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Understanding the relation between distance and train station choice behavior of cyclists in the western region of the Netherlands

Jullian van Kampen[a,b,*], Manoj Ashvin Jayaraj[a,b], Eric Pauwels[b], Rob van der Mei[a,b], Elenna R. Dugundji[a,b] *

[a] *Vrije Universiteit Amsterdam, Department of Mathematics, De Boelelaan 1111, Amsterdam 1018 HV, The Netherlands*
[b] *Centrum Wiskunde en Informatica, Science Park 123, Amsterdam 1098 XG, The Netherlands*

Abstract

With 35,000 km of bicycle pathways, cycling is common among persons of all ages less than 65 years in the Netherlands. Bicycle is often seen as a standalone travel mode but when integrated as part of a multimodal trip with train, it can be an important solution for long distance journeys, offering more flexibility and faster access time than other travel modes to a railway station. In this paper we investigate which factors influence departure train station choice on combined bicycle-train trips in the western region of the Netherlands. We explore the effects of an individual's socio-economic characteristics, their multi-modal trip attributes, as well as neighborhood characteristics and station attributes. Observations from the Dutch National Travel Survey over the years 2015-2017 are considered for analysis where bicycle is used as either an access or egress mode. A multinomial logit model is estimated in which the choice set of an individual is determined by the stations in the proximity. Results show that stations as far as the fourth closest station are considered as a relevant option for an individual. Additionally, station type and neighborhood characteristics were among the most significant contributors to station choice in the western region of the Netherlands

Keywords: Departure train station choice; socio-economic characteristics; trip attributes; station attributes; neighbourhood characteristics; multinomial logit model;

* Corresponding author. Tel.: +31 20 5924059.
E-mail address: jullian.van.kampen@cwi.nl

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1. Introduction

The use of motorized vehicles has increased at a rapid rate over the years, resulting in increased traffic casualties and traffic problems in urban environments. Therefore, policies were implemented to discourage car use and encourage other modes of transport like bicycle and public transit. These policies made bicycle one of the most important modes of transport in the Netherlands. Over the past half century there has been a significant rise in bicycle use among the Dutch [2]. With a length of 35,000 kilometers, there are almost enough cycle paths to go around the world [1]. The average Dutchman cycles on average 1000 kilometers a year and Dutch teens cycle even twice the amount of adults. Cycling is not only a sport but also a part of life, used to commute to work (41% of trips made) and school (15%), to visit friends (41%) and go shopping (17%) [1].

The Netherlands may be called a bicyclist paradise due to its flat landscapes, safe separate bicycle infrastructure, its hostile car environment due to high gas prices, lack of parking and traffic jams. According to a transport and mobility report [3] prepared for the Ministry of Infrastructure and Environment in the Netherlands, there are more bicycles (22 million) than there are people (17 million); the Dutch own more bicycles per household than the number of members in the household. Unsurprisingly, bicycles have become the most important travel mode in urban environments. As of 2017 the city of Amsterdam has over 250,000 bicycle parking spots with 7000 parking facilities near bus and metro stations [4]. This illustrates that bicycle has become an important access mode in multimodal transportation networks over the years.

With cycling being an important part of daily life for Dutch people, it can bring along many challenges, like insufficient parking spots for bicycle, increasing the complexity of exiting traffic system and many more. Especially in urbanized areas near train or metro stations, providing sufficient parking facilities can be a challenge. In this research, we analyze the relation between different socio-economic characteristics and the departure train station choice made by people using bicycle as an access mode in the four provinces of the Netherlands namely North Holland, South Holland, Flevoland and Utrecht. Since about half of the Dutch people do not simply choose the station nearest to their residence, we are interested to determine what factors strongly influence the departure train station choice in the western region of the Netherlands. Our paper is structured as follows. First we briefly review literature relevant to our topic. Then we elaborate on the data used, data selection process and how we imputed unknown values. Next we outline how the choice set is generated for each individual explain the model calibration procedures. Finally we describe our results and conclude with a discussion of those results including recommendations for future research.

2. Literature Review

With our aim to understand the factors affecting the choice of departure train station among cyclist, we review below some key literature on factors affecting bicycle mode choice and railway station choice modeling. We will draw on these contributions when estimating our model.

