UPDATING AND EXTENDING THE DISAGGREGATE CHOICE MODELS IN THE DUTCH NATIONAL MODEL

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DISCLAIMER:
This paper presents preliminary results of the final estimation stage of the Dutch National Model. The estimations and the results are not discussed with the client yet and are subject to change.
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1. INTRODUCTION

The Netherlands National Model System (NMS) is known as one of the first disaggregate national travel demand forecasting systems used in practice. The model system has been in use since 1986, and has been extensively updated and extended through its lifetime (for a brief description of the model and an overview of similar demand systems see Fox et al, 2003 or Daly and Sillaparcharn, 2008). Since its origin the model has been applied in numerous policy analysis for national road and railway planning alternatives, such as infrastructure investments, and pricing- or management policies.

The Dutch Ministry of Public Works and Water management recently issued an update and extension of the National Model System and its regional counter parts (see Smit et al., 2009). The choice models in the current version were estimated almost 10 years ago on survey data from 1995 (Hague Consulting Group, 2000b). A first objective is to update the modelling system by re-estimation of the choice models in the system on the National Travel Surveys for 2002 and 2003. In addition to that the re-estimations allowed a revision and further improvement of the model system.

One of the innovations in the update of the LMS, is the estimation and implementation of an integrated nested choice structure. This improves the coherence of the different choices in the modelling system through the inclusion of logsums from subsequent choices in the estimation of the modules.

One of the issues addressed in this paper is to improve the inclusion of accessibility effects on tour frequency (TF). In spite of its intuitive importance and the consequent political need to account for such an effect to address latent demand when the infrastructure is improved, the current version of the NMS lacks an inclusion of accessibility attributes in the TF module (Hague Consulting Group, 2000b). This is remarkable since most transport demand models that are based on disaggregate choice models do include accessibility effect (Fox et al.;

2003). In an overview of a selection of studies Daly (1997) shows that significant accessibility parameters can be obtained in TF models, as long as an appropriate measure and demand segmentation has been applied. The most appropriate measure is the logsum from mode/destination (MD) choice model for the respective travel purpose. In the current update of the NMS this issue is addressed by estimating parameters for purpose specific logsums from the MD models in the trip frequency estimations.

A further advancement is made by integrating the MD and car time-of-day (ToD) models into a single model. This model is estimated by a simultaneous SP/RP estimation; the RP travel survey data of MD choices are enriched with SP data on time-of-day and mode choice. This makes different nesting structures possible: time-of-day choice can be higher, lower or on the same level as destination choice. Additionally, the socio-economic segmentation of the MD model is improved, and the non-motorised modes are split into walking and cycling. The paper discusses these enhancements and their consequences.

For train travel a new model of station choice and access/egress mode choice has been developed. This is a major improvement for the implementation of train scenarios. The logsum from this model is used in the MD choice utility function to improve and the way train level-of-service affects MD and TF choices and to make the model system as a whole more consistent. The system is now thus specified as a single decision tree that comprises train access/egress mode choice, station choice, time of day choice, destination choice, main mode choice and tour frequency choice.

2. THE UPDATE OF THE NATIONAL MODELLING SYSTEM

2.1. A description of the Dutch National Model System

The development of the Netherlands National Model System (NMS) started in 1984 for the Dutch Ministry of Public Works and Water management. The purpose of the modelling system is to provide insight into changes into mobility patterns and to predict traffic flows on the road and rail networks, to support the impact assessment of strategic policy plans and road scheme investments.

The modelling system consists of various modules based on disaggregate discrete choice models, simulating mobility choices (Hague Consulting Group, 2000a). The mobility choices that are simulated include: tour frequency (TF), mode and destination choice (MD), time of day choice (ToD), secondary and lower level destinations and the choice of a train route. These models are estimated on a large National Travel Survey. The choices are modelled at person level, for 1308 zones for the Netherlands (the number of zones is increased to 1379 in the update of the model).

The transport modes that are included in the current version of the modelling system are: car driver, car passenger, train, regional PT (bus, tram and metro), and slow modes. The update will further segment the slow mode. The car driver alternative includes a time-of-day choice. The current version of the model includes three periods: morning peak, off-peak and evening peak. In the update of the model, the number of time periods is increased to seven to include shoulders around each peak.

The NMS distinguishes five home based travel purposes (commuting, business, education, shopping and other home-based travel), and two work-based purposes (business and other work-based travel), and two home-based tour models for children aged under 12 years (school and other home-based travel by children). The emphasis in this paper lies on the regular home-based models.

The demand model, covering mode-destination and time of day choice, iterates with the network assignment model (QBLOK), to determine the equilibrium travel times taking the influence of congestion on travel times and mode/destination choice into account.

2.2. Re-specification of the demand models

The revision of the NMS includes a major revision of the structure of the demand model. This demand model is re-specified as a single decision tree with nested choice models to reflect interdependencies between the choices considered. The modelling system currently comprises of the following choices: tour frequency choice, destination choice, time of day choice and main mode choice.

The demand models are first of all enhanced by inclusion of station choice, and train access/egress mode choice. This is a major improvement for the representation of train alternative in the choice model, and improves the flexibility for the implementation of train scenarios. The logsum from the station choice model is used in the choice utility function to improve and the way train level-of-service affects mode destination choices. Additionally, the socio-economic segmentation of the mode/destination/TOD model is improved, and the non-motorised modes are split into walking and cycling.

Figure 1 shows the decision tree of the demand model and illustrates the nested structure for subsequent choices. The nested structure improves the coherence of the different choices in the modelling system. In the model estimations, the logsums from subsequent choices in the decision tree are included in the choices at a higher level.

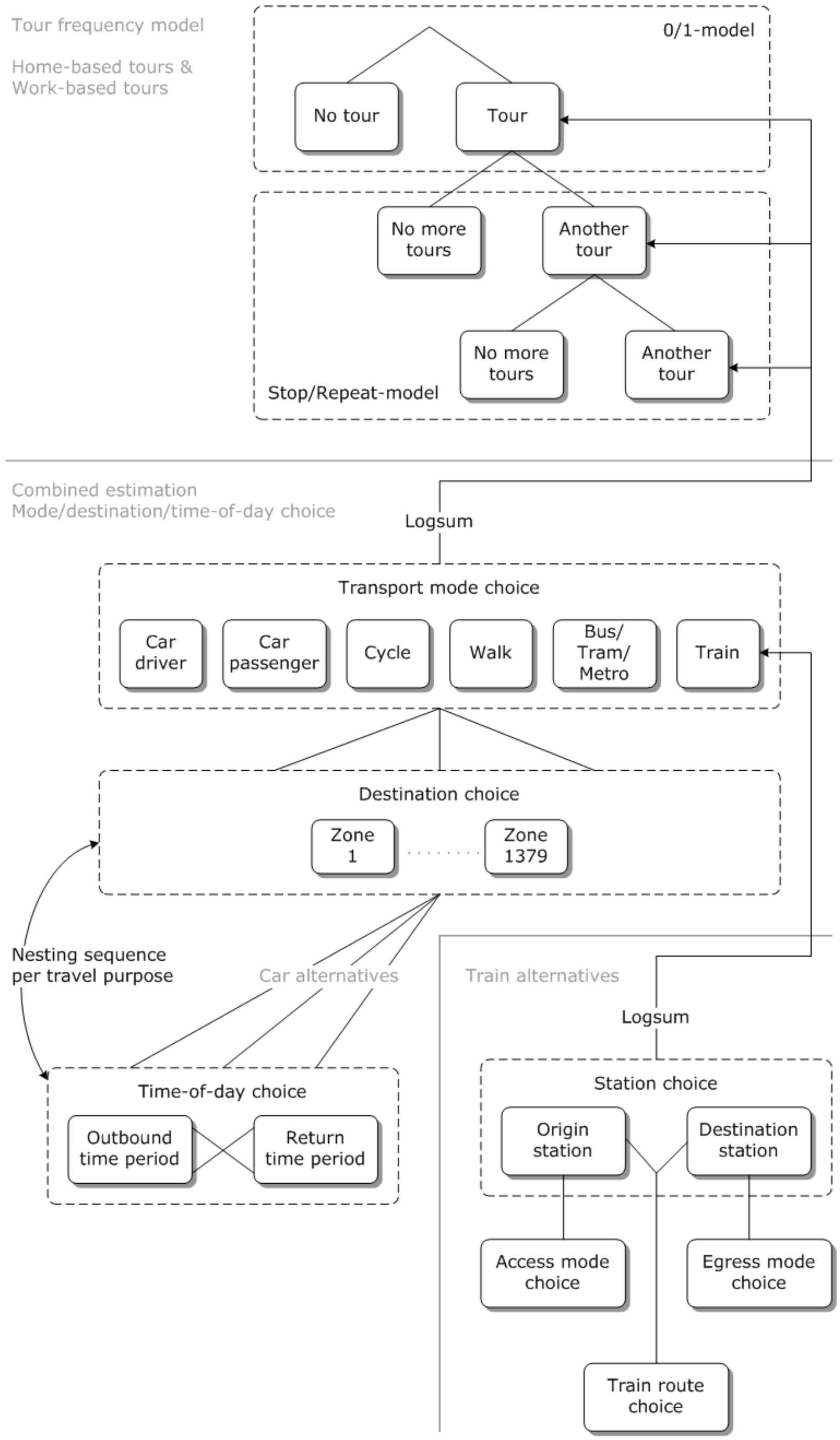

Figure 1: Structure of the NMS demand model.

