# Trends in access and egress transportation to and from train stations in The Netherlands

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## ABSTRACT
A public transport network, especially a rail-bound network, relies heavily on access and egress transportation to ensure good door-to-door connectivity. The Netherlands is known for its high bicycle use, also in combination with train use. For the reasons for this success, various reasons are mentioned in the public debate in The Netherlands. Firstly, there have been many investments in the last decades in the capacity and quality of bicycle parking facilities. Secondly, health has become increasingly important in everyday life. This could also have had an impact on mode choices, similar to the global effects due to the COVID-19 pandemic. Thirdly, local public transport services have been scaled down due to decreasing passenger numbers and limited funding availability. Fourthly and finally, the number of train passengers has increased over time. All these developments can have impacted the access and egress transportation to and from train stations. In our study, we dive into the modal shares and number of users for access and egress transportation for train stations in the Netherlands. We aim to identify the impact of different developments. When evaluating data from 2006 to 2018, different trends arise. What happens if these trends develop similarly towards the future? Are interventions necessary?

Two hundred twenty-five stations (out of four hundred stations in The Netherlands) have sufficient data to perform valid and robust analyses, as they have been in operation since 2006, and NS (main train operator) services the station. Through surveys targeting train travellers, access and egress transportation shares can be derived per train station for different time frames. In our study, we decided to use a two-year interval, which allowed for sufficient data per station and a representative sample for the population. The main modes of interest for this investigation are walking, cycling, public transport (bus/tram/metro) and Park & Ride (P&R; access mode only). A hierarchical cluster analysis is performed for each mode, with access and egress separated to spot the trends. We determine the optimal number of clusters using the sum of squares (elbow method) and the gap statistic. The results show the trends per mode for both access and egress. Per mode and cluster of stations, different trends become visible. Upward trends are for some clusters in cycling access and egress and P&R access, and downward trends become visible for access BTM and access and egress walking. A more in-depth analysis of several clusters provides a detailed understanding of why these trends are happening at these stations.

If we put the historical trends in a future perspective, we notice that spatial footprints of parking facilities near many train stations become a challenge. The Netherlands is densely populated and has a dense network of trains and roads. In the following years, there is an immense housing shortage, which the government wants to solve with the development of residential areas near train stations. This means that the urban space in the Netherlands gets even scarcer. At the same time, growing parking facilities consume valuable space that could be used for (i.e.) housing. This counts for both bicycles and P&R. Due to increasing passenger numbers at train stations and trends of increasing bike and parking share in combination with the scarcity of space, we wonder how long The Netherlands can maintain its current policies for access and egress facilities and local public transport networks. In our paper, we explore potential directions into which we can create a modal shift in such a way that fits with a sustainable, healthy future.

## 1. INTRODUCTION

Public transport is, by definition, a multimodal trip, i.e. a trip using different modes of transport for the door-to-door journey, unlike the car, which is mostly unimodal. Access and egress trips are considered a dissatisfier for (potential) public transport users (Van Hagen, 2011). Therefore, accessible public transport stops are key in unlocking the potential of public transport for a large group of users.

In the past years, the combination of bike and train trips has grown strongly in The Netherlands (Jonkeren and Kager, 2021). Dutch government policy is aimed at further stimulating the use of bicycles, both in general and as access or egress mode for the train(Ministerie van Infrastructuur en Waterstaat, 2021). Existing research attributes this success partially to the enlargement of the catchment area of a train station by a well-integrated combination of bicycle facilities (bike roads and bike parking) and public transport nodes (Shelat et al., 2018; Ton et al., 2020).

At the same time, local public transport (Bus/Tram/Metro (BTM)) has seen a decrease in the number of stops since 2018 by 7 percent (NOS, 2023). Provinces and local transit authorities have asked for 1 billion euros to stop the decay of the offered public transport service. However, no additional public funds will become available (Treinenweb, 2023). From the railways's point of view, this is a worrying trend, as the train and BTM are strong allies.

A third trend is an increasing number of local policies to discourage cars trips to cities (NOS, 2018). Many municipalities of mid-sized and large cities have implemented interventions to control car traffic through their towns, particularly in the city centres. Examples are increases in parking fees (up to €7,50 per hour in Amsterdam), introduction of one-way traffic and setting limits to the number of cars that can enter the city in a specific timeframe. The policies aim to create space for pedestrians, cyclists and activities (i.e. seating areas).

