A Framework For Integrating Pedestrians into Travel Demand Models

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Portland, Oregon, USA

Region
Population ~ 2.4 M
Urban Growth Boundary
Only elected regional government in US

Population ~ 640k
Area ~ 376 km²
Density ~ 1,689/km²
My Research Group

Travel behavior & built environment
- Residential Location
- Active travel
- Planning applications & modelling tools
- Behavioral theory
- Equity
- Assessing transport impacts of new development
- Data collection methods

http://kellyjclifton.com
A Framework For Integrating Pedestrians into Travel Demand Models

- Policy & planning context
- Experiences in modeling pedestrians
  - MoPeD – Model of Pedestrian Demand
- What is on the horizon?
  - Behavioral research
  - Data & models
- Next steps
POLICY & PLANNING CONTEXT
Pedestrian modeling outputs

Direct transportation outputs
- Walk trips generated
- Walk trips with origins & destinations
- Walk trips with “routes”

Distances walked
→ Pedestrian miles traveled (PMT)

Minutes of walking
→ Physical activity levels (METs)

Classified by...
- Geographic location
- Personal characteristics (socio-demographics)
Why model pedestrians?

- Pedestrian investments
- Mode shifts
- Greenhouse gas emissions
- Health & safety
- Transit access/egress
- New research opportunities
How do travel models estimate walking?

Among 48 large MPOs in US:

- 38% did not estimate walking
- 33% estimated non-motorized (walking + bicycling) travel
- 29% estimated walking

Lacking pedestrian built environment measures & small spatial units

Trip-based model sequence

1. Generation
2. Distribution
3. Mode choice
4. Assignment

## Pedestrian modeling applications

<table>
<thead>
<tr>
<th>Application</th>
<th>Currently</th>
<th>Future interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project prioritization</td>
<td>61% (14)</td>
<td>78% (18)</td>
</tr>
<tr>
<td>Scenario planning</td>
<td>43% (10)</td>
<td>65% (15)</td>
</tr>
<tr>
<td>Corridor planning</td>
<td>43% (10)</td>
<td>61% (14)</td>
</tr>
<tr>
<td>Traffic safety analysis</td>
<td>35% (8)</td>
<td>57% (13)</td>
</tr>
<tr>
<td>Health impact assessment</td>
<td>35% (8)</td>
<td>57% (13)</td>
</tr>
<tr>
<td>Infrastructure gap analysis</td>
<td>30% (7)</td>
<td>57% (13)</td>
</tr>
</tbody>
</table>
Incorporating pedestrians

Adapted from: Wegener and Fürst, 1999
Incorporating pedestrians

Adapted from: Wegener and Fürst, 1999
EXPERIENCES IN MODELING PEDESTRIANS - MoPeD
Project overview

• 12 years of research/development in modeling pedestrian demand

• Early work funded by Maryland DOT
  – Pedestrian risk exposure

• Recent research projects funded by NITC and Portland Metro
  – Improve representation of pedestrians in current 4-step method
  – Develop stand alone tool
  – Transferability & forecasting of built environment measures
New MoPeD method

1. Trip Generation (PAZ)
2. Walk Mode Split (PAZ)
3. 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 Trips  Pedestrian Trips  Vehicular Trips
Contributions

• Nests within current structure but can be used alone
• Pedestrian scale analysis (PAZs)
• Pedestrian-relevant variables (PIE)
• One of the first studies to examine pedestrian destination choice in demand modeling framework
• Highlights policy relevant variables: distance, size, pedestrian supports & barriers
Pedestrian analysis zones

264 feet = 80 m ≈ 1 minute walk

Metro: ~2,000 TAZs → ~1.5 million PAZs

Home-based work trip productions
Pedestrian environment

Pedestrian Index of the Environment (PIE)

20–100 score = calibrated $\sum$(6 dimensions)

ULI = Urban Living Infrastructure: pedestrian-friendly shopping and service destinations used in daily life.
Trip Generation

1. Trip Generation (PAZ)
   - Walk Mode Split (PAZ)
   - Destination Choice (PAZ)

2. Trip Distribution or Destination Choice (TAZ)
   - Mode Choice (TAZ)
   - Trip Assignment

All Trips

Pedestrian Trips

Vehicular Trips

TAZ = transportation analysis zone
PAZ = pedestrian analysis zone
Metro currently has 8 trip production models applied to ~2,000 TAZs:

- HBW – Home-based work;
- HBshop – Home-based shopping;
- HBrec – Home-based recreation;
- HBoth – Home-based other (excludes school and college);
- NHBW – Non-home-based work;
- NHBNW – Non-home-based non-work;
- HBcoll – Home-based college; and
- HBsch – Home-based school.

