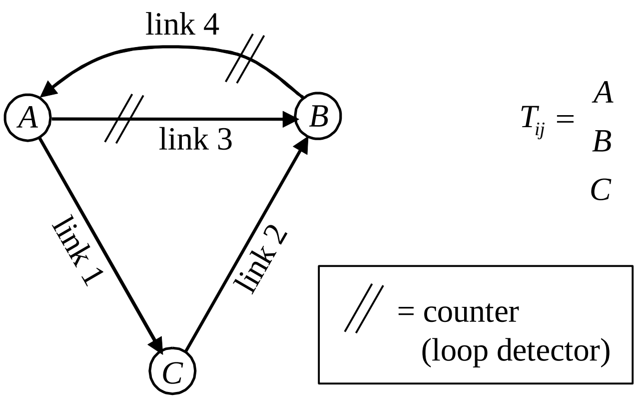
Post lecture questions Modelling in practice 2017

OD-estimation

Consider the network below with three origins and three destinations, A, B, and C. The travel demand is given by the OD trip matrix T_{ij} below.



$$T_{ij} = \begin{array}{c c} & \begin{array}{ccc} A & B & C \end{array} \\ \begin{array}{c} A \\ B \\ C \end{array} & \begin{bmatrix} 0 & 1000 & 140 \\ 400 & 0 & 160 \\ 240 & 200 & 0 \end{bmatrix} \end{array}$$

Furthermore, all links are assumed equal, having link travel times t_a depending on the link flows q_a given by the following function:

$$t_a(q_a) = 1 + \left(\frac{q_a}{400}\right)^2, \qquad a = 1, 2, 3, 4.$$

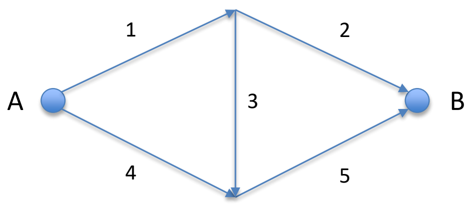
There are two counters in the network, one on link 3 and one on link 4, counting the number of vehicles passing through that link.

(a) Assuming that all travellers are assigned according to a deterministic user equilibrium, how many travellers will be assigned to link 3?

(b) Suppose that the counter on link 4 indicates 1000 passing vehicles. Change the OD trip matrix T_{ij} such that it is consistent with this count.

(c) Suppose that the OD trip matrix is unknown, but that link counts on all links are available. Is it possible to uniquely determine the OD trip matrix using these link counts? Explain your answer.

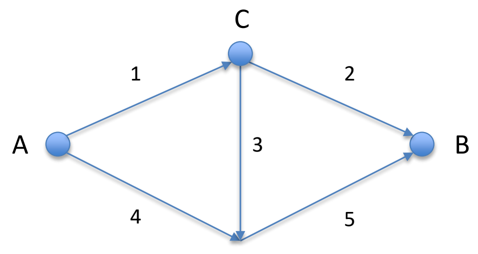
OD-estimation based on counts is not always straightforward. For instance OD-pairs could have different routes. Consider for instance the following network with link numbers:



In this network there is only one OD-pair having 3 routes. Assume there's a limited budget for traffic counts.

(a) Specify the minimum number of counts you would need to determine the flow AB based on counts only in the case that you would allocate them strategically, and in the case if you would randomly assign the counts to the links. Explain your line of reasoning.

In this network a new zone C is added:



(b) Indicate how many counts you would need to determine the 3 flows: AB, AC and CB. Explain your answer.