This paper focuses on the estimation of the tour frequency models and the combined mode/destination/time-of-day models. The estimation results are discussed in the following sections. First the choice data that is used for estimations are described and some practical issues regarding the estimation procedure are discussed.

2.3. Characteristics of the choice data

The choice models are being estimated on the OVG[1] for 2002 and 2003 (CBS – OVG, 2002/2003). These datasets contains tour observations[2] from 177 thousand individuals. Some of the person and household level attributes are presented with their associated attribute values.

Table 1: Person and household attributes in OVG estimation file

Attribute:	Values:
AgeClasses	18 5-year classes
Gender	Male/Female
Occupation	Fulltime; Parttime; Student; Retired; Housekeeping; Other
Car ownership	No car; car but no license; car under competition; car freely available
HH size	Absolute value
Personal income	10 classes
HH income	10 classes

Table 2: Tour frequency distribution by purpose.
Source: OVG 2002/2003

Tourcount	Home Commute	Home Business	Home Education	Home Shop	Home Other
0	128559	164044	149434	128555	98464
1	37007	3523	14161	33484	51365
2	2188	304	4276	5245	13689
3	152	41	54	596	2998
3+	20	14	1	46	1410
Total	167926	167926	167926	167926	167926

Table 3: Tour frequency distribution by socio economic status.
Source: OVG 2002/2003

Tourcount	Fulltime workers	Parttime workers	Student	Retired	Other
1	55791	18893	26968	20188	27870
2	7172	3231	6190	3965	6852
3	1196	723	398	787	1494
3+	289	380	47	186	928
total	64448	23227	33603	25126	37144

[1] OVG = 'Onderzoek VerplaatsingsGedrag', the yearly Dutch National Travel Survey
[2] The full set of observations also include half-tours and observations of child segment (<age 12)

Table 2 and Table 3 show some descriptive statistics for the daily tour frequencies observed in the OVG. It shows that the largest number of observations fall in the tour or no-tour category (0 or 1), illustrating the dominant importance of the 0/1+ model in the total tour generation. Further it can be seen that the distribution varies across purposes: in commuting most observations fall into the 0/1+ category, where the optional purposes (shopping or other) have relatively more observations in 2 or more tours per day.

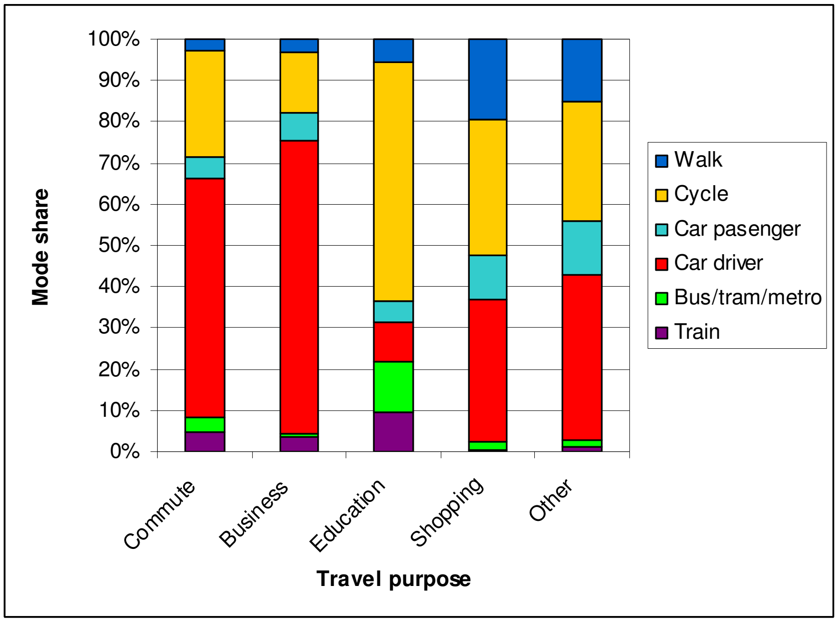

Figure 2: Mode shares by travel purpose
Source: OVG 2002/2003

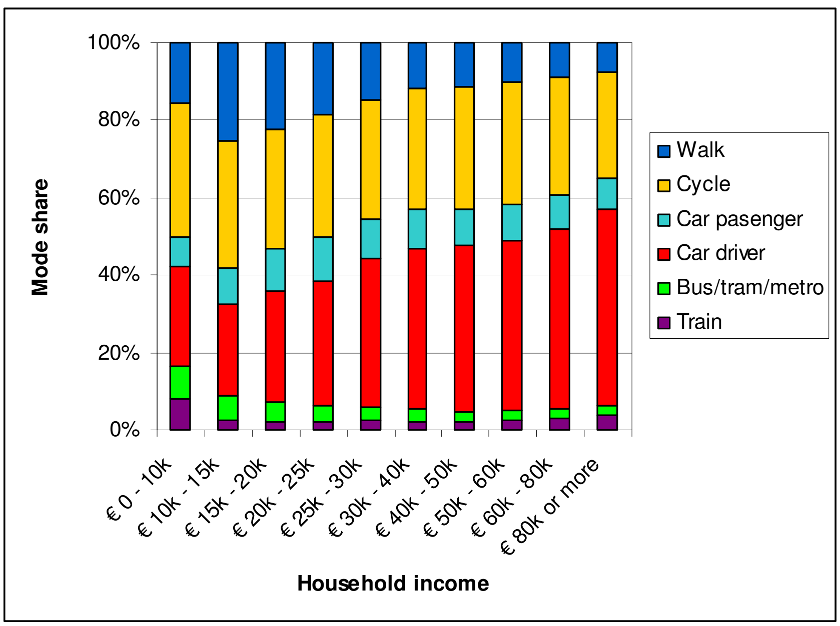

Figure 3: Mode shares by household income
Source: OVG 2002/2003

The mode shares vary across purposes. Car driver has by far the largest share for commuting and business travel. For travel purposes shopping and other, cycling is a competitive mode relative to car use. For education, cycling is even the dominant mode. Furthermore share of car driver increases with the income level of households.

2.4. The estimation procedure

The MD and car ToD models are combined into a single model. This model is estimated by a simultaneous SP/RP estimation; the RP travel survey data of MD choices are enriched with SP data on time-of-day and mode choice. This makes different nesting structures possible: ToD choice can be higher, lower or on the same level as destination choice.

The estimations took place in a number of estimation rounds. In the first round, the MD and TF models were estimated with a proxy LOS (including travel time delay from the old model). After implementation, the 2nd round of estimations were based on the LOS derived from an assignment of synthetic matrices derived from the models from round 1. In the third round of estimations, the estimations are based on the LOS derived from the assignment of the matrices from round 2, and additionally with the logsums of lower nests.

The objective of this last round is to estimate the models based on more accurate predictions of the LOS[3], to test the effect of the MD-logsum in the TF model, and to test the effectiveness of the station choice logsum in the MD model. In particular this third round of estimations is time consuming, because the estimation of nested choices can only take place in a sequential order where the final coefficients of a deeper nest need to be estimated first and implemented to derive logsums, before the higher nests can be estimated.

3. RESULTS FROM TOUR FREQUENCY MODELS

The tour frequency models are defined at the individual level, taking into account detailed personal, household and zonal characteristics. The tour frequency predicts the number of tours that are made by travel purpose, which is input to the mode destination models.

As shown in Figure 1, the tour frequency model consists of two linked models. The 0/1+ model predicts the probability a traveller will make a tour or not. The second model, the stop/repeat model, predicts if an additional tour will be made, conditional that a tour is made already.

[3] The NMS is an incremental growth model, that uses a car base matrix for the network assignment. The calibration of the car base matrix is developed parallel to the estimation of the demand model (Smit et al. 2009). For practical, and time related reasons, the estimations in this paper are based on an intermediate car base matrix.

The utility functions the 'No tour' and 'Tour' alternative for an individual in person type *p* in origin zone *o* in the 0/1+ model have the following general form:

$$U(Notour)_{p,o} = C + \overline{\beta}_p \cdot \overline{X_p} + \beta_{LS} \cdot LS_{p,o} \qquad (1)$$

$$U(Tour)_{p,o} = 0 \qquad (2)$$

With a vector of personal or household attributes belonging to person type p, and a zonal logsum LS_{po} from the mode/destination choice model for zone *o* and person type *p*. The utility functions of the stop/repeat model have a similar form. The vector of person type attributes include among others attributes for occupation, household size, age class, personal income and car ownership.

The zonal logsums from the MD models test the responsiveness of travellers to changes in transport alternatives due to a transport policy (latent demand). Despite the intuitive importance of accessibility on trip generation, the current version of the LMS lacks significant accessibility attributes in the TF module. In this update it is tried to solve this shortcoming by inclusion of purpose specific logsums from the MD models in the trip frequency models.

The most appropriate measure for accessibility is the logsum from the mode/destination models for the respective travel purpose (see Daly, 1997). The zonal person type specific MD logsums are linked to each observation to test the influence of accessibility effects. Intuitively more accessible zones should reveal higher tour frequency rates. The behavioural parameters in similar demand modelling systems reveal that the accessibility effect is stronger in 'optional' travel purposes such as shopping or other, compared to obligatory purposes such as commuting or education (Daly, 1997).

