CIE4801 Transportation and spatial modelling

Time of day

Exam question demand modelling

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• Departure time modelling

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  • (Networks)
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  • Mode choice
1. Time of day modelling
Why needed?

- 70’s: Peak hour models only
  - Focus on capacity issues

- 80’s: 24-hour models
  - Focus on environmental issues

- 90’s: Both
  - Models for morning peak, evening peak and 24-hour
  - Rest of the day is 24-MP-EP

- Shifts between periods?
Time of day choice

Zonal data → Trip production / Trip attraction → Trip frequency choice

Transport networks → Trip distribution → Destination choice

Travel resistances → Modal split → Mode choice

-> Period of day → Time choice

Assignment → Route choice

Travel times network loads etc.
To “peak” or “not to peak”

- Choice modelling approach

- Benefit of performing an activity in peak (period $i$) minus the travel costs in the peak
  versus
  Benefit of performing the activity off-peak (period $j$) minus the travel costs off-peak

- Straightforward logit model

- Benefit of performing an activity in period $i$ can be described with an ‘period specific’ constant (which can be equal to 0)
2. **Departure time modelling**
Time of day versus departure time

- Key difference?

- Timescale: periods of say 2 hours or more versus minutes

- Different type of modelling questions:
  - Strategic: time of day
  - Tactical/operational: departure time

- Similarity?

- Choice modelling
  - Differences in utility: travel time plus costs for being early or late
Departure time choice: main concept

\[ V_{ij}(t) = N_j - Z_{ij} - Z_{ij}^c(t) - E_j(t) - L_j(t) \]

observed utility for traveling from \( i \) to \( j \)
utility of the activity at \( j \)
threeel (without congestion)
extra travel time due to congestion
penalty for arriving early
penalty for arriving late

A traveler makes a trade-off between:
• A higher travel time due to congestion
• Penalties for deviating from his preferred arrival time
Departure time choice: example

\[ N_j \]

utility

\[-(Z_{ij} + Z_{ij}^c)\]

peak

time
3.

Brief overview demand modelling
## Overview of approaches for demand modelling

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<thead>
<tr>
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<th>Descriptive</th>
<th>Choice behaviour</th>
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<tr>
<td>Trip generation</td>
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<td>Distribution</td>
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<td>Time of day</td>
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## Overview of approaches for demand modelling

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<th>Descriptive</th>
<th>Choice behaviour</th>
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<tr>
<td>Trip generation</td>
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<td>Cross classification</td>
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<td>Stop &amp; Go</td>
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<td>Distribution</td>
<td>Analogy</td>
<td>Growth factor model</td>
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<td></td>
<td>• Gravity model</td>
<td>Destination choice</td>
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<td>• Entropy model</td>
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<td>Modal split</td>
<td>VF-ratio</td>
<td>Mode choice</td>
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<tr>
<td>Simultaneous distribution modal split</td>
<td>Gravity model $F_y = \sum_v F_{iyv}$</td>
<td>$c_{ij} = \text{logsum}$</td>
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<tr>
<td>Time of day</td>
<td>Fixed shares</td>
<td>TOD choice</td>
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Possible segmentations?

<table>
<thead>
<tr>
<th>Trip generation</th>
<th>Trip purpose</th>
<th>Car ownership</th>
<th>Person characteristics</th>
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<tbody>
<tr>
<td>Distribution</td>
<td>Trip purpose</td>
<td>Mode</td>
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<td>Simultaneous distribution model split</td>
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<td>Time of day</td>
<td>Trip purpose?</td>
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Conclusion: Trip purpose, household and person characteristics (incl. car ownership)
Overview special issues

<table>
<thead>
<tr>
<th>Zones</th>
<th>Cordon model</th>
<th>Study, influence and external area</th>
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<tbody>
<tr>
<td>Network</td>
<td>Connectors</td>
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<td>Trip generation</td>
<td>External zones</td>
<td>Balancing</td>
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<td>Distribution</td>
<td>Intrazonal costs</td>
<td>Through traffic</td>
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<tr>
<td>Modal split</td>
<td>Car ownership</td>
<td>Car occupancy</td>
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<td>Simultaneous distribution model split</td>
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<td>Time of day</td>
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As a starter: Some short questions
Short questions

- What are the submodels in the travel choice model system? And what travel choice is involved in each submodel?

Diagram:

- Trip generation
- Trip distribution
- Modal split
- Period of day
- Assignment

Relationships:

- Trip frequency choice
- Destination choice
- Mode choice
- Time choice
- Route choice
Short questions

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

1. Each route gets a share of 33%

2. Each route gets a share of 33%

(Implausible result due to overlapping alternatives)
Short questions

Consider the following statements concerning (shortest) paths on a network. Are they true or false?