Young and Blainey [8] cover a broad range of past research dating back to the 1970s. They compare several research works based on their statistical approach used for modeling and also discussed on the drawbacks of different modeling technique. They found that the most common used statistical models are closed-form, where multinomial logit models are used to model station choice and nested logit models are commonly used to model the combined choice of access mode and station choice. However, these modelling approaches have a weakness, namely the inability to account for spatial correlation and patterns of substitution which represent competition between stations. Additionally, They also provide an overview for the possible factors that can have an influence in station choice among rail passengers. They found that access and rail service factors have been consistently reported in previous research works. These works conclude that station utility decreases as the journey contains more transfers, has higher distance, has increased rail leg journey time, a higher fare and lower service frequency. However, they also conclude that limited attention has been given to land-use factors in station choice modelling and state that these factors may influence predictive performance significantly.

In Chakour et al. [13] an attempt is made to create a framework to better understand access mode and train station choice of train commuter behavior. By using a latent segmentation approach they jointly model access mode and station choice decisions in which the order of choices is irrelevant. Apart from rail service and a few station characteristics they also include socio-economic characteristics as explanatory variables affecting station and mode choice. Their results show that as distance from the station increases people are more likely to select access mode first, while presence of parking and train frequency increases the likelihood for choosing a station. Additionally, they found that young people, females, car owners and individuals leaving before 7:30 am are more likely to drive to the train station.

Givoni et al. [14] studied the amount of railway station required in urbanized environments and whether reducing the amount of stations in an urbanized environment has an impact. In their research Amsterdam is brought up as a case study. They use a nested logit approach to estimate the access mode and departure station of an individual. The variables used in the model include rail journey time, quality of the station perceived from the access mode, travel time, and access mode distance. Results of the nested logit model were used to estimate the effects of closing a station based on welfare gains and losses using a logsum approach. They conclude that no justification could be found in reducing the number of stations, but point out that their analysis shows that adding additional stations, or rail services might have a positive welfare effect.

Lee and Ko [6] study the relationships between neighboring environment and residents bicycle mode choice with Seoul as their geographical scope for analysis. They used neighbourhood environment, and socio-demographics factors as explanatory variables in a random intercept logit model. Their analysis shows that bicycle lane density affects the bicycle mode choice in denser cities like Seoul, implying that the accessibility of bicycle lanes is an important factors for planners in order to encourage bicycle use. Additionally, socio-economic characteristics like gender, income, occupation, vehicle ownership, shorter travel distances and housing type all showed statistical significant correlation with bicycle use. Moreover, the study showed that neighbourhoods with high levels of mixed land-use result in more bicycle travel. On the other hand, residential density did not show any statistically significant correlation.

Although it is hard to compare a city like Seoul with a country like the Netherlands, the study by Pucher and Buehler [5] show that the extensive planning in the past half century to building a good infrastructure stimulated cycling in the Netherlands. In their study they explain how bicycling is promoted in countries like the Netherlands, Denmark and Germany. They conclude that the key for success in these countries is a mixture of mutually reinforcing policies encouraging cycling. The most important approach is a combination of providing cycling facilities along busy roads and measures involving traffic calming in residential neighbourhoods. Additionally, traffic education, integration of public transport, bike parking and promotional events create a wide public support in these countries for cycling. Finally they note that car-use in these countries is way more expensive than it is in other countries like the USA, due to taxes and restrictions on car parking ownership and use.

Debrezion et al. [7] applied a multinomial logit model on the choice of departure railway station made by Dutch railway passengers, looking at which variables impact that choice including the distance to a station, the availability of park & ride (car parking), bicycle stands/safes/rental, taxi, car rental, parking, international service, the frequency of service at a station and the availability of an intercity (express train) service to each of the Dutch provinces with the cities Leeuwarden and Groningen separately. A choice set of three alternatives station was determined for each 4 digit postal code. Using data from the main rail operator in the Netherlands and statistics aggregated on four digit postal codes they determined that in 47% of the cases the passengers do not select the nearest station, making distance an interesting factor in the probability of a station being chosen. Additionally, as the frequency of service at a station increases, the probability of choosing that station also increases, but as distance increases the probability of choosing a station decreases. The intercity status of a station was the most important factor in explaining the choice of a departure station. The author's state that the intercity status of a station has on average an equivalent effect of a decrease of 2 km in distance or an increase in frequency of 300 trains per day. Additionally the presence of a park-and-ride facility poses sizable effect with about 35% of the intercity status effect.