In this paper, we explore the trends in access and egress transportation to and from train stations in The Netherlands using longitudinal access and egress data. In section 2, we present our hierarchy of access and egress modes. NS Stations uses this hierarchy to balance the use of the space around train stations, that has become very scarce in the past 15 years. In section 3, we analyse the trends in the use of access and egress modes by train passengers. For this analysis, we use a unique dataset containing data of 225 train stations from 2006-2018. In section 4, we draw a number of conclusions.

## 2. HIERARCHY OF ACCESS AND EGRESS MODES

The organisation of access and egress modes around train stations has become more complex due to the combination of railway network development, station development and urban development during the past 15 years (Van den Heuvel, 2022). Space around train stations in the Netherlands has become scarce, especially in highly dense urban areas. Figure 1 shows two aerial pictures of Utrecht Centraal station at two moments, where the trends as mentioned earlier are visible. At the same time, a continuation of passenger growth is expected in the coming decades. This spatial challenge could require a change in our policy and practice (Ministerie van Infrastructuur en Waterstaat, 2021).

Figure 1 - Utrecht Centraal station in 2010 (left) and 2019 (right) (source: Van den Heuvel, 2022)

To illustrate the challenge, we have combined recent data on the modal share of access and egress transportation to and from train stations with the space use of these modes in Figure 2. The figure shows that the transportation mode with the lowest share – 3% by car drivers – consumes almost 70% of the space for access and egress modes around train stations. The most used mode is walking, which has the smallest spatial footprint of all access and egress modes. Note that the figure shows an average for all train stations in The Netherlands for access and egress modes combined. Individual stations and/or travel directions (access of egress) can deviate significantly from this average.

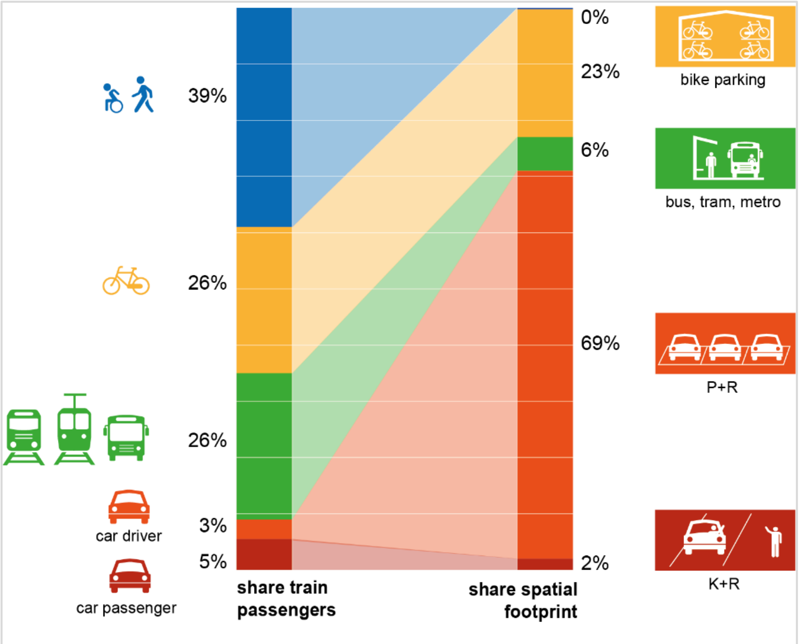


*Figure 2 - Share and land use of access and egress modes (NS Stations data (KIS10, 2018).*

In 2019, Netherlands Railways (NS) presented its vision of a journey by public transport in 2040 (NS, 2019). A vital element of this vision is the organisation of access and egress modes around train stations. According to our vision, we prioritise muscle and electric-powered modes over fossil fuel-powered modes, shared transport modes over private transport modes and space-efficient modes over space-inefficient modes. The rights of way are illustrated in Figure 3.

