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Context Dependent Stated Choice Experiments: The Case of Train Egress Mode Choice

Eric J.E. Molin [1,*] Harry J.P. Timmermans [2,†]

[1]Department of Technology, Policy and Management, Delft University of Technology, P.O. Box 5015, 2600 GA Delft, The Netherlands
[2] Department of Architecture, Building and Planning, Eindhoven University of Technology P.O. Box 513, 5600 MB, Eindhoven, The Netherlands

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Abstract

Based on the contention that the influence of context on mode choices made in multi-modal trip chains is under-researched, this paper discusses the design and results of a stated choice experiment to estimate the effects of context variables on train egress mode choice: the mode chosen after a train trip in order to reach the final destination. The results derived from a sample of 996 train travellers indicate that context variables, which were varied in the experiment (travel purpose, time of day, weather, travel party, amount of luggage, distance and route knowledge), all have significant effects on egress mode choice. Moreover, the estimated coefficients were all in anticipated directions, lending face validity to the results. Finally, the results indicate that context effects differ between some socio-demographic variables. In particular, there is evidence of strong gender differences.

Keywords: stated choice, mode choice, multi-modal, context effects

* Corresponding author, T: +31-152788510, F: + 31-152782719, e.j.e.molin@tudelft.nl
† T: +31-402474684, F: + 31-402438488, h.j.p.timmermans@tue.nl

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1 Introduction

The planning and design of transport systems that are as flawless as possible is one of the goals of transport planners and engineers. Multi-modal systems have received increasing attention in this regard over the last decade. The right combination of different modes of public transport or the combination of public and private transport is seen as one of the solutions that can help battle increasing congestion, especially within cities. In order to build and design such systems, a clear understanding of user demands and constraints is of vital importance. That is, policy makers should understand consumer preferences and behaviour with respect to mode choice decisions in multi-modal transport chains.

The literature on multi-modal choices, however, is relatively limited and seems to rely on the well-known condition-independent, utility-maximizing framework. It is typically assumed that the choice of transport mode in a multi-modal chain depends only on the attributes of the transport modes and a set of constraints that defines an individual's choice set (e.g. Ben-Akiva and Lerman 1985). While much progress has been made in exploring and modelling such choice sets (e.g. Hoogendoorn-Lanser 2005), we argue that further extensions are required to take into account the various contextual conditions that influence the mode choice decision. These contextual conditions involve the composition of the choice set and background effects, that is, the specific trip conditions that form the context in which the multi-modal choices are made.

In a previous paper (Molin et al. 2006) we explored the effects of choice set composition on egress mode choice. Choice set composition may influence the decision in the sense that the choice of a particular transport mode may be influenced by the (non)-availability of similar modes. Applying the decision principles proposed by Anderson and Wiley (1992; see also Louviere et al. 2000), we constructed a stated choice experiment in which the availability of train egress transport modes was systematically varied based on an experimental design. By estimating a universal logit model from the observed choices, we indeed found significant availability effects, suggesting that adding and removing train egress mode alternatives have different impacts on the choice probabilities of various train egress modes.

In the current paper, we focus on the external circumstances that may influence mode choice. For example, trip purpose may imply a different choice outcome: if a traveller has a business meeting and is formally dressed, he/she may decide to choose a taxi as an egress mode alternative, whereas if the traveller is travelling for leisure, he/she may decide to use the bus or rent a bicycle. While the effects of context on choice has received some attention in other fields of research (for example, Ariely and Levav 2000; Aurier et al. 2000; Bell et al. 1994; Sandel 1968; and Wakefield and Inman 2003), it is relatively under-researched in the literature about mode choice. Most mode choice applications do not explicitly take background effects into account in the specification of the utility function. Either it is assumed that the model is independent of context and it is therefore applied directly to different conditions; or data are collected for a single context only, often the commute to work, and consequently the resulting model is only valid for that particular context. However, potentially many more context variables than trip purpose may influence mode choice decisions. These include weather conditions, travel companions and amount of luggage. This may even be more prominent in multi-modal choices because of the need for transferring. In the context of transport mode choice decisions in multi-modal chains, this reasoning means that the objective of the analysis should be to examine which conditions influence mode choice in multi-modal chains, to what extent these conditions affect the decision to travel at all, and the influences behind the choice between multi-modal transport and door-to-door car use.

It is difficult to study such context or background variables in a revealed preference framework (i.e., using observed choices in real markets), because these variables need to demonstrate sufficient variation and, ideally, also satisfy some correlational structure. Hence, the demands for data collection are rather high. It may be that some circumstances are rare, implying that careful attention should be given to collecting a sufficient number of observations in order to be able to draw meaningful and statistically significant conclusions. Hence, it seems that in such situations, stated preference methods are the only realistic alternative, as these methods allow the researcher to experimentally vary the background variables and thus also to control the correlational structure among the various variables manipulated in the experiment with the added advantage of controlling for some of the response heterogeneity.

The principles of constructing stated choice experiments that allow estimating the effects of context or background effects on choices have already been discussed by Oppewal and Timmermans (1991). However, the number of applications of these design principles has been quite limited to date (e.g. Bos et al. 2004; Molin and van Gelder 2008). This is remarkable, as the method may potentially increase the validity of estimated models as it takes the different contexts into account, while it requires only a relatively small, easy-to-implement extension of the construction of the stated choice experiment. The first aim of this paper is therefore to demonstrate this and to re-draw the attention of a wider audience of researchers to these design principles. The second aim of this paper is to contribute to the literature on multi-modal choice by testing the impact of background variables on multi-modal choices. More specifically, this paper focuses on egress mode choice, this being the choice of transport mode when travelling from the destination station to the final destination.

The remainder of this paper is organized as follows. First, the applied methodology is described in more detail. Then the data collection is discussed, followed by a presentation of the modelling results. Finally, some conclusions are drawn and policy implications are discussed.

