, was not considered in our analysis.

5.1.1 Get the Data in the Surrounding of the Station

We collected all road links within the target area from the base and the safe bicycle networks and categorized them according to their origin. Using the `WorldPop` dataset, we proceeded in a similar manner and collected all the population information within the given radius.

5.1.2 Buffering and Population

After all the key information was gathered, we drew a buffer around each road link. We used a buffer size of 75 m, meaning every link had a total buffer of 150 m (75 m to the right and 75 m to the left). This buffer represents the catchment area within

which residents are assumed to have convenient access to the network. After merging the buffered links of the safe cycling network and the base cycling network, two multipolygon geometries were created, which served as the basis for subsequent analysis.
By intersecting the clipped population with the multipolygon geometries, we were able to estimate the population living in the vicinity of the safe cycling network and the base cycling network.

5.1.3 Divide Area into Sections

We subdivided the 3 km radius circle into 250 m × 250 m squares and estimated the population within each square, allowing us to identify which sections are populated. Then, similar to the previous step, we analyzed the safe and base network buffers within each square. In this way, we determined the portion of the population connected to the base cycling network and to the safe cycling network.

5.1.4 Potential per Square

Finally, we calculated, using the three variables obtained and after normalizing them, the potential for network improvement for each square.

$$\text{Potential} = \text{pop\_norm} \times (1 - \text{safe\_share}) \times \text{not\_safe\_share}$$

where:

$$\text{pop\_norm} = \frac{\text{population in the grid cell}}{\text{maximum population in all grid cells}}$$
$$\text{safe\_share} = \frac{\text{population in the safe cycling buffer}}{\text{total population in the cell}}$$
$$\text{not\_safe\_share} = \frac{\text{population in the road/base cycling buffer}}{\text{total population in the cell}}$$

As a result, we obtained a grid of squares for the target area. The potential of each cell increases with higher population density, a lower share of the population already connected to the safe network, and a higher share living on the base network.

5.1.5 Global Potential

To obtain a potential that can be compared across different stations, we need to aggregate our grid. We decided to count every cell that has a potential higher than 25% and divide this count by the number of inhabited cells.

$$\text{global potential} = \frac{\text{cells with potential} > 25\%}{\text{inhabited cells}} \tag{1}$$

In addition to this measure, we also calculated a population-weighted potential, which accounts not only for the presence of potential in a cell but also for the number of people living there. It is calculated as the weighted average of the potential values across all cells, with the population of each cell serving as the weight:

$$\text{weighted potential} = \frac{\sum_i (\text{population}_i \times \text{potential}_i)}{\sum_i \text{population}_i} \tag{2}$$

The two potentials complement each other. The first, a simpler potential using a threshold, focuses on the spatial coverage of potentials, while the weighted potential reflects the potential benefit to every inhabitant, giving more weight to areas with higher population.

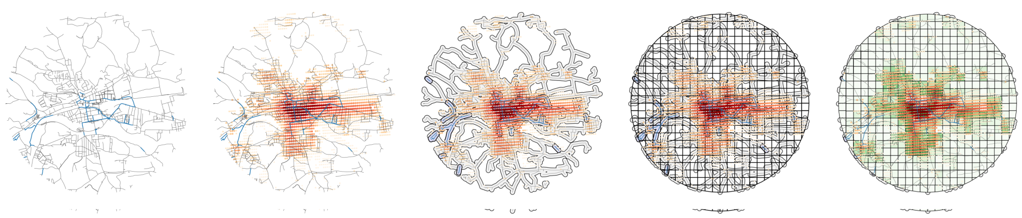


Figure 3: Potential calculation

5.1.6 Summary of the gained Variables

- **Population** inside a 3 km radius
- **Length of base cycling network**
- **Length of safe cycling network**
- **Estimated population** in the base cycling network buffer
- **Estimated population** in the safe cycling network buffer
- **Potential** for every grid cell
- **Global potential**

5.2 Public Transportation Service Performance

The purpose of the calculations presented in the following section is to derive comparable performance indicators that enable an assessment of the public transportation service quality in the surroundings of Park and Ride facilities. Similar to the analysis in Chapter 5, the objective here is not only to capture the current situation but also to identify potential areas for improvement. By highlighting weaknesses and opportunities, the aim is to provide insights into how the quality of public transportation service can be enhanced, making alternatives to car usage more attractive.

5.2.1 GTFS Data to Timetable

As a base for our analyses, we need all the public transport interactions with our target stations. To achieve this, we need to build timetables from our GTFS data; more precisely, we require the following seven tables from the GTFS package:

- `stops.txt`
- `stop_times.txt`

- routes.txt
- trips.txt
- calendar.txt
- calendar_dates.txt
- shapes.txt

Every Park and Ride facility in our study has a parent station ID, which includes the different train platforms as well as bus stops, with the only exception being Wels, where the bus terminal has a different parent station ID than the train station. Using this parent station ID, we can filter the data from stops.txt to obtain the different station IDs, which are the parent station ID extended by a specific platform code. These station IDs can then be found in stop_times.txt, which contains data about arrival and departure times, pickup and drop-off types, and the corresponding trip IDs.

