ADAPTIVE STATED CHOICE EXPERIMENT FOR ACCESS AND EGRESS MODE CHOICE TO TRAIN STATIONS

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ABSTRACT

This paper presents an analysis of an adaptive stated choice experiment in the Netherlands to quantify the influence of different factors in the access and egress mode choice to railway stations. For this purpose a sample of 1524 respondents was collected. Mixed logit choice models are estimated which include cost and time factors and variables factors describing the quality of stations and station environments. The main findings indicate that bicycle parking costs in the Netherlands play an important role in access mode choice. Furthermore, improvements in route quality are more important for cyclists than pedestrians as a determinant for access and egress mode choice. Costs and time of access modes are highly important in relation to the main mode choice. Particularly for the bicycle as feeder mode, the ratio of cost to time is a significant reason for dropping the train as main mode.

1 INTRODUCTION

Bicycle transit integration is decisively gaining attention in transport policy and research. In the Netherlands, but also elsewhere in Europe and North America and Europe measures are implemented to promote the bicycle as feeder mode for public transport, such as provision of bicycle parking, improving bicycle stations, and providing more connected bicycle networks (e.g., see Pucher and Buehler, 2007, 2008). In countries like the Netherlands, Denmark and Germany, the demand for bike-and-ride many times exceeds the supply of bicycle parking facilities at railway stations. Public transport share can be affected by the accessibility level of the feeder modes. In this paper we focus on walking and cycling as the most important public transport feeder modes in the Netherlands, having approximately the 60% share in access and egress travel.

Most studies on access and egress mode choice are based on revealed preference data. However, revealed preference methods do not always provide enough information to estimate the relative importance of different factors explaining access and egress mode choice. On the other hand, limitations of stated preference experiments are that they are based on hypothetical scenarios and and/or may have potentially biased samples of respondents (Krizek et al., 2007). However, the use of a self-selected group of respondents in stated preference surveys has both disadvantages and advantages. Particularly in a cyclist survey, the accumulated experience provided by cyclists is one of the main advantages, and yields a more accurate assessment of potential facilities. In this paper we combine a revealed and stated preference survey. An adaptive stated choice experiment for access and egress mode choice to railway stations was included in an online survey, in which (over 1500 respondents) completed a revealed preference survey, and based on the outcome, received different attribute levels in the SC experiment. *Adaptive Stated Preference* (ASP) methods are an methodological improvement in stated choice experiments, based on subsequent interactions following from the choices reported by each respondent. Adaptive preferences surveys have been adopted in transport research, and some in the context of bicycle route choice (e.g., Tilahun et al., 2007, Stinson and Bhat, 2004) and pedestrian access (e.g., Kelly et al., 2011; (Audirac, 1999), but to the authors' knowledge not yet on access and egress mode choice.

The remainder of this paper is structured as follows. Section 2describes the methodology applied in the design of the present SC experiment. Section 3 explains the analytical framework of discrete choice models for analysing the data. Subsequently, the results are discussed in Section 4 and Section 5 contains the conclusions.

2 SURVEY DESIGN

2.1 Adaptive choice experiment

In this paper we designed an adaptive stated choice experiment to study mode choice in the access stage of a public transport journey, on the basis of revealed preference questions. There are advantages to using this method. As at least one attribute level contains the level currently faced by the respondents. The present SC experiment considers changes in existing alternatives, becoming 'new alternatives'; when new alternatives are being evaluated, the attributes must be believable.

2.2 Selecting alternatives and attributes from the literature

The first step when designing a stated choice experiment is to create profiles by selecting alternatives, attributes, attribute levels and combining characteristics to obtain a profile. The selection of attributes can be based on existing research (literature review), focus groups and factors listing in order to identify which characteristics are important. The main issue is the identification of attributes to be included and the number of levels. In our case, previous studies highlighting the factors that influence cycling played a key role. The *Dutch Design Manual for Bicycle Traffic* (CROW 2007), for example, defines five elements of quality in a cyclist network: safety, directness, attractiveness and comfort. In a more specific context, Heinen et al. (2011), Heinen et al. (2010)analysed commuting by bicycle, with a definition of factors influencing bicycle use as commuter mode. Stinson and Bhat (2004) found travel time as the most important route characteristic for bicycle commuters. Only a few studies analysed the factors influencing the bicycle as feeder mode. See for example Martens (2004) and Pucher and Buehler (2009).

There are a few studies which examined the factors influencing the pedestrian-friendliness of a place, i.e. personal security and pedestrian safety. Kelly et al. (2011) identified the following factors in assessment of the walkability of the pedestrian environment: car speed, cyclists on the pavement, detours, pavement width, road crossings, street lighting, traffic volume, pavement cleanliness and pavement evenness (uniformity). Additionally, (Audirac, 1999) analysed the influence of proximity to places (spaces and parks, shopping, community centres, etc.) reachable within walking distance. The factors safety and availability of places are linked, i.e. a lively place attracts more pedestrians. However, a pedestrian route should accomplish a set of criteria (Gehl, 2010) such as protection (against traffic accidents, crime, snow, rain, etc.), comfort (opportunities to walk, stand/stay, sit, etc.), and delight (scale, opportunities to enjoy, etc.). Similarly as for the bicycle as feeder mode for public transport, few studies have looked at pedestrian behaviour in the access route to a main mode (Gehl, 2010).