2 Methodology

2.1 Constructing Experiments for Context Dependent Choices

This subsection explains how stated choice experiments can be adapted to include the observation of choices conditional to background variables or temporal trip conditions, called “context effects” in the remainder of the paper. Oppewal and Timmermans (1991) discussed the need to construct two experiments. A first experiment is constructed to vary the choice alternatives; this is a regular choice experiment. In this experiment, the attributes of the choice alternatives and/or the availability of the choice alternatives are systematically varied across the choice sets, based on an experimental design (for details on constructing such experiments see e.g. Louviere 1988 and Louviere et al. 2000). A second experiment is needed to systematically vary the context variables to arrive at a set of context descriptions. Next, the choice sets of the first experiment need to be nested under the context descriptions resulting from the second experiment to arrive at a set of context-choice set descriptions. Hence, as each choice set is combined with each context description, the total number of context-choice sets is equal to the number of choice sets times the number of context descriptions.

This is illustrated by constructing a simple experiment intended to examine the effects of context variables on mode choice. Imagine there is an interest in examining the effects of two context variables, weather and luggage, on mode choice. The context variables vary in the levels *rainy weather* or *sunny weather* and in *none* and *laptop* respectively. Combining these levels results in four context descriptions. Imagine further that choice sets are constructed to vary the availability of two public transport alternatives, bus and tram. This results in 4 different choice sets: bus and tram can be both available, either only bus or tram can be available, or none can be available. To this, we add two base alternatives, which we assume are always available: biking and walking. Nesting the four mode choice sets under the four context descriptions results in the 16 context-specific mode choice sets presented in Table 1. Note that in this simple example only the availability of alternatives is varied; it goes without saying that the choice sets can represent any set of constructed choice alternatives varying in generic or alternative-specific attributes.

2.2 Model Estimation

In order to examine the extent to which context variables influence choice, one needs to estimate interaction effects for the context variables with the coefficients of interest.

Table 1: Example of nesting choice sets under context variants

	context 1:	**sunny weather & no luggage**			
1	mode set 1	bus	tram	bike	walk
2	mode set 2	bus		bike	walk
3	mode set 3		tram	bike	walk
4	mode set 4			bike	walk
	context 2:	**rainy weather & no luggage**			
5	mode set 1	bus	tram	bike	walk
6	mode set 2	bus		bike	walk
7	mode set 3		tram	bike	walk
8	mode set 4			bike	walk
	context 3:	**sunny weather & laptop**			
9	mode set 1	bus	tram	bike	walk
10	mode set 2	bus		bike	walk
11	mode set 3		tram	bike	walk
12	mode set 4			bike	walk
	context 4:	**rainy weather & laptop**			
13	mode set 1	bus	tram	bike	walk
14	mode set 2	bus		bike	walk
15	mode set 3		tram	bike	walk
16	mode set 4			bike	walk

This may either be an interaction with an alternative-specific constant – for example, to examine to what extent weather affects the preference for the biking alternative; or it may be an interaction with an attribute coefficient – for example, to examine to what extent the coefficient for waiting for a bus varies with weather conditions. Hence, a statistically significant interaction coefficient indicates that the context variable significantly affects the coefficient of interest and thus that the coefficient differs for the various levels of the context variable.

As context variables are often categorical, the levels need to be coded. The most widely applied coding for levels of categorical variables in the choice literature is dummy coding, in which L levels are coded by *L*-1 indicator variables. The first L-1 levels are coded 1 on each respective indicator variable and 0 on all other indicator variables, while the L^{th} level is coded 0 on all indicator variables. A disadvantage of dummy coding is that an estimated constant (in some cases alternative-specific) then coincides with the utility attached to the alternative consisting of the attribute levels that are all zero coded.

Effects coding (e.g. Bech and Gyrd-Hansen 2005 and Louviere et al. 2000) is an alternative coding scheme that does not have this disadvantage. What distinguishes it from dummy coding is that the L^{th} level is coded -1 on all indicator variables instead of zero. The result is that an estimated constant (again, often alternative-specific) then has an independent interpretation and denotes the average utility attached to that alternative as specified in the experiment. Estimated coefficients for the *L*-1 indicator variables then indicate to what extent the corresponding levels affect utility, hence the marginal utility, expressed as deviations from the estimated constant. The marginal utility of the L^{th} level is the negative sum of the marginal utilities of the other *L*-1 levels.

If effects coding is applied to code context effects, an estimated main (alternative specific) constant denotes the utility derived from that alternative averaged across all varied context levels. To illustrate this, the constant estimated for bus travel in our example experiment denotes the utility derived from travelling by bus, 50 percent of all trips being in rainy weather and the other 50 percent in sunny weather. Furthermore, in 50 percent of the trips no luggage needs to be carried, and in 50 percent of the trips a laptop needs to be carried. A bus-specific coefficient for weather then indicates the extent to which the bus constant needs to be corrected for sunny and rainy weather, respectively.

2.3 The Choice Experiment

In this subsection, first the construction of the train egress mode choice experiment is discussed, followed by the construction of the context variants. Next, it is discussed how these two elements are combined and included in the questionnaire.

2.3.1 Egress Modes

In this study, the following seven egress mode alternatives were varied in the stated choice experiment: public transport (PT), taxi, train taxi, public PT bike, bike in train, bike at station, and Greenwheels (rental car based on shared car principles). Although some studies found preference differences between diverse PT vehicles, it was decided not to make such a distinction, as we did not find preference differences between bus, metro and tram in a pilot project. This reduced the size and complexity of the choice task.