With the trip IDs, we can filter the trips.txt data and merge it with the filtered stop_times.txt on the key trip_id. A second merge with calendar.txt on service_id provides boolean values for every weekday for each trip_id, describing their days of service, as well as the start and end dates. From this point, the table can be extended from the start to the end date.

The last step for creating the full timetable is to include exceptions from calendar_dates.txt, which consist of two types: deletions and additions.

After the timetable is completed, we add two additional boolean columns called is_start_of_trip and is_end_of_trip, which are needed for further calculations. The is_start_of_trip flag is straightforward to compute because we have information about the stop_sequence and shape_dist_traveled from stop_times.txt. If shape_dist_traveled equals 0.0 or stop_sequence equals 1, the is_start_of_trip flag is set to true. For the is_end_of_trip flag, we use shapes.txt to obtain the maximum shape length of a shape_id. If this maximum length equals shape_dist_traveled, the is_end_of_trip flag is set to true.

5.2.2 Train and Bus Timetable

This logic is then used to create the timetable, which represents the train traffic at the station as well as the bus traffic to and from the station. Special attention is needed when creating the bus timetable because some stations are included in more than one public transport provider's GTFS data package. To address this issue, we created a dataframe containing all stop IDs, parent station IDs, and the public transport authorities where they can be found. We then created timetables for every public transport authority in which our target station appears and combined them. To avoid duplicate entries, after manual inspection, we decided to drop rows that are identical in the following columns: arrival_time, departure_time, stop_sequence, date, trip_short_name, route_short_name, and route_id.

5.3 Key Variables of Transport Data

Once the timetables are calculated, we can derive several performance indicators that provide an impression of the quality of service.

One such indicator is the coverage of trains by local public transport. For each train, we calculate the five local transport interactions with the station prior to its departure and after its arrival. This allows us to assess how well each train is connected. A specific logic was implemented for further calculations:

- If a train **starts** at the station, it is automatically considered well connected after arrival, since no passengers can disembark to continue their journey by bus.

- If a train **terminates** at the station, it is automatically considered well connected before departure, as no passengers would board a train that ends its journey at this station.

Under these conditions, we calculated the shares of connections within time windows of 5, 10, and 15 minutes.

Another valuable metric is the share of the population with access to stops directly connected to the target station within a radius of 10 km. To derive this, we obtained all stops from `stops.txt` associated with the trip IDs in the timetable. Around these stops, we generated a 300-meter buffer to approximate easy accessibility within a maximum five-minute walking distance. To further enhance the analysis, we introduced a score that describes the frequency of service during peak hours (05:00–10:00 and 15:00–20:00 on weekdays). Stations were classified into five categories:

- **A**: frequency of service less than 10 minutes
- **B**: frequency of service between 10 and 15 minutes
- **C**: frequency of service between 15 and 30 minutes
- **D**: frequency of service between 30 and 60 minutes
- **E**: frequency of service greater than one hour

By combining the service class of each stop with its buffer, we created multipolygons representing the catchment areas for each category. Finally, we calculated the proportion of the population living within each category to provide insights into the effective reach and quality of service.

The following key variables summarize the analysis:

- Headway
- Population directly connected to bus stops linked with the station

- Number of buses before each train departure
- Number of buses after each train arrival

To calculate a final, comparable public transportation score, we used all variables related to the public transport network and derived two sub-scores.

First, we calculated a mean value for the variables `OEPNV_wh_bus_departures_l` `OEPNV_wh_bus_arrivals_next`, and `OEPNV_wh_good_connections` for each time slot (5, 10, and 15 minutes) and applied different weights to reward shorter waiting times. The maximum achievable score was set to 100, reflecting the ideal case where every train is covered by at least one public transport bus within a time window of less than 5 minutes before departure and after arrival.

$$\text{Connectivity}_i = 0.5 \cdot \overline{M_i^{(5)}} + 0.3 \cdot \overline{M_i^{(10)}} + 0.2 \cdot \overline{M_i^{(15)}}$$

where

$$\overline{M_i^{(5)}} = \frac{\text{Departures}_i^{(5)} + \text{Arrivals}_i^{(5)} + \text{Connections}_i^{(5)}}{3}$$

$$\overline{M_i^{(10)}} = \frac{\text{Departures}_i^{(10)} + \text{Arrivals}_i^{(10)} + \text{Connections}_i^{(10)}}{3}$$

$$\overline{M_i^{(15)}} = \frac{\text{Departures}_i^{(15)} + \text{Arrivals}_i^{(15)} + \text{Connections}_i^{(15)}}{3}$$

The second score we calculated was a *reachability score*, based on the shares of people connected to categories A+B, C, D, and E of public transport stops. We weighted the categories to emphasize train stations where larger shares of the population live close to stops with high service frequency (less than 15 minutes).

