Introducing MoPeD 2.0: A Model of Pedestrian Demand, Integrated with Trip-Based Travel Demand Forecasting Models

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30 April 2014  5th Innovations in Travel Modeling Conference
Outline

• Introduction and Background
• Current and Proposed Method
• Trip Generation
  – Pedestrian Analysis Zones (PAZ)
• Walk Mode Split
  – Pedestrian Index of the Environment (PIE)
  – Model Estimation
• Considerations and Future Work
• Many large MPO models (63%) forecast walking and/or “non-motorized” travel

• Recent trends
  – Activity-based surveys and models
  – Pedestrian environment data
  – Smaller or sub-TAZs
  – Walk & bike route choice

• Motivating uses
  – Evaluate mode shifts away from automobile travel
  – Calculate greenhouse gas emissions
  – Pedestrian planning and demand estimation

Literature Review

• What environmental factors appear to influence the choice to walk?
  – Residential and employment density
  – Land use mix/diversity
  – (Pedestrian) network connectivity
  – Accessibility to transit

• Challenge: many associated environmental factors are spatially correlated

Source:
Current Method

TAZ = transportation analysis zone

Trip Generation (TAZ) → Trip Distribution or Destination Choice (TAZ) → Mode Choice (TAZ) → Trip Assignment

- All Person Trips
- Pedestrian Trips
- Vehicular Trips

Background -- Method -- PIE -- Estimation -- Conclusion
New Method

Trip Generation (PAZ)

Walk Mode Split (PAZ)

Destination Choice (PAZ)

Pedestrian Trips

Trip Distribution or Destination Choice (TAZ)

Mode Choice (TAZ)

Trip Assignment

TAZ = transportation analysis zone
PAZ = pedestrian analysis zone

All Person Trips
Pedestrian Trips
Vehicular Trips
Trip Generation

• Use existing Trip Generation processes with the same trip purposes
  – e.g., trip production rates by HH size & workers

• Apply at a scale that is more sensitive to pedestrian environments
  – “Pedestrian Analysis Zones” (PAZs)

• May require disaggregation of joint distributions of HH characteristics
Walk Mode Split

• Pedestrian trip ends vs. vehicular (auto, transit, bike) trip ends

• Binary logit regression

\[ P(\text{walk}) = f(\text{household characteristics, pedestrian environment}) \]

• Estimate using trips, apply to PAZs

• Oregon Household Activity Survey (OHAS)
  – 4,500 walking (only) trips in Portland region
Pedestrian Index of the Environment

• PIE Scores range 20 to 100
• Weighted sum of 6 Context Tool dimensions, each scored 1 to 5:
  – People density, transit access, ULI\(^1\) density, block size, sidewalk density, and comfortable facilities
• Correlated with other BE measures:
  – Household ($\rho = 0.76$), employment ($\rho = 0.63$), and sidewalk ($\rho = 0.83$) densities

\(^1\) ULI = Urban Living Infrastructure: shopping and service destinations used in daily life.
Visualizing PIE

100 – Downtown core

80 – Major neighborhood centers

Background -- Method -- PIE -- Estimation -- Conclusion
Visualizing PIE

70 – Suburban downtowns

60 – Residential inner-city neighborhoods
Visualizing PIE

50 – Suburban shopping malls

40 – Suburban neighborhoods/subdivisions
Visualizing PIE

30 – Isolated business and light industry

20 – Rural, undeveloped, forested
Model Estimation

• Binary logit (logistic) regression
• OHAS 90% estimation sample (N = 50,271)
• Segmented by trip purpose:
  – Home-based work (HBW)
  – Home-based other (HBO)
  – Non-home based (NHB)
## Summary of Results

<table>
<thead>
<tr>
<th>Model</th>
<th>Walk</th>
<th>Pseudo $R^2$</th>
<th>+1 PIE  →</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBW</td>
<td>3.1%</td>
<td>0.15</td>
<td>+3.6% in walk likelihood</td>
</tr>
<tr>
<td>HBO</td>
<td>9.4%</td>
<td>0.14</td>
<td>+4.4% in walk likelihood</td>
</tr>
<tr>
<td>NHB</td>
<td>8.9%</td>
<td>0.25</td>
<td>+5.3% in walk likelihood</td>
</tr>
</tbody>
</table>

Considerations

• Scalability
  – Trip generation equations
  – Data collection and processing

• Forecasting
  – How to generate household/job forecasts to PAZs or allocate from TAZs?
  – Many options for forecasting PIE

• Operations
  – Computational processing power and time
Future Work

• Further development of method:
  ① Trip distribution / destination choice
  ② Not routing, but “potential pedestrian paths” through PAZs
    – Opportunities for a stand-alone ped. tool
    – Test method in other regions

• PIE refinements and verification:
  – Compare to other walkability measures
  – Assess transferability, alternate constructions

Questions?