Kager et al [9] demonstrate the need to analyze the synergy between bicycle and public transport by considering Netherlands as a case study. Their study explores the distinct characteristics of the bicycle-train combination and how these modalities can complement each other. They found that these two modalities have a strong synergy when considered as a single trip chain due to the high speed of the train, the high accessibility of the bicycle and the flexibility in combining both modes. Finally, They propose a research agenda to analyze the synergy between bicycle and train in a single trip which can generate an integrated transport system that is both fast (because of train) and flexible (because of bicycle) for both short and long distance travels. However they expect this synergy to be highly sensitive to shorter cycling distance and less sensitive to longer train distances when compared to car-based mobility practice.

Seeing the study by Debrezion et al [7] and Kager et al [9] we see an interesting research gap, in the impact of distances on cyclists, especially since the group of train passengers that arrive by train is steadily growing. In this research we attempt to explain how these distances impact station choice. Additionally, although Blainey mentions the use of socio-economic characteristics, the literature on railway service and access factors is way more extensive then the socio-economic characteristic. Therefore, in this paper we attempt to further investigate the effects of socio-economic characteristics in station choice.

3. Data

The yearly mobility survey OViN (Onderzoek Verplaatsingen in Nederland) from the Netherlands CBS (Central Bureau of Statistics) over the years 2015-2017 was used for our research. OViN data includes both domestic and foreign trips among the Dutch people based on sampling to ensure the survey details records trips throughout the year in every province. In the survey, people are asked to record their daily travel patterns for one specific date. The data is structured in such a way that every individual can have multiple trips where each trip consists of multiple trip segments or rides. The individual level captures all the socio-economic characteristics of the individual, the trip level captures all the accumulated information about the trip segments of each trip, and the trip segment layer contains information about the individual trip segment. Since our research only focuses on bicycle as access or egress mode to the train station, we only select the trip segments where train was chosen as a transportation mode, and bicycle was used as an access or egress mode.

The scope of this research is the western region of the Netherlands which is defined here as the four provinces: North-Holland, South-Holland, Flevoland, and Utrecht. In the initial dataset 1666 observations are filtered from the 2015-2017 OViN dataset where for each train ride, bicycle was used as either an access mode, egress mode or both. These observations consist of individuals which had a train ride inside the four provinces as well as train rides going out of the four provinces and vice versa. In total 84.3% travelled only inside the four provinces, 8,1% travelled from the four provinces to any of the other provinces and 7.6% travelled from other provinces inside the four provinces.

Before analyzing the data we still had to consider duplicate entries or missing values. These data points are either missing information about the access or egress station, or contain return trips resulting in duplicate entries. Therefore the return trips as well as the data with missing information where removed from the dataset. Additionally, records where the departure station was outside one of the four provinces and not followed by a bike ride were also removed from the dataset, since these are considered to be out of the scope of our research focus. This eventually resulted in 1341 observations for our analysis.

4. Choice set generation

From the available 1341 observations, 183 unique departure station codes were identified where 25% of the departure train stations have only one respondent traveling by bicycle to those stations and 7% with more than 30 people choosing the same train station. Considering the 7% alone will leave us with a disaggregate choice set of 13 alternatives, but some of the categorical attributes might not have enough observations which can result in an unreliable estimate due to smaller sample size. Instead of having a station specific alternative with smaller sample sizes we define a disaggregate choice set consisting of four generic alternatives where the alternative one to four corresponds to the first, second, third and the fourth closest station in every departure postcode reported in the OViN data and the stations are chosen to be present within a 10 km radius from the postcode centroid. Since the OViN data has information about departure postcode (4-digit) on trip level and departure train station code, we combined the share of the choices made by the respondents to each of the first four closest stations in a postcode. This resulted in each individual having four alternatives namely first closest station contributing 58.2%, second closest station contributing to 18.5%, third closest station contributing 5.4% and the fourth closest station contributing 3%. Out of 1341 observations 15% of the data does not fit into any alternative, reason being that the station reported by the user was not among the first four closest station from the departure postcode centroid or inconsistency in the data reported by the respondent, resulting in 1149 observations valid for model estimation.

5. Methodology

The mathematical framework for estimating the departure train station choice for commuters using bicycle as access mode is based on the theory of utility maximization as discussed in Debrezion et al [7]. Readers are advised to refer to Ben-Akiva and Lerman [10] for mathematical details. The utility function corresponding to an alternative j in the choice set $\boldsymbol{C_n}$ for an individual n is divided into two components: $\boldsymbol{U_{in} = V_{in} + \varepsilon_{in}}$, where $\boldsymbol{U_{in}}$ is the total utility; $\boldsymbol{V_i}$ represents the systematic component of the utility (consist of a constant term and observed heterogeneity) and $\boldsymbol{\varepsilon_i}$ is the random part of the utility (also referred to as error term, which accounts for the unobserved heterogeneity). McFadden [11] shows that if $\boldsymbol{\varepsilon_i}$ follows an extreme value distribution function, the choice situation results in multinomial logit model (MNL). In this research we will estimate the coefficients of different attributes corresponding to every alternative by means of an MNL model.