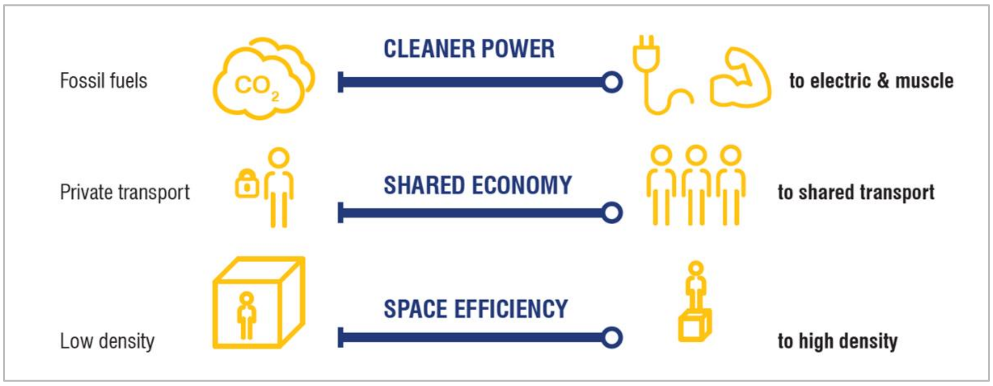


*Figure 3 - "Rights of way" rules for access and egress modes*

For the Dutch case, our prioritisation results in the hierarchy illustrated in Figure 4. A mode with a higher priority is supposed to be situated closer to a train station entrance.

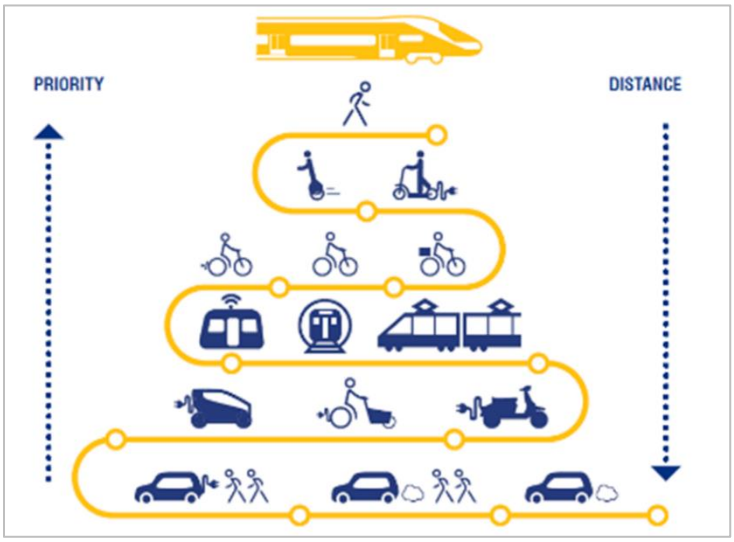


*Figure 4 – Proposed hierarchy of access and egress modes at train stations in The Netherlands*

Figure 5 illustrates the implications of this hierarchy for the Jaarbeursplein entrance (non-city side) of Utrecht Centraal station. At this location, hundreds of bike parking places have been relocated to a large indoor bike parking facility under the stairs of the station entrance. The result is an urban space for pedestrians only. In the past 15 years, access and egress modes have been reorganised at numerous mid-sized and large train stations in The Netherlands. At smaller stations, the capacity and quality of bike parking facilities have been improved significantly (Piersma and Ritzema, 2021).

Figure 5 – Non-city side entrance of Utrecht Central in 2014 (left) and 2019 (right) (source: NS Stations)

In the next section, we explore the trends in access and egress transportation by analysing our unique dataset with 12 years of data. Our objective is to assess to which extent our envisioned hierarchy of access and egress is compatible with the trends at the train stations in The Netherlands.

## 3. TRENDS IN ACCESS AND EGRESS TRANSPORTATION DATA

NS has collected access and egress transportation data from 2006 to 2018 without changing the research method. The data has been systematically logged in NS' *Keten Informatie Systeem (KIS)*. See Van Hagen and De Bruyn (2002) for more information. Our dataset contains data on 225 train stations in The Netherlands.

For this study, we have performed hierarchical cluster analyses on our dataset (Hair et al., 1998). With this statistical technique, we have classified train stations according to similarity in access and egress transportation modes over time. Within the clusters, homogeneity is maximised, while heterogeneity has been maximised between clusters. To identify the optimum number of clusters for our data, we have used the within-sum-of-squares method, the silhouette method and the gap statistic. The optimal numbers of clusters for access and egress modes were 9 and 7, respectively.

### 3.1 Station clustering based on access modes

Figure 6 shows the nine station access mode cluster profiles. The bundle of graphs per access mode and cluster indicate that the clustering of the 225 stations in our dataset has resulted in relatively homogeneous clusters of stations.