After testing for scalability, we applied the same models to our pedestrian scale ~1.5M PAZs
Walk mode split

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 Trips  Pedestrian Trips  Vehicular Trips
Walk mode split

Probability of walking:

\[ \text{Prob(walk)} = f(\text{traveler characteristics, PIE}) \]

**Data:**
- 2011 OHAS, Production trip ends,
- 90% sample

**Method:**
- Binary logit model

**Spatial unit:**
- Pedestrian analysis zone (PAZ)
Walk mode split models

Traveler characteristics:
Household size, income, age, # of workers, # children, # vehicles

Built environment:
PIE
Walk model application
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 Trips

Pedestrian Trips

Vehicular Trips
1. Aggregate PAZs to superPAZs

2. Apply destination choice model

3. Allocate trips from each superPAZ to PAZs
Destination choice

\[ \text{Prob}(\text{dest.}) = \text{function of...} \]

- network distance, \(-\text{size} / \# \text{ of destinations}\)
- pedestrian environment, traveler characteristics

**Data:** 2011 OHAS

**Method:** multinomial logit model

**Spatial unit:** super-pedestrian analysis zone

Six trip types:

- **home-based:**
  - work (HBW)
  - shopping (HBS)
  - recreation (HBR)
  - other (HBO)

- **non-home-based:**
  - work (NHBW)
  - non-work (NHBNW)
Destination Choice
Model Validation – % Correct Destination

<table>
<thead>
<tr>
<th>Destination</th>
<th>Correct Destination</th>
</tr>
</thead>
<tbody>
<tr>
<td>HBW</td>
<td>54%</td>
</tr>
<tr>
<td>HBS</td>
<td>75%</td>
</tr>
<tr>
<td>HBR</td>
<td>38%</td>
</tr>
<tr>
<td>HBO</td>
<td>53%</td>
</tr>
<tr>
<td>NHBW</td>
<td>55%</td>
</tr>
<tr>
<td>NHBNW</td>
<td>53%</td>
</tr>
</tbody>
</table>
Model Validation – Avg. Distance Walked

- HBW: Correct 0.75, Modeled 0.55
- HBS: Correct 0.57, Modeled 0.47
- HBR: Correct 0.53, Modeled 0.14
- HBO: Correct 0.51, Modeled 0.29
- NHBW: Correct 0.38, Modeled 0.19
- NHBNW: Correct 0.41, Modeled 0.16

Distance walked, mean, in miles
ON THE HORIZON

Behavioral research/data/methods

Adapted from: Wegener and Fürst, 1999
Behavioral research

Decision sequencing: activity, mode, destination; mode, destination, activity; destination, activity, mode

Destination choice considerations
– choice set generation

Willingness to walk

Path/route choice considerations
Behavioral Research

Built environment
- Thresholds & nonlinearities
- Mixing
- Scale

Lifestyle questions:
- Vehicle ownership & residential location
- Attitudes, motivations & values

Positive Utility of Travel
- What aspects?
- Diminishing returns?

Mode feedbacks to trip generation
Spatial/Temporal Scale

• How much detail do we need?
• Depends on output needed for policy/research
• Capture variations in the pedestrian built & natural environment
• Spatial accuracy
• Theory/Behavior
Trip distance & scale

- **Tract**: 1.2 mi
- **Block Group**: 0.7 mi
- **TAZ**: 0.6 mi
- **PAZ**: 0.05 mi

![Graph showing observed walk trip distances](chart.png)
Walking Behavior

• Passive data sources
  – Trip-level information
  – Multi-day
  – Multi-modal
  – Destinations
  – Routes & speeds

• But also need...
  – Motivations & considerations
  – Barriers
  – Trips not made
Built environment

- How & what to represent?
- Indices, proxies
- Forecasting


Networks

• Network representation
• How do we attribute networks?
• Feedbacks of travel costs

**Networks**

- **Network representation**
- **How do we attribute networks?**
- **Feedbacks of travel costs**

**Table:**

<table>
<thead>
<tr>
<th>Actual route</th>
<th>Measurement area</th>
<th>Origin/destination</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</tbody>
</table>

**Legend:**

- **Zone-based:** Aggregate built environment into irregular zones around trip origin and destination (may not cover entire trip).
- **Buffer:** Aggregate built environment into circular or network-based polygon buffers around trip origin and destination (may not cover entire trip).
- **Route:** Measure built environment around or along shortest path or actual (reported) path (shortest path may not correspond to actual path; reported path may not correspond to actual path for all modes).

Broach, J. P. (2016). *Travel mode choice framework incorporating realistic bike and walk routes* (Order No. 10061477). Available from Dissertations & Theses @ Portland State University; ProQuest Dissertations & Theses Global.
Network assignment?
Validation

• Set aside estimation sample
• Compare to intersection counts
• Transferability: Evaluate the performance of models in many different communities
• Compare the performance of several different types of models in the same study area
• Have practitioners and advocates carefully review predicted volumes against their local knowledge
Link to Health Outcomes

- Health impact analysis
- Total time spent walking + speeds
- Physical activity budgets
- Crash risk exposure
- Pollutant exposure
- Feedback into life expectancy

Conclusions

- Tools for pedestrian (& bicycle) demand have matured
- Still lag behind motorized modes in sophistication and application
- Expanding list of policy issues
- More information & data
- Plenty of research questions!
Questions?

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Project info & reports:
http://trec.pdx.edu/research/project/510
http://trec.pdx.edu/research/project/677