Separate models are estimated for each of the travel purposes. Since the research project is still ongoing, this paper focuses on a selection of the home based travel purposes of which the results are available: commuting, education, shopping and other. Commuting is divided into separate models for two socio-economic segments: full-time workers and others. Education is divided into two different socio-economic segments: students and others.

The detailed estimation results of the estimated frequency model can be found in appendix 1. The coefficients from the 0/1+ model are presented in the top half of the tables (names starting with 'b_'). The stop/repeat coefficients are presented in the lower half of the tables (starting with 's_'). For each travel purpose two models are presented: the model without logsums that resulted from the specification study in the first estimation round, and the model that was estimated with inclusion of the person type specific logsums from the MD model. The accessibility effects will be discussed first and next the general findings.

Table 4 specifies the estimated accessibility parameter in the 0/1+ model and stop/repeat model for each travel purpose. The estimated accessibility parameters reveal a significant and intuitive effect[4] on the tour frequency models for commuting (segment workers), education (segment non-students) and shopping.

The positive accessibility effect in the 0/1+ model for commuters means that travellers living in less accessible areas have a lower probability of making a commuting tour. This can be explained by a larger share of tele-working for workers from these areas. The positive accessibility effect in shopping confirms the findings in literature that this effect is stronger in 'optional' travel purposes (Daly, 1997). However, we did not find the same result for purpose other, which includes many 'optional' travel as well (e.g. leisure). However, other contains a variety of purposes of which some obligatory (e.g. personal business, health) diminishing the effect of the optional purposes. The parameters in the stop/repeat models for commuting are significant but counter intuitive. This segment concerns a small segment, because commuting is a purpose with relatively few instances of travellers making two or more commuting tours a day. The accessibility parameter is not significant in the other travel purposes. It is concluded that the accessibility effect is not very strong and only applies to specific segments of travellers.

Table 4: Estimated accessibility parameters.
Significant parameters in bold; counter intuitive sign in red

Travel purpose	0/1+ b_LS	stop/repeat s_LS
Commuting - Workers	**-0.143 (-5.6)**	**0.776 (14.3)**
Commuting - Other	0.0396 (1.4)	**0.439 (5.6)**
Education - student	-0.0364 (-0.9)	0.0076 (0.1)
Education - non-student	**-0.0587 (-2.1)**	-0.0208 (-0.1)
Shopping	**-0.0711 (-11.1)**	**-0.0590 (-4.1)**
Other	0.0103 (0.8)	0.0340 (1.8)

The estimation parameters provide the following general conclusions regarding tour frequency per travel purpose. The number of commuting tour for workers is mainly predicted with personal income and age. Workers aged between 18-29 have the highest probability of making one or more tours. The higher the income the more likely one commuting tour is made. However, the probability of making additional commuting tours is lower for higher incomes. The number of commuting tours for non-workers is predicted by a large number of attributes: occupation, age, license and car ownership and income. Retired persons and persons aged 12-17 have a lower probability of making a commuting tour.

[4] A negative accessibility parameter implies a larger probability to choose the 1+ alternative (0/1+) or the repeat alternative (stop/repeat). Hence, a negative parameter has a positive effect on tour generation and is therefore valued as intuitive

The tour frequency for education is mainly predicted by age and education, but the effect varies between the student and non-student segments. Students in the age of 20-24 have the highest probability of making an educational tour. In the group of non-students between the age 12-24, and individuals with a higher education level have a higher probability of making an education tour. Full time workers have a lower probability of making an education tour.

The most dominant parameters predicting frequency of shopping tours are occupation, income, education level and age. Individuals in the age of 40-49, with higher income, and higher education levels are more likely to make one or more shopping tours. Individuals in the age of 12-24, and fulltime workers have a lower probability of making one or more shopping tours.

The frequency of ‘other’ tours is mainly predicted by the occupation and licence ownership of individuals. Full time workers, and students without driver’s license are less likely to make one or more other tours. Retired persons with driver’s licence, and persons working in their household have a higher probability of making one or more other tours.

4. RESULTS FROM MODE/DESTINATION MODELS

The mode/destination models predict the choice between the six alternative transport modes in combination with 1379 alternative destination zones. Separate models are estimated for each of five home-based tour models (commuting, business, education, shopping and other home-based travel), two work-based tour models (business and other work-based travel) and two home-based tour models for children aged under 12 years (school and other home-based travel by children). The emphasis in this paper lies on the regular home-based models. The models are nested logit models, with a nesting that can be different between travel purposes.

For car drivers also time-of-day choice is modelled in combination with mode and destination choice. A stated preference (SP) data set a combined time-of-day and mode choice is linked to the (revealed preference) mode/destination choice models. See De Jong et al. (2003) for more background on the SP data set and stand alone analyses; this paper primarily deals with the revealed preference data analyses.

Coefficients for travel cost and travel time are estimated jointly for these two data sets. The principle objective of including the SP model is to estimate the nest coefficient for time-of-day choice relative to mode and destination choice. For stand-alone analyses of the SP data it is known that time-of-day choice should be positioned below or equal to mode choice in the choice tree (i.e. time-of-day-choice is more elastic or equally elastic to mode choice). The optimal position of time-of-day choice relative to destination choice is identified by estimations of different combinations of choice order.

The time-of-day choice only applies for the car driver alternative; other modes are modelled as if only one time period can be chosen. As time-of-day choice is not included in the revealed choice data set, no time-period attributes occur in the utility functions for these data.

Logit model specification

The probability to choose a mode/destination alternative depends on the zonal attraction (or size, *S*) and the (negative) utility (*U*) of travelling to the zone by that particular transport mode. Size functions are a linear function of zonal socio-economic variables, particularly population size and employment.

The costs attributes in the utility functions require special attention in the nested choice structure. In the current version of the NMS travel costs appear in logarithmic form in the utility function of the MD model and with the same coefficient for all transport modes. This ensures a consistent effect of cost changes across modes: if for two transport modes the travel cost increases with the same percentage then their market shares will have a similar decrease. In the new model a logsum from the train route module includes different cost elements from train access/eggress station choice and access and eggress modes. The coefficients for train cost are thus modelled separately from the other modes' cost coefficients, which required abandonning of the restriction between cost coefficients. Additionally, because of the separate estimation of station choice and access/eggress mode choice, train costs were included linearly instead of logarithmic.

For commute and business travel the cost function is more complex. Firstly, in the NMS the cost coefficient is segmented on the basis of household income. Travellers in higher income households are less sensitive to travel cost (and thus have a higher value of time) than travellers in lower income households.
Secondly, in the new estimations explicit account is taken of the funding of commuting and business travel that employees receive from their companies. This funding reduces the cost that is actually paid by the employee, who is here considered to be the actor who makes the travel choices. Several alternatives have been tested to include funding in the cost or utility function. One approach using a correction factor gave satisfactory results in the estimations. This correction factor is based on the ratio between the total funding per year and the yearly net household income:

$$fc = \left(\frac{net\ income + funding}{net\ income} \right)^{e}, \text{ with } e = -0.5 \qquad (3)$$

The basic utility functions for travelling by each mode are as follows, with explanation below:

$$U\left(Driver,d\right)=\beta_c\cdot\ln\left[0.43+carcost_d\right]\cdot fc+\beta_{t,dr}\cdot cartime_d+\overline{\beta_{p,dr}}\cdot\overline{X_p}$$
$$+\overline{\beta_{p,dist}}\cdot\overline{X_p}\cdot dist_d+MSC_{dr} \tag{4}$$

$$U\left(Passenger,d\right)=\beta_{t,ps}\cdot cartime_d+\overline{\beta_{p,ps}}\cdot\overline{X_p}+\overline{\beta_{p,dist}}\cdot\overline{X_p}\cdot dist_d+MSC_{ps} \tag{5}$$

$$U\left(BTM,d\right)=\beta_c\cdot\ln\left[0.43+BTMcost_d\right]\cdot fc+\beta_{ivt,btm}\cdot BTMivtime_d+\beta_{ovt,btm}\cdot BTMovtime_d$$
$$+\overline{\beta_{p,btm}}\cdot\overline{X_p}+\overline{\beta_{p,dist}}\cdot\overline{X_p}\cdot dist_d+MSC_{btm} \tag{6}$$

$$U\left(Train,d\right)=\theta_{tr}\cdot Logsum\ station\ choice+\overline{\beta_{p,tr}}\cdot\overline{X_p}+\overline{\beta_{p,dist}}\cdot\overline{X_p}\cdot dist_d+MSC_{tr} \tag{7}$$

$$U\left(Cycle,d\right)=\beta_{d0,cy}\cdot dist_d+\beta_{d2,cy}\cdot\max\left[0,dist_d-8km\right]+\beta_{d4,cy}\cdot\max\left[0,dist_d-16km\right]$$
$$+\overline{\beta_{p,cy}}\cdot\overline{X_p}+\overline{\beta_{p,dist}}\cdot\overline{X_p}\cdot dist_d+MSC_{cy} \tag{8}$$

$$U\left(wk,d\right)=\beta_{d0,wk}\cdot dist_d+\beta_{d2,wk}\cdot\max\left[0,dist_d-2km\right]+\beta_{d4,wk}\cdot\max\left[0,dist_d-4km\right]$$
$$+\overline{\beta_{p,wk}}\cdot\overline{X_p}+\overline{\beta_{segdist}}\cdot\overline{X_p}\cdot dist_d \tag{9}$$

With:

dr	=	Car driver
ps	=	Car passenger
btm	=	Bus/tram/metro
tr	=	Train
cy	=	Cycle
wk	=	Walk
d	=	Destination
p	=	person type
MSC	=	Mode specific constant
Carcost	=	Variable car driver costs (includes fuel cost and other variable costs)
Cartime	=	Travel time by car
Dist	=	Travel distance
BTMcost	=	Cost of travel by bus, tram and/or metro
BTMivtime	=	In-vehicle time by bus, tram and/or metro
BTMovtime	=	Out-of-vehicle time by bus, tram and/or metro

The functions above include a great number of segmentation factors. For each travel purpose a different segmentation is applied, to better take account of the specific nature of the different travel purposes. Segmentation factors include driving licence holding, car onwership, age, gender. employment, household income, students, level of educational and household composition.