For estimating the coefficients associated to each attribute of an alternative we used the Biogeme [12] software package which uses the maximum likelihood estimation technique to estimate the coefficients. Using the choice set defined in the previous section, an iterative approach was followed where the first model only had the alternative specific constant in the utility function and observed heterogeneity has been added along with the constant term in an iterative process to obtain the final model. In every iteration the following measures were taken to reduce the margin of uncertainty:

- High standard error: regroup the segmentation of categorical variable for possible reduction in standard error or exclude that variable with small sample size from the corresponding alternative.
- Correlations between coefficients (not considering the alternate specific constant) that are above 0.69 are removed by assigning a unique coefficient.

Additionally, during the calibration procedure log-likelihood ratio tests were conducted to see whether the reduced model is acceptable when compared to the full model. The test statistic is given by $\boldsymbol{-2[L(\beta_R) - L(\beta_U)]}$ where $\boldsymbol{\beta_R}$ denotes the estimated coefficients of the restricted model- the model that is true under the null hypothesis- and $\boldsymbol{\beta_U}$ denotes the coefficient estimates of the unrestricted model. This statistic is $\boldsymbol{x^2}$ distributed with $\boldsymbol{(K_U - K_R)}$ degrees of freedom, where $\boldsymbol{K_U}$ and $\boldsymbol{K_R}$ are the numbers of estimated coefficients in the unrestricted and restricted models, respectively. If the following equation is true, we can reject the null hypothesis that the restrictions are true.

$$-2\left[L\left(\beta_R\right) - L\left(\beta_U\right)\right] > \chi^2_{K_U - K_R}$$

The utility function is represented as a linear function although this is not always the case. Though several non-linear transformations exist, we applied one form of non-linear transformation namely piecewise linear approximation, on continuous variable and every new iteration was based on the findings from the previous or past iterations.

6. Model Results

Table-1 lists the factors that can possibly affect the bicycle parking choice at the departure train station. It shows the final result of the iterative process which was explained in the previous section. The third column tells us specifically for which alternative or alternatives the coefficient was estimated, the fourth column shows the value of the estimated coefficient, and the last column shows us the estimated t-test values in which a * indicates that it was significant at the 90% confidence interval level. The performance of our model is evaluated by means of the adjusted rho square. In the initial model, where only the alternative specific constants were considered, the model had a final log-likelihood of -1008.171 with an adjusted rho-square of 0.346. By consequently adding attributes, and thus adding observed heterogeneity, the final model estimated had a final log-likelihood value of -870.921 with an adjusted rho-square of 0.425.

The distance travelled by bicycle provided the highest increase in the rho squared and log likelihood value during the model calibration. As distance increases it becomes less likely that a station is chosen. Additionally, the results show that as the bicycle distance to the station increases the significance on station choice also decreases. The fact that distance is significant even for the furthest station indicates that people are willing to travel far to the train station. Moreover, all the coefficients appear to be significant even at a 99% confidence level.

Table 1: Multinomial logit results

Characteristics	Name	Choice Alternative	Coefficient Value	t-test
Travel characteristic	Bicycle travel distance	1 & 2	-0.834	-11.59*
	Bicycle travel distance	3	-0.719	-7.78*
	Bicycle travel distance	4	-0.467	-4.81*
Socio economic characteristics	Single person household	1 & 2 & 3	-0.168	-0.37
	Couples only household	1 & 2 & 3	0.316	0.69
	Couples with children	1 & 2 & 3	1.06	1.31
	No paid working hours during the week	1 & 2 & 3	0.812	1.69*
	Working hours less than 30 hours per week	1 & 2 & 3	0.762	1.38
	Spendable household income less than Euro 50,000	1 & 2 & 3	-0.638	-1.61
Neighbourhood and station characteristics	Residential municipality not part of the city	3	0.744	2.84*
	Train station type	1	1.03	4.87*
Alternative Specific Constant	Constant	1	1.90	3.7
	Constant	2	2.05	3.55
	Constant	3	0.802	1.21

Household composition being a categorical variable is divided into the following categories, category-1 represents single person household, category-2 comprises only of couples, category-3 consist of couples with children and couples with children and other members in the household and category-4 consist of household members who are single parent, single parent with children and single parent with children and other members. The estimated coefficients are compared to household compositions in category-4. Results show that household composition did not have any significant effect on the choice of departure station.

