Estimating Use of Non-Motorized Infrastructure: Models of Bicycle and Pedestrian Traffic in Minneapolis, MN

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Issue

• Transportation managers lack data about use of bicycle and pedestrian facilities.

• Federal, state, & local governments and nonprofits spending billions on new facilities.

• Need information & tools to plan, manage, evaluate, and optimize investments in facilities.
Objective

Goal: Develop estimates of non-motorized traffic for all streets in Minneapolis.

So what? → Evaluate infrastructure use and exposure to hazards (i.e., crashes, air pollution).
Approach

Summarize bike/ped counts from multiple agencies/non-profits.

Normalize to standard time periods.

Develop regression models to predict bike/ped volumes.
Non-motorized traffic counts
Minneapolis, MN

<table>
<thead>
<tr>
<th>Count Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Method of observation</strong></td>
</tr>
<tr>
<td>Manual</td>
</tr>
<tr>
<td><strong>Traffic observed</strong></td>
</tr>
<tr>
<td>Cyclist - separate</td>
</tr>
<tr>
<td>Pedestrian - separate</td>
</tr>
<tr>
<td><strong>Locations in Minneapolis</strong></td>
</tr>
<tr>
<td>On/off-street bike facilities and no bike facilities</td>
</tr>
<tr>
<td>(n=259)</td>
</tr>
<tr>
<td><strong>Period of observation</strong></td>
</tr>
<tr>
<td>2007-2010</td>
</tr>
<tr>
<td><strong>Number of observations</strong></td>
</tr>
<tr>
<td>436</td>
</tr>
<tr>
<td><strong>Length of observations</strong></td>
</tr>
<tr>
<td>12-hour (n=43)</td>
</tr>
<tr>
<td>2-hour peak period (n=352)</td>
</tr>
<tr>
<td>Other</td>
</tr>
<tr>
<td><strong>Limitations</strong></td>
</tr>
<tr>
<td>Human error</td>
</tr>
</tbody>
</table>
Counts by road/facility type

<table>
<thead>
<tr>
<th>Type of Street / Facility</th>
<th>Daily Auto Traffic Volume</th>
<th>% all count locations</th>
<th>% of count location type with bike facilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Principal Arterial</td>
<td>15,000 - 100,000</td>
<td>1%</td>
<td>0%</td>
</tr>
<tr>
<td>Minor Arterial</td>
<td>5,000 - 30,000</td>
<td>42%</td>
<td>25%</td>
</tr>
<tr>
<td>Collector</td>
<td>1,000 - 15,000</td>
<td>18%</td>
<td>20%</td>
</tr>
<tr>
<td>Local</td>
<td>&lt; 1,000</td>
<td>24%</td>
<td>18%</td>
</tr>
<tr>
<td>Off-street trail</td>
<td>0</td>
<td>15%</td>
<td>100%</td>
</tr>
</tbody>
</table>
Daily patterns in non-motorized traffic (n=43)
### Scaling factors for “daily” traffic