2.3. No choice option

The objective of the current stated choice experiment is to test the relative importance of factors influencing the mode choice in the access to a railway station. We were specifically interested in the choice of non-motorized modes, and in how the status of both route and facilities at a station influences the modal choice. For this purpose, our stated choice experiment considered four attributes: time, cost, and the status of pedestrian and cycling facilities. Five alternatives were included: car, BTM (Bus-Tram-Metro), walk, bicycle and no choice. Including a 'no choice' option is a point of major discussion in the literature about designing SC experiments. Some authors indicates that having a 'no choice' alternative enables a more realistic experiment as well as predictions of total demand (Louviere and Hensher, 1983). Other authors state that 'no choice' is actually a substitute for the 'real profile' rather than a real 'no choice' (Mabel, 2003). By contrast, the 'no choice' option is also called: opt-out alternative, non-participation or status-quo alternative. It avoids the forced choice, allowing the respondents to select another alternative if they do not prefer any of the options in the choice set (Ruby Banzhaf et al., 2001). Choice experiments involving a competition between new product concepts and existing (fixed) products may incorporate no-choice or delay-of-choice options (Batsell and Louviere, 1991).

In our experiment design we divided the '*no choice*' in two options: '*I would not travel by train*' or '*I would find another way to go the station*'. Similarly, in the egress experiment, the following alternatives were included: BTM, *OV-fiets* (a system of 'public transport' rental bicycles present at almost all Dutch railway stations), bicycle (own), walk and no choice. By including two no choice options we intend to:

(1) provide to the respondent the possibility of stating that if no alternative fits with his/her situation, then s/he will find another way to access the station. Moreover, the selection of option (a) means that the individual would like to keep the status quo.

(2) verify whether the railway operator would lose market under these specific conditions; then the respondent would choose ‘I would not travel by train’.

The attributes were selected based on a literature review, as presented in Section 2.2, factors listing and a focus group. The literature review focused on inputs and outputs of studies about the influence of cyclist and pedestrian factors that influence the modal choice. We identified that many different factors can influence both cyclist and pedestrian behaviour, converting the selection of widely understandable factors into a challenging task.

Three main criteria guided our selection of the attributes. Firstly, we were looking for compact measures, understandable but technically measurable. Secondly, each attribute should be adaptable to access as well as egress mode choice for railway stations. Finally, the attributes selected should be suitable for suggesting policy implementations as result of the study, such as regarding bicycle parking costs, location of bicycle parking, and improvement of pedestrian environment.

Based on the literature review and identification of potential factors that influence the choice, we analysed the strengths and weakness of the train stations by completing a fieldwork visit to 15 railway stations. The fieldwork consisted on assessing the station status as itself and station catchment area (factors listing);) in respect to both pedestrian and cyclist facilities. During the fieldwork visit, 49 indicators were collected in 2 sets of factors. The indicators were evaluated in a scale from 1 to 10. The 2 sets of factors were composed by pedestrian, cyclist and indicators of station environment as follows:

1. At the station: which includes five station indicators; two pedestrian indicators, such as existence of places to sit, existence of places to talk and listen, etc.; seventeen cycling indicators such as proximity of bicycle facilities to the platform and quality of bicycle parking.
2. Around the station: nine cycling indicators (i.e. quality of bicycle paths, road safety and comfort) and sixteen pedestrian indicators (i.e. existence of sidewalks, quality of traffic lights; lively and dynamic environment).

We calculated the average for the 49 indicators in fifteen railway stations. The problem was identified by the lowest-performing indicators, those with scores lower than 5. Those indicators were the location of bicycle parking, existence/quality of infrastructure for cycling, quality of traffic lights, and environment at station (lively, opportunities to see). Those indicators were transformed into attributes of a pilot stated choice experiment

Afterwards, the stated choice experiment was tested during a workshop of experts and practitioners. The latter suggested using the approach of delays instead of only presenting improvements to the facilities. The use of delays instead of quality or status introduces an objective interpretation of the effects of different quality levels in the route.

Accordingly, three types of attributes were used in the stated choice experiment: cost, time and status of facilities. The variation of the attributes is described as follows:

- **Costs** for three alternatives. In the access experiment, two levels of cost were proposed in the BTM alternative, and two levels of car parking cost in the car alternative, whereas bicycle parking costs varied among three levels. In the Netherlands, there are two possible prices of bicycle parking: free or 1.25 €/time. The levels in the cost attribute of the present experiment cover the real situation. Additionally, we test the effect of doubling the current price (2.5 €/time).

- In the egress experiment, the public bicycle (*OV-fiets)* option varied between two levels of cost. Currently, the price of renting a public bicycle is close to 3 €/time. The real price is covered by including a cost level of 2.85€ per time as OV rental price. Additionally, we test possible substitution between public and private bicycle by including 0.5 €/time as price of public bicycle.
- **Adaptive time.** The travel time of the chosen mode was increased by 0', 5'and 10'. The travel time for the not-chosen alternatives in the revealed preference part was estimated as function of the chosen alternative, and increased by 5' and 10' as well.
- **Status of facilities.** This was presented as minutes of delay along the route, and at the station. The delays were presented from both pedestrian and cyclist perspectives in terms of cycling accessibility and pedestrian accessibility. In the cycling accessibility attribute, we defined four levels: no delays over the route, delays of 2 minutes during the route, delay of 2 minutes due to the distance from the bicycle parking place to the train platform, 5 minutes delay given distance from the bicycle parking to the train platform..
- Similarly, for pedestrian accessibility, we defined four levels as follows: 2 and 5 minutes of waiting time along the route, given traffic lights or interruptions along the route; improvements in the station environment (availability of places to see, sit, liveliness, etc.) and no improvements.

- Table 1 shows the attributes and levels. Figure 1 shows a screenshot of the online application for the stated choice experiment. As can be observed, pictures were used to present the improvements.

