Choices between stairs, escalators and ramps in stations

W. Daamen, P. H. L. Bovy & S. P. Hoogendoorn
Department of Transport & Planning, Delft University of Technology, The Netherlands

Abstract

In assessing the design of a public transfer station it is very important to be able to predict the routes taken by the passengers. Most simulation tools use very simple route choice models, only taking into account the shortest walking distance or walking time between a passenger's origin and destination. In order to improve this type of route choice model, other factors affecting passenger route choice need to be identified. Also, the way these factors influence route choice behaviour needs to be determined, indicating how each factor is valued. In this research, route choice data have been collected in two Dutch train stations by following passengers through the facility from their origins to their destinations. These data have been used to estimate extended route choice models. The focus in this contribution is on the influences of level changes in walking routes on passenger route choice behaviour. It appears that the different ways of bridging level changes (ramps, stairs, escalators) each have a significant and different impact on the attractiveness of a route to the traveller.
Keywords: passenger behaviour, route choice, vertical infrastructure, choice models.

1 Introduction

Public transport passengers are subjected to the problem of making route choice decisions in interchange nodes. This route choice becomes more and more complex, since public transport stations are slowly turned into multi-purpose facilities, including shopping and catering services. While this increases the number of activities that may be performed in a station, it also makes the station

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less understandable and thus complicates the route choice process for individuals.

In assessing public transport facility design, understanding pedestrian route choice is very important, since it is one of the key factors affecting the occurrence of crowding. In illustration: when all pedestrians take the same route, large concentrations of pedestrians will occur, whereas when interchanging passengers are more evenly distributed over the different routes in the station, the infrastructure will be more efficiently used and pedestrian comfort – expressed in terms of densities and speeds [1] – is likely to be higher.

Unfortunately, most simulation tools used for such assessments only include a fairly simple route choice model, derived from shortest path models. We argue that to improve our knowledge on the route choice process and to identify the factors affecting this process more varied and detailed observations are needed. With such observations, we may be able to derive more complex and accurate route choice prediction models.

This paper presents results from an effort to improve the predictive performance of pedestrian route models for public transport facilities by collecting dedicated data and estimating route choice models. We focus on the influences of level changes in walking routes and the different impacts of various ways of bridging these changes of level such as by ramps, escalators, and stairs.

This contribution starts with an overview of the state-of-the-art on route choice in public transport facilities. The main part of the contribution consists of the data collection and the estimation of route choice models including various variables. We end with some conclusions.

2 Passenger route choice in public transport nodes

For a general reference about travel behaviour in transfer stations, see [2]. This paper is on the influence of level changes on passenger route choice in public transport facilities. Reason for the hypothesized large influence is the fact that bridging level differences costs physical effort to the pedestrian. Physical abilities have major importance in the route choice process. Personal characteristics are important in order to see their effects on route choice.

Considering the vertical dimension, pedestrians do not only consider walking time (including delays in front of and on escalators and stairs) and walking distance, but also the effort involved in climbing a grade (with similar travel times, only few pedestrians choose the stairs in ascending direction) [3].

Especially in transfer stations, walking in vertical direction is very important. Apart from Cheung and Lam’s study [3] no systematic analyses of the route choice impact of different forms of bridging level changes are known. Therefore, the study described in this paper focuses on the influence of level changes in routes and the type of their overcoming on passenger route choice behaviour. To that end, we have tried to gather a more extensive route data set, also taking into account several other factors identified in literature as potentially affecting route choice behaviour.

3 Adopted research approach

The research question to be dealt with in this paper may be formulated as: ‘Do the various types of walking facility influence passenger’s route choice in train stations, with special attention to the way of vertical height bridging?’ We try to address this question by empirical observations of revealed choices of train users under varying conditions with respect to trip lengths, origins and destinations, choice set compositions and route choice factors, especially types of vertical height bridging (level, stairs, escalators, ramps). To that end, passengers’ route choices will be observed in different railway stations having enough variability in route choice conditions. The observations will be used to derive parameter estimates by adopting discrete choice models.