For each station i:

$$\text{Reachability}_i = 0.5 \cdot \text{Share}_{A+B,i} + 0.25 \cdot \text{Share}_{C,i} + 0.10 \cdot \text{Share}_{D,i} + 0.05 \cdot \text{Share}_{E,i}$$

6 Analysis

After calculating each metric for the 25 facilities across Austria, we obtained several noteworthy results, which are discussed in detail in the following sections. The focus of the analysis is on the potential for strengthening alternatives to private car use. The complete table of results is provided in the Appendix and in the accompanying GitHub repository.

6.1 Bicycle as an Alternative

If we focus solely on the availability of safe bicycle infrastructure, a useful indicator is the ratio of safe to base network. A ratio of 1 indicates that for every kilometer of base bicycle infrastructure, there is one kilometer of safe bicycle infrastructure—in other words, the lengths of the base and safe networks are equal. Among the facilities, five stand out positively: Salzburg with a ratio of 0.8244, Klagenfurt with 0.7617, the Bike and Ride station at Wien Westbahnhof with 0.7049, Wiener Neustadt with 0.6740, and Dornbirn with 0.5132. Somewhat unexpectedly, Innsbruck Hauptbahnhof does not belong to this group of facilities with ratios above 0.5. With a value of 0.3628, it still lies well above both the average (0.2745) and the median (0.1746) across all train stations, but reaches only about half the ratio observed at Wien Westbahnhof. On the opposite end of the ranking are Hollabrunn, Deutsch Wagram, and Tullnerfeld, each with a ratio well below 0.05. If we include population in the analysis, we observe similar, though not identical, results. The variable percentage_safe_buffer describes the share of people with access to the safe bicycle network relative to the total population within the three kilometer radius. The top five facilities remain the same as in the ratio ranking, all reaching at least 90%. The mean for this metric is around 53% and the median 46%, indicating a slightly right skewed distribution. The standard deviation of 28 underlines the relatively high variability, which becomes evident when comparing the highest value of more than 95% at Wien Westbahnhof with the lowest of around 7% at Tullnerfeld, the only facility below 10%. For comparison, the metric percentage_road_buffer ranges from 99% in Dornbirn to 91% in Amstetten, reflecting a much more even distribution. More insightful, however, is the difference between percentage_road_buffer and percentage_safe_buffer, which serves as an initial indicator of the extent of potential improvement. Here we can see that the facilities in Hollabrunn, Amstetten, Leibnitz, Tullnerfeld, and Deutsch Wagram all have a percentage difference of over 70%. Our dedicated potential approach provides further valuable insights. We classified the grid squares into four categories based on their potential: below 25%, above 25%, above 50%, and above 75%. The interpretation is as follows: a large number of squares with potential below 25% combined with only a few above 25% indicates limited room for improvement. Conversely, a high count of squares with potential above 75% highlights that population hotspots are not yet well connected. In such cases, even limited extensions of the infrastructure could lead to substantial improvements in the bicycle network. Unsurprisingly, stations that already possess extensive safe bicycle infrastructure show very low overall potential, with almost no grid squares exceeding the 25% threshold. The highest numbers of squares with potential above 75% are observed in Bad Vöslau (6), followed by Tullnerfeld (4), Mödling and Leobersdorf (3 each), Deutsch Wagram and Amstetten (2 each), and Tulln an der Donau and Stockerau (1 each).

6.2 Public Local Transport as an Alternative

In this section, we attempt to identify stations where trains are not covered by the local public transport. We have three time windows, which give us a good overview of the coverage during the predefined working hours.

Table 5: Share of trains with good public transport connections within 5, 10, and 15 minutes.

