Representing Walking in Trip-Based Travel Demand Forecasting Models

~~ A Proposed Framework ~~

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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
Overview

• Partner with Metro on research grant
  – “Improving the representation of the pedestrian environment in travel demand models”

• Motivating uses
  – Evaluate policy-sensitive mode shifts away from automobile travel
  – Calculate greenhouse gas emissions
    • Oregon SB 1059, HB 2001
  – Utilize archived walking and environmental data for pedestrian planning
State of the Practice

• Most large MPO models (62%) forecast walking and/or “non-motorized” travel

• Recent trends
  – Activity-based surveys and models
  – Pedestrian environment data
    • e.g., sidewalk networks
  – Smaller or sub-TAZs for some aspects
  – Walk & bike network assignment/route choice
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
Current Method (Metro)

TAZ = transportation analysis zone

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

Pedestrian Trips

All Person Trips  Pedestrian Trips  Other Mode Trips
Proposed Method

A. Trip Generation (PAZ)

B. Walk Mode Split (PAZ)

C. Trip Distribution (PAZ)

Pedestrian Trips

Destination Choice (TAZ)

Mode Choice (TAZ)

Trip Assignment

TAZ = transportation analysis zone
PAZ = pedestrian analysis zone

All Person Trips
Pedestrian Trips
Other Mode Trips

Background -- Method -- PIE -- Estimation -- Conclusion
Trip Generation

• Use Metro’s existing Trip Generation processes for the same 8 trip purposes
  – Trip production rates by HH size and workers

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

- From Metro’s Context Tool
  - [https://gis.oregonmetro.gov/cistool/](https://gis.oregonmetro.gov/cistool/)
- 264 feet by 264 feet raster grid cells
  - $\frac{1}{20}$ mile $\approx$ 1 minute walk (3 mph)
- 1.5 million in four-county region
- Scale is more sensitive to walking environments and variations in land use
Trip Generation Outputs

PAZ Home-Based Work Productions

PAZ:
HB Work

- 0 (trips/PAZ)
- 0 - 1
- 1 - 2.5
- 2.5 - 5
- 5 - 10
- 10 - 25
- 25 - 50
- 50 - 100
- 100 - 250
- 250 - 500
- 500 - 1000
- 1000 - 2500
- 2500 - 5000
- 5000 - 10000

Scale: 0 0.25 0.5 1 1.5 2 Miles
Walk Mode Split

- Pedestrian vs. non-pedestrian trip ends
- Binary logit (logistic) regression

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

- Estimate using trips, apply to PAZs
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)
  - Scores range 20 to 100
  - Weighted sum of 6 Context Tool dimensions, each scored 1 to 5:

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>People density</td>
<td>4.615</td>
</tr>
<tr>
<td>Transit access</td>
<td>3.529</td>
</tr>
<tr>
<td>ULI(^1) density</td>
<td>3.120</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Block size</td>
<td>3.086</td>
</tr>
<tr>
<td>Sidewalk density</td>
<td>2.842</td>
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<tr>
<td>Bicycle access</td>
<td>2.808</td>
</tr>
</tbody>
</table>

What is PIE?

• “Reason for travel” (people density) weighted highest of all dimensions
• Correlated with walking ($\rho = 0.26$)
• Highly correlated with other “direct” measures of the built environment:
  – Household density ($\rho = 0.76$)
  – Employment density ($\rho = 0.63$)
  – Sidewalk density ($\rho = 0.83$)
Visualizing PIE

100 – Downtown core (Portland Downtown)

80 – Major neighborhood centers (Hollywood, Lloyd District)
Visualizing PIE

70 – Suburban downtowns (Beaverton, Gresham, Hillsboro)

60 – Residential inner-city neighborhoods (Brooklyn, Laurelhurst)
Visualizing PIE

50 – Suburban shopping malls (Clackamas Town Center)

40 – Suburban neighborhoods/subdivisions (Aloha, Metzger)
Visualizing PIE

30 – Isolated business and light industry (Marine Drive)

20 – Rural, undeveloped, forested (Forest Park, Damascus)
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)
## 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 $R^2 = 0.151$

+1 point on PIE scale $\rightarrow$ +3.6% in walk likelihood
HBO Model

<table>
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<tr>
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<th>Variable</th>
<th>Sign</th>
</tr>
</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>
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<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>
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<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 R² = 0.137

+1 point on PIE scale → +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>
<td>-</td>
<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>

1,329 Walk Trip Ends / 14,904 = 8.92%  
Pseudo R² = 0.253

+1 point on PIE scale \(\Rightarrow\) +5.3% in walk likelihood
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
Possible Future Work

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

• Further development of method:
  C Trip distribution / destination choice
  D Not routing, but “potential pedestrian paths” through PAZs
  – Opportunities to develop a stand-alone pedestrian planning tool
  – Test method in other regions
Project report will be available online:

http://otrec.us/project/510

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