Coefficients

A full overview of the estimated coefficients is given in appendix 2. Here we limit ourselves to presenting the most important coefficients for mode and destination choice: those for travel time and travel cost.

Table 5 shows the estimated cost and time coefficients. All are highly significant and have the expected sign. The results seem plausible.

The ratios of time coefficients show some differences between travel purposes. Remarkable values might be the high OVT/IVT ratios for travel by bus/tram/metro. Transfers and high access/egress times strongly diminishes bus/tram/metro as a reasonable option for many travellers, especially for commuting (note that the number of transfers is not included as a variable in the model).

Table 5: Estimated time and cost coefficients and their ratio's

Coefficient	Household income	Travel purpose Commute	Education	Shopping	Other
Cost	< €30k	-0.51			
(logarithmic)	€30k – 40k	-0.46	-0.38	-0.53	-0.97
	>= €40k	-0.35			
Car driver time	All	-0.039	-0.041	-0.101	-0.056
Car pass. time	All	-0.045	-0.060	-0.099	-0.067
BTM IVT	All	-0.006	-0.014	-0.015	-0.009
BTM OVT	All	-0.090	-0.050	-0.105	-0.074
Ratio's					
Pass./Driver	All	1.18	1.44	0.98	1.20
BTM IVT/Driver	All	0.15	0.35	0.15	0.17
BTM OVT/IVT	All	15.09	3.43	7.06	7.85

* = fixed value

Nesting structure

During the estimation process different nesting sequences were tested. In the first round of estimations it was tested whether mode choice should be positioned above or below destination choice in the choice tree. In the second round of estimations the time-of-day nesting was added and its position relative to destination choice was determined. Besides the nest coefficients estimated by full information maximum likelihood, the model also contains logsums, from the station choice model, which can be seen as nest coefficients estimated by limited information maximum likelihood.

Table 6 shows the resulting nest coefficients. Due to the theoretical restriction that nest coefficients should be in the 0 to 1 interval, several nest coefficients needed to be restricted. Mostly this was because the estimated nest coefficient was above 1, although also cases occurred where nest coefficient would iterate towards 0 and the model consequently failed to converge. Overall a structure was found optimal where mode choice is positioned above or equal to time-of-day choice, which is positioned above or equal to destination choice, which is positioned above or equal to station choice. These findings are in line with the findings in Fox *et al.* (2008) where a nested structure of mode above time, and time above destination gave the best fit to the data from a household interview in the UK.

Table 6: Nest coefficients in the mode/destination/time-of-day models

Choices	Commute	Education	Shopping	Other
Mode				
	0.41	1.00	1.00	1.00
Time-of-day				
	1.00	0.55	1.00	0.27
Destination				
	0.40	0.90	1.00	1.00
Station				

As a result of the differences in nest coefficients between travel purposes, a different effect will be found if, for example, travel time or travel cost changes for a particular choice alternative. The lower the nest coefficient the higher the differences in elasticity will be between choice alternatives below and above this nest, at least for an individual observation with all else being equal.

For commuting, destination choice (for this purpose a long-term effect) and time-of-day choice will change most strongly. For business, education and other travel time-of-day choice is much less elastic and destination choice is solely the most sensitive. For shopping trips, destination choice is less elastic relatively to mode and time-of-day choice, compared to other travel purposes.

It should be mentioned that for elasticities on an aggregated level other aspects, such as segmentation, are just as important, but the nest coefficients give a good indication of what can be expected in model applications.

5. Conclusions

The results for the tour frequency models show significant accessibility effects for some travel purposes. Although the effect is not dominant, it is statistically significant and therefore useful: is intuitively correct and fits with a policy objective to quantify generation effects of transport infrastructure improvement. However, the logsum effect on tour frequencies has practical implications that need to be considered upon deciding to implement it in a large scale modelling system.

First, the implementation implies an additional module that needs to be integrated into the iterative procedure between demand – assignment models. The model completes three full iterations, and the inclusion of responsiveness of the TF model to the MD model, introduces extra running time and more dynamics in the iterative procedure. It is complicated to predict the total effect on running time and convergence of the system, but it needs to be tested and evaluated in the project.

Second, the generation effect adds a component to the evaluation of consumer surplus. Changes in logsum accessibility can be attributed fully to existing travellers but new travellers that are induced by the improvement obtain benefit as well. Their benefits can be calculated with a rule of half or a more precise approach as suggested in Daly and Miller (2006).

The estimations of the mode/destination/time-of-day models have lead to time and cost parameters that are all highly significant with the expected sign. Therefore the results are valued plausible.

The inclusion of time-of-day choice and station choice in the decision tree should also lead to more realistic responses of the model outcomes to changes in the travel attributes. The positioning of destination choice below mode choice for all travel purposes and the positioning of time-of-day choice of car drivers between mode choice and destination choice, instead of modelling time-of-day choice conditionally on mode/destination choice, will possibly structurally change the sensitivities of the model system. Sensitivity analyses should make clear what the consequences are of this new model structure.

This paper did not yet analyse the implicit elasticities and value-of-times of the estimated models but this task is foreseen as one of the next research steps. The remaining travel purposes that will estimated still include home based business, non-home based business, non-home based other and the child motives home based education and home based other.

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Appendix 1: Estimated Tour Frequency Models

Explanation of coefficient name labels

Const	Constant
h1_w0	1 person household, 0 fulltime workers
h1_w1	1 person household, 1 fulltime workers
h2_w0	2 person household, 0 fulltime workers
h2_w1	2 person household, 1 fulltime worker
h2_w2	2 person household, 2 fulltime workers
h3_w0	3 person household, 0 fulltime workers
h3_w1	3 person household, 1 fulltime workers
h3_w2p	3 person household, >= 2 fulltime workers
h4p_w0	>=4 person household, 0 fulltime workers
h4p_w2p	>=4 person household, >=2 fulltime workers
hhgr3	3 person household
hhgr5	5+ person household
hhgr6	6+ person household
a1_hs4p	child 0-5 year in household > 4 persons
carc0	no car available
carc1	car available no license
carc2	car in competition
carc3	car freely available
age02	age 06-11 year
age0304	age 12-17 year
age0506	age 18-24 year
age0507	age 18-29 year
age0509	age 18-39 year
age0709	age 25-39 year
age0809	age 30-39 year
age0811	age 30-49 year
age08p	age >= 30 year
age1011	age 40-49 year
age10p	age >= 40 year
age1214	age 50-64 year
age12p	age >= 50 year
age15p	age >= 65 year
edu1	primary-, lower education
edu3	Medium education, or highschool
edu4	BSc or MSc

m_w_nl	working man without license
m_ot_li	occupation other, man with license
m_ot_nl	occupation other, man without license
aow_li	retired with license
aow_nl	retired without license
f_ot_li	occupation other, female with license
f_ot_nl	occupation other, female without license
f_w_li	working female with license
f_w_nl	working female without license
mp_67	occupation: werkloos of WAO
st_li	student with license
st_nl	student without license
w_home	works in own household
ftime	fulltimer (>= 30 uur)
female	female
Pink1	Personal income : 0-10 k€
Pink2	Personal income : 10-15 k€
Pink3	Personal income : 15-20 k€
Pink4	Personal income : 20-25 k€
Pink5	Personal income : 25-30 k€
Pink6	Personal income : 30-40 k€
Pink7	Personal income : 40-50 k€
Pink8	Personal income : 50-60 k€
Pink9	Personal income : 60-80 k€
Pink10	Personal income : > 80 k€
Pink0	Personal income unknown
Pink1_2	Personal income : 0-15 k€
Pink3_4	Personal income: 15-25 k€
Pink5_6	Personal income: 25-40 k€
Pink7_10	Personal income: > 40 k€
Hink1_4	Gross household income: 0-25 k€
Hink5_6	Gross household income: 25-40 k€
Hink7_8	Gross household income: 40-60 k€
Hink9_10	Gross household income: > 60 k€