Attribute	Attribute levels	Levels	Code
Alternatives access mode	**Car driver/passenger, BTM, Bicycle (own), Walking, No choice**	**5**	
Alternatives egress mode	**BTM, Bicycle (own), *OV-fiets*, Walking, No choice**	**5**	
Travel time access/egress: Adaptive RP	+0', 5, 10'	3	0
			3
Cost bus	3.6 €/return-journey	2	0
	2.2 €/return-journey		1
Cost car parking	8 €/day	2	0
	12 €/day		1
Cost bicycle parking	Free	3	0
	1.25 €/day		1
	2.5 €/day		2
Cost *OV-fiets*	2.85 €/day	2	0
	0.5 €/day		1
Accessibility improvements		**4**	
(1) Cycling accessibility	**Delays**		
	No delays	**0**	
	Addition of 5 minutes in the route by bicycle due to number of interruptions, cyclist priority in traffic lights, intersections	**1**	
	Addition of 2 minutes in walking from bicycle parking to platform	**2**	
	Addition of 5 minutes in walking from bicycle parking to platform	**3**	
(2) Pedestrian accessibility	**Delays**		
	2 minutes waiting time for pedestrians at traffic lights on the route to the station	**0**	
	5 minutes waiting time for pedestrians at the traffic lights on the route to the station	**1**	
	Improvement of current station environment for train passengers (commercial areas, cafés, restaurants, etc.)	**2**	
	No improvement of current station environment	**3**	

Table 1: Attributes of stated choice experiment

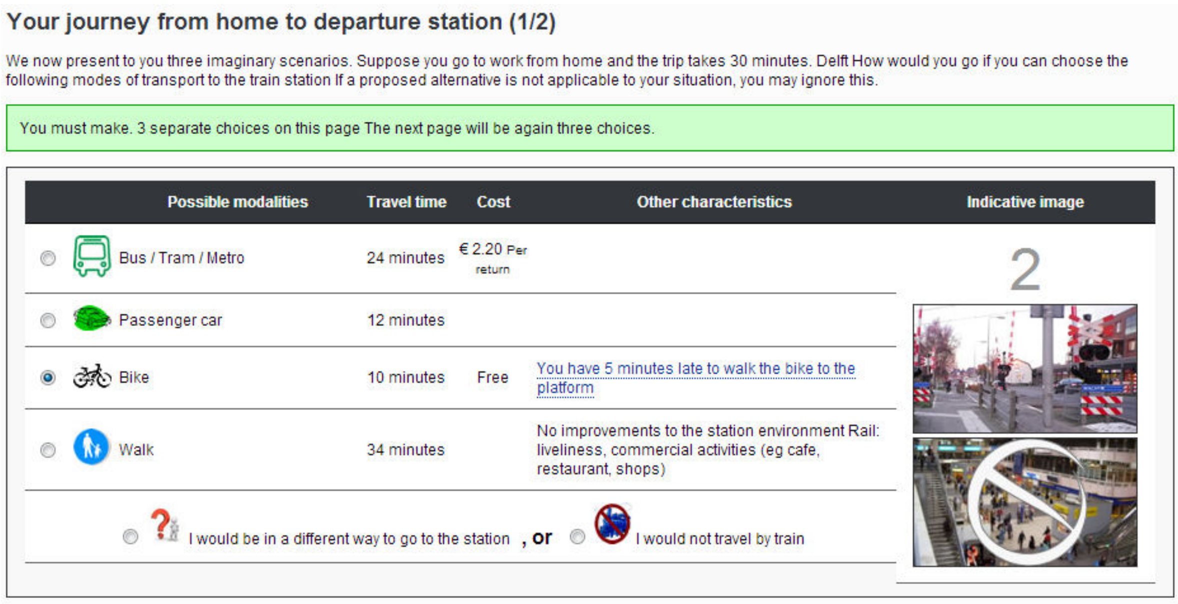

Figure 1: Screenshot of show cards used in the data collection phase

Following the level balance criterion, which requires that the levels of each attribute occur with equal frequency in the design, each respondent completed twelve cards. Six cards pertained to access and the remaining six cards to egress.

2.3 Field work design

The survey took place in the middle of summer and early autumn of 2013. The recruitment was based on the following three criteria:

(1) Residential location. Only people living in the area Leiden – The Hague-Rotterdam – Dordrecht were selected. The catchment area of the railway station was limited to 5 km.

(2) Frequency of travelling by train for both work and non-work purposes. Three types of passenger were established: *frequent* (a person who travels by train up to four times per week), *infrequent* (a person who travels once per month up to once per year), and *never* (a

person who travels once per year or never). The objective was a balanced distribution of user type, but the non-users were very reluctant to complete the survey. As a result, 44% of the respondents who completed the survey belong to the frequent traveller category, 40% are infrequent travellers, and only 16% expressed that they never travel by train.

(3) Type of departure station. Figure 2 displays the study area which is located in the area of Leiden – The Hague – Rotterdam – Dordrecht; considered the southwest of the Netherlands (Randstad South).