Working hours per week has been grouped into three categories with category-1 corresponding to people with no paid work, category-2 contains respondents with less than 30 hours of work per week and respondents working more than 30 hours per week, or unknown working hours, belong to category-3. The coefficients are positive indicating that people with less than 30 working hours are more likely to travel to the train stations closer by compared to the train station furthest away. The t-test however shows that these results are not significant on a 90% confidence level, even though it is close.

For the spendable income variable, respondents with a spendable income less than 50,000 are compared to people with an income of 50,000 or more. This was done to avoid a high standard error for the coefficients as was discovered during the model calibration. Additionally, high correlations were found between coefficients so a generic coefficient was considered. The results show that in the final model respondents with an income less than 50,000 are less susceptible to the departure train station compared to people with an income over 50,000. The t-test however shows that this result is insignificant at a 90% confidence level.

Respondents' residential municipality not part of the city were compared with respondents' which are part of the city. During model calibration it was found that the first and second coefficient had a negative coefficient while the third closest station showed a positive coefficient. Moreover, all the coefficients were highly correlating with each other. Since we estimate coefficients for respondents not living in a residential municipality we thought it might be interesting to only consider the coefficient for respondents travelling to the third closest station since the number if train stations in non-urban area's is less than in urban area's. Surprisingly, it was found that respondents not part of the city prefer to travel to the third closest station over any of the other stations. More importantly, This result appeared to be significant showing the importance of neighborhood characteristics in our model.

Finally we consider station type where the choice for a sprinter station is compared to an intercity station. The difference between these two station types is that sprinter trains stop at all stations, but intercity trains do not stop at sprinter stations. Since there aren't many observations where sprinter stations where chosen as the second third or fourth closest station, we only estimated a coefficient for the first closest station. Results show that respondents prefer to travel to a sprinter station compared to an intercity station if and only if this is the closest station. Furthermore, the significance indicates the importance of station characteristics in our model.

7. Discussion

Young & Blainey [8] highlighted some of the important station choice modeling dating back to 1974. They have grouped the factors that influences the utility function of a station choice by relating to the station accessibility attributes, railway service attributes and decision maker characteristics which can be related to the travel characteristics, neighborhood characteristics and station characteristics and the socio-economic characteristics variable used in our research, thereby including some of the key attributes for departure station choice among bicycle commuters. Although we did find importance in the neighborhood, station and travel characteristics of the individual, we did not find a lot of significance in the socio-economic characteristics. This might be caused by the fact that the survey data considered mostly consisted out of categorical data. If more disaggregate data of the individual would be available we might be able to find more significance in the socio-economic characteristics.

The most significant findings in this study are the distance travelled by bicycle, the station type and the respondents not part of a residential municipality. First of all, The distance travelled by bicycle shows that people are willing to travel even to the fourth closest station. This is in line with Debrezion et al [7] who showed that in the Netherlands about 47% of the cases passenger do not choose the nearest station as their departure train station. Additionally, the results of Kager et al [9] are also similar to our results where the influence of bicycle travel time decreases as distance to the station increases. Secondly, the significance in the station type variable is different from Debrezion et al [7], since we found significance in the sprinter status of a train station, where Debrezion et al [7] found significance in the intercity status of a train station. This difference in result might be explained by the fact that we focus our research on three of the four most urbanized provinces of the Netherlands where Debrezion et al. found the intercity status to be the least significant. In these provinces the sprinter status of a station is more important than the intercity status since sprinters stop at every station while intercities don't. Finally, the reason why respondents who are not part of a residential municipality would choose the third closest station is obscured to us. This result might imply that station choice behavior is different in residential municipalities not part of the city. If this holds, then it makes sense to model station choice separately for these two groups.

Moreover, the motive of respondents travelling to work and education attributes to 75% of the data used for modeling and so the results discussed in the last section can be biased towards the choices made by the respondents travelling to work and education purposes. However, the analysis of the survey data shows that respondents bicycling to a station most often do this for work and education. Therefore, the bias represented in this model is not seen as a limitation but as a result that station choice modelling is for a large part influence by these educational and work trips.