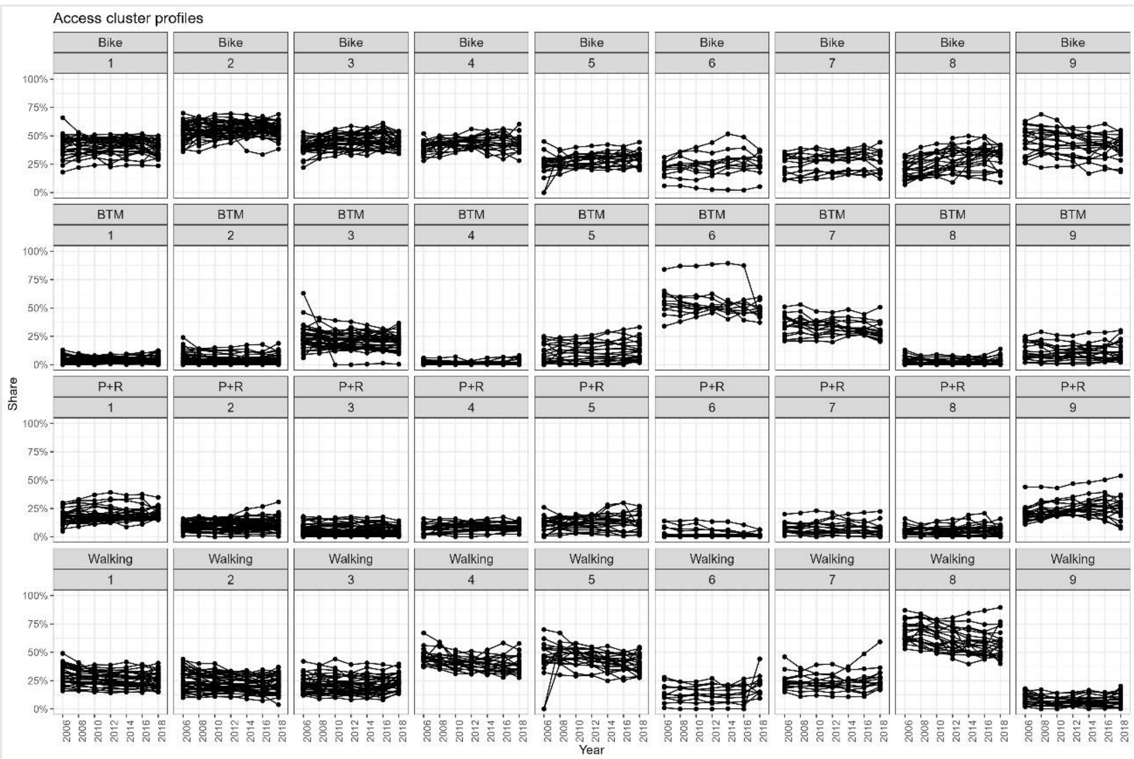


*Figure 6 – Station cluster profiles for access modes*

In Table 1 we have classified these profiles qualitatively using the results of Figure 6 and the location of each station (Figure 7). This results in the following set of clusters:

1. Stations in villages or suburbs in larger cities, with
    a. a high share of walking (i.e. Eindhoven Strijp-S, Amsterdam Muiderpoort)
    b. a high share of cycling (i.e. Harderwijk, Heerhugowaard)
    c. a high share of park & ride (i.e. Abcoude, Bussum Zuid)
    d. a mix of walking and cycling (i.e. Delft Campus, Vleuten)
    e. a mix of walking and bus/tram/metro (i.e. Almere Parkwijk, Den Dolder)
    f. a mix of cycling and park & ride (i.e. Veenendaal-de Klomp, Breukelen)
2. Stations in mid-sized cities, with
    a. all access modes except park & ride (i.e. Alkmaar, Hilversum)
    b. a mix of walking and bus/tram/metro (i.e. Maastricht, Dordrecht)
3. Public transport nodes in cities (i.e. Amsterdam Central, Rotterdam Central)

| **Nr.** | **Bike** | **BTM** | **P+R** | **Walking** | **Size** | **Qualitative description** |
|---|---|---|---|---|---|---|
| 1 | Medium | Low | High | Medium | 33 | Village/suburb, P+R |
| 2 | High | Low | Low | Medium | 44 | Village/suburb, bike |
| 3 | Medium | Medium | Low | Medium | 37 | Mid-sized city, low P+R |
| 4 | Medium | Low | Low | High | 21 | Village/suburb, bike and walking |
| 5 | Low | Medium | Low | High | 21 | Village/suburb, BTM and walking |
| 6 | Low | High | Low | Low | 11 | Public transport nodes in cities |
| 7 | Low | High | Low | Medium | 15 | Mid-sized city, BTM, low bike |
| 8 | Low | Low | Low | High | 23 | Village/suburb, walking |
| 9 | High | Medium | High | Low | 20 | Village/suburb, bike and P+R |

*Table 1 - Classification of stations based on access modes*


*Figure 7 - Access cluster locations*

### 3.2 Station clustering based on egress modes

Figure 8 shows the seven station egress mode cluster profiles similar to the access mode-based clustering.