The sample size was 1524 respondents. A pilot survey took place with 50 respondents; the respondents sent feedback about the survey tool. Figure 2 shows the stations selected in the corridor from Leiden to Dordrecht. In total, 41 stations were integrated into this study. The sample covers smaller (i.e. *Barendrecht*), medium-sized (i.e. *Leiden, Delft* and *Rotterdam Alexander*) and large stations (i.e. *The Hague, Rotterdam*)

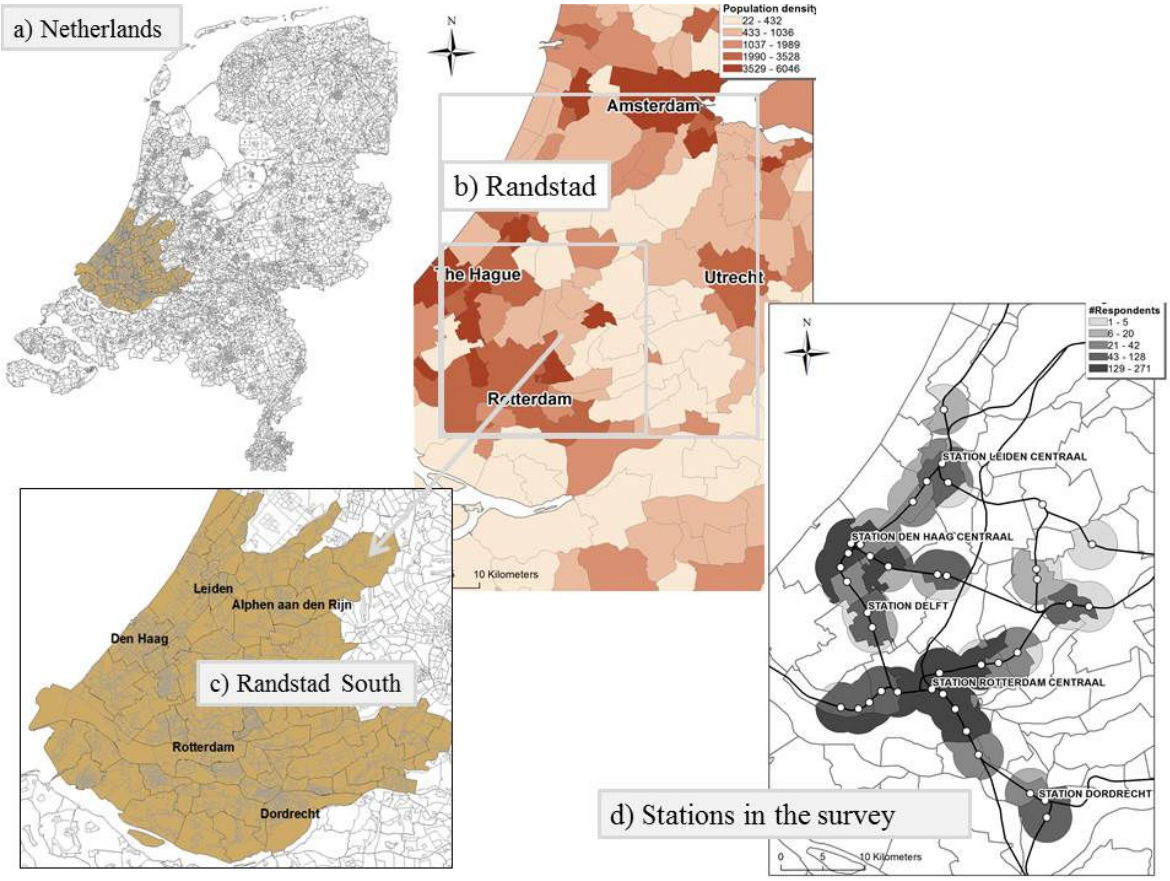

FIGURE 2: Study area in the southwest of the Netherlands

Figure 3 presents the modal split in the access to the 41 railway stations. At least 15% of access occurs as car driver and car passenger; walking takes up close to 25%; whereas around 27% cycle to the railway station. Almost 30% of the train passengers go to the station by BTM. These results are consistent with results of the survey conducted yearly by Dutch Railways (Brons et al., 2009).