Commuting - Workers

File	comm_freq_1a6.F12	comm_freq_1a7.F12
Title	LMS2004 model 1a.6	LMS2004 model 1a.7
Converged	TRUE	TRUE
Observations	35423	35423
Final log (L)	-26595.3	-26477.7
D.O.F.	29	31
Rho²(0)	0.458	0.461
Rho²(c)	0.017	0.022
Prepared	5-Oct-09	5-Oct-09
Estimated	5-Oct-09	5-Oct-09
Scaling	1	1
b_const	-0.0118 (-0.2)	0.971 (5.3)
b_h3_w2p	0.185 (4.4)	0.180 (4.3)
b_age0304	-0.329 (-3.1)	-0.361 (-3.4)
b_age0507	-0.582 (-11.6)	-0.604 (-12.0)
b_age0811	-0.270 (-6.4)	-0.272 (-6.4)
b_age14	0.351 (4.0)	0.353 (4.0)
b_age15p	1.08 (4.9)	1.08 (4.9)
b_age12	-0.187 (-3.6)	-0.185 (-3.6)
b_edu2	-0.0734 (-2.5)	-0.114 (-3.8)
b_m_w_nl	-0.209 (-3.1)	-0.156 (-2.3)
b_f_w_li	0.174 (6.0)	0.194 (6.6)
b_Pink3_4	-0.615 (-12.8)	-0.616 (-12.8)
b_Pink5_6	-0.878 (-19.4)	-0.872 (-19.2)
b_Pink7_10	-0.765 (-15.6)	-0.743 (-15.1)
b_LS		**-0.143 (-5.6)**
s_const	2.39 (20.7)	-2.80 (-7.4)
s_h2_w2	0.294 (3.8)	0.286 (3.6)
s_hhgr5	-0.384 (-4.7)	-0.325 (-3.9)
s_hhgr6	-0.603 (-3.7)	-0.536 (-3.3)
s_carc3	-0.344 (-6.7)	-0.265 (-5.1)
s_age0507	0.442 (5.5)	0.548 (6.7)
s_age14	-0.816 (-5.6)	-0.831 (-5.6)
s_age15p	-0.719 (-1.5)	-0.825 (-1.7)
s_age12	-0.253 (-3.5)	-0.268 (-3.7)
s_edu4	0.140 (2.3)	-0.111 (-1.7)
s_f_w_li	0.172 (2.4)	0.0879 (1.2)
s_Pink0	0.460 (1.9)	0.482 (2.0)
s_Pink3_4	0.243 (2.0)	0.236 (1.9)
s_Pink5_6	0.575 (5.0)	0.556 (4.8)
s_Pink7_10	0.334 (2.7)	0.253 (2.1)
s_LS		**0.776 (14.3)**
theta	0 (*)	0 (*)

Commuting - Other

File	comm_freq_1b4.F12	comm_freq_1b5.F12
Title	LMS2004 model 1b.4	LMS2004 model 1b.4
Converged	TRUE	TRUE
Observations	59394	59394
Final log (L)	-18920.7	-18904.4
D.O.F.	43	45
Rho²(0)	0.77	0.77
Rho²(c)	0.31	0.31
Prepared	5-Oct-09	5-Oct-09
Estimated	5-Oct-09	5-Oct-09
Scaling	1	1
b_const	0.0217 (0.3)	-0.241 (-1.3)
b_h2_w0	0.178 (3.7)	0.177 (3.7)
b_h2_w1	-0.166 (-3.8)	-0.167 (-3.8)
b_h3_w0	-0.127 (-1.8)	-0.128 (-1.8)
b_h4p_w0	-0.186 (-2.9)	-0.184 (-2.9)
b_h4p_w2p	-0.135 (-2.3)	-0.133 (-2.3)
b_carc0	1.12 (11.9)	1.09 (11.5)
b_carc2	0.908 (11.9)	0.901 (11.8)
b_carc3	-0.0930 (-2.9)	-0.0912 (-2.8)
b_age03	1.88 (13.8)	1.89 (13.8)
b_age0507	0.379 (7.0)	0.385 (7.1)
b_age0809	0.326 (7.7)	0.330 (7.8)
b_age1214	0.320 (7.3)	0.321 (7.3)
b_age15p	0.872 (7.3)	0.870 (7.2)
b_age04	0.950 (10.2)	0.961 (10.3)
b_edu1	0.239 (4.9)	0.239 (4.9)
b_edu3	0.176 (4.9)	0.172 (4.8)
b_edu4	0.263 (6.2)	0.251 (5.8)
b_m_w_nl	-1.67 (-12.9)	-1.67 (-12.9)
b_f_w_li	-0.286 (-5.5)	-0.284 (-5.5)
b_f_w_nl	-1.69 (-18.9)	-1.69 (-18.9)
b_st_li	0.710 (8.5)	0.704 (8.4)
b_aow_li	3.35 (30.2)	3.36 (30.2)
b_aow_nl	3.95 (15.2)	3.96 (15.3)
b_m_ot_li	2.84 (25.5)	2.84 (25.5)
b_m_ot_nl	1.37 (7.3)	1.38 (7.3)
b_f_ot_li	1.54 (20.7)	1.54 (20.7)
b_f_ot_nl	0.796 (6.1)	0.799 (6.2)
b_w_home	1.59 (25.2)	1.59 (25.2)
b_Pink0	1.22 (20.3)	1.22 (20.3)
b_Pink3_4	-0.171 (-4.7)	-0.173 (-4.7)
b_Pink5_6	-0.457 (-9.0)	-0.460 (-9.0)
b_Pink7_10	-0.444 (-5.5)	-0.447 (-5.6)
b_LS		**0.0396 (1.4)**
s_const	2.56 (25.4)	-0.332 (-0.6)
s_hhgr5	-0.247 (-1.9)	-0.233 (-1.8)
s_carc0	0.325 (1.2)	0.133 (0.5)
s_carc2	0.682 (3.5)	0.702 (3.6)
s_carc3	-0.223 (-2.4)	-0.196 (-2.1)
s_age0507	0.447 (3.4)	0.468 (3.5)
s_age0809	0.257 (2.3)	0.281 (2.6)
s_age15p	-0.522 (-2.3)	-0.519 (-2.3)
s_f_w_li	0.180 (1.9)	0.140 (1.5)
s_f_w_nl	-0.382 (-1.6)	-0.480 (-2.0)
s_LS		**0.439 (5.6)**
theta	0 (*)	0 (*)

Education - student

File	edu_freq_4a_4.F12	edu_freq_4a_5.F12
Title	LMS2004 model 4a.4	LMS2004 model 4a.4
Converged	TRUE	TRUE
Observations	10896	10896
Final log (L)	-8416.4	-8416
D.O.F.	23	25
Rho²(0)	0.443	0.443
Rho²(c)	0.042	0.042
Prepared	5-Oct-09	5-Oct-09
Estimated	5-Oct-09	5-Oct-09
Scaling	1	1
b_const	-0.810 (-6.4)	-0.498 (-1.4)
b_h2_w1	0.238 (2.1)	0.248 (2.1)
b_hhgr5	-0.100 (-2.0)	-0.102 (-2.0)
b_a1_h4p	-0.342 (-2.6)	-0.341 (-2.6)
b_carc1	-0.356 (-2.4)	-0.339 (-2.2)
b_carc2	-0.146 (-1.9)	-0.124 (-1.6)
b_carc3	-0.0946 (-1.0)	-0.0879 (-0.9)
b_age0304	0.131 (2.4)	0.130 (2.4)
b_age0507	0.793 (6.7)	0.795 (6.7)
b_age0809	0.676 (2.6)	0.676 (2.6)
b_edu1	-0.373 (-6.3)	-0.371 (-6.3)
b_edu3	0.207 (2.7)	0.212 (2.8)
b_edu4	0.199 (1.9)	0.205 (1.9)
b_st_nl	-0.268 (-2.4)	-0.270 (-2.4)
b_Pink3_4	0.405 (2.0)	0.410 (2.1)
b_LS		**-0.0364 (-0.9)**
s_const	1.30 (5.2)	1.23 (1.6)
s_h1_w0	-1.04 (-3.4)	-1.05 (-3.4)
s_carc2	0.366 (2.3)	0.361 (2.2)
s_age0304	0.816 (7.2)	0.816 (7.2)
s_age0507	1.71 (6.8)	1.71 (6.8)
s_age0809	1.59 (2.1)	1.59 (2.1)
s_edu1	-0.240 (-1.8)	-0.240 (-1.8)
s_edu4	1.14 (2.6)	1.14 (2.6)
s_LS		**0.0076 (0.1)**
theta	0 (*)	0 (*)