To estimate whether height bridging facilities affect route choice in stations we choose to adopt a path-size logit model since this model type is known to be sufficiently robust to cope with the necessary simplifying assumptions.

In this paper, we will focus on the data collection and the results of the choice estimation. For more details on the choice estimation, we refer to [4].

4 Passenger route data collection in stations

New data had to be collected in order to enable addressing the research question on level difference impacts on passenger route choice in public transport facilities. We chose the Dutch railway stations of the cities of Delft and Breda (the Netherlands) for this data collection, since the number of different choice situations and route alternatives is reasonably high in these stations. Also, the total range of infrastructure elements, that is, level elements, stairs, escalators, and ramps, can be found by pooling the data of Delft and Breda. The average daily volume in both stations is similar (21,750 passengers in Breda and 19,500 passengers in Delft). Also, the distribution over the trip motives is similar (38% work and business, 27% school and study and 36% social and leisure). Differences in route choice are therefore mainly affected by the infrastructure layout.

The data collection on chosen routes has been performed by unobtrusively following passengers, while monitoring personal characteristics (gender, age) as well as the route they chose from an entry point to the exit point.

In Delft the choice situations to be observed differ in various respects such as in length, in length of the sheltered part of the route, in level difference, and in facility type for bridging these heights (stairs or ramp). Only trips to and from platform 1 (see Figure 1:) are taken into account in this study, since no route alternatives exist to platform 2.

In Breda, alternative routes differ in the type of facility for bridging levels (stairs or escalator). Figure 1: shows plans of both stations.

The observations in Delft have taken place during both the morning peak hour and the evening peak hour during three weeks in November 2003. In Breda, observations have also been performed during both peak hours, but only during one week in January 2004.