In the Netherlands, bicycle as an egress mode alternative has as least three different variants, which are all distinguished in the experiment. A first possibility is *bike in train:* travellers take their own bicycle with them in the train, which costs 6 Euros per day, although collapsible bikes can be taken for free. While one can bring a collapsible bike onto the train at all times of day, it is not allowed to bring a regular bike during rush hours. A second possibility is *bike at station*: commuters and students who have to make regular trips to the same destination often park a bicycle at the station at the activity end of their train trip. Open-air bike racks are commonly placed in front of train stations and can be used for free, while the usually guarded railway station shelters charge about 10 Euros a month, or 87 Euros a year. The final bike option, *public transport (PT) bike,* is a relatively new concept: travellers can rent a bicycle at a train station for only 2.75 Euros a day. However, travellers have to register for this service in advance and pay an annual fee of 7.50 Euros.

The next choice option is the taxi. In front of major train stations, regular taxi vehicles are usually waiting for passengers; at smaller stations, however, taxis are usually not waiting, they have to be called. Taxi rides in the Netherlands are not cheap: more than five Euros is the starting fee plus two Euros for every kilometre and about 50 cents per minute of waiting time, for instance at a stop light. Therefore, the Dutch railways introduced a cheaper taxi alternative in the early nineties, the train taxi, which is a shared taxi at a fixed price, charging about four Euros for each ride. The train taxi must wait a maximum of 10 minutes for more passengers after the first one gets in. As Dutch railways subsidize this service, they recently cut down the number of stations where train taxis are available in order to reduce costs.

The final egress mode that is varied in the experiment is Greenwheels. This is a rental car membership service based on shared car principles. There are several packages of fixed-variable cost combinations, of which the cheapest subscription fee is five Euros per month. Based on this description, one pays 10 cents per kilometre and between 2.50 and 5 Euros per hour, depending on the type of subscription. It is a general car-sharing system, with cars parked at various fixed places all over town. In the experiment, subjects were informed that Greenwheels cars are available at the relevant train station.

As this study focused on estimating context effects, none of the choice attributes in the choice experiment were varied, with the exception of frequency of the PT service, so as to limit the size of the experiment. In half of the choice sets, public transport was specified as a high-frequency service departing every 5 minutes, and in the other half as a low-frequency service departing every 25 minutes. Basic information on the choice alternatives, including the price specification described above, was provided in the questionnaire.

The mode choice sets were constructed by varying the availability of the seven egress modes in the choice sets according to the smallest possible orthogonal fraction of the 2^7 design and its foldover (Anderson and Wiley 1992). A foldover design is a design that mirrors the design from which it is derived; that is, an alternative available in a choice set is not available in its foldover, and vice versa. The smallest orthogonal fraction of a 2^7 full factorial design involves eight choice sets. Adding its foldover design resulted in 16 choice sets, which is only 1/8 of the number of choice sets implied by the full factorial design. Note that this design allows for the estimation of availability effects, the results of which can be found in Molin et al. (2006). This paper reports only on the context effects.

Three basic options were added to each of these choice sets. First, walking was added because it is always available and a feasible option for most travellers in reaching the final destination. Second, travelling by other means of transport than train was added. This operational decision was motivated by the argument that travellers may consider the egress modes offered in the choice sets to be insufficient and thus decide not to travel by train at all, but rather to use another transport mode, most likely the car. Third, respondents are allowed to indicate that they would not travel at all but stay at home under the varied conditions. This choice option serves as a reference choice and is given a utility of zero by definition. It implies that the utility of all other modes is estimated relative to the utility of this reference option. The latter two basic choice alternatives allow us to examine under which conditions travellers do not opt for multi-modal transport, but rather prefer other uni-modal modes like the car or opt not to travel at all.

2.3.2 The Contexts

The following context variables were assumed to influence egress mode choice: trip purpose, knowledge of the route, weather, distance to final destination, amount of luggage, time of day and travel party. All these variables are divided into two levels. Trip purpose can either be *recreational* or *business*. It is often argued that time factors less and money factors more if one travels for recreational purposes when compared to travelling for business purposes. Hence, we expect that less costly (often slower) modes will be more preferable for recreational purposes than for business purposes.

Route knowledge was divided into *knowing the route* and *not knowing the route*. If one does not know how to reach the destination, he/she may be less inclined to choose a mode that requires him/her to find his/her own route. Modes that include a chauffeur, like the taxi alternatives and possibly also public transport (although with this mode the last part of the route may still be problematic) may then be preferred.

Weather conditions were distinguished as being either *rainy* or *dry*. It is to be expected that in rainy weather, the alternatives of walking and bicycling are less preferred than modes that provide more shelter. It is also expected that in rainy weather, travellers are less inclined to travel at all, and hence a larger share of the travellers may choose to stay at home.

Two levels were also defined for the distance from the final destination context variable: *1 kilometre*, denoting relatively short distances, and *5 kilometres*, denoting relatively long distances. It is expected that long distance will especially affect *walking*.

The amount of luggage is the next selected context variable. It also has two levels: *none or little luggage* and *heavy luggage* (e.g. suitcases). It is expected that the motorized modes, especially the taxi alternatives, are more preferred if heavy luggage has to be carried. It is also expected that in this case, travellers will more frequently choose the option *not by train* (thus, opt less frequently for multi-modal transport).

A distinction was made in time of day between *daylight* (i.e., travelling during daylight hours), and *evening or night* (i.e., travelling in the dark). This context variable relates to feelings of safety. It is expected that the slow modes of walking and bicycling will be more popular during the day than in the evening or at night.

The final context variable is travel party, described as either *alone* or *with others.* Travelling with others makes the taxi alternative cheaper and may make some bike options more problematic, because all travellers in the party would need to have a bike.