Education - non-student

File	edu_freq_4b_4.F12	edu_freq_4b_5.F12
Title	LMS2004 model 4b.4	LMS2004 model 4b.5
Converged	TRUE	TRUE
Observations	83921	83921
Final log (L)	-7207.3	-7205.1
D.O.F.	22	24
Rho²(0)	0.938	0.938
Rho²(c)	0.084	0.084
Prepared	1-Oct-09	1-Oct-09
Estimated	1-Oct-09	1-Oct-09
Scaling	1	1
b_const	3.83 (53.8)	4.28 (18.6)
b_h2_w0	0.332 (3.7)	0.330 (3.6)
b_h3_w1	0.345 (3.4)	0.345 (3.4)
b_h4p_w0	-0.461 (-3.5)	-0.465 (-3.5)
b_hhgr5	-0.120 (-1.3)	-0.126 (-1.4)
b_age0304	-1.61 (-22.4)	-1.61 (-22.2)
b_age0506	-1.42 (-18.3)	-1.42 (-18.3)
b_age15p	0.822 (6.4)	0.822 (6.4)
b_edu1	0.365 (3.2)	0.357 (3.2)
b_edu3	-0.499 (-7.3)	-0.492 (-7.2)
b_edu4	-0.717 (-9.7)	-0.702 (-9.4)
b_aow_nl	0.655 (3.1)	0.625 (2.9)
b_m_ot_nl	-0.702 (-4.1)	-0.695 (-4.0)
b_f_ot_nl	-0.285 (-1.7)	-0.288 (-1.8)
b_Ftime	0.725 (10.1)	0.690 (9.3)
b_Pink0	0.234 (2.4)	0.230 (2.4)
b_Pink3_4	0.268 (3.6)	0.269 (3.6)
b_Pink5_6	0.197 (2.3)	0.205 (2.4)
b_Pink7_10	0.381 (3.5)	0.393 (3.6)
b_LS		**-0.0587 (-2.1)**
s_const	3.89 (15.4)	4.05 (2.7)
s_w_home	-1.15 (-3.0)	-1.16 (-3.0)
s_Ftime	0.505 (1.1)	0.494 (1.1)
s_LS		**-0.0208 (-0.1)**
theta	0 (*)	0 (*)

Shopping

File	shop_freq_5_4.F12	shop_freq_5_5.F12
Title	LMS2004 model 5.4	LMS2004 model 5.5
Converged	TRUE	TRUE
Observations	94817	94817
Final log (L)	-62437.6	-62366.4
D.O.F.	48	50
Rho²(0)	0.525	0.526
Rho²(c)	0.068	0.069
Prepared	5-Oct-09	5-Oct-09
Estimated	5-Oct-09	5-Oct-09
Scaling	1	1
b_const	0.886 (31.6)	1.20 (30.0)
b_h1_w0	0.0911 (3.3)	0.123 (4.5)
b_h1_w1	-0.234 (-5.6)	-0.185 (-4.4)
b_h2_w2	-0.111 (-2.9)	-0.104 (-2.7)
b_h3_w0	0.0875 (1.6)	0.0983 (1.8)
b_h4p_w0	0.242 (4.5)	0.245 (4.6)
b_a1_h4p	0.131 (3.0)	0.129 (3.0)
b_carc1	-0.187 (-4.7)	-0.167 (-4.2)
b_carc2	0.120 (4.1)	0.135 (4.6)
b_age0304	0.586 (19.1)	0.582 (19.0)
b_age0506	0.614 (14.5)	0.600 (14.1)
b_age1011	-0.171 (-7.9)	-0.167 (-7.8)
b_age15p	0.187 (4.5)	0.172 (4.1)
b_edu2	-0.221 (-9.8)	-0.219 (-9.7)
b_edu3	-0.318 (-12.8)	-0.308 (-12.4)
b_edu4	-0.390 (-14.6)	-0.370 (-13.8)
b_st_li	0.144 (1.8)	0.143 (1.8)
b_st_nl	0.381 (3.3)	0.412 (3.5)
b_aow_li	-0.658 (-15.2)	-0.666 (-15.3)
b_aow_nl	-0.248 (-4.8)	-0.231 (-4.5)
b_m_ot_li	-0.491 (-9.6)	-0.497 (-9.7)
b_m_ot_nl	-0.483 (-5.1)	-0.455 (-4.8)
b_w_home	-0.613 (-22.9)	-0.623 (-23.3)
b_Ftime	0.949 (32.7)	0.942 (32.5)
b_Female	0.374 (18.7)	0.411 (20.3)
b_Hink5_6	-0.0667 (-3.3)	-0.0665 (-3.3)
b_Hink7_8	-0.0702 (-3.7)	-0.0781 (-4.2)
b_LS		**-0.0711 (-11.1)**
s_const	2.05 (33.1)	2.34 (25.1)
s_h1_w0	0.284 (4.4)	0.305 (4.8)
s_h1_w1	0.212 (1.9)	0.243 (2.1)
s_h2_w2	0.178 (1.8)	0.175 (1.7)
s_carc1	-0.175 (-2.0)	-0.159 (-1.8)
s_carc2	0.0670 (1.0)	0.0796 (1.2)
s_age0304	0.343 (3.7)	0.341 (3.7)
s_age0506	0.332 (2.8)	0.323 (2.8)
s_age0809	0.0948 (1.7)	0.0899 (1.6)
s_age1011	-0.0710 (-1.5)	-0.0729 (-1.5)
s_edu1	0.267 (4.5)	0.263 (4.5)
s_edu3	-0.157 (-3.5)	-0.149 (-3.3)
s_edu4	-0.237 (-4.8)	-0.221 (-4.4)
s_f_w_nl	0.188 (1.3)	0.202 (1.4)
s_st_li	0.455 (1.9)	0.454 (1.9)
s_aow_li	-0.226 (-4.3)	-0.227 (-4.4)
s_w_home	-0.155 (-3.2)	-0.169 (-3.5)
s_Ftime	0.224 (3.8)	0.232 (3.9)
s_Hink5_6	-0.199 (-3.4)	-0.203 (-3.5)
s_Hink7_8	-0.246 (-4.1)	-0.257 (-4.3)
s_Hink9_10	-0.259 (-4.1)	-0.267 (-4.3)
s_LS		**-0.0590 (-4.1)**
theta	0 (*)	0 (*)

Other

File	oth_freq_6_4.F12	oth_freq_6_5.F12
Title	LMS2004 model 6.4	LMS2004 model 6.5
Converged	TRUE	TRUE
Observations	94817	94817
Final log (L)	-85693.6	-85691.7
D.O.F.	60	62
Rho²(0)	0.496	0.496
Rho²(c)	0.048	0.048
Prepared	5-Oct-09	5-Oct-09
Estimated	5-Oct-09	5-Oct-09
Scaling	1	1
b_const	0.712 (15.2)	0.641 (6.7)
b_h2_w0	0.148 (6.3)	0.148 (6.3)
b_h2_w1	0.346 (13.6)	0.347 (13.6)
b_h2_w2	0.283 (8.6)	0.283 (8.6)
b_h3_w0	0.219 (4.3)	0.219 (4.3)
b_h3_w1	0.272 (10.0)	0.272 (10.0)
b_h3_w2p	0.333 (8.4)	0.333 (8.4)
b_h4p_w0	0.190 (4.1)	0.190 (4.1)
b_h4p_w2p	0.0957 (3.2)	0.0957 (3.2)
b_a1_h4p	-0.343 (-9.1)	-0.343 (-9.1)
b_carc0	0.373 (9.6)	0.372 (9.6)
b_carc2	0.183 (5.5)	0.183 (5.5)
b_carc3	-0.0423 (-2.5)	-0.0419 (-2.5)
b_age0304	-0.0956 (-4.0)	-0.0954 (-4.0)
b_age0507	-0.0824 (-3.3)	-0.0824 (-3.3)
b_age0809	-0.162 (-7.6)	-0.162 (-7.6)
b_age15p	0.269 (6.5)	0.269 (6.5)
b_edu1	-0.115 (-2.8)	-0.115 (-2.8)
b_edu2	-0.250 (-6.2)	-0.250 (-6.2)
b_edu3	-0.471 (-11.4)	-0.471 (-11.4)
b_edu4	-0.572 (-13.6)	-0.573 (-13.6)
b_f_w_nl	0.175 (3.0)	0.175 (3.0)
b_st_li	0.423 (6.8)	0.422 (6.8)
b_st_nl	0.545 (5.9)	0.545 (5.9)
b_aow_li	-0.530 (-12.4)	-0.530 (-12.4)
b_aow_nl	-0.148 (-2.6)	-0.148 (-2.6)
b_f_ot_li	-0.394 (-9.2)	-0.394 (-9.2)
b_w_home	-0.464 (-17.5)	-0.464 (-17.5)
b_Ftime	0.674 (30.4)	0.674 (30.4)
b_Hink5_6	-0.0679 (-2.8)	-0.0679 (-2.8)
b_Hink7_8	-0.140 (-5.6)	-0.140 (-5.6)
b_Hink9_10	-0.108 (-4.2)	-0.109 (-4.2)
b_LS		**0.0103 (0.8)**
s_const	0.672 (13.3)	0.443 (3.2)
s_h1_w0	0.855 (15.7)	0.853 (15.6)
s_h1_w1	0.926 (11.8)	0.923 (11.8)
s_h2_w0	0.605 (14.1)	0.603 (14.1)
s_h2_w1	0.808 (17.1)	0.808 (17.1)
s_h2_w2	1.03 (14.0)	1.03 (14.0)
s_h3_w0	0.488 (6.2)	0.487 (6.2)
s_h3_w1	0.373 (8.9)	0.374 (8.9)
s_h3_w2p	0.638 (8.1)	0.637 (8.1)
s_h4p_w0	0.253 (3.8)	0.253 (3.9)
s_h4p_w2p	0.176 (3.5)	0.176 (3.5)
s_a1_h4p	-0.505 (-12.4)	-0.506 (-12.4)
s_carc2	0.454 (10.0)	0.454 (10.0)
s_carc3	0.0974 (3.9)	0.0982 (3.9)
s_age0809	-0.409 (-14.3)	-0.410 (-14.3)
s_edu1	0.266 (7.0)	0.266 (7.0)
s_edu2	0.101 (3.6)	0.101 (3.6)
s_edu4	-0.0904 (-3.1)	-0.0914 (-3.1)
s_f_w_li	-0.300 (-8.3)	-0.300 (-8.3)
s_f_w_nl	-0.161 (-1.5)	-0.163 (-1.6)
s_st_li	0.495 (4.3)	0.494 (4.3)
s_st_nl	0.244 (2.5)	0.243 (2.5)
s_aow_li	-0.445 (-10.3)	-0.444 (-10.2)
s_f_ot_li	-0.528 (-9.6)	-0.528 (-9.6)
s_w_home	-0.584 (-15.6)	-0.585 (-15.6)
s_Ftime	0.398 (9.5)	0.398 (9.5)
s_Hink7_8	0.0384 (1.3)	0.0374 (1.2)
s_Hink9_10	0.124 (3.7)	0.121 (3.7)
s_LS		**0.0340 (1.8)**
theta	0 (*)	0 (*)

