Post lecture questions Basic concepts plus some answers

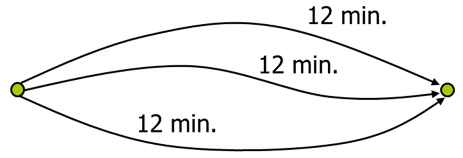
Model structure and model dimensions

What are the components of the 4-stage transport model system? Which travel choice is involved in each component? In some cases, a fifth sub model is added to the four-step model. Which travel choice does this fifth sub model describe?
For each component of the 4-stage transport model, an aggregate (on a zonal level) or disaggregate (on a household or individual level) approach can be taken. Name the main advantage and the main disadvantage of the disaggregate approach.
If a traveller makes a trip from A to B, and from B to C, then the trip from A to C is called a tour: True or false?
Explain the main advantage of using tours as opposed to using trips
What is the trip purpose of a trip from work to a shop? And from work to home?
Explain why different trip purposes are distinguished.
Explain why a city might choose for a cordon model?

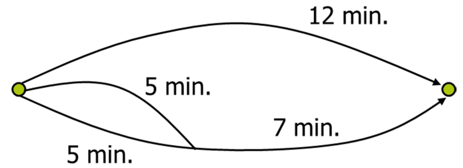
Choice modelling

Consider the following two networks with three routes. How will the travellers distribute themselves, according to the logit model?

I



II



What would change if a nested logit model is applied?

The standard logit model assumes for both cases three routes which have the same travel time and which are independent. Therefore each of the routes gets 33.3% of the flow.
The nested logit model accounts for correlation between alternatives, which is relevant for situation II. As a result the share for the correlated alternatives will be lower compared to the case where the alternatives are fully independent. The exact results depend on the ratio of the scale parameters of the nested model, but as an example, the upper routes might have 40% and both lower routes 30% each, instead of 33.3% as in the case of a standard logit model.

For a certain OD-pair the shares for car and train trips are 80:20. The mode choice can be described by a logit model with exponent 0.03*-Z, where Z is the travel time. How much is the difference in travel time?

$$P_{car} = \frac{\exp(0.03 \cdot -t_{car})}{\exp(0.03 \cdot -t_{car}) + \exp(0.03 \cdot -t_{train})} = \frac{1}{1 + \exp(0.03 \cdot (-t_{train} + t_{car}))} = 0.8$$

$$\Rightarrow 1 = 0.8 + 0.8 \cdot \exp(0.03 \cdot (-t_{train} + t_{car})) \Rightarrow \exp(0.03 \cdot (-t_{train} + t_{car})) = \frac{0.2}{0.8}$$

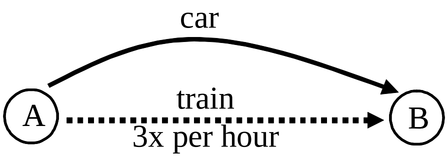
$$\Rightarrow 0.03 \cdot (-t_{train} + t_{car}) = \ln\left(\frac{0.2}{0.8}\right) \Rightarrow (-t_{train} + t_{car}) = -46.2$$

Note that the equation for P_{train} would yield $(-t_{car}+t_{train})=46.2$

City X considers building a metro system. In order to determine parameter values for a choice model, they conduct a survey among users of an existing metro system in city Y. Questions concerning total travel time and waiting time are asked. Using these survey outcomes, parameters for a logit model for computing the future number of travellers for the metro system in city X are determined.
Will this future number of travellers be correct, overestimated, or underestimated?

Biased sample since non-users are not included, thus overestimated

Consider cities A and B that are connected by a local road. Furthermore, between these cities is a train service available with a frequency of 3 trains per hour (departing every 20 minutes). The travel time by car is 60 minutes, and by train is 40 minutes. The total number of travellers between A and B is 1000.



In order to determine the modal split, a multinomial logit model is used with the following estimated utility functions:

$$V^{car} = 1.0 - 0.09TC$$

$$V^{train} = -0.12A - 0.10TT - 0.16F$$

where
TC is the in-vehicle travel time by car [min.],
TT is the in-vehicle travel time by train [min.],
A is the average access waiting time [min.] (waiting time to board the first train)
F is the average transfer waiting time [min.] (waiting time to transfer to another train)

(a) Determine the number of travellers taking the train (scale parameter is equal to 1).

The train service departs every 20 minutes. Given that the arrival at the station and departure of the train are unsynchronized (note that only a frequency schedule is given, not a time schedule), the average access waiting time is half the headway and thus equal to 10 minutes. The utility for each alternative can be computed using the given utility functions:

$$V^{car} = 1.0 - 0.09 \cdot 60 = -4.4$$

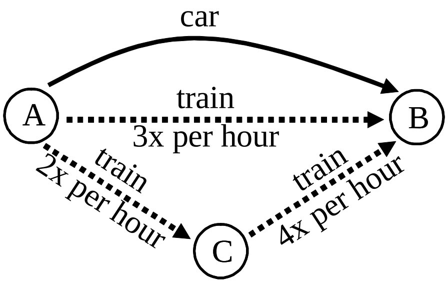
$$V^{train} = -0.12 \cdot 10 - 0.10 \cdot 40 - 0.16 \cdot 0 = -5.2$$

The share of travellers taking the train is computed using the logit model:

$$\frac{e^{V^{train}}}{e^{V^{car}} + e^{V^{train}}} = \frac{e^{-5.2}}{e^{-4.4} + e^{-5.2}} = 0.31$$

The number of travellers taking the train then equals 0.31·1000 =310 travellers

Suppose that a high-speed rail connection is opened such that travellers from city A to city B can travel by a new train service. This new service is not a direct connection, but a transfer in city C is required, as illustrated in the next figure. The travel times (A,C) and (C,B) are both 10 minutes. The high-speed train service from A to C has a frequency of 2 trains per hour (departing each 30 minutes) and the high-speed train service from C to B has a frequency of 4 trains per hour (departing each 15 minutes).