Station	**5 min**	**10 min**	**15 min**
St. Pölten Hbf	0.977	0.999	0.999
Salzburg Hbf	0.964	0.973	0.973
Klagenfurt Hbf	0.950	0.980	0.980
Innsbruck Hbf	0.912	0.913	0.915
Wiener Neustadt Hbf	0.902	0.953	0.983
Dornbirn	0.892	0.932	0.933
Wien Westbahnhof	0.890	0.890	0.890
Wels Hbf	0.823	0.939	0.974
Mödling	0.742	0.957	0.973
Amstetten	0.675	0.759	0.828
Gänserndorf	0.616	0.950	0.983
Baden	0.600	0.730	0.743
Tullnerfeld	0.524	0.726	0.925
Bischofshofen	0.495	0.681	0.855
Wolkersdorf	0.494	0.952	1.000
Jenbach	0.493	0.766	0.914
Mistelbach	0.483	0.771	0.881
Hollabrunn	0.479	0.740	0.757
Wien Wolf in der Au	0.442	0.526	0.528
Parndorf Ort	0.420	0.519	0.587
Tulln an der Donau	0.395	0.782	0.965
Korneuburg	0.392	0.851	0.920
Leibnitz	0.340	0.638	0.760
Deutsch Wagram	0.255	0.519	0.739
Stockerau	0.248	0.620	0.690
St. Valentin	0.238	0.421	0.513
Gramatneusiedl	0.207	0.551	0.836
Leobersdorf	0.188	0.515	0.648
Ennsdorf	0.177	0.420	0.424
Bad Vöslau	0.135	0.359	0.750
Melk	0.117	0.353	0.484

When comparing the best with the worst performing stations in terms of train connectivity, a substantial decline is observed in the 5-minute window, with differences of more than 80%. This indicates that, while top-ranked stations provide almost immediate connections to trains, lower-ranked stations force commuters to wait significantly longer for a local transport option. Interestingly, many of the poorly performing stations in the 5-minute window show a marked improvement in the 15-minute window, suggesting that connections do exist but are less frequent, resulting in longer waiting times. The best examples herefore are Wolkersdorf and Tulln an der Donau. Ennsdorf and Melk show a notable exception, performing poorly even in the 15-minute window, with not even having a connection within the 15-minute time window for more than half of the passing trains.

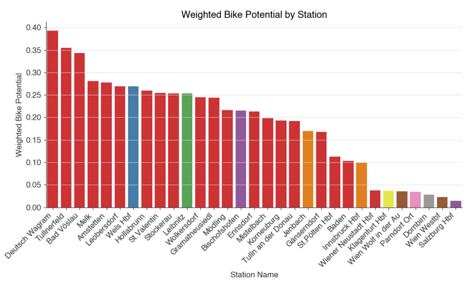
If we look at the individual components of `good_connection` (bus arrivals prior to train departure and bus departures after train arrival), we can observe unsurprisingly similar trends. To emphasize the positive aspect, no stations drop below 50%, the lowest being St. Valentin with 56%, and in the 15-minute time window only Parndorf Ort, St. Valentin, and Ennsdorf do not reach 75%. In the second component, the scores are slightly worse, with a mean percentage of 83% of trains directly served after the arrival of the train, compared to 85%. The lowest is Wien Wolf in der Au with 53%.

6.3 Share of People Directly Connected

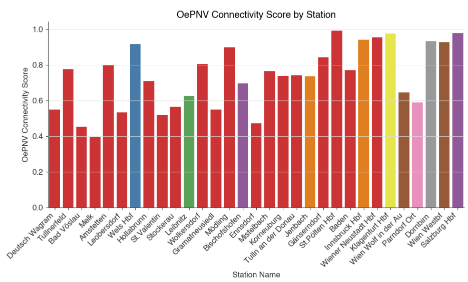
If we look at how many people live near bus stops that are directly connected to the station without having to change buses, we can estimate how well a train station is connected and how easily it can be reached by bus. As described in the methodology section, we classified the stops according to the frequency of bus services and obtained the following results: the highest share of the population in the A-class buffer is found in Innsbruck with 63.98%, followed by Salzburg with 52.07% and Klagenfurt with 40.87%. Seventeen stations do not have any A-class stops, and ten of them do not even have B-class stops. The stations in Stockerau, St. Valentin, and Leobersdorf stand out especially negatively, not even having a C-class share. The highest share in the D class is found in Mistelbach with 55%, and in the E class in Stockerau, Leibnitz, and Hollabrunn with around 25%. The lowest overall connected percentage, meaning the train stations where within a 10 km radius the fewest people are connected to a bus stop that reaches the station directly, can be found in Wien Wolf in der Au and Deutsch Wagram, both not having more than 15% coverage.

7 Results

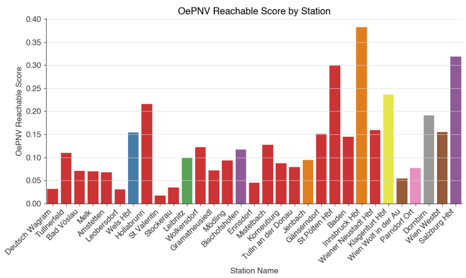
In the following section, we will assess which of the analyzed stations have major deficits in their surrounding infrastructure and the greatest room for improvement, in order to make alternatives to the car more attractive to the population.



(a) Weighted Bike Potential



(b) OePNV Connectivity Score



(c) OePNV Reachable Score

Figure 4: Comparison of bike potential and OePNV scores by station.