Appendix 2: Estimated MD/ToD models

Explanation of coefficient name labels

Cd	ASC car driver
Ps	ASC car passenger
Tr	ASC train
Bt	ASC bus/tram/metro
Cy	ASC cycling
IntraCd	Intra zonal dummy car driver
IntraPs	Intra zonal dummy car passenger
IntraBt	Intra zonal dummy bus/tram/metro
IntraSl	Intra zonal dummy slow modes
IntraCy	Intra zonal dummy cycling
IntraWk	Intra zonal dummy walking
LogCost	cost coefficient
LogCost0	cost coefficient for unknown income class
LogCost1	cost coefficient for income class 1 t/m 4
LogCost2	cost coefficient for income class 5 t/m 8
LogCost3	cost coefficient for income class 9 and 10
CdTime	travel time for cardrivers
PsTime	travel time for carpassengers
PsADist	Squared distance maximised at 40 km for carpassenger
CarTime	travel time for cardrivers and -passengers
SlDist	distance for slow modes
SlDist08	distance above 8 km (tourdistance) for slow modes
SlDist16	distance above 16 km (tourdistance) for slow modes
CyDist	distance for cycling
CyDist08	distance above 8 km (tourdistance) for cycling
CyDist16	distance above 16 km (tourdistance) for cycling
WkDist	distance for walking
WkDist02	distance above 2 km (tourdistance) for walking
WkDist04	distance above 4 km (tourdistance) for walking
TrIVT	In-vehicle tijd for train
TrWait	Wait time for train
TrTimeS2S	In-vehicle tijd + Wait time (station-to-station tijd) for train
TrAEDist	Acc- egress distance for train
BtIVT	In-vehicle tijd for BTM
BtWalk	Walk time (Acc- egress + transfer) for BTM
BtWait	Wait time for BTM
BtWWTime	Wait time + Walk time for BTM
CdCarCo3	car driver x car available no competition
CdCarCo2	car driver x car available with competition
CdLicNoCar	car driver x license but no car
PsCarCo3	car passenger x car available no competition
PsCarCo2	car passenger x car available with competition
PsCarCo1	car passenger x car available but no license
PsCarCo0	car passenger x no car available
PsCarCo01	car passenger x no car and/or no license
TrCarCo01	train x no car and/or no license
BtCarCo01	BTM x no car and/or no license
OVCarCo0	OV x no car available
OVCarCo1	OV x car available but no license
OVCarCo2	OV x car available available with competition
NoWrkDst	distance coefficient if no worker
PartWrkDst	distance coefficient if part-time worker
FTDst	distance coefficient if full time worker
StudentDst	distance coefficient if student
EduPrLoDst	distance coefficient if educational level is primary- or lower education
EduHigDst	distance coefficient if educational level is higher education
AgeCl0Dst	distance coefficient if age is lower dan 18
AgeCl23Dst	distance coefficient if age is 35 or up
CdMale	car driver x Man
PsMale	car passenger x Man
TrMale	train x Man
BtMale	Bus/tram/metro x Man
CyMale	cycling x Man
WkMale	walking x Man

CdStudent	car driver x Student
PsFulltime	car passenger x full time worker
PsParttime	car passenger x Part-time worker
TrStudent	train x Student
BtParttime	BTM x Part-time worker
OVFulltime	Public transport x full time worker
OVStudent	Public transport x Student
CyStudent	cycling x Student
CyWorker	cycling x worker
CyHousehld	cycling x Huishoud worker
WkWorker	walking x worker
WkStudent	walking x Student
SlFulltime	slow modes x full time worker
SlWorker	slow modes x worker
CdAgeCl2	car driver x age is 35 – 65 yr.
CdAgeCl3	car driver x age is 65 yr. or up
PsAgeCl3	car passenger x age is 65 yr. or up
PsAgeCl23	car passenger x age is 35 yr. or up
PsChild0_5	car passenger x age is onder 6 yr.
OVAgeCl2	Public transport x age is 35 – 65 yr.
CyAgeCl0	cycling x age is onder 18 yr.
CyAgeCl1	cycling x age is 18 – 35 yr.
CyAgeCl2	cycling x age is 35 – 65 yr.
WkAgeCl1	walking x age is 18 – 35 yr.
WkAgeCl2	walking x age is 35-65 yr.
WkAgeCl23	walking x age is 35 yr. or up
SlAgeCl0	slow modes x age is onder 18 yr.
PsPrLoEdu	car passenger x educational level is primary school or lower education
TrPrimEdu	train x educational level is primary school
TrMedEdu	train x educational level is medium education or highschool
TrHighEdu	train x educational level is BSc or MSc
BtPrimEdu	BTM x educational level is primary school
CyHighEdu	cycling x educational level is higher education
WkMedEdu	walking x educational level is medium education or highschool
CdNPersU12	car driver x household has 1 or more persons below 12 yr.
PsNPers1	car passenger x one person household
OVAdlt1	Public transport x household has 1 adult
CyAdlt1	cycling x household has 1 adult
CyNPers1	cycling x one person household
CyNPersU12	cycling x household has 1 or more persons below 12 yr.
WkNPers1	walking x one person household
WkNPersU12	walking x household has 1 or more persons below 12 yr.
SlAdlt1	slow modes x household has 1 adult
CBD75	Constant for employment density higher than 75 jobs per ha
CdCBD75	Constant for employment density higher than 75 jobs per ha for cardriver
PsCBD75	Constant for employment density higher than 75 jobs per ha for carpassenger
CarCBD75	Constant for employment density higher than 75 jobs per ha for cardriver and passenger
TrUrban	Constant for train to large Cities in Randstad
Popdens	Population density destination zone
PsOPopdens	car passenger x Population density origin zone
SizeWork	Additional size variable: number of jobs
SizeMBO	Additional size variable: number of students medium education
SizeVO	Additional size variable: number of students highschool
SizeSO	Additional size variable: number of students special education
SizeServic	Additional size variable: number of jobs services
SizePop	Additional size variable: number of inhabitants
SizeRetail	Additional size variable: number of jobs retail
ThetaMode	Nest coefficient for mode above destination
ThetaDest	Nest coefficient for destination above mode

COMMUTING

File	comm_2_11b_t2a.F12	
Title	NSES/ToD Commuting	
Converged	TRUE	
Observations	38053	
Final log (L)	-156402.7	
D.O.F.	91	
Rho²(0)	0.5	
MSC's		
Cd	9.162	(21.5)
Ps	0.6387	(2.0)
Tr	-4.552	(-19.7)
Bt	2.567	(9.7)
Cy	5.327	(18.9)
Cost		
LogCost1	-0.5128	(-18.5)
LogCost2	-0.4647	(-18.8)
LogCost3	-0.3484	(-22.1)
Time		
CdTime	-0.03863	(-82.7)
PsTime	-0.04548	(-38.9)
BtIVT	-0.00594	(-5.4)
BtWWTime	-0.08964	(-20.8)
BtTime		
Distance		
PsADist	-0.02979	(-2.3)
CyDist	-0.1620	(-15.5)
CyDist08	-0.07308	(-5.0)
CyDist16	0.1350	(17.0)
WkDist		
WkDist02	-0.8342	(-11.0)
WkDist04	0.6499	(8.3)
Segmentation		
CdMale	1.034	(13.3)
PsMale		
BtMale	-1.005	(-6.7)
CdAgeCl2	-0.4606	(-4.6)
CdAgeCl3		
PsAgeCl2_3	-0.8021	(-5.3)
CyAgeCl0		
CyAgeCl23	0.6715	(6.5)
CdCarCo2	-3.635	(-23.5)
PsCarCo0	-1.852	(-6.9)
PsCarCo01		
PsCarCo3	0.5030	(3.2)
BtCarCo01	1.054	(6.0)
OVCarCo0	1.419	(9.3)
CdLicNoCar	-8.543	(-20.2)
CyWorker		
NoWrkDst	-0.02816	(-20.7)
PartWrkDst	-0.01867	(-29.2)
PsPrLoEdu	1.226	(9.0)
TrPrLoEdu	-0.7159	(-3.2)
TrHighEdu	2.585	(15.8)
WkMedEdu		
CyHighEdu	0.1284	(1.7)
EduPrLoDst	-0.01297	(-28.3)
EduHigDst	-0.00458	(-14.6)
CdStudent	-2.332	(-6.8)
OVStudent		
CyStudent	0.5805	(3.0)
TrUrban		
CBD75	0.2918	(8.9)
CdCBD75	-0.4531	(-8.8)
PsCBD75	-0.8489	(-6.3)
....		