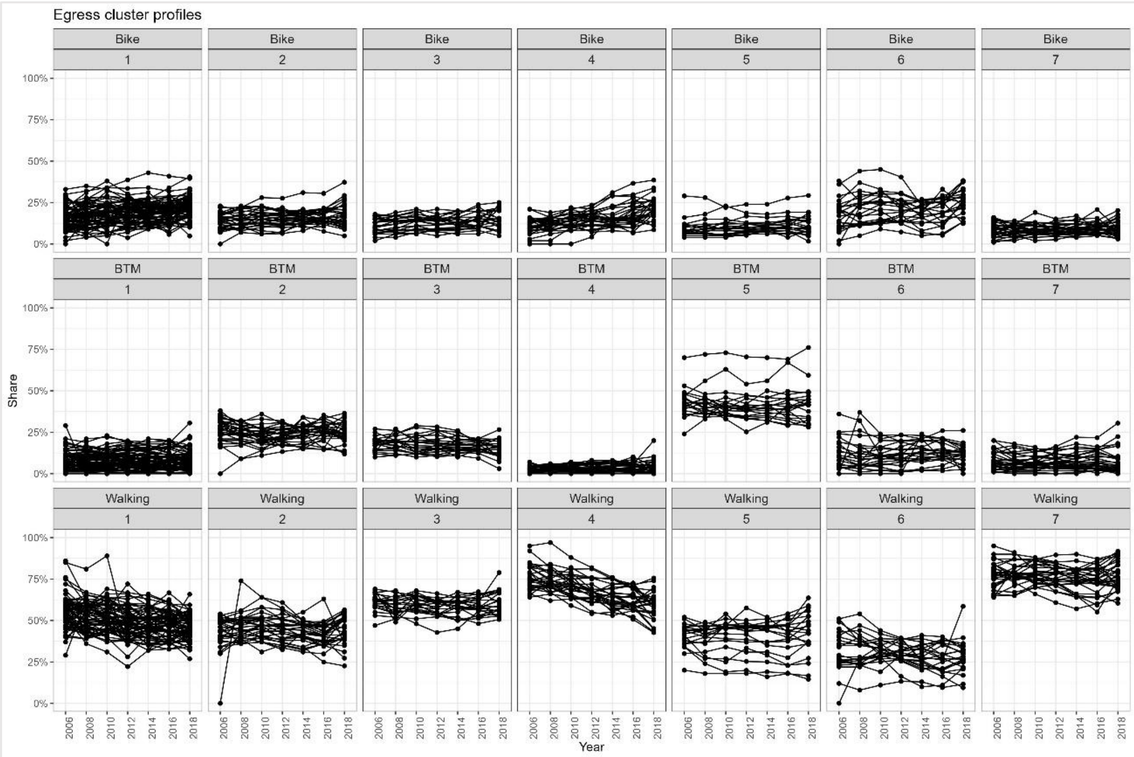


*Figure 8 - Station cluster profiles for egress modes*

In Table 2 we have classified these profiles qualitatively using the results of Figure 8 and the location of each station (Figure 9). This results in the following set of clusters:

1. Stations in villages or suburbs, with
    a. a high share of walking (i.e. Arnhem Presikhaaf, Hilversum Sportpark)
    b. a high share of cycling (i.e. Geldermalsen, Steenwijk)
    c. two clusters with a mix of walking and cycling (i.e. Abcoude, Delft Campus)
2. Mid-sized city (i.e. Arnhem Centraal, Haarlem)
3. Village, suburb or mid-sized city with low cycling (i.e. Gouda, Leiden Central)
4. Public transport nodes in cities (i.e. Amsterdam Central, Rotterdam Central)

| Nr. | Bike | BTM | Walking | Size | Qualitative description |
|---|---|---|---|---|---|
| 1 | Medium | Low | Medium | 72 | Village/suburb, bike and walking |
| 2 | Medium | Medium | Medium | 30 | Mid-sized city |
| 3 | Low | Medium | High | 22 | Village, suburb or mid-sized city, low bike |
| 4 | Medium | Low | High | 29 | Village/Suburb, bike and walking |
| 5 | Low | High | Low | 20 | Public transport nodes in cities |
| 6 | Medium | Low | Low | 23 | Village/suburb, bike |
| 7 | Low | Low | High | 29 | Village/suburb, walking |

*Table 2 - Classification of stations based on egress modes*


*Figure 9 - Egress cluster locations*

### 3.3 Trends in access and egress trips to/from train stations

Using the clusters of train stations of the previous section, we have calculated both the average share of each transport mode and the total number of trips per average workday over the period 2006-2018. Figures 10 and 11 show the trends per cluster for each of the access and egress modes, respectively.