7.1 Suggestions for new Bicycle Infrastructure

In total, we have seven facilities with a weighted global bike potential greater than 0.25. Those stations are Deutsch Wagram with 0.39, Tullnerfeld with 0.35, Bad Vöslau with 0.34, Amstetten with 0.28, Leobersdorf and Wels with 0.27 each, and Hollabrunn with 0.26. At these stations, the expansion of the safe bicycle network would have the most impact on the inhabitants who want to reach the station by bicycle.

Such measures would directly affect some of the respondents who answered the survey question "Why do you drive to the station?" with "for reasons of comfort." [5] Furthermore, optimization would also be in line with the guidelines of the Federal Ministry for Climate Protection, Environment, Energy, Mobility, Innovation, and Technology, and much could be achieved with little new infrastructure.

7.2 Suggestions for improving Public Transportation

When we summarize our performance indicators for public transport infrastructure, we can see that certain stations stand out negatively, where there is a particular need to catch up in terms of public transport infrastructure in order to enable as many citizens as possible to switch to the train in a comfortable and time-efficient manner.

We have identified the greatest need for action in terms of public transport connections to trains and buses after train arrival at the stations in Leibnitz, Parndorf Ort, Stockerau, Gramatneusiedl, Deutsch Wagram, Leobersdorf, and Bad Vöslau. At these stations, arriving and departing trains cannot be reached comfortably by public transport without expecting long waiting times at the station on average.

If we look at the variables that describe from where people can easily reach the station without having to switch buses, we see a similar picture, with the same stations underperforming alongside Amstetten and Tulln an der Donau. In these locations, it is difficult for residents to reach the train station, either because there is no direct connection or because feeder buses run very infrequently during the work week.

If we plot our three scores in a pairwise scatter plot, we can observe different trends. Although we are only working with 25 stations, we can see a trend that the higher the bicycle potential, the lower the public transportation scores. This makes perfect sense if we look at the stations with the lowest bicycle potential, which are big cities like Vienna and Salzburg, known for their well-developed public transport infrastructure.