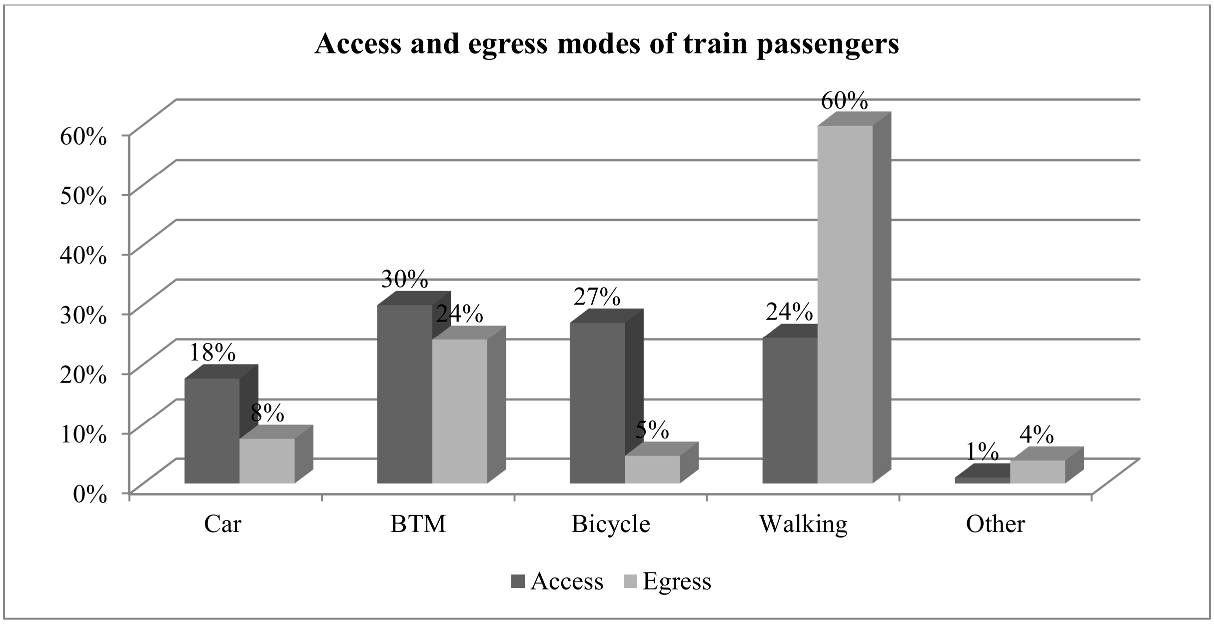

Figure 3: Modal split in the access and egress to/from railway stations

3 ANALYTICAL FRAMEWORK MIXED LOGIT FOR MODELLING STATED CHOICE EXPERIMENT

The choice set in the stated preference experiment consisted of five alternatives; see Section 3. We modelled the stated preference data via a mixed logit model, as it is most suitable for this type of experiment (Cherchi and Ortúzar, 2006).

The MNL is characterised by the Independence of Irrelevant Alternatives Property (IIA), which states that for each specific individual, the ratio of the choice probabilities of any two alternatives is entirely unaffected by the presence or absence of any other alternatives in the choice set and by systematic utilities of any other alternatives.

The mixed logit (ML) is a highly flexible model that can approximate any random utility model (McFadden and Train, 1997). The ML does not exhibit independence of irrelevant alternatives

(IIA) or the restrictive substitution of patterns of the MNL because the ratio of mixed logit probabilities P_{ni}/P_{nj} depends on all the data, including attributes of alternatives other than i or j. The cross elasticity is not the same for all values of i, so an improvement in one alternative does not affect the other alternatives proportionally.

The ML has been widely applied in the field of transport econometrics for many years(see as reference Brownstone et al. (2000) and Hensher and Greene (2003)) . The mixed logit probability can be derived from utility-maximizing behaviour in several ways; although formally equivalent, they provide different interpretations, i.e. error components and random coefficients. In this case, we applied the error components to represent the individuals' taste.

A person faces a choice among J alternatives, which can be modified by two error components, of which one is stochastic and the other non-stochastic. The stochastic part (ε_{in}) is assumed to be independently and identically distributed over alternatives and people. The non-stochastic part (ω_{in}) depends on the individuals' tastes. The utility can be expressed as follows:

$$U_{ij} = \beta x_{in} + [\,\omega_{in} + \varepsilon_{in}]$$

Eq. 1

Here, the person n faces a set of characteristics x_{in} in the alternative i. ω_{in}expresses the random term with zero mean and σ_{ω} standard deviation, which is estimated over the distribution of the observed data. In general, the distribution over people and alternatives depends on underlying parameters and observed data relating to alternative i and person n. ε_{in} is independent and identically distributed over the alternatives. For standard logit, $\omega_{in}$is zero.

Let's use θ as a vector of fixed parameters. According to Train (2003), the ML is any model of which the choice probabilities can be expressed in the form:

$$P_{nj} = \int L_{ni}(\omega) f(\omega|\theta) d\omega \qquad \textbf{Eq. 2}$$

In this equation, $L_{ni}(\omega)$ is the logit probability evaluated at parameters of ω_{in}, and $f(\omega)$ is the density function.

$$L_{ni}(\omega) = \frac{e^{V_{ni}(\beta x_{ni}+\omega)}}{\sum_{j=1} e^{V_{nj}(\beta x_{ni}+\omega)}} \qquad \textbf{Eq. 3}$$

The probabilities do not exhibit IIA. Simulation is usually applied to estimate the ML. Given the values that describe the population parameter of the individual parameters, R values of $\boldsymbol{\omega}$ are drawn from its distribution and the probability in Eq.6 is calculated conditional on each realization. The simulated probability (SP) is the average of the conditional probabilities over R draws:

$$SP_n = \frac{1}{R} \sum_{r=1,\dots,R} L_{ni}(\omega^r) \qquad \textbf{Eq. 4}$$

Then, the simulated log-likelihood function is constructed as $SLL(\omega_n) = \sum_n ln\,(SP_n)$ and the estimated parameters are those that maximize SLL. The bias is that SLL decreases as the number of repetitions increases.

4 MODELLING RESULTS

4.1 Results of the adaptive stated choice experiment

We tested several specifications before arriving at the final model specifications presented in this section. The selection of explanatory variables followed a systematic test of variables. Insignificant variables were removed from the model specification.

Table **2** shows the model results for the stated choice experiment. All the coefficients present the expected sign; time and cost are negative for all the alternatives. Pedestrians are more sensitive than cyclists to travel time, but less sensitive so during the egress journey. However, five minutes of waiting time along the route discourages the travellers much more than only two minutes. The result is reasonable, two minutes of waiting time en route is worthwhile when other attributes compensate for this waiting (for example, lower costs and good infrastructure facilities).

The travel time by bicycle acts as key predictor in the modal choice to access the station. Similarly, the walking time is determinant. This indicates that both pedestrians and cyclists are more sensitive to variations in travel time than car drivers or bus users. The magnitudes of the travel time coefficients of the walking and cycling modes are greater than for other modes. Additionally, the parameter of travel time by foot presents the largest t-test.

A delay seems to be irrelevant for cyclists during the access stage, whereas it is more important for pedestrians. Moreover, a delay produced by bicycle parking located far from the train platform does not discourage the travellers from selecting the bicycle as egress mode. However, this cyclist is not likely to sacrifice cost as a trade-off for proximity of bicycle parking to the platform during the egress stage. This is demonstrated by the negative sign of the coefficient 'no delays' because the cards were a combination of positive and negative levels of attributes.

