Trip distribution

What is trip distribution?
- Predict the spatial patterns of people's trip making behavior
- Connecting between productions and attractions — creating flows between different zones

Terminology
- Friction factor: it is a function of the "travel time/cost" (impedance) between production and attraction; the longer the travel time, the smaller the friction factor
- Gravity model: adapted from Newton's law of gravity. The number of trips between production and attraction depends on their relative attractiveness and the travel time
- K-factors: used to account for individual zonal variation that is not accounted for in the gravity model
- Skim table: matrix showing impedances between pairs of zones
- P-A table: matrix showing the number of trips between an production zone and an attraction zone

Gravity model
- Gravity requires forecasted productions and attractions and
- Skim table between zones
Gravity model

- Law of gravity: the amount of gravitational force between two bodies is a function of the masses of the bodies and the distance between them
- In trip distribution, we have:
  - “distance” in broad terms: can be travel time, travel cost, or a combination of them
  - Relative attractiveness instead of body masses

Friction factors

- Get them from graphs/lookup tables
- Calculate them from equations

<table>
<thead>
<tr>
<th>Friction factor type</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exponential</td>
<td>$f(d_{ij}) = e^{-d_{ij}^c}, c &gt; 0$</td>
</tr>
<tr>
<td>Inverse power</td>
<td>$f(d_{ij}) = d_{ij}^a, a &gt; 0$</td>
</tr>
<tr>
<td>Gamma (combined)</td>
<td>$f(d_{ij}) = d_{ij}^a e^{-d_{ij}^c}, a &gt; 0, c &gt; 0$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Travel estimation techniques for Gamma functions (NCHRP 363)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trip purpose</td>
</tr>
<tr>
<td>HNV</td>
</tr>
<tr>
<td>HNO</td>
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<tr>
<td>NIH</td>
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</tbody>
</table>

Friction factor: it is a function of the “travel time/cost” (impedance) between production and attraction; the longer the travel time, the smaller the friction factor.
Gravity model equation

\[ \text{Trips} = \text{Production} \times \frac{\text{Attractions}}{\sum \text{Attractions}} \times K_{ij} \]

where,

- \( \text{Trips} \) = trips between TAZs i and j,
- \( \text{Production} \) = productions from TAZs i,
- \( \text{Attractions} \) = attractions from TAZs i and j,
- \( K_{ij} \) = socio-economic adjustment factor for TAZs i and j.

Example problem

<table>
<thead>
<tr>
<th>TAZ</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4</td>
<td>12</td>
<td>8</td>
<td>15</td>
<td>21</td>
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<tr>
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<tr>
<td>5</td>
<td>24</td>
<td>10</td>
<td>22</td>
<td>15</td>
<td></td>
</tr>
</tbody>
</table>

Travel time distance matrix (min)

<table>
<thead>
<tr>
<th>Distance</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distance</td>
<td>45</td>
<td>29</td>
<td>27</td>
<td>28</td>
<td>24</td>
<td>22</td>
<td>18</td>
</tr>
</tbody>
</table>

Example problem (cont’d)

Gravity model equation

\[ \text{Trips} = \text{Production} \times \frac{\text{Attractions}}{\sum \text{Attractions}} \times K_{ij} \]

where,

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- \( \text{Production} \) = productions from TAZs i,
- \( \text{Attractions} \) = attractions from TAZs i and j,
- \( K_{ij} \) = socio-economic adjustment factor for TAZs i and j.
Travel time matrix = friction factors

K factors

- K factors are calibrated after the friction factors/parameters have been calibrated. They are computed as the ratio between observed values and values produced by estimated friction factors. This allows the calibrated gravity model to exactly replicate the base year P.A. matrix.

How do we obtain the travel time matrix?

- Cold start vs. Warm start

- Well, the generation of friction factors requires a travel time matrix.
Question

Two zones (zone 1 and zone 2) produce identical number of trips, yet they are characteristically different: the average age of zone 1 is about 25 years old while the average age of zone 2 is about 58 years old.
• Do you think the destination choices of people in zone 1 are the same as those in zone 2 if all else are equal?
• What would be the results from the gravity model?

Question

Two zones (zone 1 and zone 2) attract identical number of trips, yet they are characteristically different: zone 1 is a large hospital and zone 2 is a commercial zone.
• Do you think zone 1 and zone 2 attract the same number of the trips from the same zones if all else are equal?
• What would be the results from the gravity model?

Question

• Can the gravity model be used to estimate the effects on destination choices resulted from:
  – A change in the land use?
  – Congestion pricing?
  – A change in parking pricing?
• How well does gravity model address the different destination choices made by people of different socio-demographic characteristics in the same zone?