2.3.3 Overall Design and Administration

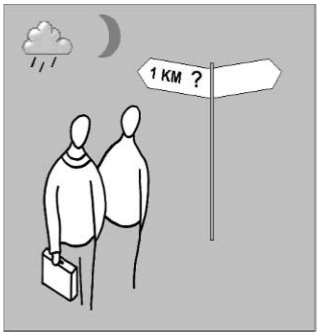
Thus, in summary, a total of seven context variables were selected, which were all divided into two levels. Assuming that interaction effects between the context variables are equal to zero, the smallest orthogonal fraction of the 2^7 full factorial design was chosen to vary these context variables. This resulted in 8 context variant descriptions or profiles. The 16 egress mode choice sets are nested under the 8 context variants. This resulted in $16 \times 8 = 128$ combined mode-context choice sets in which the mode choice sets are observed an equal number of times for each context profile, implying that context effects can be estimated independently from availability and attribute effects. Respondents are presented with all 16 egress choice sets, but in order to limit task load, context variants varied only per four choice sets. The layout of the questionnaire was such that at the top of each page the context variant was described and respondents were requested to explicate their transport mode choice for all four egress choice sets presented on that page, assuming the presented context variant applied. Hence, each respondent only saw half of the context variants. To construct fully balanced combined mode-context choice sets for each respondent, eight variants of the questionnaire were constructed, in which the order of the choice sets was systematically varied to avoid any order effects. Figure 1 provides an example of a page in the questionnaire (translated from Dutch). Note that an additional drawing is included that shows similar information on the context variables as the top text box.

To familiarize respondents with all contexts and choice options, respondents were first asked to articulate the context of their current trip. This was followed by a brief introduction of all the selected egress transport modes, providing information to respondents who are less familiar with certain modes.

2.3.4 Sample

The stated choice data were collected in the spring of 2005 using a questionnaire format. More specifically, passengers on intercity trains were requested to fill out a questionnaire, which took them approximately 15 to 20 minutes to complete. Questionnaires were distributed and collected on trips between several main train stations in the centre of the Netherlands, with a typical duration of about 30 minutes. About 50 percent of the contacted train travellers agreed to participate in the study. Of the 1,014 collected questionnaires, 18 did not have any choices in the stated choice experiment. Of the remaining respondents, 973 respondents provided complete responses on all segments' variables of interest. Of those respondents, 11.3 percent had one or more missing values in the stated choice experiment. This is in line with previous data collections, including stated choice experiments on trains in which there also were relatively large percentages of randomly missing values in the choice sets. This is probably caused by unexpected movements of trains, causing respondents to overlook one or more choice sets. In total, 14,750 valid choices were observed.

Table 2 presents some respondent characteristics. It can be seen that the sample included more females than males. Closer examination revealed that gender did not correlate with any of the other variables. In addition, the younger age group is represented more than the older age group. This is probably caused by the fact that students in the Netherlands have a free public transport card, and therefore many train travellers are students. This is also the reason why more than half of the travellers have a bus season ticket. Finally, Table 2 shows that almost half of the respondents have a higher vocational or university education.



Travel situation 2
You travel for **recreational** purposes. You do **not** know the **route** to your final destination **well**. You carry **light** luggage (hand bag, schoolbag, attaché-case). The final destination is **1 km** from the station. It is **raining**. You travel with someone else. You travel in the **evening or at night**.

Make one choice per question from the offer of egress transport modes considering the travel situation described above. The travel situation applies for all questions on this page.

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18. Your choice:

☐ Public Transport
☐ Greenwheels
☐ Train taxi
☐ Own bike at station
☐ Walk
☐ I do not travel by train
☐ I stay at home

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19. Your choice:

☐ Bike in train
☐ Public transport
☐ PT bike
☐ Greenwheels
☐ Walk
☐ I do not travel by train
☐ I stay at home

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20. Your choice:

☐ Own bike at station
☐ PT bike
☐ Taxi
☐ Greenwheels
☐ Walk
☐ I do not travel by train
☐ I stay at home

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21. Your choice:

☐ Taxi
☐ Bike in train
☐ Train taxi
☐ Public Transport
☐ Walk
☐ I do not travel by train
☐ I stay at home

Figure 1. Example page of choice experiment

Table 2. Distribution of respondent characteristics

gender		**age group**	
Females	60.0%	< 30 years	64.1%
Males	40.0%	>= 30 years	35.9%
level of education		**season ticket bus**	
< = middle vocational	54.8%	yes	53.9%
higher vocational & university	45.2%	no	46.1%

3 Results

3.1 Analysis

In order to estimate the context-dependent choice model, the choice alternatives were all dummy coded, while the alternative *stay at home* served as a reference alternative. The context variables were all effects-coded and alternative-specific, as earlier explained. Furthermore, the four segment variables were effects-coded as well and were included as interaction effects with the alternative-specific context variables.

In order to estimate the relative impact of the context variables on egress mode choice and to examine whether this differs among various segments, a basic multinomial logit (MNL) model was estimated from the observed choices. This model involved nine alternative-specific constants, 63 (7×9) alternative-specific context effects that express deviations from the alternative-specific constants, and 252 (4×63) segment specific context effects that express deviations from the alternative-specific context effects. Thus, in total, 324 coefficients were included in the model. This model was estimated using Biogeme (Bierlaire 2003), a free software package for estimating discrete choice models that has no upper limit in the number of coefficients to be estimated.

The loglikelihood of the model with only alternative-specific constants is equal to -21,809, which is significantly higher than the loglikelihood of the null model (-26,584; χ^2= 9,550, d.f. = 9, p = 0.000). If the model is extended to include all 63 alternative-specific context-effects, the loglikelihood is significantly improved to -19,345 (χ^2= 4,928, d.f. = 63, p = 0.000). If the model is further extended to include the 252 interactions of the context effects with the segment variables, the loglikelihood is again significantly improved to -18,987 (χ^2= 715, d.f. = 252, p = 0.000). The ρ^2 of the final model is equal to 0.286 (adjusted 0.274). Although all coefficients were estimated simultaneously, the results are divided across five (3A thru 3E) tables for presentational reasons.