It is important to mention the effect of time related to the *OV-fiets* (public bicycle), which is less significant than the effect of travel time when using the own bicycle from the station. It means that individuals are more willing to travel longer distances by public bicycles than on private bicycles in the egress journey. This result can be associated to trip purpose. The model estimated only for work journeys shows a higher significance of travel time by public bicycles than the model estimated for all journey purposes.

The specific constants for the alternatives '*OV-fiets*', 'no train use' and 'other option to access the station' are very large, which means that there is a lot of uncontrolled variation in those alternatives, i.e. given by socioeconomic characteristics. By contrast, the choice behaviour of both cyclists and pedestrians can be clearly explained by the attributes cost, time and infrastructure among the available alternatives (cycling, BTM, car and public bicycle).

A set of error components was estimated to represent preference heterogeneity. Table 3 shows the standard deviation of the error components. As can be observed, the standard deviation is alternative-specific, which means that individuals perceive each alternative in the choice set differently. A large value of these standard deviations means that socioeconomic characteristics are influencing the choice behaviour. After addition of age and gender to the model specification, the absolute magnitude of the error components became smaller. Particularly older populations tend to use BTM more often and cycle less. This result is consistent with the descriptive statistics.

4.1.1 The 'no choice' option

The main advantage of the 'no choice' option is the possibility to estimate total market shares of train users and non-users. The results shows that bicycle costs have a significant influence on the 'no choice' selection. It means that non-train users do not reject using train only because of high bicycle parking costs. Therefore, the effect of bicycle parking costs and access time by bicycle was tested as ratio parameter (time/cost). This parameter shows the trade-off between one minute less in the access time and one euro more in the bicycle parking cost, for example parking a bicycle closer to the platform which implies a higher cost.

Name	Affected utility	All journeys – Access		Work journeys - Access		Non-work journeys – Access		All journeys - Egress		Work journeys - Egress	
		Value	Robust t-test	Value	Robust t-test	Value	Robust t-test	Value	Robust t-test	Value	Robust t-test
Alternative-specific constants											
ASC_{0SP}	BTM *Reference alternative*										
ASC_{1SP}	Car	-1.15	**-3.00**	-1.55	-1.83	-1.17	**-2.00**				
ASC_{2SP}	Bicycle	0.17	0.50	0.587	0.68	0.36	0.31	0.09	0.31	1.03	**2.81**
ASC_{3SP}	Walk	2.55	**7.16**	2.46	**2.55**	2.46	**3.27**	-0.10	-0.34	0.42	0.93
ASC_{4SP}	No train	-3.58	**-8.78**	-4.23	**-4.84**	-3.78	**-6.94**	-2.65	**-8.64**	-3.68	**-7.37**
ASC_{5SP}	Other mode	-1.93	**-5.18**	-2.39	**-2.87**	-2.27	**-4.25**	-1.54	**-5.62**	-2.02	**-4.75**
ASC_{OVFIET}	*OV-fiets*							0.28	1.11	-0.40	-0.98
Socio economic characteristics											
$\beta_{ageBTMSP}$	BTM	0.01	**5.61**	0.0009	0.52	0.002	0.86	0.34	1.49	0.00	-0.22
β_{age}	Other mode	0.003	**4.78**	0.0027	**5.82**	0.003	**2.37**	0.003	**2.29**	0.004	**2.48**
$\beta_{genderCARSP}$	Car	-0.49	**-2.44**	-0.352	-1.04	-0.38	-1.45				
$\beta_{genderBTMSP}$	BTM	0.34	1.43	0.538	1.28	0.35	1.20	0.004	**3.34**	0.05	0.16
$\beta_{genderBIKESP}$	Bicycle	-0.14	-0.70	-0.617	**-2.01**	0.13	0.40	0.12	0.67	-0.53	**-2.13**
$\beta_{genderWALKSP}$	Walk	0.42	1.88	0.483	1.39	0.38	1.20	0.51	2.75	0.32	0.83
LoS parameters											
$\beta_{costovfiets}$	*OV-fiets*							-0.11	**-7.25**	-0.59	**-7.18**
$\beta_{bikecost}$	Bicycle	-0.41	**-11.47**	-0.511	**-7.85**	-0.32	**-7.19**	-0.43	**-12.19**	-0.55	**-9.90**
$\beta_{btmcost}$	BTM	-0.27	**-6.18**	-0.275	**-3.65**	-0.24	**-4.28**	-0.43	**-9.01**	-0.40	**-6.25**
$\beta_{timecarSP}$	Car	-0.04	**-3.43**	-0.064	**-3.34**	-0.04	**-2.81**				
$\beta_{timebtmSP}$	BTM	-0.09	**-7.78**	-0.105	**-3.95**	-0.08	**-5.05**	-0.06	**-6.32**	-0.09	**-6.28**
$\beta_{timebikeSP}$	Bicycle	-0.11	**-6.03**	-0.141	**-4.55**	-0.08	**-3.53**	-0.14	**-8.73**	-0.19	**-8.22**
$\beta_{timewalkSP}$	Walk	-0.19	**-17.01**	-0.197	**-11.91**	-0.19	**-12.56**	-0.09	**-13.82**	-0.15	**-9.50**
$\beta_{timeovfiets}$	*OV-fiets*							-0.68	**-2.49**	-0.16	**-6.81**
Status of infrastructure											
$\beta_{C_{sp}}$ **no delays**	Bicycle	0.28	**3.57**	0.302	**2.26**	0.22	**2.08**	-0.16	**-2.13**	-0.19	-1.68