Project report is available online: http://otrec.us/project/510

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Bonus Slides
What are PAZs?

• Many options:
  – Raster grid cells; nested sub-TAZs; or parcels
• 264 feet by 264 feet raster grid cells
  – $1/20^{th}$ mile ≈ 1 minute walk (3 mph)
  – 1.5 million in four-county region
• Scale is more sensitive to walking environments and variations in land use

Travel(er) Data

• Oregon Household Activity Survey (OHAS)
• Portland region dataset (2011)
  – 6,100 households; 13,400 people
  – 56,000 trips (linked/full)
  – 4,500 walking (only) trips
• Personal characteristics limited to household variables in Metro model:
  – Size, income, age, workers, children, autos
Pedestrian Environment

- “Pedestrian Index of the Environment” (PIE)

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Weight</th>
<th>Dimension</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>People density</td>
<td>4.615</td>
<td>Block size</td>
<td>3.086</td>
</tr>
<tr>
<td>Transit access</td>
<td>3.529</td>
<td>Sidewalk density</td>
<td>2.842</td>
</tr>
<tr>
<td>ULI(^1) density</td>
<td>3.120</td>
<td>Bicycle access</td>
<td>2.808</td>
</tr>
</tbody>
</table>

## HBW Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sign</th>
<th>Variable</th>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of Household Head, 0 - 24</td>
<td>+</td>
<td>Number of Vehicles, 0</td>
<td>+</td>
</tr>
<tr>
<td>Age of Household Head, 55 - 64</td>
<td>+</td>
<td>Number of Vehicles, 2</td>
<td>-</td>
</tr>
<tr>
<td>Household Size, 3</td>
<td>+</td>
<td>Number of Vehicles, 3+</td>
<td>-</td>
</tr>
<tr>
<td>Number of Children, 2</td>
<td>+</td>
<td>Pedestrian Index of Environment</td>
<td>+</td>
</tr>
<tr>
<td>Number of Children, 3+</td>
<td>+</td>
<td>Constant</td>
<td>-</td>
</tr>
<tr>
<td>Household Income, $25K - $35K</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

275 Walk Trip Ends / 8,917 = 3.08%

Pseudo R² = 0.151

+1 point on PIE scale → +3.6% in walk likelihood
## HBO Model

<table>
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<th>Sign</th>
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</thead>
<tbody>
<tr>
<td>Age of Household Head, 55 - 64</td>
<td>-</td>
<td>Number of Vehicles, 2</td>
<td>-</td>
</tr>
<tr>
<td>Household Size, 2</td>
<td>+</td>
<td>Number of Vehicles, 3+</td>
<td>-</td>
</tr>
<tr>
<td>Number of Workers, 1</td>
<td>+</td>
<td>Freeway Miles w/in Eighth Mile</td>
<td>-</td>
</tr>
<tr>
<td>Number of Workers, 2</td>
<td>+</td>
<td>Pedestrian Index of Environment</td>
<td>+</td>
</tr>
<tr>
<td>Number of Children, 1</td>
<td>+</td>
<td>Home-Based Shopping Trip</td>
<td>-</td>
</tr>
<tr>
<td>Number of Children, 2</td>
<td>+</td>
<td>Home-Based Recreation Trip</td>
<td>+</td>
</tr>
<tr>
<td>Number of Children, 3+</td>
<td>+</td>
<td>Home-Based School Trip</td>
<td>+</td>
</tr>
<tr>
<td>Number of Vehicles, 0</td>
<td>+</td>
<td>Constant</td>
<td>-</td>
</tr>
</tbody>
</table>

2,490 Walk Trip Ends / 26,450 = 9.41%

Pseudo $R^2 = 0.137$

+1 point on PIE scale $\Rightarrow$ +4.4% in walk likelihood
# NHB Model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sign</th>
<th>Variable</th>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of Household Head, 55 - 64</td>
<td>-</td>
<td>Number of Vehicles, 3+</td>
<td>-</td>
</tr>
<tr>
<td>Age of Household Head, 65 - 98</td>
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<td>Pedestrian Index of Environment</td>
<td>+</td>
</tr>
<tr>
<td>Household Income, $75K+</td>
<td>+</td>
<td>Non-Home-Based Non-Work Trip</td>
<td>-</td>
</tr>
<tr>
<td>Number of Vehicles, 0</td>
<td>+</td>
<td>Constant</td>
<td>-</td>
</tr>
<tr>
<td>Number of Vehicles, 2</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\text{1,329 Walk Trip Ends / 14,904} = 8.92\%
\]

\[
Pseudo R^2 = 0.253
\]

+1 point on PIE scale $\rightarrow$ +5.3\% in walk likelihood