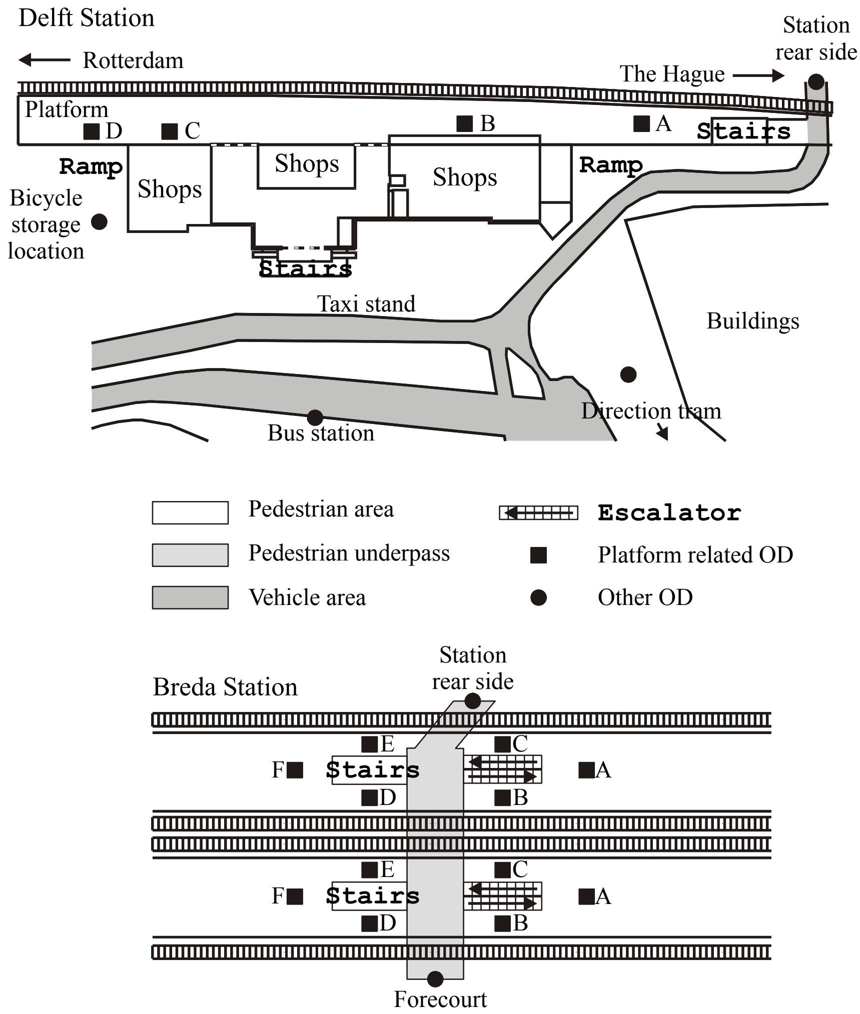

Figure 1: Plans of Delft Station and Breda Station (below).

Fixed characteristics of the stations have been observed once during an off-peak period. All other observations have been made while following the passengers from their origin, using a stopwatch to record walking times and writing the data on a dedicatedly designed observation form.

In Delft, 745 observations have been collected for 68 different origin-destination combinations, whereas in Breda 180 observations have been collected for 48 origin-destination combinations. The level changes in Delft are limited and are bridged by ramps and (short) stairs, whereas in Breda pedestrians have to choose between stairs and escalators to arrive at the platform. The average number of routes to choose between is larger in Delft (3-4 route alternatives) than in Breda (2-3 routes).

Choice category	Freq.	Perc.
Number of observations	817	100%
# of direct OD-pairs	471	57.6%
# of activity pairs	274	33.5%
# passengers to platform 2	30	3.7%
No choice	42	5.2%

	Freq.	Perc.
To platform (boarding)	298	63.3%
From platf. (alighting)	173	36.7%

	Freq.	Perc.
To platform (boarding)	241	88.0%
From platf. (alighting)	33	12.0%

	Freq.	Perc.
Buying a ticket	85	37.3%
Other	156	62.7%

Figure 2: Overview of trip types observed in Delft Station.

Figure 2: gives an overview of various observed trip types in Delft according to direction and activity participation in the station. Trips with intermediate activities are split into separate direct routes. Trips to and from platforms are assumed to show different route choice behaviour. Table 1 summarises some of the observed person characteristics in both Delft Station and Breda Station. Unfortunately, only few observations with heavy luggage are available in the sample.

In order to give the reader a feeling of the collected data, Table 2 and Table 3 show some results for station Breda. Table 2 shows the route observations pertaining to the trips in Breda between platform 5/6 and the station hall. For each of the 16 distinguished origin-destination relations the number of route alternatives (used and non-used) and some attributes of chosen routes are given. The table shows sufficient variability in walking times between relations as well as in composition of stairs and escalators. It shows that only in a minority of cases all alternatives are indeed used by travellers.

Table 3 summarises for each route in a choice situation the number of pedestrians having chosen this route as well as the corresponding average walking time. Only the trips in Breda Station between platform 5/6 and the hall are included in the table. The routes in this table are numbered according to the location where they enter the platform. Route 1 is via the escalator on the right, while route 2 uses the stairs on the left. Route 3 is the route using the stairs

Table 1: Overview of observed characteristics.

	Delft		Breda		Total	
	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.
Men	452	60.7%	93	51.7%	545	58.9%
Women	293	39.3%	87	48.3%	380	41.1%
Children / students	218	29.3%	63	35.0%	281	30.4%
Commuters	509	68.3%	115	63.9%	624	67.5%
Seniors	18	2.4%	2	1.1%	20	2.2%
With luggage	25	3.4%	11	6.1%	36	3.9%
Without luggage	720	96.6%	169	93.9%	889	96.1%

Table 2: Some characteristics for route choices in Breda Station.