3.2 The Estimated Context-Effects

The estimated alternative-specific constants and the estimated context effects are presented in Table 3A. As earlier explained, an estimated alternative-specific constant is the main utility derived from that alternative averaged across the levels of the context variables. By design, all context levels appeared an equal number of times for all observed choices, which is not representative of the number of times the context levels apply in reality. Hence, the estimated constants cannot directly be used to gain an indication of the mode shares of the included egress transport alternatives in the real transport market. We therefore concentrate the interpretation of the results on the relative impact of the context variables on the mode choice alternatives.

An estimated alternative-specific context effect indicates the extent to which the average utility of an alternative changes if that context level applies. As the context variables are effects-coded, the presented coefficients express deviations from the alternative-specific constants. The coding of the levels of the context variables is included in the table. For example, trip purpose is categorized into recreational trips, coded +1, and work related trips, coded -1. The estimated coefficient for the effect of the context level *trip purpose* on *taxi* is -0.413. This indicates that the utility of transport by taxi increases by 0.413 if one travels for work related purposes, while it decreases by -0.413 if one travels for recreational purposes. For work-related trips the utility of taxi travel is thus equal to 2.099 + 0.413 = 2.412, whereas the utility of taxi travel for recreational trips is equal to 2.099 - 0.413 = 1.686. *t*-values are included in the table in brackets, which allow conclusions to be drawn on the statistical significance of the coefficients.

The results for *trip purpose* indicate that, as expected, the more costly modes, involving both taxi alternatives and Greenwheels, are more often chosen for work-related purposes than for recreational purposes. Furthermore, for work-related purposes, travellers more often opt for the alternative *not by train*, which means that for work-related purposes travellers are more inclined to choose an alternative to the train as the main mode of transport, which probably often will involve the car.

Table 3A. Context Effects (*t*-statistic in brackets)

	PT	Green-wheels	taxi	train taxi	PT bike	bike station	bike in train	walking	not by train
constant	2.837	-1.071	2.099	2.257	-0.530	1.304	0.079	1.577	1.386
	(50.041)	(-7.515)	(35.569)	(38.841)	(-4.711)	(20.060)	(0.884)	(27.714)	(24.539)
trip purpose									
recreation (+1) - work (-1)	0.102	-0.242	-0.413	-0.245	-0.025	0.007	0.072	0.077	-0.155
	(1.863)	(-2.078)	(-7.317)	(-4.415)	(-0.259)	(0.117)	(0.864)	(1.481)	(-2.922)
route knowledge									
knows (+1) - does not (-1)	0.152	-0.330	-0.118	-0.040	0.173	0.337	0.311	0.294	0.136
	(2.765)	(-2.681)	(-2.079)	(-0.715)	(1.716)	(5.291)	(3.651)	(5.56)	(2.534)
weather									
dry (+1) - rain (-1)	0.283	0.274	0.220	0.132	0.551	0.486	0.558	0.644	0.156
	(5.076)	(2.369)	(3.843)	(2.335)	(5.444)	(7.565)	(6.536)	(12.01)	(2.872)
distance									
5 km. (+1) - 1 km (-1)	0.163	0.158	0.052	0.109	0.148	-0.087	0.11	-0.575	0.033
	(4.149)	(1.826)	(1.292)	(2.721)	(1.934)	(-1.916)	(1.763)	(-14.570)	(0.858)
luggage									
heavy (+1) - none/little (-1)	0.029	0.303	0.243	0.230	-0.584	-0.459	-0.404	-0.524	0.070
	(0.542)	(2.563)	(4.328)	(4.159)	(-5.593)	(-7.193)	(-4.691)	(-9.977)	(1.322)
time of day									
dark (+1) - daylight (-1)	-0.505	-0.163	-0.115	-0.162	-0.370	-0.434	-0.311	-0.540	-0.142
	(-9.038)	(-1.417)	(-2.001)	(-2.841)	(-3.645)	(-6.766)	(-3.630	(10.050)	(2.596)
travel party									
with others (+1) - alone (-1)	0.108	0.193	0.163	0.100	0.090	0.143	0.196	0.155	0.129
	(1.979)	(1.695)	(2.905)	(1.803)	(0.893)	(2.274)	(2.321)	(2.962)	(2.435)

The results for *route knowledge* indicate that if one is familiar with the route, the slow modes of walking and bicycling are clearly more often chosen than if one is not. Also public transport and the option 'not by train' are more often chosen under this condition. As expected, travelling by taxi is preferred if one does not know the route. Greenwheels then also becomes more attractive. Travellers possibly less mind figuring out a route when driving a car compared to walking and bicycling.

The positive coefficients for the context variable *weather* indicate that travellers, as expected, overall are more inclined to travel in dry weather than in rainy weather. In other words, this indicates that in rainy weather travellers are overall more inclined not to travel at all, thus to stay at home. Also as expected, the slow modes of walking and bicycling are most often utilized in good weather. The magnitudes of the coefficients indicate that weather has a huge impact on the choice of slow mode.

The results for the context variable *distance* indicate that, as expected, especially walking is chosen much less often when the distance is five kilometres compared to a distance of one kilometre. Longer distances lead to a larger share of bicycle alternatives, but even so to a larger share of motorized modes. However, the *bicycle at station* mode is less often chosen, suggesting that this mode is especially used for short distances.

As expected, when travellers travel with heavy luggage they are far less inclined to choose the slow modes, opting more often for the motorized modes. Furthermore, under this condition, travellers are more inclined to choose the *not by train* option*,* suggesting that under this condition they more often opt for the car as their main means of transport instead of multi-modal transport.

The negative coefficients estimated for the *time of day* context variable suggest that travellers are, overall, less inclined to travel in the evening and at night as compared to travelling by daylight. As expected, this especially applies for the slow modes, but travelling in the evening or at night also has a huge negative impact on the choice for public transport. One is then also more inclined to choose another mode of transport than the train (resulting in less multi-modal transport).

