

Written Exam Transport Modeling

Written Exam	Transport Modeling
Teacher	van Berkum
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Remarks	Closed book Calculator allowed Dictionary allowed. Formulas and tables are, when necessary, are part of the question.

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Calculation of the marks:

- The maximum number of points, P_{max} , is 100
- The marks for the written exam, C , is calculated by the sum of points, P , times ten divided by the maximum number of points:

$$C = 10 \cdot \frac{P}{P_{max}}$$

Part I (33 points) Choice Modelling

Imagine the future scenario where monetary incentives ('bonus') are provided for drivers to switch to routes that are deemed safe. The insurance company pays for this and the amount is determined per origin-destination (OD) pair. If the 'safe route' is followed in full, the driver receives the full amount of the bonus; if the safe route is partially followed, the driver receives the bonus *pro rata* (i.e. proportionally).

An on-board unit (OBU) is equipped on the vehicle with an embedded navigation system. For each OD trip, the OBU has the following functions:

- calculate and display the safest route and the amount of route incentives,
- record drivers' actual route choice,
- calculate to what extent the driver has been following the safest route and the amount of incentives (bonus) the driver is eligible for, and
- register the earned incentives on the driver's personal account.

A route choice simulator is developed to study drivers' route choice behaviour under a dynamic environment. The simulator utilizes a computer screen to visualize the road network as well as the traffic. Drivers participate in the simulator by completing a trip from a given origin to a given destination. At each intersection, drivers have to select a route out of two or three alternatives; each route is highlighted on the screen and displays the following information:

- estimated travel time (from the current position to the final destination),
- distance (to the final destination), and
- the extra potential bonus (to be earned if this route is followed in full from now on)

Question a [5 points]: Compare the choice situations that drivers face in the simulator with the situations in reality when the application is implemented. Describe the differences and discuss the consequences.

A route choice experiment is conducted with selected drivers under a before-and-after setup:

- before scenarios: with the safety incentives disabled; the bonus information is also not displayed, and
- after scenarios: with the safety incentives enabled.

The experiment provides choice data that can be used to analyze the dynamic route choice behaviour. The logit model is adopted; the utility of route r at time t is formulated as

$$V_r(t) = \beta_1 T_r(t) + \beta_2 D_r(t) + \beta_3 B_r(t) + \beta_4 \Delta_r,$$

where T , D , B represent travel time, distance, and bonus, respectively. The binary variable Δ_r is defined as

$$\Delta_r = \begin{cases} 0, & \text{if } r \text{ follows the same route as chosen at the last intersection;} \\ 1, & \text{otherwise.} \end{cases}$$

Question b [6 points]: Comment on the composition of the utility function above (discuss in detail the parts that you agree with and the parts that you do not agree with). What aspect of choice behaviour does Δ_r represent?

Maximum likelihood estimation is applied to the logit choice model with dispersion parameter $\mu = 1$. Three sets of results are generated: one for the before scenarios only, one for after only, and one for the overall results. The estimation results are given below:

Attribute	Unit	Parameter	Overall		Before		After	
			Value	T-test statistic	Value	T-test statistic	Value	T-test statistic
travel time	minute	β_1	-0.236	-4.72	-0.284	-4.00	-0.167	-2.33
distance	km	β_2	-0.008	-0.21*	0.018	0.40*	-0.064	-0.78*
incentives	euro	β_3	0.953	4.42	—	—	1.10	3.45
Δ_r	-	β_4	-1.58	-8.70	-1.39	-6.17	-1.83	-5.79

*: insignificant

Question c [4 points]: c) Based on the table above, can you say something about goodness-of-fit for the logit model? If not, what extra results do you need to take into account?

Question d [6 points]: Describe the regression results in general. What do they imply with respect to driver's choice behaviour?

Question e [4 points]: Derive the drivers' value of time. Is there a difference between the before and after scenarios?

Question f [4 points]: Quantify the aspect represented by Δ_r .

Sub question g [4 points]: Comment in general on the experiment study described here. Any suggestions for improvement?

Part II (33 points) Stated Preference & Activity Based

Question 1 [4 points]: Describe the differences between stated preference and revealed preference data by stating their characteristics (minimum four characteristics for each type of data).

Imagine a case in which you want to generate an experimental design using 5 attributes each with 2 levels.

Question 2a [2 points]: How many number of profiles should it be in a full factorial design?

Question 2b [3 points]: Given the research budget, you can only run an experiment using a (half) fraction of the full factorial design. Therefore, you decide to apply a design that is both orthogonal and balance. Explain what the orthogonal and balanced design mean.