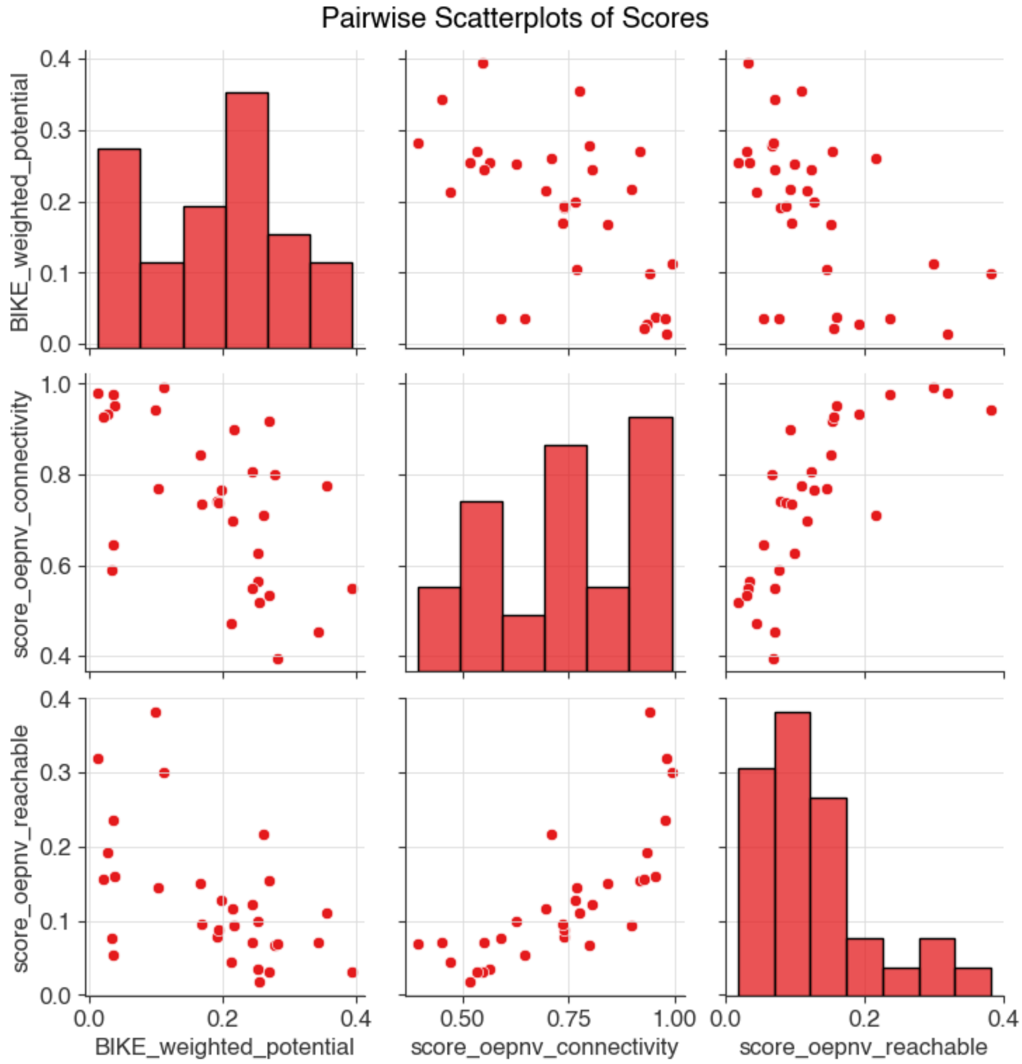


Figure 5: Pairwise plot of the performance scores

7.3 Comparison of the results with the occupancy data

When we compare our calculated scores with the occupancy data provided by ÖBB Infra AG, we observe only weak correlations and no clear patterns, partly due to the small sample size (data was available for only 14 stations). Noteworthy here is the Park and Ride facility in Melk, which shows high bicycle potential but scores poorly in public transportation and has one of the highest occupancy rates, with over 50% of the hours exceeding 95% occupancy and a mean occupancy of 86%.

Amstetten and Bischofshofen follow a similar trend, while facilities such as St. Pölten or Wien Wolf in der Au, which have high occupancy, deviate from this trend by showing low bicycle potential. On the other side of the table, we can observe similar inconsistencies: Korneuburg, Hollabrunn, and Ennsdorf show low occupancy rates and have good room for improvement in the bikeability and public transportation scores.

7.4 Answers to the Research Questions

> *RQ T.1: Are there significant differences between the biggest Park and Ride stations among Austria in terms of accessibility of the station by alternative modes (bike and bus)?*
> *RQ T.2: Can we see differences between solely Bike and Ride and Park and Ride facilities*
> *RQ T.3: Can we observe patterns in the usage behavior that get influenced by the surrounding circumstances*

RQ T.1: Yes, there are notable differences, as discussed throughout the thesis. Some stations feature good public transportation service and a strong bicycle network, while others lack safe bicycle infrastructure and offer poor transit service, making it less attractive for residents to switch from cars to alternative modes.

RQ T.2: No. The two Bike and Ride stations at Wien Westbahnhof and Innsbruck, and the Park and Ride station in Salzburg—where only bicycles and motorcycles are allowed—perform very well on bicycle network metrics, as expected. However, when compared to car Park and Ride stations such as Klagenfurt, Wiener Neustadt, or Dornbirn, performance is similar. On public transportation metrics, the three bike-focused facilities also perform well but not significantly better than others. Their high scores are largely due to their central locations in major cities, where both public transportation service and bicycle infrastructure are strongest.

RQ T.3: No, we cannot see any significant influence of the analyzed variables on the parking capacity data. Although some stations, like Melk, fulfill our assumption, other stations do not, which leads us to no significant result.

8 Current Limitations and Future Work

The analysis is based on two main data sources: open data and data provided by ÖBB Infrastructure. For the open data, we rely on the accuracy and completeness of the public transportation data, as it was the only source available for local transit.
The population data from WorldPop is continuously improved, and the dataset used is an alpha version that may be updated next year if enhancements are made [23].

Bicycle network data from AustriaTech is based on the Graphen-IntegrationsPlatform (GIP). We verified its accuracy by comparing it with our own calculations, which, although less precise, showed similar patterns. It is important to note that the GIP is constantly evolving, with new infrastructure being built and streets opening or closing.

Other limitations of this thesis include the fact that we selected 30 out of more than 800 stations to gain an overview. Time and computing resources restricted us to this small subset. Furthermore, we had occupancy data for only 22 stations (14 overlapping with our subset), which limited the analysis to a very small sample.

8.1 Future Work

For future work, all metrics could be calculated for every single station in Austria to obtain a broader picture and draw more robust conclusions. In addition, although not currently possible due to the unavailability of IoT devices in all stations, occupancy data could be analyzed in more detail across a larger set of stations.

Valuable information to include in future analyses would be train occupancy data as well as delay data for both trains and local public transportation. This is important because just because the timetable indicates that a connection is possible, it does not necessarily mean that the bus arrives in time. If delays occur regularly, they can strongly influence travelers' decisions not to use local public transportation. Further the occupancy analysis can be enhanced by analyzing each parking spot inside the facility and not only an hourly aggregation of the occupancy.

In the end we can say that it is a topic worth researching to enhance the positive aspects of Park and Ride facilities and to find root causes and strategies to diminish unintended usage.

