5-1-2015

Travel Decisions & Their Implications for Urban Transportation: From Campus Transportation to Statewide Modeling

Gulsah Akar
Ohio State University - Main Campus

Let us know how access to this document benefits you.

Follow this and additional works at: http://pdxscholar.library.pdx.edu/trec_seminar

Part of the Transportation Commons, and the Urban Studies and Planning Commons

Recommended Citation
Akar, Gulsah, "Travel Decisions & Their Implications for Urban Transportation: From Campus Transportation to Statewide Modeling" (2015). TREC Friday Seminar Series. 16.
http://pdxscholar.library.pdx.edu/trec_seminar/16

This Book is brought to you for free and open access. It has been accepted for inclusion in TREC Friday Seminar Series by an authorized administrator of PDXScholar. For more information, please contact pdxscholar@pdx.edu.
TRANSPORTATION CHOICES & THEIR IMPLICATIONS

From Campus Transportation to Statewide Modeling

Gulsah Akar, PhD
Assistant Professor
The Ohio State University

Seminar
Portland State University
May 1st, 2015
Bio

• The Ohio State University (OSU)
  • 2009-2010 Visiting Assistant Professor
  • 2010- present, Assistant Professor,
  • 2013- present, Master’s Program Chair

• University of Maryland (UMD) Civil Engineering
  • PhD 2009, with a focus in Transportation

• METU Civil Engineering
  • BS 2002, MSc 2004
Today’s Talk

- Research focus
- Detailed discussion on
  - Campus transportation related research
  - Integrated land-use transportation models
- Ongoing work
Research Overview

- Travel demand forecasting
- Travel behavior
- Links between land-use & transportation

Special focus:
- Modeling travel behavior, travel choices & individuals’ perceptions.
- Forecasting future transportation patterns under changing socio-economic, land-use & built environment scenarios.
- Use of the latest methodological & conceptual advances.
Various Applications & Publications

- VMT (vehicle miles traveled) estimations with a focus on household vehicle fleet characteristics
- Traffic accident analysis
- Demand assessment for alternative modes for airport ground access
- Design & use of visual preference surveys to identify preferable street characteristics
- Siting future work facilities and their impacts on workers’ transportation patterns
- Campus transportation
- Integrated land-use transportation models
Various Applications & Publications

- VMT (vehicle miles traveled) estimations with a focus on household vehicle fleet characteristics
- Traffic accident analysis
- Demand assessment for alternative modes for airport ground access
- Design & use of visual preference surveys to identify preferable street characteristics
- Siting future work facilities and their impacts on workers’ transportation patterns

- **Campus transportation**
  - 5 published journal articles, 1 under review and 8 conference presentations.

- **Integrated land-use transportation models**
  - 2 funded research grants through ODOT, 1 journal article, 2 under review
CAMPUS TRANSPORTATION
Campuses
General Trends Extend to Campuses

• Auto travel (particularly single occupancy vehicle travel) is high and dominates the road design, financial policies and mode choice.

• Several experience congestion particularly during peak hours on campus roads and off-campus roads close to campus.

• Growing enrollments, growing parking demand.

• Although there is increasing awareness, still limited sources for alternative travel modes.

  • Congestion
  • Reduced air quality
  • Costly parking
  • Reduced quality of life
  • Reduced physical activity
Why Focus on Campuses?

• There is an increasing interest among colleges and universities to
  • reduce local congestion,
  • reduce contributions to greenhouse gases,
  • provide leadership in sustainable development.

• Campus setting differs from the other urban areas
  • unique population with younger and more active individuals,
  • continuous movement of people throughout the day
  • irregular schedules.

• Reshaping society’s transportation patterns.
  • The behavior adopted in college years can disseminate to the whole nation.
Campus Travel Surveys

University of Maryland, 2008
The Ohio State University, 2010-14


M. Namgung and G. Akar (2015) "Influences of Neighborhood Characteristics and Personal Attitudes on University Commuters’ Public Transit Use, accepted, Transportation Research Record (TRR)
Background

• Early research identifies travel time and cost as the most important determinants of mode choice.

• Long line of research on land-use and travel behavior (sometimes ambiguous):
  • Employment density, population density, and land-use mix are positively related to transit, biking and walking, and negatively related to auto use.

• Effects of individuals’ attitudes toward travel time, cost, comfort, convenience, reliability, and safety have been the focus of several studies within the past decade.

• Causality: whether the built environment determines travel behavior or whether the reverse is true.
  • Residential self-selection. If individuals’ attitudes influence how they choose their residential locations, the effects of altering the built environment - density and land-use - may be overstated and overestimated.
Research Questions

1) Do attitudes toward public transit affect public transit use? If so, how do attitudes affect people’s transit use?

2) Does the built environment affect public transit use? If so, how does the built environment influence people’s transit use?

3) Do the attitudinal factors, neighborhood types or a combination of both explain the resulting transit use better?

