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Valuation of a transfer in a multimodal public transport trip

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ABSTRACT

Improvement of chain mobility is considered a major issue in public transport use. Transfers within a public transport trip are the least appreciated part of the trip. This research quantifies the experienced transfer disutility of a transfer between BTM and train. The influence of travel time, transfer time, headway, costs and station facilities on the valuation of a transfer is estimated, based on a web-based stated preference (SP) experiment with over 1145 respondents. A set of mixed logit models was estimated, including sub-models by trip purpose, travel frequency, access/egress mode and journey stage (access or egress). The modeling results show that the total disutility during the interchange depends on the total time, the distribution of the time spent (access, transfer, waiting time) and headway. In general, the most optimal transfer time is found to be 8 min, but relevant differences are found among respondents and stations. The highlighted preferences of different groups of travelers can be used by public transport service to meet the travelers' needs in a transfer, and decrease the transfer disutility.

1. Introduction

Chain mobility is an increasingly important subject among both public transport service providers and policy makers. A trip by public transport usually involves one or more transfers from one mode to another mode, which requires a substantial amount of effort from the traveler. It is common in transport demand and public transport route choice models to use penalties for transfers in generalized cost functions. However, there is not a rich literature on the transfer disutility of transfers, and transfers between bus/tram/metro (BTM) and train in particular. Available studies show that passenger dislike interchanges, but there is a considerable variation between trip purpose (i.e. commuters are more sensitive than leisure travelers) and from place to place (e.g., see Balcombe et al. (2004)).

In general, the disutility of a trip consists of three components: time, costs and effort (Hoogendoorn-Lanser, 2005; Horowitz and Thompson, 1994; Van Hagen, 2011). These three components consist of several attributes which all contribute to the total disutility of the trip. We will briefly describe these here.

Firstly, travel time is one of the three components contributing to the disutility of travel. An important concept when considering travel time is the travel time perception of a traveler. This travel time perception of the traveler is not constant (Van Hagen, 2011), but consists of several components, with their own characteristics and specific influence on mode choice (Vande Walle and Steenberghen, 2006). For example, Van Hagen (2011) distinguishes the time on the origin and destination, the time during access and egress trips, the train movement and the transfer between modes. Van Hagen concluded that the transfer between modes is the least appreciated (or least useful) part of the trip. The in-vehicle time in access and egress modes is appreciated less than the in-vehicle time in the train. A number of studies estimated value of time (VOT) values for different parts of public transport trips. Abrantes and Wardman (2011) for example performed a meta-analysis of UK values of time and found that waiting time is experienced as 1.7 times the in-vehicle times (27 studies) and walking time is experienced as 1.65 times the in-vehicle time (63 studies). In an earlier UK meta-study. Wardman (2001) finds that a train–train transfer, apart from wait time is valued the equivalent of around 18 min of travel time. Arentze and Molin (2013) finds a train–train with 10 min time between trains is equivalent to 22 min extra in-vehicle time, based on stated choice experiments in the Netherlands. Similarly, de Keizer et al. (2015) found a penalty of 23 min of experienced travel time (ETM), for train–train transfers in the Netherlands. In this case, the ETM is equivalent to the generalized travel time GTT used in Keizer et al. (2014). The *GTT* is the utility value of an attribute divided by the utility value of in-train time. In the literature, however, we did not find studies estimating value of time (VOT) values in the journey interchange between public transport modes .

Secondly, the monetary travel costs contribute to the financial

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disutility of the trip. Public transport in the Netherlands mostly uses one integrated ticketing system (OV-chip card) which can be used for all modalities. However, there is not one ticket price for the complete trip. Each public transport service provider in the trip chain calculates its own fare. This fare is based on a basic fare and a variable fare dependent on the distance of the trip. If a traveler transfers between train and BTM, the basic fare should be paid to both public transport service providers, while only one basic fare will be paid in a direct trip. Therefore, it is difficult to allocate a specific monetary cost to the transfer. However, it is possible to quantify the generalized travel time based on the time disutility of the total trip, as above described.

Finally, next to travel time and monetary travel costs, effort is the third element contributing to the disutility of travel. Effort is not limited to physical effort but includes cognitive (mental) and affective (emotional) effort as well (Wardman et al., 2001). Effort consists of elements like travel information, safety, uncertainty, reliability and station facilities. Particularly, Cascetta and Cartenì (2014) found that station quality is valued in 35–50 euro-cents per trip. Headway had shown to be a critical element in transfer time valuation. For example, a low frequency of trains allows for more transfer time but a high frequency may have to contend with a possible lack of transfer time (Hine and Scott, 2000). Furthermore, the valuation of the different components of transfer disutility differs for personal- and trip characteristics (Hine et al., 2003; Wardman and Hine, 2000). Differences are identified in previous studies based on characteristics like trip motive, familiarity with the stations, travel frequency, gender, age, trip length, time of day and type of access/egress mode.

