Topic 8 (Part I)
Transportation Planning
(Chapters 11, 12)
Role of Transportation Planning

- Evaluation and selection of highway and transit projects to serve present and future land uses (traffic demands).
- Travel demand forecasting establishes the basis for planned projects.
The 4-Step Process

- **Trip Generation**
  - How many trips are generated by a land use plan

- **Trip Distribution**
  - Where do the trips come and go?

- **Mode Choice**
  - How many are vehicle trips, transit trips, and bike/pedestrian trips

- **Traffic Assignment**
  - Which routes do these trips take?
Trip Generation

- **Types of trips**
  - Home-based: work (HBW), and other (HBO)
  - Non-home-based (NHB)

- **Each trip has two ends:** origin and destination

- **Trip ends are classified into Production and Attraction**
  - Production – the home end of HBW, HBO; the origin of NHB
  - Attraction – the non-home end of HBW, HBO; the destination of NHB

- **Trip generation is to calculate trip ends**
What is the total number of trips?

What are the number of productions and attractions for each zone?

What are the number of origins and destinations for each zone?

What are the types of the trips?
ITE Trip Generation Method

- Estimate trip ends based on land use type
- Primarily vehicle trips
- Mainly for traffic impact studies
- Regression models and average rates
  - Regression - >=20 points with $R^2 > 0.75$
Shopping Center (820)

Average Vehicle Trip Ends vs: 1000 Sq. Feet Gross Leasable Area
On a: Weekday

Number of Studies: 302
Average 1000 Sq. Feet GLA: 328
Directional Distribution: 50% entering, 50% exiting

Trip Generation per 1000 Sq. Feet Gross Leasable Area

<table>
<thead>
<tr>
<th>Average Rate</th>
<th>Range of Rates</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>42.94</td>
<td>12.50 - 270.89</td>
<td>21.38</td>
</tr>
</tbody>
</table>

Data Plot and Equation

Fitted Curve Equation: \( \ln(T) = 0.65 \ln(X) + 5.83 \)
\( R^2 = 0.78 \)
Shopping Center
(820)

Average Vehicle Trip Ends vs: 1000 Sq. Feet Gross Leasable Area
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 7 and 9 a.m.

Number of Studies: 98
Average 1000 Sq. Feet GLA: 287
Directional Distribution: 61% entering, 39% exiting

Trip Generation per 1000 Sq. Feet Gross Leasable Area

<table>
<thead>
<tr>
<th>Average Rate</th>
<th>Range of Rates</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.03</td>
<td>0.10 - 9.05</td>
<td>1.40</td>
</tr>
</tbody>
</table>

Data Plot and Equation

Fitted Curve Equation: \( \ln(T) = 0.60 \ln(X) + 2.29 \)
\( R^2 = 0.52 \)
Shopping Center (820)

Average Vehicle Trip Ends vs: 1000 Sq. Feet Gross Leasable Area
On a: Weekday,
Peak Hour of Adjacent Street Traffic,
One Hour Between 4 and 6 p.m.

Number of Studies: 407
Average 1000 Sq. Feet GLA: 379
Directional Distribution: 48% entering, 52% exiting

Trip Generation per 1000 Sq. Feet Gross Leasable Area

<table>
<thead>
<tr>
<th>Average Rate</th>
<th>Range of Rates</th>
<th>Standard Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.75</td>
<td>0.66 - 29.27</td>
<td>2.75</td>
</tr>
</tbody>
</table>

Data Plot and Equation

Fitted Curve Equation: \( \ln(T) = 0.56 \ln(X) + 3.40 \)

\( R^2 = 0.81 \)
Example

Estimate the average daily trips generated by a 5400 s.f. shopping center. What would be the origins and destinations? What would be the productions and attractions if 70% of the trips are generated from homes?
Trip Distribution

Gravity Model

\[ T_{ij} = P_i \left[ \frac{A_{jk}F_{ij}K_{ij}}{\sum_j A_{jk}F_{ij}K_{ij}} \right] \]

- \( T_{ij} \) – trips produced by Zone \( i \) and attracted by Zone \( j \)
- \( F_{ij} \) – an inverse function of travel time (friction factor)
- \( k_{ij} \) – socioeconomic factor (not counted by travel time)
### Example 12.4