For the share of park & ride of the access modes, we notice a decreasing trend for all clusters, except 1, 2 and 4 (village and suburb clusters). Growth in the number of trips is strongest for clusters 1 and 9, which we labelled P+R train stations. A sharp decrease of P+R train users in both share and number of trips is visible in cluster 3 (Mid-sized city, low car). For bus, tram and metro, the decreasing share in clusters 3 (mid-sized city), 5 (village/suburb, BTM and walking) and 6 (Public transport node in cities) stands out. The absolute number of trips has been stable, which means that the BTM trips to the station have not kept track of the growth in train users.

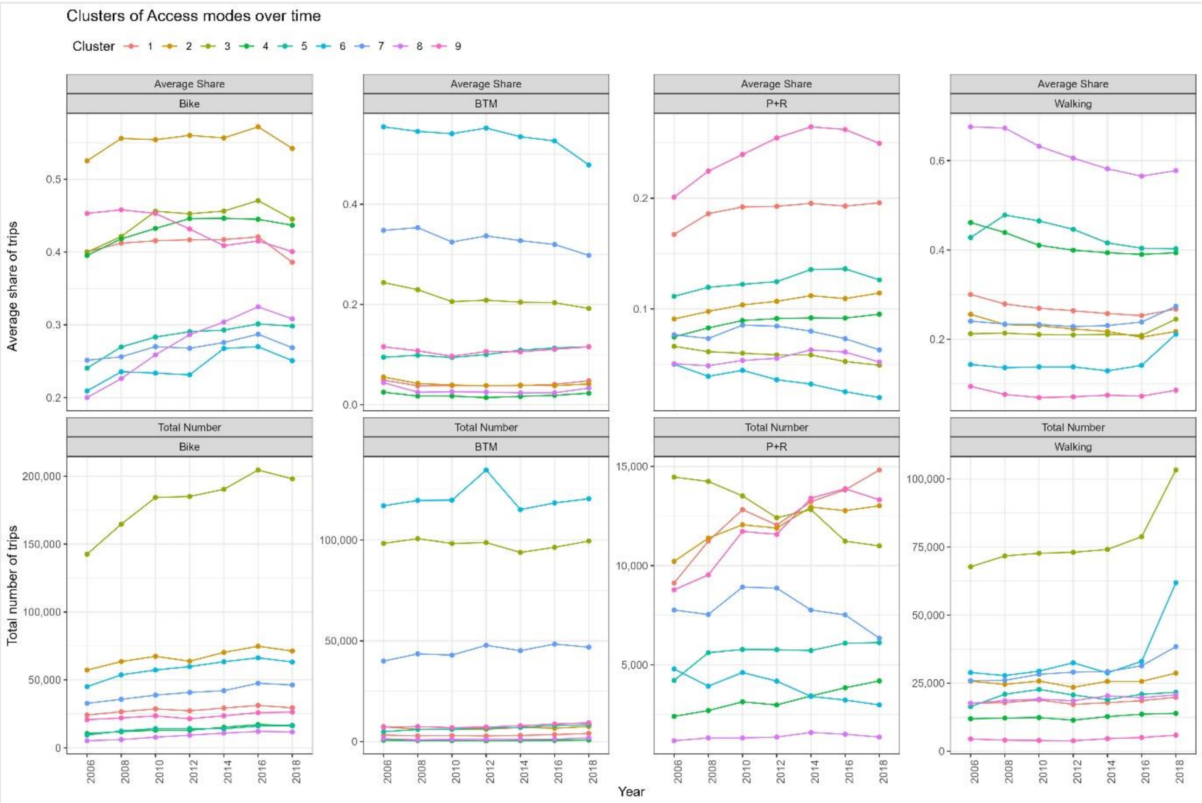


*Figure 10 - Trends in access modes over time*

The opposite trend is visible for cycling. This access mode has grown both in share and absolute numbers. Looking at the number of bicycle trips to the station, cluster 3 (mid-sized city) stands out with a growth of under 150,000 per average workday in 2006 to 200,000 in 2018. Although less strong than cycling, walking has grown in absolute number of trips for all types of clusters. However, the modal share of walking has been stable or decreasing until 2016. Only in the last year, we signal a potential reversal of the trend.