Name	Affected utility	All journeys – Access		Work journeys - Access		Non-work journeys – Access		All journeys - Egress		Work journeys - Egress	
		Value	Robust t-test	Value	Robust t-test	Value	Robust t-test	Value	Robust t-test	Value	Robust t-test
β_{Csp1} 5'delay during route	Bicycle	0.65	**4.25**	0.725	**2.60**	0.49	**2.44**	0.96	**6.41**	1.14	**5.31**
β_{Csp2}: 2'delay to platform	Bicycle	0.57	**5.56**	0.655	**3.49**	0.49	**3.39**	0.52	**5.14**	0.62	**4.19**
β_{Psp}: 2'waiting time pedestrians	Walk	0.07	0.98	0.025	0.20	0.05	0.56	0.02	0.31	-0.08	-0.77
β_{Psp1}: 5' waiting time pedestrians	Walk	-0.214	-1.85	-0.304	-1.91			-0.07	-1.08	0.08	0.64
β_{Psp1}: 5' waiting time pedestrians	Other mode	-0.833	**-3.69**								
Improvement of current station environment for train passengers (commercial areas, cafés, restaurants, etc.)											
β_{Psp2_1}	Car	0.07	1.06								
β_{Psp2_4}	Other mode	-0.354	**-2.25**								
Standard deviations of error components											
σ_{CAR}	Car	-1.78	**-8.78**	-1.98	**-5.62**	-1.39	**-3.14**				
σ_{BIKE}	Bicycle	-2.42	**-17.02**	2.42	**10.12**	-2.29	**-7.90**	-2.49	**-15.96**	-2.05	**-11.23**
σA_{WALK}	Walk	0.66	**2.06**	-0.843	**-2.31**	-1.38	**-3.28**	1.20	**6.11**	2.20	**7.93**
σ_{BTM}	BTM	2.67	**11.07**	-2.09	**-4.48**	-2.32	**-3.13**	3.02	**9.94**	2.56	**10.24**
$\sigma_{OVFIETS}$	*OV-fiets*							-0.49	**-10.60**	-0.16	-0.72

All journeys **Work journeys** **Non-work journeys** **All journeys - Egress** **Work journeys - Egress**

Sample size:	9144 (N=1524)	3864 (N=644)	5508 (N=918)	9144 (N=1524)	3864 (N=644)
Rho bar of initial model:	0.36	0.38	0.33	0.32	0.38

Table 2: Model estimation for stated choice experiment

4.1.2 Differences by journey purpose

Table 3 shows the model results distinguished by journey purpose as follows: all journey purposes (N=1524 respondents), work journeys (N=644), and non-work journeys (N=918). Firstly, as can be observed, the bigger differences concern the coefficient of travel time for all modes. Travel time becomes more important for work journeys started by car and bike. and still highly significant. The results suggest that people are less flexible and willing to spend more time in both car and bike when the journey is for work purposes. Penalties for delays are lower for a non-work journey than for a work journey.

Secondly, the contribution of bicycle cost is greater in the model of work journeys than in the model of non-work journeys. The perceived penalty of the cost of parking the bicycle at the station slightly increases for those who travel for work purposes. This result is contrary to our expectations; we assumed that workers would be more likely to pay higher costs for parking the bicycle, and then this coefficient would be less significant, as it is for non-work journeys. In despite of this contradiction with bicycle users, the penalty for BTM cost is consistent with the expectations.

Thirdly, the standard deviations for the panel effect of car and BTM users are slightly smaller in the non-work journeys. This means that fewer socioeconomic characteristics intervene in the decision process of travellers for non-work purposes, and more stochastic effects are captured in this model than in the model for work journeys.

Furthermore, the egress part clearly shows different results in both socioeconomic and level-of-service attributes. In the case of bicycle use, delays are irrelevant in the egress mode, which is reasonable because of the availability of public bicycles (*OV-fiets).* Importantly, the most important type of delay occurs en route. People are less likely to spend more time en route than for parking the bicycle 2 or 5 minutes from the platform. Additionally, the results for pedestrians in the egress part are consistent with the results for the access part. A waiting time of 2 or 5 minutes is perfectly acceptable for pedestrians. Consistent with the analysis of stated choice in the access mode, the influence of socioeconomic characteristics and individual tastes is stronger for work journeys than for non-work journeys.

4.2 Model applications: Market shares and elasticity

We calculated the market shares and elasticities with the developed model. By measuring the market shares we can estimate the probabilities of choosing each transport mode to access the station. Whereas the elasticity allows to measure the variation in market shares after changing attributes of the alternatives. Figure 4 shows the estimated market shares of access modes controlled by access travel time on foot, calculated with the stated choice experiment. There is a distance decay effect, which is different for each transport mode. As expected, the probability of walking to the station suddenly decreases after 20 minutes, whereas the probability of accessing the station by car increases. The bicycle is a very attractive mode for even journeys of more than 20 minutes; 35% of train users would cycle to the station up to 40 minutes. This result is consistent with Dutch Railway survey. According to Givoni and Rietveld (2007), 38% of train users cycle to the station up to 3 km (40 minutes walking).