- The number of links in a shortest path tree is always exactly $N-1$ (where $N$ is the number of nodes)  
  \[ \checkmark \]

- The path between any two nodes in a shortest path tree is again a shortest path  
  \[ \times \]

- For each OD Pair there is only a single shortest path  
  \[ \times \]
In a survey, 500 households have been asked the following questions:
- what is the family size?
- what is the household income?
- how many cars are in the household?
- how many trips are made per week?

Which models can be applied for determining the trip production? And how?

1. Regression model
2. Cross-classification model (multiple class analysis)
3. Discrete choice model (stop/repeat logit model)
• Formulate the direct demand model for trip distribution and define its variables.

\[ T_{ij} = \rho Q_i X_j F_{ij} \]

- \( T_{ij} \) = number of trips from \( i \) to \( j \)
- \( \rho \) = measure of average trip intensity
- \( Q_i \) = production potential of zone \( i \)
- \( X_j \) = attraction potential of zone \( j \)
- \( F_{ij} \) = accessibility of zone \( j \) from \( i \)
Short questions

• Suppose a city would like to build more houses in a certain suburb. This implies that more road infrastructure is needed for all residents in that suburb. Which trip distribution model can be best applied for computing the OD trip matrix?

A model based on the gravity model (either origin-based singly constrained or doubly constrained).

Not the growth factor model, since it cannot capture new travel patterns for new residential areas (it is based on historical data).
Short questions

- For transportation planning purposes, two OD matrices have been determined: one for the peak and one for the off-peak. What would happen to these matrices if
  (a) new road infrastructure becomes available?
  (b) more flexible working hours are introduced?

(a) New road infrastructure means less congestion (at least in the short run). Travelers will adapt their departure time towards the peak, such that the number of trips increases in the peak.

(b) People will experience less penalties for arriving early or late, such that they will deviate more from their preferred arrival time and try to avoid the congestion. The number of trips in the peak decreases.
5.1

Exam questions Travel choice behaviour
Chapter 2 – Travel choice behavior

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 \(-0.03Z\), where \(Z\) is the travel time. How much is the difference in travel time?

\[
p_{\text{car}} = \frac{\exp(-0.03Z_{\text{car}})}{\exp(-0.03Z_{\text{car}}) + \exp(-0.03Z_{\text{train}})} = \frac{4}{5}
\]

\[\Rightarrow\]

\[
\exp(-0.03Z_{\text{car}}) = 4 \cdot \exp(-0.03Z_{\text{train}})
\]

\[\Rightarrow\]

\[
\exp(0.03Z_{\text{train}} - 0.03Z_{\text{car}}) = 4
\]

\[\Rightarrow\]

\[
Z_{\text{train}} - Z_{\text{car}} = \frac{\ln(4)}{0.03}
\]
Chapter 2 – Travel choice behavior

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 travelers for the metro system in city X are determined.

Will this future number of travelers be correct, overestimated, or underestimated?

Overestimated, since the survey only consisted of metro users, such that the survey population is not representative.
5.2

*Exam question Networks*
Compute the shortest paths from A to B, C, D, and E.
Chapter 3 – Networks

A 10 22 52 62
B 75 85 87
C 55 47 77
D 65 67 77 102 107
E 33 35 30 40 67

TU Delft
5.3

Exam question Trip generation
Chapter 4 – Trip generation

In disaggregated trip generation models, sometimes the so-called stop/repeat models are used.
(a) How do these models work?
(b) What is the purpose of trip balancing?
(c) How does one balance trips for a whole day?

(a) In each stage, there is a choice to make no more trips or to make extra trips.
(b) The total trip production should equal the total trip attraction.
(c) For each zone, the trip production equals the trip attraction.

Not always correct
5.4

Exam question Trip distribution
Chapter 5 – Trip distribution

Consider two zones with the following data:

<table>
<thead>
<tr>
<th></th>
<th>number of inhabitants</th>
<th>number of jobs</th>
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<tbody>
<tr>
<td>Zone A</td>
<td>1000</td>
<td>300</td>
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<tr>
<td>Zone B</td>
<td>800</td>
<td>200</td>
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</table>

The number of inhabitants has been determined with a higher precision than the number of jobs. On average, the number of departing trips is 0.25 per inhabitant, and the number of arriving trips is 0.8 per job. All the travel resistances (intrazonal and interzonal) may be assumed equal.