If we compare the composition of access modes of the most notable clusters, we notice a decrease in BTM and P+R and an increase in cycling and walking in cluster 3 (Mid-sized city, low P+R). Walking decreased at cluster 4 (Village/suburb, bike and walking) while cycling and P+R increased. Cluster 6 (Public transport nodes in cities) shows a sharp decrease in BTM with a sharp increase in walking. At cluster 8 (Village/suburb, walking), we notice a reduction in walking combined with an increase in cycling. Cluster 9 sets itself apart from all others by the rise in P+R at the expense of cycling.

For the egress modes, we see a stable share and number of trips for bus, tram and metro (Figure 11). Similar to the access modes, cycling has seen strong growth in both share and number of trips. The share of walking has been decreasing, particularly at cluster 4 (Village/Suburb, bike and walking). At the same time, the absolute number of walking trips from the station to the destination has either been stable or grown.

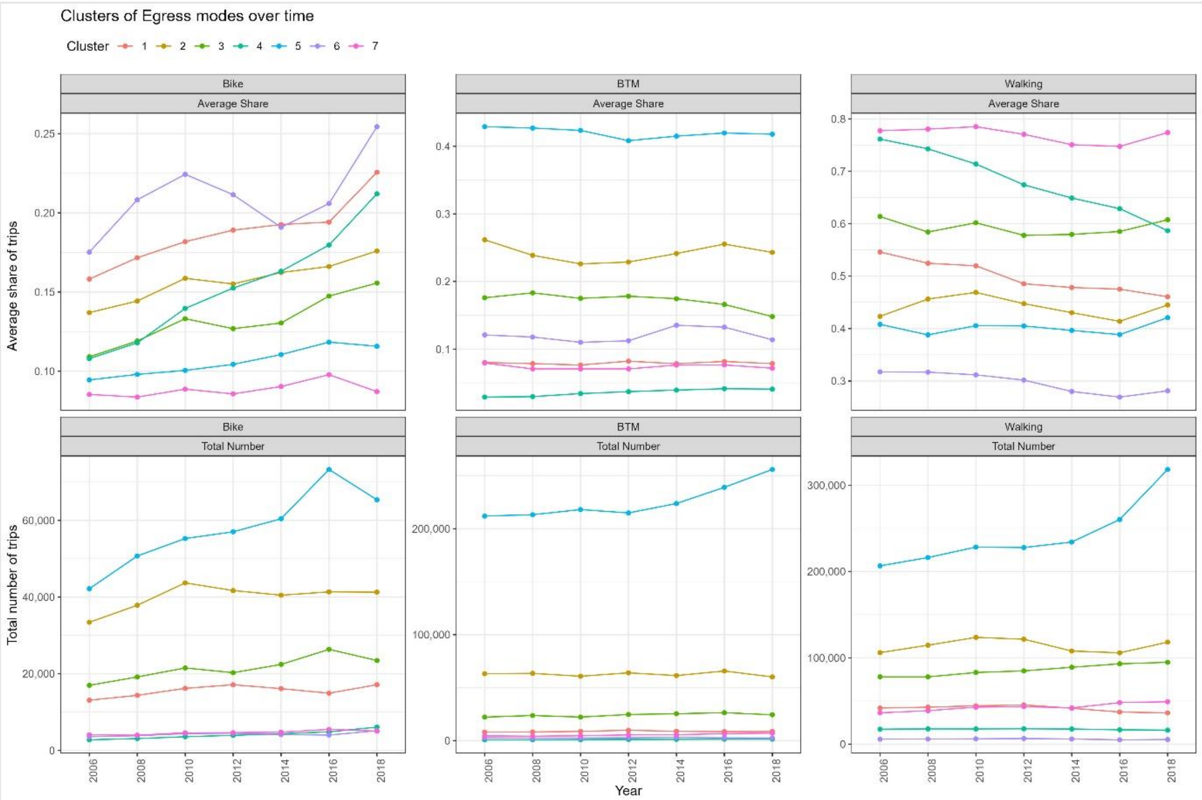


*Figure 11 - Trends in egress modes over time*

Comparing the composition of clusters, clusters 4 (Village/Suburb, bike and walking), 5 (Public transport nodes in cities) and 6 (Village/suburb, bike) stand out. Clusters 4 and 6 show a sharp increase in cycling as a share, combined with a relative decrease in walking and BTM, respectively. The absolute number of trips for both clusters are low. For cluster 5, the absolute number of walking, BTM and cycling trip are remarkable. This reflects the strong growth in passenger numbers at these stations. For this cluster, walking substitutes cycling as an egress mode to some extent.