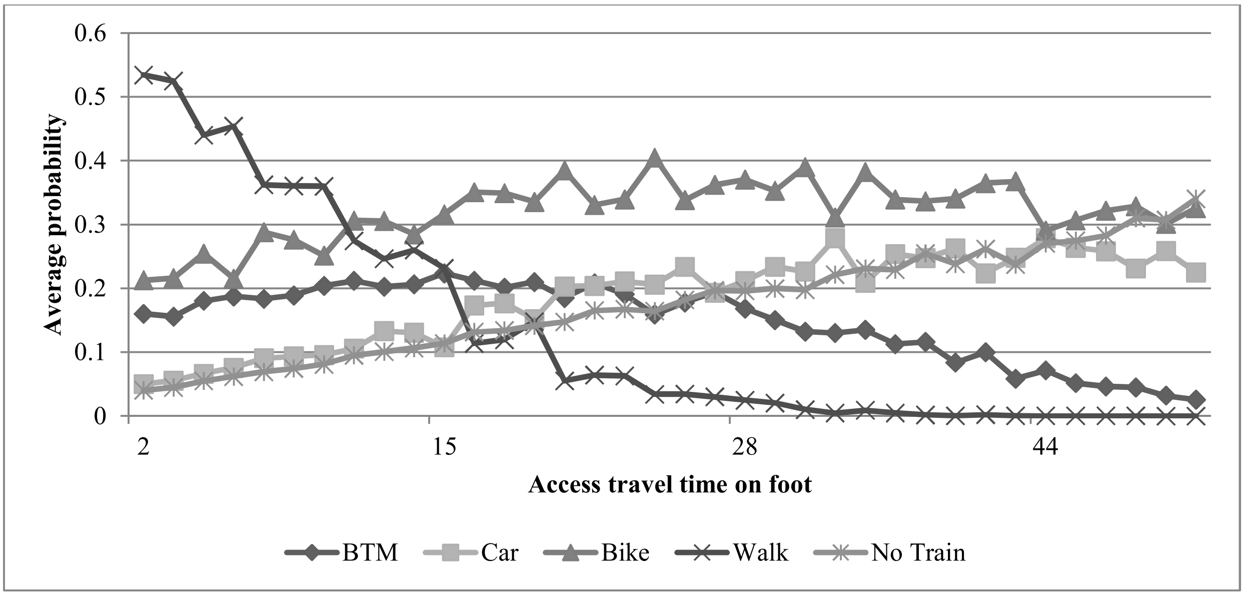

Figure 4: Market shares and travel time

4.3 Elasticities

With the developed mode we can calculate elasticites indicating the variations in the probabilities of choosing one alternative when one specific attribute is modified by 1%.. Both direct and cross elasticity are estimated. The direct elasticity of demand measures the responsiveness of the quantity demanded of an alternative to a change in an attribute of the same alternative. The cross elasticity of demand measures the responsiveness of the quantity demanded of an alternative to a change in an attribute of another alternative.

Table 3 shows the direct and cross elasticities for cost and time in our experiments. The elasticities take on both positive and negative values. The negative elasticities indicate the decrease in the share given the increase in cost or time. Similarly, a positive elasticity means the increase in the market shares given the increase by 1% in either cost or time. For example, Figure 5 shows,that, according to the attributes controlled in this experiment (cost, time and quality), an increase in 10% (0.125 €) in bicycle parking cost produces a decline by 1.0% of the bicycle share as access mode, and an increase by less than 0.1% in the share of non-train users.

However, an increment of 10% in BTM fares would increase the share of non-train users by 0.5%, five times the effect of bicycle shares. At the same time, the analysis of elasticities shows the stronger variations in market shares given by bicycle access time and BTM cost.

	Elasticity values
Direct elasticity bicycle time	-0.564
Direct elasticity BTM cost	-0.302
Direct elasticity bicycle cost	-0.099
Cross-elasticity BTM cost (Non-train user)	0.049
Cross-elast bike cost (Non-train User)	0.008

TABLE 3 Direct and cross elasticities for time and cost

5 CONCLUSIONS

This paper contains an analysis of an adaptive stated choice experiment concerning access and egress to train stations. A set of carefully selected attributes were used to control the experiment of modal choice for both access and egress journey (to and from the train station). The results show the influence of different attributes on access mode choice. As consequence, conclusions are drawn on the hierarchy of attributes to address by public transport strategies : cost, time and status of bicycle infrastructure.

One of the main findings of this study is the significant role of bicycle parking costs in the selection of the bicycle as access mode for all journey purposes (work and non-work journeys). The level of service of public transport modes in the access to station can also substantially influence the market share variations. Variations in local accessibility levels can change the train users share dramatically. In this case, local accessibility is represented by cost and time impedances of access modes.

The results of the SC experiment show firstly that the selection of the train as main mode is influenced by both cost and time of the access modes. Particularly for the bicycle as feeder mode, the ratio of cost to time is a significant reason for dropping the train as main mode. Railway companies could be losing part of the market in highly unbalanced situations of high bicycle parking costs and short distances to access the station. Secondly, the route status is more important for cyclists than pedestrians. Therefore, strategies to improve route quality in the access route to the station must mainly focus on the cyclist infrastructure.

The stated choice enables the detailed analysis of the effect of route and station infrastructure, i.e. show that inadequate parking bicycle facilities can discourage bicycle use as feeder transit mode and that improvements in the station environment (retail, cafés, restaurants, etc.) will increase the share taken up by non-motorized modes. On its own, the SC experiment also allows measuring variations in attributes, which do not (yet) exist in the real market situation, such as the costs of bicycle parking. This makes it possible to look into whether, for instance, such costs would discourage people from travelling by train.

There are several directions that future research could take building upon the work presented in this paper. Future research might firstly be directed at estimating choice models based on joint revealed preference and stated preference data, in which the revealed preference parameters would be considered the true parameters and the revealed preference would enrich the estimation. Secondly, the revealed preference survey data can be further exploited, for example testing the influence of unobserved effects of journey satisfaction. A third line of research that can be pursued is to improve accessibility modelling, estimating cost impedance functions for measuring accessibility to spatially distributed socio-economic activities by public transport including access and egress impedances, which to date are typically excluded in accessibility analysis.

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