COMMUTING

...continued		
Intrazonal		
Intra	2.557	(13.9)
IntraCd	-1.834	(-12.4)
IntraPs	-1.607	(-8.6)
IntraBt	-2.468	(-7.8)
IntraCy	-1.647	(-11.6)
IntraDs	-0.3851	(-5.2)
IntraDs2	0.8027	(8.9)
IntraDs4	-0.2745	(-8.5)
IntraDs2_D	-0.06817	(-4.9)
IntraDs4_P	-0.06606	(-2.0)
IntraDs_B	-0.3255	(-4.7)
Size function		
SizeWork		
Nest coefficients		
thetamode	0.4128	(25.9)
thetatod	1.0000	(*)
TrLogsum	0.3972	(16.2)
Time-of-day SP		
SPscale	0.7777	(13.3)
ECscale	1.388	(11.6)
train_c	-6.008	(-10.7)
Con_earf	-1.923	(-13.3)
Con_earnf	-1.898	(-12.8)
Con_latf	-1.571	(-12.2)
Con_latnf	-2.539	(-12.8)
Con_ear		
Con_lat		
1_3	0.04986	(0.0)
1_5	-1.470	(-4.0)
1_6	-2.087	(-5.7)
1_7	-2.212	(-6.3)
2_3	-2.629	(-2.2)
2_5	-1.248	(-3.6)
2_6	-0.4567	(-2.3)
2_7	-0.6249	(-4.9)
2_8	-1.073	(-3.7)
2_9	-2.621	(-4.6)
3_3	-1.401	(-1.2)
3_4		
3_5	-0.7147	(-2.1)
3_6	-0.2082	(-0.9)
3_8	-0.3222	(-2.2)
3_9	-1.297	(-4.5)
4_5	-1.917	(-4.3)
4_6	-0.9293	(-1.9)
4_7	-0.7078	(-3.9)
4_8	-1.070	(-5.1)
4_9	-1.296	(-5.0)
5_5	-1.193	(-2.6)
5_6	-1.014	(-1.8)
5_7	-1.646	(-6.2)
5_8	-1.248	(-4.3)
5_9	-2.219	(-7.7)
6_9	-1.280	(-0.7)
7_9	0.7055	(0.5)
8_9	-1.769	(-0.9)
9_9	0.7956	(0.4)

	EDUCATION	SHOPPING	OTHER
File	educ_2_11_t3.F12	shop_2_11b.F12	othr_2_11a_t3b.F12
Title	NSES/ToD Education	NSES/ToD Shopping	NSES/ToD Other
Converged	TRUE	TRUE	TRUE
Observations	9658	31091	48087
Final log (L)	-29055.3	-83102	-159753.7
D.O.F.	87	97	103
Rho^2(0)	0.605	0.688	0.619
MSC's			
Cd	6.038	-2.476	4.625
Ps	2.45	-2.166	0.1749
Tr	-1.384	-12.8	-17.7
Bt	5.328	-4.082	-7.182
Cy	6.216	-2.55	1.178
Cost			
LogCost	-0.3785	-0.526	-0.9732
Time			
CdTime	-0.04134	-0.1014	-0.05593
PsTime	-0.05955	-0.09931	-0.067
BtIVT	-0.01448	-0.01486	-0.00946
BtWWTime	-0.04959	-0.1049	-0.07423
Distance			
PsADist	-0.03854	-0.09169	-0.1066
CyDist	-0.2294	-0.3699	-0.3072
CyDist08	0.08706	-0.0382	-0.06494
CyDist16		0.3471	0.3043
WkDist	-0.2457	-2.232	-0.8525
WkDist02		1.454	-0.5324
WkDist04		0.6087	1.291
Segmentation			
CdMale		0.9413	2.708
PsMale	-0.7238	-0.5716	-1.927
SlMale		0.357	
CyMale			0.9484
WkMale			0.7467
CdAgeCl3		-0.2136	
PsAgeCl3			0.7626
OVAgeCl2	-1.695		
CyAgeCl0		0	
CyAgeCl2		0.4519	0.7459
WkAgeCl0		-1.157	
WkAgeCl1			0.372
WkAgeCl2		-0.1899	
WkAgeCl23	1.734		
SlAgeCl0	2.095		
AgeCl0Dst	-0.02978		
AgeCl23Dst	-0.01083		
CdCarCo2	-1.69	-0.7379	-2.47
PsCarCo0	-2.352	-1.767	-2.311
PsCarCo1			2.103
PsCarCo2		-0.5079	
PsCarCo3		-0.8701	-0.9661
OVCarCo0	0.2101	1.117	4.901
OVCarCo1		0.6311	
OVCarCo2			-1.622
CdLicNoCar	-4.98	-3.272	-11.17
CdWorker		0.2453	
PsParttime			-0.529
PsFulltime			0.6842
OVFulltime	-1.892		
WkWorker			-1.099
CyWorker			-0.4595
CyFulltime		-0.3015	
SlWorker	-1.896		
FTDst	0.00387		
PartWrkDst		-0.00849	0
CdHighEdu		-0.2041	
TrPrimEdu	-2.333		
TrMedEdu	0.9116		
BtPrimEdu	-1.086		
TrStudent	0.9983		
OVStudent			0
CyStudent			1.355
WkStudent			-2.669
StudentDst		0.00201	0
CdNPersU18		0.2779	
CdNPersU12			1.774
PsNPers2			1.387
PsNPersU18		-0.3529	
CyNPers1			0.68
CyNPersU12			3.462
CyHousehld			1.055
WkNPers1			1.58
WkNPersU12	0.8001		4.274
WkAdlt1		0.5703	
Popdens	0		-0.00445
CBD75		0	0.2463
CarCBD75		-0.1512	
PsOPopdns		-0.00367	-0.01455
....			

	EDUCATION	SHOPPING	OTHER
...continued			
Intrazonal			
Intra	5.482	0.3046	1.748
IntraCd	-1.629	1.011	-1.115
IntraPs	-3.671	0.5268	-2.304
IntraBt	-3.969	1.831	-2.216
IntraCy	-5.808	0	-0.9866
IntraDs	-1.489	0.8869	0
IntraDs1	0	0	0.7904
IntraDs2	1.627	-0.5218	0
IntraDs4	-0.1416	-0.3425	-0.6394
IntraDs_D	0	-1.293	-0.5159
IntraDs2_D	0	1.177	0
IntraDs4_D	0	0.07499	0.4135
IntraDs_P	0.5453	-1.454	0
IntraDs1_P	0	0	-0.9121
IntraDs2_P	0	1.764	1.126
IntraDs4_P	-0.6029	-0.4181	-0.4019
IntraDs_B	0	-1.788	0
IntraDs2_B	0	0	-2.021
IntraDs4_B	0	1.893	1.964
IntraDs_C	1.7	0	0
IntraDs1_C	0	-1.516	-1.269
IntraDs2_C	-1.693	1.688	1.29
Size function			
SizeMBO	-0.03188		
SizeVO	1.229		
SizeSO	1.736		
SizeServic		-5.524	-0.05954
SizeRetail			2.41
Nest coefficients			
thetatod	0.5517	1	0.2712
TrLogsum	0.8996	1	1
Time-of-day SP			
SPscale	1.303	0.298	1.848
ECscale	2.063	5.007	2.857
train_c	-3.578	-8.586	-5.165
Con_ear	-1.596	-3.835	-2.302
Con_lat	-1.658	-4.001	-2.371
1_3	0	0	0
1_5	-2.353	-5.628	-3.42
1_6	0.2731	0.696	0.3492
1_7	0	0	0
2_3	-4.685	-11.2	-6.834
2_5	-2.448	-5.837	-3.588
2_6	0	0	0
2_7	-2.948	-7.097	-4.238
2_8	-2.438	-5.851	-3.534
2_9	0	0	0
3_3	-0.964	-2.275	-1.442
3_4	-1.832	-4.357	-2.706
3_5	-1.407	-3.349	-2.064
3_6	-2.009	-4.82	-2.906
3_8	-0.6036	-1.478	-0.8293
3_9	-3.944	-9.463	-5.705
4_4	-0.2967	-0.582	-0.5824
4_5	-0.2528	-0.565	-0.4097
4_6	2.281	5.545	3.221
4_7	-0.0435	-0.07611	-0.09192
4_8	-1.179	-2.794	-1.747
4_9	-0.02961	0.01113	-0.1308
5_5	-0.3499	-0.7503	-0.6048
5_6	0.1616	0.4465	0.1707
5_7	-0.2206	-0.4836	-0.373
5_8	0.1338	0.365	0.1443
5_9	-1.529	-3.592	-2.303
6_6	1.139	2.801	1.574
6_7	0.3222	0.8244	0.4121
6_8	-1.92	-4.572	-2.819
6_9	-0.4556	-0.9618	-0.7953
7_7	0.146	0.3758	0.1827
7_8	-0.9951	-2.356	-1.476
7_9	-0.839	-1.947	-1.285
8_8	-1.103	-2.696	-1.539
8_9	0.1894	0.5312	0.1871
9_9	0.2401	0.6516	0.2602