Determine the trip distribution.
Chapter 5 – Trip distribution

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<td>120</td>
<td>80</td>
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<td>270</td>
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5.5

Exam questions Mode choice
Chapter 6 – Mode choice models

Consider the following table with distribution values for computing the trip distribution:

<table>
<thead>
<tr>
<th></th>
<th>A</th>
<th>B</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>car</td>
<td>PT</td>
<td>car</td>
</tr>
<tr>
<td>A</td>
<td>67</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>B</td>
<td>19</td>
<td>0.7</td>
<td>67</td>
</tr>
<tr>
<td>C</td>
<td>26</td>
<td>7</td>
<td>7</td>
</tr>
</tbody>
</table>

The mode-specific values of the trip distribution function have been generated from: $F_{ijv} = c \cdot \exp(-t_{ijv})$

(a) What is the PT share on the relation A-C when computing the doubly constrained simultaneous modal split / distribution?

(b) What is the PT share when performing a sequential trip distribution and modal split, using a logit model for the modal split based on travel times with scale parameter 2?
Chapter 6 – Mode choice models

(a) The PT share remains 7/(7+26) = 21%, even after scaling.

(b) The modal split share can be computed by

\[ p_{pt} = \frac{\exp(-2t_{pt})}{\exp(-2t_{pt}) + \exp(-2t_{car})} \]

We know

\[
\begin{align*}
F_{pt} &= c \cdot \exp(-t_{pt}) = 7 \\
F_{car} &= c \cdot \exp(-t_{car}) = 26
\end{align*}
\]

\[
\begin{align*}
\exp(-2t_{pt}) &= (7/c)^2 \\
\exp(-2t_{car}) &= (26/c)^2
\end{align*}
\]

\[
p_{pt} = \frac{(7/c)^2}{(7/c)^2 + (26/c)^2} = 6.7%\]
Chapter 6 – Mode choice models

In the sequential trip distribution / modal split computation, you have to specify the travel resistance per OD pair in order to compute the distribution. If for a certain OD pair more mode alternatives are available, characterized by their own travel resistances $c_{ijv}$, how would you express the general (combined) travel resistance $c_{ij}$ for this OD pair? Motivate your answer.

If there is a large overlap between the alternatives:

$$c_{ij} = \min_v \{c_{ijv}\}$$

If there is hardly any overlap:

$$c_{ij} = -\frac{1}{\alpha} \ln \sum_v \exp(-\alpha c_{ijv})$$
Chapter 6 – Mode choice models

For a certain OD pair there are two mode alternatives, car and bike. Travelers are assumed to consider two attributes: costs and travel time (see table below)

<table>
<thead>
<tr>
<th></th>
<th>costs $c_i$ (€)</th>
<th>travel time $t_i$ (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>car</td>
<td>2,00</td>
<td>10</td>
</tr>
<tr>
<td>bike</td>
<td>0,10</td>
<td>30</td>
</tr>
</tbody>
</table>

Travelers are assumed to maximize their utility given by $V_i = -(\alpha t_i + c_i)$ where $\alpha$ is the value of time (VOT).

(a) What value should $\alpha$ at least be for the car to be the preferred alternative?

(b) If there is also a bus connection available with travel time 20 min., what is the maximum price the bus should charge? Assume the VOT is the same as computed in (a).
Chapter 6 – Mode choice models

(a) \[ V_{\text{car}} = -(\alpha t_{\text{car}} + c_{\text{car}}) = -10\alpha - 2 \]
\[ V_{\text{bike}} = -(\alpha t_{\text{bike}} + c_{\text{bike}}) = -30\alpha - 0.1 \]

The car will be used if \( V_{\text{car}} \geq V_{\text{bike}} \)
\[ \Rightarrow -10\alpha - 2 \geq -30\alpha - 0.1 \]
\[ \Rightarrow 20\alpha \geq 1.9 \]
\[ \Rightarrow \alpha \geq 0.095 \ (€/\text{min}) \]

(b) \[ V_{\text{car}} = V_{\text{bike}} = -2.95 \]
\[ V_{\text{bus}} = -(\alpha t_{\text{bus}} + c_{\text{bus}}) = -0.095 \cdot 20 - c_{\text{bus}} = -1.9 - c_{\text{bus}} \]

The bus is an attractive alternative if \( V_{\text{bus}} \geq -2.95 \)
\[ \Rightarrow -1.9 - c_{\text{bus}} \geq -2.95 \]
\[ \Rightarrow c_{\text{bus}} \leq 1.05 \ (€) \]