<table>
<thead>
<tr>
<th>Time period</th>
<th>Bicycle</th>
<th></th>
<th></th>
<th>Pedestrian</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Percent of 12-hour count</td>
<td>Scale factor</td>
<td>$R^2$</td>
<td>Percent of 12-hour count</td>
<td>Scale factor</td>
<td>$R^2$</td>
</tr>
<tr>
<td>7-8am</td>
<td>7.5%</td>
<td>13.2</td>
<td>0.88</td>
<td>6.9%</td>
<td>14.5</td>
<td>0.91</td>
</tr>
<tr>
<td>8-9am</td>
<td>9.3%</td>
<td>10.7</td>
<td>0.90</td>
<td>5.3%</td>
<td>18.7</td>
<td>0.96</td>
</tr>
<tr>
<td>9-10am</td>
<td>7.8%</td>
<td>12.9</td>
<td>0.89</td>
<td>6.1%</td>
<td>16.4</td>
<td>0.97</td>
</tr>
<tr>
<td>10-11am</td>
<td>6.4%</td>
<td>15.6</td>
<td>0.89</td>
<td>5.9%</td>
<td>16.8</td>
<td>0.96</td>
</tr>
<tr>
<td>11-noon</td>
<td>5.9%</td>
<td>16.9</td>
<td>0.87</td>
<td>9.2%</td>
<td>10.9</td>
<td>0.99</td>
</tr>
<tr>
<td>noon-1pm</td>
<td>5.2%</td>
<td>19.1</td>
<td>0.77</td>
<td>9.7%</td>
<td>10.3</td>
<td>0.99</td>
</tr>
<tr>
<td>1-2pm</td>
<td>7.2%</td>
<td>14.0</td>
<td>0.88</td>
<td>8.7%</td>
<td>11.5</td>
<td>0.99</td>
</tr>
<tr>
<td>2-3pm</td>
<td>7.5%</td>
<td>13.3</td>
<td>0.84</td>
<td>8.8%</td>
<td>11.4</td>
<td>0.98</td>
</tr>
<tr>
<td>3-4pm</td>
<td>9.3%</td>
<td>10.8</td>
<td>0.90</td>
<td>7.8%</td>
<td>12.8</td>
<td>0.98</td>
</tr>
<tr>
<td>4-5pm</td>
<td>12.0%</td>
<td>8.4</td>
<td>0.93</td>
<td>10.4%</td>
<td>9.6</td>
<td>0.97</td>
</tr>
<tr>
<td>5-6pm</td>
<td>12.6%</td>
<td>7.9</td>
<td>0.89</td>
<td>12.3%</td>
<td>8.2</td>
<td>0.996</td>
</tr>
</tbody>
</table>

Example:

Multiplying 4-5 pm traffic by 8.4 yields 12-hour traffic volume.
Estimated vs. actual 12-hour volumes

- 4-6pm
- 4-5pm
- 5-6pm

5-6 pm
y = 1.1135x - 16.747
R^2 = 0.8907

4-6 pm
y = 1.012x + 2.1606
R^2 = 0.9249

4-5 pm
y = 0.905x + 22.065
R^2 = 0.925
Regression models

Goal 1: Explore correlates of non-motorized traffic.
Goal 2: Estimate bike/ped traffic on all streets in Minneapolis.

Model 1: Negative Binomial
Model 2: Ordinary least squares

Compare models
Independent variables

**Neighborhood SES**
- Percent white
- Age
- HH income
- Percent w/ college degree
- Crime

**Neighborhood built environment**
- Population density
- Land use mix
- Distance to water
- Distance to CBD
- Employment access (by transit)

**Weather**
- Max daily temp
- Precipitation

**Road type**
- Arterial
- Collector
- Local
- Off-street

**Bike facility**
- On-street facility

**Temporal**
- Year of count
## Regression results

### Bicycle models

| OLS | • % college (+)  
• HH income (-)  
• Distance to CBD (-)  
• Precipitation (-)  
• Arterial (+)  
• Off-street (+)  
• Year (+)  
• NB | • % non-white (+)  
• % college (+)  
• HH income (-)  
• LU mix (+)  
• Distance to CBD (-)  
• Precipitation (-)  
• Arterial (+)  
• On/Off-street (+)  
• Year (+) |

### Pedestrian models

| OLS | • Crime (+)  
• LU Mix (-)  
• Employment (+)  
• Precipitation (-)  
• Arterial (+)  
• Collector (+)  
• NB | • % non-white (+)  
• % college (+)  
• Distance to water (-)  
• Distance to CBD (-)  
• Precipitation (-)  
• Arterial (+)  
• Collector (+) |
Model validation

- Bicycle: OLS
  - Actual count
  - Model prediction

- Pedestrian: OLS
  - Actual count
  - Model prediction

- Bicycle: Negative Binomial
  - Actual count
  - Model prediction

- Pedestrian: Negative Binomial
  - Actual count
  - Model prediction
Estimated 12-hour bicycle traffic
Estimated 12-hour pedestrian traffic
Implications for counting and modeling non-motorized traffic

Core conclusions:
1. Bicycle traffic is associated with facilities and increasing over time (pedestrian traffic is not increasing).
2. Negative binomial over OLS.

Key limitations:
1. Data is largely peak-hour weekdays in September.
2. Limited information on within-location variability.
Thank you.

Questions?