Question 2c [3 points]: By coding the levels as (-1, +1), show how to construct a half-fraction design for the case above (step-by-step), and write down your final design.

Flights from Schiphol to Madrid are assessed based on 4 attributes, each with two levels:

X1= number of stop; level= 0 stop, 1 stop

X2= cost; level= 200 EUR, 300 EUR

X3= meal; level= with meal, without meal

X4= baggage; level= free, extra cost of 25 EUR

You generate a fractional factorial design using half of the full factorial design and ask a respondent to rate the attractiveness of each profile from 0 (very unattractive) to 10 (very attractive). His assessment can be found below.

Profile	X1	X2	X3	X4	Assessment
1	0 stop	200 EUR	Meal	Free	10
2	1 stop	200 EUR	Meal	25 EUR	6
3	0 stop	300 EUR	Meal	25 EUR	4
4	1 stop	300 EUR	Meal	Free	4
5	0 stop	200 EUR	No meal	25 EUR	5
6	1 stop	200 EUR	No meal	Free	7
7	0 stop	300 EUR	No meal	Free	6
8	1 stop	300 EUR	No meal	25 EUR	2

Based on this data, calculate:

Question 3a [3 points]: The basic utility of this participant

Question 3b [3 points]: The partial utilities of the attribute levels

Question 3c [3 points]: Write down the utility function associated with this respondent

Question 4a [2 point]: Explain what are the focus of transport development in 1970s, 1980s, and 1990s. You can add some examples in your explanation.

Question 4b [2 points]: Explain why the 4-step procedure is considered as insufficient to many researchers and city authorities.

Question 4c [2 points]: Explain why the 4-step procedure is still attractive until now (the advantages of the 4-step procedure).

Question 5a [3 points]: Explain the fundamental differences between the trip-based procedure and the AB models.

Question 5b [3 points]: A famous example of Activity-Based models is Albatross, developed for Dutch Ministry of Transportation, Public Works and Water Management. Describe briefly what Albatross is, what the purpose of the model is, and how schedules are generated?

Part III (34 points) Aggregated models & Calibration

Question 1 [3 points]: Describe what is meant by Ecological fallacy. Indicate when this may occur. You may provide concrete examples to support your answers.

From a mobility survey, we obtain 90 commuting trips within and between three cities A, B and C. The average commuting distance within each city is 1 km, the distance between city A and B, and between B and C is 5 km. The distance between A and C is 9 km. For city A, 17 respondents work in the same city, 10 commute to city B, and 3 to city C. For city B, 13 people stay in the city, 7 commute to A, and 10 commute to C. For city C, 17 respondents stay in C, 6 respondents commute to A, and 7 to B.

Question 2a [3 points]: Provide the general gravity model in formula. The model does not need to be single or double constrained

Question 2b [1 points]: The trip distribution as function of cost has a particular form according to entropy maximization (equivalent with a logit model from discrete choice models). Provide the corresponding gravity model as function of costs.

Question 2c [6 points]: The outcomes from the mobility survey can be used to estimate the distribution function. Use three distance bins and estimate the corresponding distribution values.

Question 2d [3 points]: Assume that the distance is proportional to cost. Use the results from the mobility survey to estimate the free parameter (normally denoted by β) in the distribution function as derived from entropy maximization. If you cannot recall the correct function shape, just estimate the decay parameter in your own distribution function. Hint: plot the values from c) in a log-linear plot.

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Consider a very simple OD matrix: $T = [[T_{11}, T_{12}], [T_{21}, T_{22}]] = [[140, 50], [60, 130]]$, with T_{ij} the number of trips from origin i to destination j . The OD matrix was calculated with a gravity model without constraints. According to a trip generation model, however, the trip totals, i.e. the total number of trips from zone 1, from zone 2, to zone 1 and to zone 2, were in all cases 200. The total number of trips should therefore be 400. In addition, according to an observed trip length distribution 300 trips should be made internally (from 1 to 1, and from 2 to 2), and 100 trips are inter-zonal (from 1 to 2, and from 2 to 1).

Question 3a [2 points]: Give the constraints (in mathematical equations) that follow from the tri-proportional fitting approach (equivalent to Furness method).

Question 3b [3 points]: Use the tri-proportional fitting approach to calibrate the 2 by 2 matrix. Do exactly one iteration.

Question 3c [3 points]: The tri-proportional fitting is not generally suited for a 2 by 2 matrix. Explain why.

Question 3d [3 points]: Use the constraints from a) to derive the exact outcome for this particular tri-proportional problem. How does the answer compare with the original matrix and the one calculated in b)?