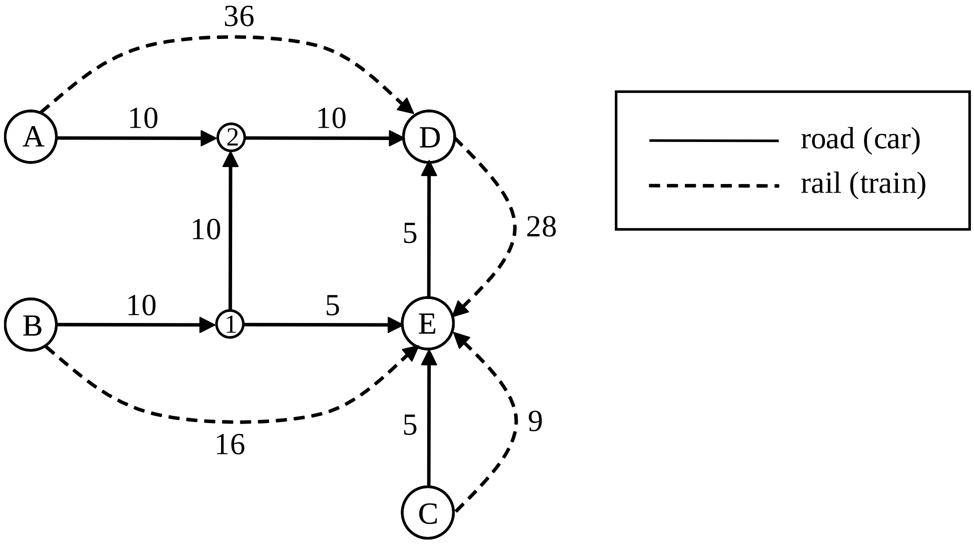
Up until now the uncongested situation was considered. Determining an OD-matrix in congested networks brings in a new perspective.

(c) Explain which issue should be dealt with in case of estimating OD matrices in congested networks, compared to OD-estimation in uncongested networks.

Full 4-stage model

Aggregated modelling approach

Consider a transportation network with infrastructure for two modes: car and train. There are three residential zones (A, B, and C) and two employment zones (D and E). The road and rail segments are indicated as directed links in the following figure. The travel time (in minutes) in uncongested situations is indicated for each link. We only consider unimodal trips, no multimodal trips.



The focus is on the commuters from home to work in the morning peak, hence zones A, B, and C are considered origins and zones D and E are considered destinations.

From a cross-classification model the following relationship between income, number of cars, and the average number of trips made by an individual has been determined:

	low income	high income
0 cars	0.6	1.1
1 or more cars	0.8	1.4

For example, an individual with a low income and no car makes on average 0.6 commuting trips in the morning peak.

The following table provides the number of residents for each of these classes in each of the origin zones A, B, and C:

		low income	high income
Zone A	0 cars	402	120
	1 or more cars	241	60
Zone B	0 cars	30	110
	1 or more cars	40	235
Zone C	0 cars	165	104
	1 or more cars	103	103

For example, there are 402 residents with a low income and no car in zone A.

Using employment data on a zonal level in a regression model, the commuting trip attractions in the morning peak have been determined, yielding 750 and 799 arriving trips in zone D and E, respectively.

The residential data is collected with a higher accuracy than the employment data.

(a) Determine the trip production for origins A, B, and C.

(b) Determine the travel time impedance (skim) matrices for car and train (assuming zero transfer delays for trains).

Assume the following power functions as trip distribution functions for car and train:

$$f(c_{ij}^{\text{car}}) = \frac{60}{c_{ij}^{\text{car}}}, \quad \text{and} \quad f(c_{ij}^{\text{train}}) = \frac{12}{\sqrt{c_{ij}^{\text{train}}}},$$

where c_{ij}^{car} and c_{ij}^{train} are the car and train travel times (in minutes), respectively.

(c) Sketch the two trip distribution functions in one graph. Assuming equal travel times, for which travel times will the car be the preferred mode for the majority of travellers?

(d) Show that the simultaneous trip distribution/modal split based on the doubly constrained gravity model leads to the following car trip matrix:

	D	E
A	300	0
B	150	200
C	120	240

(e) Plot the trip frequency distribution for the car (use four bins, around 5, 10, 15, and 20 minutes travel time).

Assume that all links are uncongested, except for the link from node 1 to the destination node E. The travel time on this link is given by the following function:

$$t(q) = 5 + \frac{q}{30},$$

where t is the travel time (in minutes) and q is the car flow in the morning peak.