Origin-destination relation	# Alternatives	# Used alternatives	Min. travel time [s]	Mean travel time [s]	St. dev. Travel time [s]	# Observations	# Alternatives with: Stairs up	Stairs down	Escalator up	Escalator down
Station hall – platform 5/6 part A	3	1	15	51,7	13,9	35	2	0	1	0
Station hall – platform 5/6 part B	2	2	50	55	7,1	2	1	0	1	0
Station hall – platform 5/6 part C	2	1	56	62	6,6	3	1	0	1	0
Station hall – platform 5/6 part D	2	1	48	48	-	1	1	0	1	0
Station hall – platform 5/6 part E	2	1	28	28	-	1	1	0	1	0
Station hall – platform 5/6 part F	3	2	32	47,6	8,9	14	1	0	2	0
Platform 5/6 part A – station hall	3	1	45	51	8,5	2	0	2	0	1
Platform 5/6 part B – station hall	2	1	62	72	14	3	0	1	0	1
Platform 5/6 part C – station hall	2	-	-	-	-	0	0	1	0	1
Platform 5/6 part D – station hall	2	1	38	48	14	3	0	1	0	1
Platform 5/6 part E – station hall	2	-	-	-	-	0	0	1	0	1
Platform 5/6 part F – station hall	3	1	49	50	1,4	2	0	1	0	2

or A, route 1 includes the escalator, route 2 includes the stairs and parts C and E of the platform, while route 3 also includes the stairs as well as parts B and D of the platform). Sometimes, the number of routes is limited, since one of the routes is worse in all aspects. This route is then left out.

Table 3: Observed route choices in Breda Station.

Origin-destination relation	# Observations	Route 1 # Chosen	Route 1 Mean travel time	Route 2 # Chosen	Route 2 Mean travel time	Route 3 # Chosen	Route 3 Mean travel time
Station hall – platform 5/6 part A	35	35	51.7	0	79.3	0	79.3
Station hall – platform 5/6 part B	2	1	52.0	1	60.7		
Station hall – platform 5/6 part C	3	3	62.0	0	74.9		
Station hall – platform 5/6 part D	1	0	63.5	1	48.0		
Station hall – platform 5/6 part E	1	0	37.0	1	28.0		
Station hall – platform 5/6 part F	14	0	72.4	13	45.7	1	72.4
Platform 5/6 part A – station hall	2	2	51.0	0	78.8	0	78.8
Platform 5/6 part B – station hall	3	3	72.0	0	89.9		
Platform 5/6 part C – station hall	0	-	-	-	-		
Platform 5/6 part D – station hall	3	0	67.4	3	48.0		
Platform 5/6 part E – station hall	0	-	-	-	-		
Platform 5/6 part F – station hall	2	0	80.9	2	50.0	0	80.9

925 out of 1010 observations appeared useful for model estimation. The data clearly show that travel time is an important factor in route choice. Table 3 shows that many passengers choose for the route with the shortest travel time. The data collected in Breda also shows that passengers prefer the use of the escalator instead of the stairs. We will elaborate on these findings more specifically using choice model estimation in section 5.

5 Model estimation outcomes

We will confine ourselves to a discussion of the outcomes of the model estimation and refer to [4] and [5] for details about the estimation procedure.

First of all, we can conclude (as expected) that routes with short walking times are preferred over routes with longer walking times. This is a general observation, corresponding to other findings in literature, and independent of the types of facilities routes consist of.

Secondly, the facility types in routes do influence the route choice behaviour of passengers. We distinguish between level elements (platform, corridors and hallways), stairs, escalators, and ramps. Passengers prefer walking on a level element, since this is the most natural way of walking. However, in most stations tracks are crossed at different levels for safety reasons. Passengers are therefore obliged to overcome differences in height using stairs, escalators, or ramps. Comparing the different facility types, stairs are valued much more negative than escalators and ramps. While escalators and ramps are valued similar, escalators are slightly preferred.