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Station Scores Table

Name	Bundesland	Bike w. Potential	ÖPNV Conn.	ÖPNV Reach.
Wiener Neustadt Hbf	Niederösterreich	0.0381	0.9532	0.1594
St.Pölten Hbf	Niederösterreich	0.1124	0.9921	0.2993
Tullnerfeld	Niederösterreich	0.3549	0.7748	0.1098
Mödling	Niederösterreich	0.2164	0.8978	0.0936
Baden	Niederösterreich	0.1038	0.7703	0.1446
Gänserndorf	Niederösterreich	0.1674	0.8422	0.1508
Wolkersdorf	Niederösterreich	0.2452	0.8056	0.1225
Amstetten	Niederösterreich	0.278	0.7988	0.0672
Wels Hbf	Oberösterreich	0.2692	0.9179	0.1546
Tulln an der Donau	Niederösterreich	0.1919	0.7406	0.079
Hollabrunn	Niederösterreich	0.2602	0.7093	0.2162
Stockerau	Niederösterreich	0.2532	0.5648	0.0347
Bad Vöslau	Niederösterreich	0.3434	0.4523	0.0705
Korneuburg	Niederösterreich	0.1935	0.7387	0.0873
Leibnitz	Steiermark	0.253	0.6261	0.0991
Deutsch Wagram	Niederösterreich	0.3929	0.5489	0.0319
Gramatneusiedl	Niederösterreich	0.244	0.5492	0.0716
Innsbruck Hbf	Tirol	0.0993	0.9419	0.3826
St.Valentin	Niederösterreich	0.254	0.519	0.0176
Jenbach	Tirol	0.1695	0.7364	0.0949
Mistelbach	Niederösterreich	0.1988	0.7644	0.1271
Leobersdorf	Niederösterreich	0.2696	0.5326	0.031
Dornbirn	Vorarlberg	0.028	0.9344	0.1916
Salzburg Hbf	Salzburg	0.0143	0.9791	0.3189
Klagenfurt Hbf	Kärnten	0.0369	0.9761	0.2364
Parndorf Ort	Burgenland	0.035	0.5903	0.0764
Wien Westbf	Wien	0.0228	0.9264	0.1556
Melk	Niederösterreich	0.2811	0.3956	0.0693
Bischofshofen	Salzburg	0.2155	0.6965	0.1169
Wien Wolf in der Au	Wien	0.0357	0.645	0.0539
Ennsdorf	Niederösterreich	0.2131	0.4718	0.0447

Bicycle related variables

Name	Bike Ratio Safe	Bike % Safe Buff.	Bike % Road Buff.
Wiener Neustadt Hbf	0.674	90.022	97.6138
St.Pölten Hbf	0.4713	76.4973	96.8205
Tullnerfeld	0.0214	7.0595	92.6294
Mödling	0.1782	50.9105	95.4621
Baden	0.489	73.8299	97.2275
Gänserndorf	0.0829	46.6198	95.3943
Wolkersdorf	0.0585	31.139	95.6506
Amstetten	0.0622	20.6119	91.175
Wels Hbf	0.0827	36.5528	93.65
Tulln an der Donau	0.2496	58.6379	94.4521
Hollabrunn	0.0375	26.3772	96.5699
Stockerau	0.1218	44.4003	95.365
Bad Vöslau	0.0897	25.8988	95.5218
Korneuburg	0.2383	48.629	95.6175
Leibnitz	0.0963	23.4488	97.0164
Deutsch Wagram	0.0217	10.2881	96.6545
Gramatneusiedl	0.0991	40.413	94.094
Innsbruck Hbf	0.3628	78.7508	98.3263
St.Valentin	0.0842	27.4298	89.126
Jenbach	0.1049	41.3434	96.1783
Mistelbach	0.075	42.3068	96.0356
Leobersdorf	0.1746	40.709	94.3443
Dornbirn	0.5132	93.2449	99.0491
Salzburg Hbf	0.8244	94.5902	98.3147
Klagenfurt Hbf	0.7617	89.7397	94.6512
Parndorf Ort	0.3721	80.4137	92.2265
Wien Westbf	0.7049	95.2158	98.8835
Melk	0.0918	23.4785	92.9118
Bischofshofen	0.0939	32.0209	94.8678
Wien Wolf in der Au	0.5859	89.2516	97.5392
Ennsdorf	0.0597	21.4627	89.7472