The positive coefficients estimate for the context variable *travel party* indicate that travellers are overall more inclined to travel when they travel together with other people. All modes profit roughly to the same extent from travelling in a party. Contrary to our expectation, the bicycle alternatives are not chosen less often if one travels together with other persons. On the other hand, travelling in company also increases the choice of transport modes other than train, thus increasing the probability that the car will be chosen.

The results indicate that the context effects are in expected directions, which lends face validity to the results. Moreover, many effects are quite large, certainly when compared to the availability effects estimated from the same data reported in an earlier study (Molin et al. 2006). Most of the availability effects were not significant and those that were typically had values smaller than 0.20 (in absolute terms), while many of the context effects exceed 0.40 or even 0.50. Overall, it can be concluded that context effects have a relatively strong effect on egress mode choice.

3.3 Estimated Context-Effects by segment groups

This section examines the extent to which the context effects vary between categories of gender, age, level of education and bus season ticket. As all segment effects are estimated simultaneously, each segment variable effect is controlled for the other segment variables in the model. The estimated coefficients presented in Tables 3B to 3E concern the interaction effects of context effects and segment variables, and they express the deviations from the estimated context effects presented in Table 3A. The applied effects coding for the segment groups is described in each table. A significant context-segment interaction effect indicates that the alternative-specific context effect differs significantly between two distinguished segment levels. For example, whereas Table 3A indicates that the utility of taxi usage for recreational trip purposes decreased by -0.413, Table 3B indicates that for males this figure needs to be corrected by -0.173, indicating that the utility of taxi usage for recreational purposes for males is -0.586, while it is -0.340 for females.

Comparing the segment interaction effects across all segments, it becomes clear that of all segment variables, most significant differences are found between the categories of gender. Males and females differ especially with respect to trip purpose, time of day and travel companions. The negative coefficients for trip purpose found in Table 3B indicate that males overall intend to travel less for recreational purposes, but the coefficient for *not by train* is also negative, suggesting that males are less inclined than females to choose the car for recreational trips. The positive coefficients for time of day for the *bike* alternatives and *walking* indicate that females are less inclined to choose these alternatives in the evening and at night compared to males. The negative coefficients for travel companions indicate that females overall are more inclined to travel when they have company than males are. A final systematic difference is observed for distance: all coefficients are positive, indicating that males are overall more inclined to travel when distances are large than are females.

Table 3C, presenting the differences between the ‘young’ (younger than 30 years) and ‘old’ (older or equal to 30 years) age groups, shows that relatively few systematic differences exist between younger and older travellers. The largest differences are observed for trip purpose: the positive and relatively strong coefficients indicate that older travellers are much more inclined to travel for recreational purposes than younger travellers. Furthermore, the overall positive coefficients for route knowledge indicate that compared to the younger travellers, older travellers are more inclined to travel when they are well familiar with the route towards their final destination.

Table 3D indicates that also not many systematic differences exist between educational groups. The positive coefficients for luggage indicate that the more highly educated persons are somewhat more inclined to travel with heavy luggage, which especially applies for the bike alternatives. The negative coefficients for weather indicate that the more highly educated persons are somewhat more inclined to travel in rainy weather, which especially applies to the *bicycle at station* alternative. However, in rainy weather, the highly educated are also more inclined to choose other alternatives than the train. Finally, the negative coefficients for travel groups suggest that less educated persons are more inclined to travel when they travel together with other persons.

More differences are found for the segmentation variable *bus season ticket holder,* presented in Table 3E. Overall, bus season ticket holders are more inclined to travel for recreational purposes. This especially holds true for public transport, but also for the slow mode alternatives. The bus season ticket holders are, overall, also somewhat more inclined to travel when they know the route to the destination well, which especially applies to public transport and the *bike in train* alternative. Finally, the bus season ticket holders are also more inclined to travel in the evening and at night, which especially applies for *Greenwheels* and *public transport bike rental*, both alternatives that need to be hired. They also then choose more often for the *bike at station* mode.

Table 3B. Interaction of gender (male (+1), female (-1)) and context effects

	PT	Green-wheels	taxi	train taxi	PT bike	bike station	bike in train	walking	not by train
trip purpose									
recreation (+1) - work (-1)	-0.233	-0.138	-0.173	-0.212	-0.137	-0.197	-0.061	-0.221	-0.241
	(-4.549)	(-1.27)	(-3.252)	(-4.053)	(-1.498)	(-3.339)	(-0.775)	(-4.466)	(-4.818)
route knowledge									
knows (+1) - does not (-1)	-0.019	-0.004	-0.031	-0.035	0.003	-0.154	-0.055	-0.126	-0.007
	(-0.381)	(-0.036)	(-0.592)	(-0.671)	(0.031)	(-2.624)	(-0.701)	(-2.571)	(-0.145)
weather									
dry (+1) - rain (-1)	-0.041	0.134	-0.024	0.061	-0.038	-0.003	0.098	0.018	0.127
	(-0.805)	(1.237)	(-0.459)	(1.183)	(-0.400)	(-0.058)	(1.250)	(0.376)	(2.583)
distance									
5 km. (+1) - 1 km (-1)	0.085	0.133	0.042	0.056	0.151	0.034	0.129	0.032	0.041
	(2.345)	(1.718)	(1.129)	(1.514)	(2.229)	(0.814)	(2.267)	(0.924)	(1.169)
luggage									
heavy (+1) - none/little (-1)	-0.017	0.061	0.013	-0.030	-0.017	0.007	0.027	0.047	-0.094
	(-0.333)	(0.565)	(0.252)	(-0.582)	(-0.174)	(0.113)	(0.338)	(0.954)	(-1.884)
time of day									
dark (+1) - daylight (-1)	0.073	0.128	-0.052	-0.020	0.197	0.122	0.255	0.148	-0.076
	(1.433)	(1.184)	(-0.978)	(-0.386)	(2.074)	(2.070)	(3.170)	(3.011)	(-1.536)
travel party									
with others (+1) - alone (-1)	-0.174	-0.239	-0.105	-0.085	-0.028	-0.132	-0.160	-0.100	-0.119
	(-3.439)	(-2.217)	(-2.020)	(-1.661)	(-0.291)	(-2.267)	(-2.021)	(-2.067)	-2.428