The main aim of this paper is to determine the transfer disutility of a transfer between BTM and train. The influence of a selection of attributes, based on the literature review, namely: travel time, transfer time, headway, costs and station facilities on the valuation of of such a transfer will be quantified. This quantification will be done by comparing the relative utilities of each of these attributes, converted to *generalized travel time*. This way, the contribution of each attribute to the total transfer disutility can be expressed as in-train time. Furthermore, the importance of these attributes will be differentiated for personal and trip characteristics. To the authors' knowledge, this is the first study to examine value of time (VOT) values in the journey interchange between public transport modes.

2. Survey design and data collection

In this research, a stated preference experiment is carried out to determine the transfer disutility of a transfer between BTM and train. The conducted stated preference (SP) experiment was part of a larger survey also including revealed preference (RP) questions. Respondents were asked about characteristics of their last trip by public transport to adapt the SP experiment to the personal experience of the respondent. Furthermore, respondents were asked about personal characteristics to distinguish several types of travelers. This section introduces the setup of the SP experiment.

2.1. Recruitment of respondents

The sampling frame consists of members of the Netherlands Railways (NS) panel. This is a panel which consists of train travelers who agreed to participate in several surveys, of different topics, that are conducted by Netherlands Railways (NS). To avoid sampling bias, the survey introduction did not explicitly mention the topic ‘value of transfer time’. The survey was sent to a total of 3247 individuals, among which 1145 completed the survey (with response rate of 35.3%). The same size accounted on 1064 respondents, who remained after cleaning. A group of 81 respondents was excluded from the dataset based on the survey completion time and the description of their last trip. Respondents were assigned either to an SP experiment with an access transfer (from BTM to train) or an egress transfer (from train to BTM), based on their last reported trip. Table 1 shows the distribution of respondents per trip motive and travel frequency. Furthermore, the real distribution of the trip motives and travel frequencies of total Netherlands Railways (NS) trips is given. The sample is not fully representative for the population of NS. Travelers with the trip motive school/study and high-frequent travelers are underrepresented. A weighting on trip motive is applied to correct for unrepresentative distribution among trip motives. With the weighting on trip motives, the distribution of travel frequencies is close to the population distribution as well. Therefore no further weighting on frequency needs to be applied.

Table 1
Distribution of respondents among sample

	Access		Egress		Total		NS population (trips 2010)
	Absolute	%	Absolute	%	Absolute	%	%
Trip motive							
Work/business	177	34	184	34	361	34	45
School/study	39	8	44	8	83	8	31
Social	155	30	186	34	341	32	11
Recreational/ other	144	28	135	25	279	26	13
Travel frequency							
Once a week or more	244	47	291	53	535	50	77
1–3 times a month	129	25	139	25	268	25	10
Less than once a month	142	28	119	22	261	25	13

2.2. Attributes and attribute levels

The alternatives are described by six attributes: access/egress trip time, transfer time, in-train time main trip, headway of the connecting mode, costs and station facilities. The attribute levels for access/egress trip time, in-train time and costs were adaptive to values experienced by the respondent in the reported trip. This way, the choice situations are close to the experience of the respondents, which yields more reliable results. The attribute level for headway of the connecting mode varied between 15, 20 and 30 min and five levels of transfer time were included (3, 5, 8, 11 and 15 min). Station facilities are included as a qualitative attribute describing the type of transfer station (medium, large or very large). Additional questions were included in the survey, asking respondents about socioeconomic characteristics like age, gender, income and working situation. Furthermore, the respondents assessed the transfer station of their recent trip on six different aspects. A summary of the included attributes and attribute levels is included in Table 2.

The choice situations are presented to respondents in a web-based survey. An example of a choice situation as presented to a respondent is shown in Fig. 1. Besides the two alternatives in each choice situation, two no choice options are included: ‘I would travel to station B in another way’ and ‘I would not make this trip by public transport’. By including the first no choice option, respondents are not forced to make a choice between one of the two alternatives when they would not choose any of the presented alternatives in reality. The second no choice option was added to allow an analysis of the importance of transfers between public transport modes in the decision to travel or not to travel by public transport.