For a quantitative comparison, we use the relative level penalty, comparing walking time on a specific type of facility to walking time on a level element. Table 4 shows the results for such a comparison. We see that walking time on stairs is valued 1.86 times that of walking on a level element, thus 1 second walking on stairs is valued similar to 1.86 seconds walking on a level element. For escalators and ramps, a single second of walking time is equal to respectively 1.28 seconds and 1.37 seconds of walking on a level element.

When we distinguish between the directions a facility is used (upwards versus downwards) we see that passengers prefer the downward direction (lower relative level penalties). Walking downwards on an escalator or ramp is even preferred over walking on level elements.

Table 4: Relative level penalties for different types of facilities.

	All directions	**Upwards**	**Downwards**
Level element	*1*	*1*	
Stairs	1.86	2.78	n.s.
Escalator	1.28	1.86	0.72
Ramp	1.37	1.66	0.95

n.s. = non-significant

In addition to the influence of the facility type, we have also looked at the influence of passenger characteristics, trip characteristics and observational characteristics, see [4] and Table 5. In Table 5, the second column indicates the reference group (in italics). The weight that the other groups give to travel time is given relative to this reference group.

With respect to passenger characteristics, we tested differences in choice behaviour between men and women, between children, adults, and seniors, and between passengers with and without luggage. The only considerable distinction in behaviour is found for seniors, having a very strong preference for short routes (nearly eight times as much as adults). The trip characteristics (boarding or alighting passengers and whether passengers performed an intermediate activity or not) did not change passenger's behaviour.

Finally, observational characteristics have been looked at. No differences were found in route choice during the morning peak and the evening peak. However, weather conditions and the day of the week did influence route choice behaviour. Bad weather conditions made passengers choose even more for the shortest routes, whereas passengers valued walking times significantly worse on Monday than on Tuesday and Thursday. This might also be due to the passenger type (less regular travellers on Monday versus regular travellers on the other days of the week).

Table 5: Influence of passenger, trip and observational characteristics.

	Reference group			
Personal characteristics	Men	Women		
	1	1.00		
	Children	Adults	Seniors	
	1	0.82	6.34	
	With luggage	Without luggage		
	1	0.92		
Trip characteristics	Boarding	Alighting		
	1	1.21		
	With activity	Without activity		
	1	1.09		
Observational characteristics	Morning peak	Evening peak		
	1	0.93		
	Sunny weather	Clouded		
	1	1.58		
	Monday	Tuesday	Wednesday	Thursday
	1	0.71	0.79	0.69

6 Conclusions

In this paper, we have discussed data collection for modelling passenger route choice in public transfer stations. These data have been collected in two Dutch train stations by following passengers and recording their chosen route as well as some personal characteristics. Based on these data a route choice model has been estimated, taking into account not only walking times, but also the influences of different types of facilities (level elements, stairs, escalators, and ramps). The estimated model came up with very reliable results. Including a route choice model like this with such explanatory power in a passenger flow simulation tool, the assignment of passengers to the station infrastructure network will be more accurate, thus leading to better predictions of the simulation tool with respect to concentrations of passengers in a station.

Although intended for use in a simulation tool, the values for infrastructure types estimated in this research may directly be applied in facility design decisions on supporting e.g. the installation cost of escalators. The estimated values are passengers' qualifications of the infrastructure elements, different for upward and downward direction and as such an indication for the distribution of the passengers over the elements. Cost and comfort of an infrastructure type may be assessed directly in the design stage, together with the offered capacity.

Although this is already a remarkable improvement, further research is recommended. First, the existing data set might be applied for more detailed models. More variables, also with respect to personal characteristics and observational characteristics will be included in a single utility function. Also, other types models will be looked at. To be able to predict passenger route choice in an arbitrary station or already in the design stage, more data will be collected on other stations with different layouts. We will look for a more extended number of infrastructure types (elevators), where also characteristics of the infrastructure will differ (length, grade). We also plan to observe different passenger types, focussing among other things on the amount of luggage that passengers carry, passengers' habit and passenger behaviour in groups or travelling with small children.

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