(f) Determine all the link flows for cars in a deterministic user equilibrium assignment.

(g) Will the car flow on the link from node 1 to node 2 increase, decrease, or stay the same if the transfer delays for trains are taken into account? Explain your answer.

Disaggregated modelling approach

In a disaggregated approach the choices for individuals are determined by computing the probabilities for each choice alternative given the utilities of the alternatives.

For *trip choice*, let the probability of making an additional trip be given by the following binary logit model,

$$p = \frac{1}{1+\exp(-V)}, \quad \text{with } V = 0.3 + 0.2 \cdot C + 0.005 \cdot I,$$

where V is the utility of a traveller of making an additional trip, C equals 1 if the traveller owns a car and zero otherwise, and I is the traveller's income (in thousands of euros).

(a) Using the stop-repeat model, determine the expected number of trips made by a traveller who owns a car and has an income of 20 thousand euros.

Destination choice and mode choice are assumed to be taken simultaneously and therefore modelled using the following logit model:

$$p_m^d = \frac{\exp(V_m^d)}{\sum_{m'} \sum_{d'} \exp(V_{m'}^{d'})} \text{ (= probability of choosing destination } d \text{ and mode } m\text{)},$$

where the utility of traveling to destination d using mode m is given as

$$V_m^d = 0.01 A^d - 0.05 T_m^d,$$

with A^d the attraction of destination d and T_m^d the travel time (in minutes) needed for traveling to destination d using mode m.

(b) Considering the same car and train network and the same attractions (750 and 799) as in Question 2, how many car trips will be made from zone A to zone D if the trip production from zone A is given by 650 travellers?

Route choice is assumed to be determined by a logit model based on the uncongested route travel times,

$$p_{mr}^{od} = \frac{\exp(V_{mr}^{od})}{\sum_{r'} \exp(V_{mr'}^{od})} \text{ (= probability of choosing route } r\text{)},$$

where the utility of taking route r (for a specific given origin-destination pair od and a specific mode m) is given as

$$V_{mr}^{od} = -0.05 T_{mr}^{od},$$

with T_{mr}^{od} the travel time (in minutes) on route *r* from *o* to *d* with mode *m*.

(c) Considering the same car and train network and the same trip matrix as in Question 2(d), determine the link flows for cars in a stochastic assignment based on the above logit model.

Also the trains can be assigned to the network based on a logit model with a certain utility function for each route/line. In-vehicle travel time could be one of the attributes included in this utility function.

(d) Name two other attributes that could be included in the train utility functions for route/line choice.

LMS/NRM and 4-stage model

In the Dutch national transport model, LMS, some methods and techniques are applied that are different in traditional transport models. For example, LMS considers tours instead of trips. In computing the future origin-destination (OD) matrix, LMS uses the so-called pivot point method. For traffic assignment, QBLOK is used instead of more traditional assignment techniques.

(a) Explain the main advantage of using tours in LMS as opposed to using trips.

(b) Explain how the pivot point method works.

(c) What is a major disadvantage of such a pivot point method?

(d) Explain the main difference between QBLOK and traditional traffic assignment models.

(e) The estimated OD matrix in the LMS model should only be assigned with QBLOK and not with another assignment method. Explain this dependence between the OD matrix and the assignment technique.

A classical transportation model consists of four sub models.

(a) Which are these four sub models? And what travel choices are being modelled in each of these sub models?

In the Dutch transportation models LMS and NRM, two of these sub models have been combined.

(b) Which two sub models have been combined? And give two reasons why these sub models are usually combined.

For each sub model, an aggregate (on a zonal level) or disaggregate (on a household or individual level) approach can be taken.

(c) Name the main advantage and the main disadvantage of the disaggregate approach.

Often, a fifth sub model is added to the four-step model.

(d) What travel choice behaviour does this fifth sub model describe?

The model systems LMS and NRM use tours instead of trips.

(e) What the advantage is of using tours in a model system?