8. Conclusion

This paper focuses on the different socio-economic characteristics of people, train station type, neighborhood and travel characteristics that can influence in choosing a departure train station among those people using bicycle as an access or egress mode to the train station. The four provinces North-Holland, South-holland, Utrecht and Flevoland were used as a study area and OViN data from 2015 till 2017 has been used in this research. A disaggregate choice set consisting of four alternatives based on the four closest station near the postcode centroid, within a radius of 10km was considered for this research. A Multinomial logit model was used to estimate the coefficients for each alternative through multiple iterations and the results are reported in table 1.

The main findings were that the distance to the station by bicycle from the postcode centroid has a negative influence on all four train stations expressing the willingness of the Dutch train passengers to travel to a station farther away to board a train. Additionally, the station type variable shows people prefer to bicycle to a train station with only Sprinter service, if it is the first closest train station. Moreover, the neighborhood characteristics show that residents living in a municipality that is not part of the city are significantly more interested in choosing the third closest station when compared to the residents who are part of a municipality region inside the city. Finally, people having no paid working hours during the week are more likely to choose a station close by instead of a station further away, highlighting the importance of socio-economic characteristics in station choice.

Future research should focus on collecting information on the bicycle travel and bicycle parking behavior to better understand the choices made in bicycle parking. This will help in making better decision on policies concerning bicycle travel and parking, thereby further promoting the usage of bicycle, and overcome the issues of bias due to small sample sizes. Moreover, future research is encouraged to look into the difference in choice behavior of people living in cities and outside cities to validate the results found in this paper. Investigating the effects of land-use on station choice may hold important implications for the rationale behind station choice of individuals.

References

[1] Statistics Netherlands (CBS). *Factsheet the Netherlands: Cycling country*, 2015. Available at: https://www.cbs.nl/NR/rdonlyres/9F9F3F71-9324-46D3-AD7E-076C59F8392D/0/2015factsheetnederlandfietsland_ENG.pdf. Accessed Jul. 1, 2018.

[2] Dutch Bicycling Council. *Fietsberaad publication 7. Continuous and integral: The cycling policies of Groningen and other European cycling cities*, 2016. Available at: http://www.fietsberaad.nl. Accessed Jul. 1, 2018.

[3] Statistics Netherlands (CBS). *Transport and mobility report*, 2016. Available at: https://www.cbs.nl/-/media/_pdf/2016/38/2016-transport-and-mobility.pdf. Accessed Jul. 1, 2018.

[4] I amsterdam. Cycling in Amsterdam. url: https://www.iamsterdam.com/en/our-network/media-centre/city-hall/dossier-cycling/cycling-faq. (accessed: 01.07.2018).

[5] Pucher, J., and R. Buehler. Making Cycling Irresistible: Lessons from The Netherlands, Denmark and Germany. *Transport Reviews*, 2008. 28:4, 495-528.

[6] Lee, K. H., and E. J. Ko (2014) Relationships between neighborhood environments and residents' bicycle mode choice: a case study of Seoul. *International Journal of Urban Sciences*, 2014. 18:3, 383-395.

[7] Debrezion, G., Pels, E., and P. Rietveld. Choice of departure station by railway users. *European Transport report*, 2007. 37: 78–92.

[8] Young, M., and S. Blainey. Railway station choice modelling: a review of methods and evidence, *Transport Reviews*, 2018. 38:2, 232-251.

[9] Kager, R., L. Bertolini, and M. Te Brömmelstroet, Characterization of and reflections on the synergy of bicycles and public transport. *Transportation Research Part A: Policy and Practice*, 2016. 85: 208-219.

[10] Ben-Akiva, M., and S. Lerman. *Discrete Choice Analysis: Theory an Application to Travel Demand*. MIT Press Cambridge, MA, 1985.

[11] McFadden, D. Conditional Logit Analysis of Qualitative Choice Behavior. In *Frontiers in Econometrics* (P. Zarembka, ed.), Academic Press, New York, 1973.

[12] Bierlaire, M. BIOGEME: A free package for the estimation of discrete choice models, Proceedings of the 3rd Swiss Transportation Research Conference, Ascona, Switzerland, 2003.

[13] Chakour, V., & Eluru, N. (2014). Analyzing commuter train user behaviour: A decision framework for access mode and station choice. *Transportation*, 41 (1), 211-228.

[14] Givoni, M. & Rietveld, P. (2014). Do cities deserve more railway stations? The choice of a departure railway station in a multiple-station region. Journal of Transport Geography, 36, 89-97