#### Trip Productions and Attractions

<table>
<thead>
<tr>
<th>Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>3</td>
<td>Total</td>
</tr>
<tr>
<td>Productions</td>
<td>140</td>
<td>330</td>
<td>280</td>
<td>750</td>
</tr>
<tr>
<td>Attractions</td>
<td>300</td>
<td>270</td>
<td>180</td>
<td>750</td>
</tr>
</tbody>
</table>

#### Travel Time Between Zones (min)

<table>
<thead>
<tr>
<th>Zone</th>
<th>Time (min)</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5</td>
<td>82</td>
</tr>
<tr>
<td>2</td>
<td>2</td>
<td>52</td>
</tr>
<tr>
<td>3</td>
<td>3</td>
<td>50</td>
</tr>
</tbody>
</table>

#### Travel Time vs. F-factor

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>82</td>
</tr>
<tr>
<td>2</td>
<td>52</td>
</tr>
<tr>
<td>3</td>
<td>50</td>
</tr>
<tr>
<td>4</td>
<td>41</td>
</tr>
<tr>
<td>5</td>
<td>39</td>
</tr>
<tr>
<td>6</td>
<td>26</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>13</td>
</tr>
</tbody>
</table>
Example (continued)

- Step 1: Determine $F_{ij}$ (assume $K_{ij} = 1$ if not given)

<table>
<thead>
<tr>
<th>Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39</td>
<td>52</td>
<td>50</td>
</tr>
<tr>
<td>2</td>
<td>52</td>
<td>26</td>
<td>26</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Example (continued)

**Step 2: Determine** \( T_{ij} \)

\[
T_{1-1} = 140 \left[ \frac{300 \times 39}{300 \times 39 + 270 \times 52 + 180 \times 50} \right] = 47
\]

**Zone-to-zone Trips: First Iteration**

<table>
<thead>
<tr>
<th>Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>47</td>
<td>57</td>
<td>36</td>
<td>140</td>
</tr>
<tr>
<td>2</td>
<td>188</td>
<td>85</td>
<td>57</td>
<td>330</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>( C_{jki} )</td>
<td>379</td>
<td>210</td>
<td>161</td>
<td>750</td>
</tr>
<tr>
<td>Given ( A_i )</td>
<td>300</td>
<td>270</td>
<td>180</td>
<td>750</td>
</tr>
</tbody>
</table>

\[
A_{jk} = \frac{A_j}{C_{j(k-1)}}
\]

\[
T_{ij} = P_i \left[ \sum_j \frac{A_{jk} F_{ij} K_{ij}}{A_{j(k-1)}} \right]
\]

\[
A_{j1} = A_j
\]
Example (continued)

- **Step 3: Second Iteration …..**

  - **Calculate** $A_{jk}$ (adjusted attraction factor)
    
    $A_{jk} = \frac{A_j}{C_{j(k-1)}} A_{j(k-1)}$

    - $k = 2$
    - $C_{jk}$ is actual attraction from iteration $k$
    - $A_{j1} = A_j$

  - **Apply Gravity Model Using the Adjusted $A_{jk}$**

    $$T_{ijk} = P_i \left[ \frac{\sum_j A_{jk} F_{ij} K_{ij}}{\sum_j A_{jk} F_{ij} K_{ij}} \right]$$
Example (continued)

\[ A_{jk} = \frac{A_j}{C_{j(k-1)}} A_{j(k-1)} \]

\[ A_{12} = \frac{300}{379} \times 300 = 237 \]

\[ A_{22} = \frac{270}{210} \times 270 = 347 \]

\[ A_{32} = \frac{?}{?} \times ? = 201 \]
Example (continued)

\[ T_{ijk} = P_i \left[ \frac{A_{jk} F_{ij} K_{ij}}{\sum_j A_{jk} F_{ij} K_{ij}} \right] \]

\[ T^{(1-1),2} = 140 \left[ \frac{237 \times 39}{237 \times 39 + 347 \times 52 + 201 \times 50} \right] = 34 \]

Zone-to-zone Trips: Second Iteration

<table>
<thead>
<tr>
<th>Zone</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>34</td>
<td>68</td>
<td>38</td>
<td>140</td>
</tr>
<tr>
<td>2</td>
<td>153</td>
<td>112</td>
<td>65</td>
<td>330</td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C_{jk}</td>
<td>303</td>
<td>268</td>
<td>179</td>
<td>750</td>
</tr>
<tr>
<td>A_{i}</td>
<td>300</td>
<td>270</td>
<td>180</td>
<td>750</td>
</tr>
</tbody>
</table>