Train connectivity table

Name	ÖPNV % A	ÖPNV % B	ÖPNV % C	ÖPNV % D	ÖPNV % E
Wiener Neustadt Hbf	12.62	0.0	25.62	32.08	0.39
St.Pölten Hbf	30.29	24.09	5.57	10.33	6.36
Tullnerfeld	0.0	15.44	0.0	29.25	6.68
Mödling	8.32	7.09	5.95	0.11	3.14
Baden	0.0	12.02	28.94	11.38	1.46
Gänserndorf	0.0	13.32	28.96	4.14	15.29
Wolkersdorf	0.0	15.35	11.59	15.39	2.9
Amstetten	0.0	0.0	13.61	24.49	17.44
Wels Hbf	4.23	14.87	16.93	16.1	1.3
Tulln an der Donau	0.0	0.0	24.71	9.81	14.81
Hollabrunn	0.0	36.86	0.0	21.4	21.03
Stockerau	0.0	0.0	0.0	21.93	25.51
Bad Vöslau	0.0	0.0	21.5	13.76	5.93
Korneuburg	0.0	14.04	3.47	7.72	1.5
Leibnitz	0.0	14.53	0.0	14.86	23.17
Deutsch Wagram	0.0	0.0	12.68	0.0	0.51
Gramatneusiedl	0.0	0.0	15.42	33.04	0.0
Innsbruck Hbf	63.98	7.84	7.26	4.75	1.25
St.Valentin	0.0	0.0	0.0	14.59	5.92
Jenbach	11.02	0.0	3.1	28.84	6.43
Mistelbach	13.96	0.0	0.62	55.32	0.9
Leobersdorf	0.0	0.0	0.0	31.04	0.0
Dornbirn	3.39	10.3	48.1	2.88	0.0
Salzburg Hbf	52.07	6.27	9.72	0.86	3.99
Klagenfurt Hbf	40.86	3.33	0.0	9.92	11.03
Parndorf Ort	0.0	0.0	25.71	11.86	0.61
Wien Westbf	31.03	0.0	0.07	0.26	0.0
Melk	0.0	7.49	0.0	21.98	19.69
Bischofshofen	4.26	0.0	32.72	8.67	10.33
Wien Wolf in der Au	0.99	9.79	0.0	0.0	0.0
Ennsdorf	0.0	0.0	14.92	5.35	4.01

OEPNV coverage table

Name	ÖPNV % A	ÖPNV % B	ÖPNV % C	ÖPNV % D	ÖPNV % E
Wiener Neustadt Hbf	12.62	0.0	25.62	32.08	0.39
St.Pölten Hbf	30.29	24.09	5.57	10.33	6.36
Tullnerfeld	0.0	15.44	0.0	29.25	6.68
Mödling	8.32	7.09	5.95	0.11	3.14
Baden	0.0	12.02	28.94	11.38	1.46
Gänserndorf	0.0	13.32	28.96	4.14	15.29
Wolkersdorf	0.0	15.35	11.59	15.39	2.9
Amstetten	0.0	0.0	13.61	24.49	17.44
Wels Hbf	4.23	14.87	16.93	16.1	1.3
Tulln an der Donau	0.0	0.0	24.71	9.81	14.81
Hollabrunn	0.0	36.86	0.0	21.4	21.03
Stockerau	0.0	0.0	0.0	21.93	25.51
Bad Vöslau	0.0	0.0	21.5	13.76	5.93
Korneuburg	0.0	14.04	3.47	7.72	1.5
Leibnitz	0.0	14.53	0.0	14.86	23.17
Deutsch Wagram	0.0	0.0	12.68	0.0	0.51
Gramatneusiedl	0.0	0.0	15.42	33.04	0.0
Innsbruck Hbf	63.98	7.84	7.26	4.75	1.25
St.Valentin	0.0	0.0	0.0	14.59	5.92
Jenbach	11.02	0.0	3.1	28.84	6.43
Mistelbach	13.96	0.0	0.62	55.32	0.9
Leobersdorf	0.0	0.0	0.0	31.04	0.0
Dornbirn	3.39	10.3	48.1	2.88	0.0
Salzburg Hbf	52.07	6.27	9.72	0.86	3.99
Klagenfurt Hbf	40.86	3.33	0.0	9.92	11.03
Parndorf Ort	0.0	0.0	25.71	11.86	0.61
Wien Westbf	31.03	0.0	0.07	0.26	0.0
Melk	0.0	7.49	0.0	21.98	19.69
Bischofshofen	4.26	0.0	32.72	8.67	10.33
Wien Wolf in der Au	0.99	9.79	0.0	0.0	0.0
Ennsdorf	0.0	0.0	14.92	5.35	4.01

Download links of the data and GitHub Repository

Data Source	**Link**
GitHub	`https://github.com/DanielZipp/bachelor_thesis_ST_2025`
GTFS Data	`https://data.mobilitaetsverbuende.at/en/data-sets`
ÖBB Data	`https://data.oebb.at/de/datensaetze~netex-geodaten~`
WorldPop Data	`https://hub.worldpop.org/geodata/summary?id=72446`
AustriaTech Data	`https://files.austriatech.at/d/5cf05b8c6b8a4b6b93ee/`

Table 6: Overview of data sources used in the analysis and link to the GitHub repository