## 4. CONCLUSION

In general we conclude that cycling and walking as transportation modes for trips to and from train stations have grown significantly. The use of bus, tram and metro as access mode has been stable in absolute numbers of trips and decreased in the modal share. This confirms the observations in the introduction of this paper.

Our analysis has revealed that park & ride (P+R) as an access mode has decreased significantly over the years at train stations in mid-sized cities. At these stations, the number of trips by local public transport (bus/tram/metro (BTM)) has been stable. At the same time, cycling and walking have increased. The growth in cycling has been exceptionally strong. Walking is becoming more important at the public transport nodes in cities as access and egress mode.

These trends are consistent with our envisioned hierarchy of access modes. However, park & ride is still an essential mode of transport to travel to the station for specific groups of train stations in villages and suburbs, despite the decreasing trend in general. Tens of thousands of daily train trips are facilitated by this access mode. If we look at the map, these stations are often located close to main roads between cities (i.e. motorways). This trend could indicate that these regional train stations also serve trips to mid-sized and large cities with strong car-discouraging policies.

For walking as access mode, we signal a potential trend change. In the final years of our dataset (2014-2018), the share of walking has stopped decreasing at all types of train stations. It started to grow at public transport nodes in cities and train stations in mid-sized cities. The growth seems only moderate regarding the model share but is very strong in absolute numbers of trips.

If the trend reversal of walking as an access mode can be confirmed over the period 2018-2023, policymakers should consider giving more attention to walking facilities around train stations. As shown earlier in this paper, bike facilities, particularly bike parking and walking facilities compete for the same scarce space around train stations.

## BIBLIOGRAPHY

Hair, J.E., Anderson, R.E., Tatham, R.L., Black, W.C. Multivariate Data Analysis (5th Edition). Prentice-Hall Inc. New Jersey, 1998.

Jonkeren, O., Kager, R. Bicycle parking at train stations in the Netherlands: Travellers' behaviour and policy options. *Transportation Business & Management*, 2021, 40: 100581.

Ministerie van Infrastructuur en Waterstaat. Ontwikkelagenda Toekomstbeeld OV. Nu instappen naar 2040. Den Haag, 2021.

Netherlands Railways (NS). *Journey of the future. A Passenger Experience*. Utrecht, 2019.

NOS. *Minder auto's in de binnensteden: 'Geef ruimte aan de fietsers'*. 28 May 2018. https://nos.nl/nieuwsuur/artikel/2233949-minder-auto-s-in-de-binnensteden-geef-ruimte-aan-de-fietsers

NOS. *Ruim 1500 bushaltes minder dan in 2018, impact verschilt lokaal sterk*. 25 February 2023. https://nos.nl/collectie/13923/artikel/2465241-ruim-1500-bushaltes-minder-dan-in-2018-impact-verschilt-lokaal-sterk

Piersma, F., Ritzema, W. *Fietsparkeren bij stations. 20 jaar ontwikkeling, ontwerp en realisatie.* Uitgeverij Thoth, Bussum, 2021.

Shelat, S., Huisman, R. van Oort, N. Analysing the trip and user characteristics of the combined bicycle and transit mode*. Research in transportation economics*, 2018, 69: 68-76.

Ton, D., Shelat, S., Nijënstein, S., Rijsman, L., van Oort, N., Hoogendoorn S. Understanding the role of cycling to urban transit stations through a simultaneous access mode and station choice model. *Transportation research record*, 2020, 2674.8: 823-835.

Treinenweb. *Provincies sturen brandbrief aan tweede kamer tegen verschraling openbaar vervoer.* 19 May 2023.
https://www.treinenweb.nl/nieuws/10012/provincies-sturen-brandbrief-aan-tweede-kamer-tegen-verschraling-van-openbaar-vervoer.html

Van den Heuvel, J. *Mind your passenger! The passenger capacity of platforms at railway stations in the Netherlands.* Trail Research School, Delft, 2022.

Van Hagen, M., De Bruyn, M. Typisch NS. Elk station zijn eigen rol. *Colloquium Vervoersplanologisch Speurwerk, 2002.*

Van Hagen, M. *Waiting Experience at train stations*. Eburon Academic Publishers, Delft, 2011.