Table 3C.Interaction of age (< 30 years (-1), 30+ years (+1)) and context effects

	PT	Green-wheels	taxi	train taxi	PT bike	bike station	bike in train	walking	not by train
trip purpose									
recreation (+1) - work (-1)	0.334	0.515	0.270	0.213	0.101	0.296	0.339	0.286	0.269
	(4.652)	(3.267)	(3.626)	(2.906)	(0.788)	(3.563)	(3.070)	(4.145)	(3.836)
route knowledge									
knows (+1) - does not (-1)	0.198	-0.206	0.083	0.066	0.087	0.077	0.240	0.116	0.173
	(2.773)	(-1.309)	(1.120)	(0.902)	(0.660)	(0.931)	(2.138)	(1.696)	(2.471)
weather									
dry (+1) - rain (-1)	0.118	0.018	-0.008	0.021	0.100	0.031	0.130	0.108	0.030
	(1.645)	(0.120)	(-0.110)	(0.284)	(0.761)	(0.370)	(1.159)	(1.577)	(0.435)
distance									
5 km. (+1) - 1 km (-1)	-0.042	0.016	-0.035	-0.002	0.094	-0.035	-0.049	-0.059	-0.105
	(-0.818)	(0.146)	(-0.662)	(-0.043)	(0.991)	(-0.590)	(-0.606)	(-1.191)	(-2.111)
luggage									
heavy (+1) - none/little (-1)	-0.030	0.004	-0.143	-0.050	-0.092	0.077	-0.073	-0.054	-0.008
	(-0.412)	(0.025)	(-1.918)	(-0.679)	(-0.696)	(0.918)	(-0.645)	(-0.786)	(-0.116)
time of day									
dark (+1) - daylight (-1)	-0.135	0.215	-0.032	0.008	0.130	0.141	0.133	-0.072	0.039
	(-1.871)	(1.384)	(-0.428)	(0.106)	(0.979)	(1.687)	(1.167)	(-1.034)	(0.555)
travel party									
with others (+1) - alone (-1)	-0.104	0.052	0.045	0.029	-0.043	0.017	0.092	0.036	0.090
	(-1.456)	(0.336)	(0.618)	(0.407)	(-0.328)	(0.202)	(0.815)	(0.523)	(1.300)

Table 3D.Interaction of level of education (high (+1), low (-1)) and context effects

	PT	Green-wheels	taxi	train taxi	PT bike	bike station	bike in train	walking	not by train
trip purpose									
recreation (+1) - work (-1)	-0.095	0.054	-0.092	-0.020	-0.182	-0.020	0.018	0.013	-0.001
	(-1.822)	(0.479)	(-1.712)	(-0.384)	(-1.929)	(-0.340)	(0.224)	(0.263)	(-0.026)
route knowledge									
knows (+1) - does not (-1)	-0.095	-0.023	-0.003	-0.028	-0.188	-0.029	-0.073	-0.084	-0.016
	(-1.826)	(-0.204)	(-0.062)	(-0.520)	(-1.934)	(-0.490)	(-0.895)	(-1.678)	(-0.311)
weather									
dry (+1) - rain (-1)	-0.030	-0.047	-0.084	-0.039	0.013	-0.072	-0.161	-0.033	-0.116
	(-0.587)	(-0.422)	(-1.581)	(-0.757)	(0.132)	(-1.213)	(-1.983)	(-0.671)	(-2.330)
distance									
5 km. (+1) - 1 km (-1)	-0.017	0.029	0.052	-0.009	0.030	0.005	-0.013	-0.033	0.009
	(-0.455)	(0.360)	(1.373)	(-0.232)	(0.428)	(0.120)	(-0.232)	(-0.932)	(0.250)
luggage									
heavy (+1) - none/little (-1)	0.060	0.033	0.070	0.069	0.194	0.100	0.164	0.086	0.077
	(1.149)	(0.292)	(1.290)	(1.302)	(1.976)	(1.664)	(1.999)	(1.717)	(1.512)
time of day									
dark (+1) - daylight (-1)	-0.010	-0.161	0.021	-0.016	0.114	0.026	0.070	0.008	0.064
	(-0.187)	(-1.444)	(0.388)	(-0.295)	(1.170)	(0.437)	(0.860)	(0.164)	(1.263)
travel party									
with others (+1) - alone (-1)	-0.164	-0.028	-0.064	-0.077	-0.031	-0.178	-0.111	-0.108	-0.093
	(-3.180)	(-0.248)	(-1.209)	(-1.468)	(-0.316)	(-2.992)	(-1.381)	(-2.196)	(-1.869)