(b) Using the same utility functions and again applying a logit model, what percentage of *train users* will use the high-speed train service?

The average access waiting time now becomes 15 minutes. Similarly, the average transfer waiting time (given that the services are not synchronized) is half the headway and thus equal to 7.5 minutes. The utility to use the high-speed train service is:

$$V^{hs\text{-}train} = -0.12 \cdot 15 - 0.10 \cdot 20 - 0.16 \cdot 7.5 = -5.0$$

The share of train travellers taking the high-speed train is:

$$\frac{e^{V^{hs-train}}}{e^{V^{train}} + e^{V^{hs-train}}} = \frac{e^{-5.0}}{e^{-5.2} + e^{-5.0}} = 0.55$$

Since the train alternatives cannot be seen as independent alternatives, a simple multinomial logit model is not the correct model to apply and may make incorrect forecasts about the modal split between car and train.

(c) How can the model be improved such that the modal split rates between car and train are more accurate?

The two train services can be combined to a new combined (virtual) train service, where the costs of this new train service can be computed using, for instance, the minimum costs, or logit analogy. Then the share of travellers choosing the car alternative and (virtual) train alternative (i.e. the modal split) can be calculated as before, after which the share of train travellers can be distributed over the two train services using a logit model. This corresponds to applying a nested logit model.

Suppose that from a travel survey, a choice model has been estimated for describing the choice between the alternatives car and train. The following systematic (observable) utility functions have been estimated:

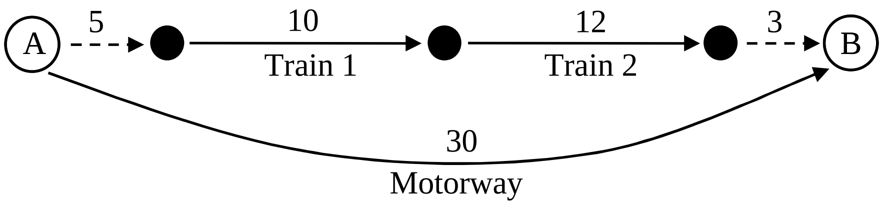
$$V_{car} = 0.6 - 0.12 \cdot TT_{car} - 0.55 \cdot TC_{car}$$
$$V_{train} = -0.10 \cdot TT_{train} - 0.28 \cdot WT_{train} - 0.15 \cdot AET_{train} - 0.55 \cdot TC_{train}$$

where TT is the in-vehicle travel time (in minutes), TC is the travel cost (in euros), WT is the waiting time (in minutes), and AET is the access and egress walking time (in minutes).

(a) What does the mode-specific constant 0.6 represent? And what does this specific value mean from a behavioural point of view?

The mode-specific constant describes the attractiveness of that specific mode, in comparison to the other modes, and includes for example attributes like comfort and status. A positive car-specific constant versus a zero constant for the train means that the car is overall preferred by travellers, all other attributes ignored.

Consider Traveller 1 from city A to city B that has the choice of taking the car or the train. The travel time by car is 30 minutes, with a travel cost of 2.50 euro. There is no direct train connection, so there is a transfer from train service 1 to train service 2. The walking time to the first train station is 5 minutes, while the walking time from the last train station to the final destination is 3 minutes. The first train service has a frequency of 4x per hour, while the second train service has a frequency of 6x per hour. The travel time of the first train is 10 minutes, while the second train takes 12 minutes. The total price for the train ticket is 1.50 euro. We assume that Traveller 1 has no knowledge of the train schedule (time table). The situation is depicted below.



(b) Assuming a multinomial logit model with a scale parameter equal to one, what is the probability that Traveller 1 will take the train? [4]

$TT_{car} = 30$

$TC_{car} = 2.50$

$TT_{train} = 10 + 12 = 22$

$WT_{train} = 7.5 + 5 = 12.5$

$AET_{train} = 5 + 3 = 8$

$TC_{train} = 1.50$

$V_{car} = 0.6 - 0.12 \cdot 30 - 0.55 \cdot 2.50 = -4.375$

$V_{train} = -0.10 \cdot 22 - 0.28 \cdot 12.5 - 0.15 \cdot 8 - 0.55 \cdot 1.50 = -7.725$

$V_{car} = 0.6 - 0.12 \cdot 30 - 0.55 \cdot 2.50 = -4.375$

$$P_{train} = \frac{\exp(-7.725)}{\exp(-7.725) + \exp(-4.375)} = 0.034 = 3.4\%$$

Consider now Traveller 2 from the same household, who knows the schedule (time table) of both train services, in which the second train service is synchronized with the first train service.

(c) Assuming a multinomial logit model with a scale parameter equal to one, what is the probability that Traveller 2 will take the train? [3]

This means that the waiting time for both train services can be assumed to be close to zero, i.e. $WT_{train} = 0$, such that $V_{train} = -4.225$. Hence,

$$P_{train} = \frac{\exp(-4.225)}{\exp(-4.225) + \exp(-4.375)} = 0.537 = 53.7\%$$