Table 3E. Interaction of bus season ticket (yes (+1), no (-1)) and context effects

season ticket	PT	Green-wheels	taxi	train taxi	PT bike	bike station	bike in train	walking	not by train
trip purpose									
recreation (+1) - work (-1)	0.344	0.154	0.184	0.187	0.231	0.412	0.299	0.346	0.274
	(5.079)	(1.039)	(2.615)	(2.704)	(1.909)	(5.284)	(2.872)	(5.291)	(4.143)
route knowledge									
knows (+1) - does not (-1)	0.149	-0.275	0.060	0.014	-0.049	0.135	0.224	0.153	0.105
	(2.211)	(-1.847)	(0.859)	(0.204)	(-0.396)	(1.739)	(2.126)	(2.372)	(1.601)
weather									
dry (+1) - rain (-1)	0.007	-0.153	-0.115	-0.076	0.072	0.008	0.019	0.133	-0.105
	(0.111)	(-1.044)	(-1.657)	(-1.132)	(0.583)	(0.106)	(0.184)	(2.076)	(-1.624)
distance									
5 km. (+1) - 1 km (-1)	-0.040	0.011	-0.046	-0.040	-0.013	-0.049	-0.077	-0.049	-0.088
	(-0.828)	(0.102)	(-0.926)	(-0.812)	(-0.142)	(-0.891)	(-1.014)	(-1.056)	(-1.878)
luggage									
heavy (+1) - none/little (-1)	0.105	-0.019	-0.002	0.036	0.085	0.080	0.083	0.073	0.042
	(1.548)	(-0.127)	(-0.032)	(0.522)	(0.685)	(1.023)	(0.781)	(1.119)	(0.639)
time of day									
dark (+1) - daylight (-1)	0.099	0.373	0.067	0.101	0.406	0.255	0.188	0.112	0.095
	(1.460)	(2.540)	(0.945)	(1.455)	(3.252)	(3.262)	(1.759)	(1.710)	(1.433)
travel party									
with others (+1) - alone (-1)	-0.091	-0.053	0.072	0.038	-0.025	-0.073	-0.008	0.000	0.050
	(-1.362)	(-0.360)	(1.041)	(0.570)	(-0.201)	(-0.952)	(-0.076)	(0.003)	(0.765)

4 Conclusions

Arguing that context may play an important role in the choice of transport mode in multi-model trips, we conducted a stated choice experiment to estimate such context effects on the choice of egress mode. The availability of the following seven egress modes was varied in the experiment: public transport, taxi, train taxi, PT bike, bike in train, bike at station, and Greenwheels. To each of the resulting choice sets, the basic alternatives walking, not travelling by train and staying at home were added, assuming that these options are always available. The effects of the context variables trip purpose, distance, travel companions, amount of luggage, weather, route knowledge and time of day on choosing each of the alternatives were estimated. Results indicate that these context effects have a significant impact on the choice of egress transport mode. Moreover, these effects were in expected directions, lending face validity to the experiment and the results. It implies that according to respondents' stated choices, egress mode choice varies considerably by context.

The following main conclusion can be drawn. First, the probability of choosing slow modes as bike and walking as egress mode is increased under the following contexts: dry weather, not carrying heavy luggage, the route is well known, travelling in daylight and if one travels with company. The slow modes are differently affected by a large distance: this heavily decreases the probability of walking, while it increases the probability of choosing PT bike. Second, travellers are more inclined to use the automobile modes taxi, train taxi and Greenwheels as the egress mode in multi-modal chains if they travel for work related purposes, if they do not know the route, in dry weather, if they have to carry heavy luggage, and if they have company. Third, the probability of choosing public transport especially tends to increase when travelling in daylight and to a lesser extent if the route is well known, if the distance is large and in dry weather. Finally, the popularity of not travelling by train, hence, travelling by another mode of transport, most probable by car, increases if one travels for work related purposes, if one knows the route well, in dry weather, if one travel in daylight and if one travels with company.

Implications of these findings depend on the specific context variable. First, it suggests a need to simultaneously estimate trip purpose, distance, time of day, travel companions and choice of egress mode. To some extent this has become common practice in conventional transport mode choice modelling, but it is still rare in the literature on multi-modal trip chains. Second, the effect of variables, such as amount of luggage and weather, should be assumed to be quite large in simulation models of traffic flows.

We also found some evidence that context variables vary by socio-demographics. We found gender differences to be especially significant. The results are relevant in terms of policy assessment but also indicate that gender and other socio-demographic variables should be included in models of egress mode choice decisions to reduce the heterogeneity in decision-making.

In this study we have assumed that responses are based on the current attributes of the choice alternatives. In marketing studies, however, there may be an interest in the effect of changing one or more attributes such as price on market share. In that case, the experimental design should also vary the relevant attribute levels, and the attribute effects would be added to the estimated utility function. It goes without saying that although technically this can be done, respondent burden would be further increased.

As the purpose of our analysis was to examine the relative impact of the context variables on egress mode choice, a basic MNL suited this purpose. Hence, we did not make an effort to apply the most advanced choice models and acknowledge that the estimated model has limitations. One of the basic assumptions of the MNL model - that all observations are independent - does not hold as we observed multiple responses from each respondent. This may have led to biased estimates for standard errors of the estimated coefficients, and therefore one should be cautious about drawing conclusions on statistical significance of the estimated coefficients (Ortúzar and Willemsen 2001). Currently, the most widely applied approach for dealing with pseudo panel data is estimating a mixed logit model, which additionally allows for capturing taste heterogeneity (e.g. Revelt and Train 1998). The whole sequence of observed choices for a single person then becomes the unit of analysis instead of each separate observation. However, as estimating alternative-specific context dependent coefficients substantially increases the number of coefficients, as in the model presented in this paper, estimating random parameters for all context effects is likely not feasible, as only so much can be estimated from things that are not observed. Alternatively, an error components model (e.g. Train 2003) may be estimated that relates random elements rather than attributes to alternatives (e.g. Brownstone and Train 1998). In analogy to the nested and cross-nested logit models, error component models allow arranging the error components in tree-like structures with branches that may overlap. Hence, their estimated coefficients capture correlations among alternatives and therefore relax the strict substitution patterns of the MNL model. Therefore, if the model includes many context-dependent coefficients, estimating an error components model may be a feasible option, as this typically requires a relatively small number of additional random coefficients to be estimated. We plan to explore these estimation issues in future research.

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