4) Is there evidence of residential-self selection effects?
Conceptual Framework

Travel Behavior (Transit Use)

Socio-demographics
- Age
- Education
- Employment Status
- Household Size
- Income
- Car ownership

Attitudes
- Travel Cost
- Travel Time
- Congestion
- Access to bus information
- Weather
- Accessibility
- Safety
- Car dependent
- Intent to reduce car use

Neighborhood Characteristics
- Land use
- Density
- Diversity
- Design
The Ohio State University (OSU)

OSU’s main campus in Columbus, Ohio is one of the area’s largest employers generating a large amount of traffic in the area. ~80,000 people attend/work at OSU.

- Campus Area Bus Service (CABS)
- The Central Ohio Transit Authority’s (COTA)

**Commute mode: Transit**

- OSU (2012): 16%
- Portland State University (2011): 39%
- University of North Texas (2012): 25%
- Indiana University (2012): 29%
Data Collection

- Data collection started on May 3, 2012 and ended on May 19, 2012.

- Web-based survey available via two sources:
  - Collector 1
    - Emails sent by the research team to a randomly selected sample
      - Sent to 21,500 email addresses - ~25% of the campus pop.
      - 2,643 responses
  - Collector 2
    - Links available to the public: university e-newsletters
      - 642 responses

- A total of 3,285 respondents began the survey and 2,638 respondents completed the survey.
Survey questions

- Commute mode choices
- Residential locations

- Socio-demographic characteristics:
  - Status (undergraduate student, graduate student, faculty, staff)
  - Gender
  - Ethnicity
  - Car ownership

- Attitudes towards driving and taking public transit including reliability, safety, flexibility, convenience, accessibility and comfort
## Transit choice of off-campus residents

Transit user: an individual uses public transit at least once a week for their commute.

<table>
<thead>
<tr>
<th></th>
<th>Transit User (%)</th>
<th>Non-Transit User (%)</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faculty</td>
<td>15.6%</td>
<td>84.4%</td>
<td>186</td>
</tr>
<tr>
<td>Staff</td>
<td>10.6%</td>
<td>89.4%</td>
<td>781</td>
</tr>
<tr>
<td>Graduate Student</td>
<td>40.2%</td>
<td>59.8%</td>
<td>301</td>
</tr>
<tr>
<td>Undergraduate Student</td>
<td><strong>58.7%</strong></td>
<td>41.3%</td>
<td>688</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than a mile</td>
<td><strong>44.9%</strong></td>
<td>55.1%</td>
<td>425</td>
</tr>
<tr>
<td>1 to 5 miles</td>
<td><strong>44.4%</strong></td>
<td>55.6%</td>
<td>685</td>
</tr>
<tr>
<td>6 to 10 miles</td>
<td>23.5%</td>
<td><strong>76.5%</strong></td>
<td>425</td>
</tr>
<tr>
<td>11 to 15 miles</td>
<td>19.4%</td>
<td><strong>80.6%</strong></td>
<td>392</td>
</tr>
<tr>
<td>More than 16 miles</td>
<td>19.3%</td>
<td><strong>80.7%</strong></td>
<td>388</td>
</tr>
<tr>
<td><strong>Bus stop</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 to 5 minutes</td>
<td><strong>45.0%</strong></td>
<td>55.0%</td>
<td>797</td>
</tr>
<tr>
<td>6 to 10 minutes</td>
<td>38.4%</td>
<td>61.6%</td>
<td>315</td>
</tr>
<tr>
<td>11 to 15 minutes</td>
<td>27.3%</td>
<td>72.7%</td>
<td>154</td>
</tr>
<tr>
<td>16 to 20 minutes</td>
<td>19.3%</td>
<td>80.7%</td>
<td>57</td>
</tr>
<tr>
<td>Over 20 minutes</td>
<td>20.6%</td>
<td>79.4%</td>
<td>248</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>32.0%</td>
<td>68.0%</td>
<td>1,159</td>
</tr>
<tr>
<td>Male</td>
<td>33.1%</td>
<td>66.9%</td>
<td>794</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>32.2%</strong></td>
<td><strong>67.8%</strong></td>
<td>2,320</td>
</tr>
</tbody>
</table>
Research Design

**Step 1**
Attitudes

- New Attitudinal Components
  - Analysis of Effects of New Attitudinal Components on Transit Use

**Step 2**
Land Use & Built Environment Characteristics

- New Neighborhood Types
  - Analysis of Effects of New Neighborhood Types on Transit Use

**Step 3**
Effects of New Attitudinal Components & New Neighborhood Types on Transit Use
Step 1
Attitudes

New Attitudinal Components

Analysis of Effects of New Attitudinal Components on Transit Use

Step 2
Land Use & Built Environment Characteristics

New Neighborhood Types

Analysis of Effects of New Neighborhood Types on Transit Use

Step 3
Effects of New Attitudinal Components & New Neighborhood Types on Transit Use
1. I often make other trips during my commute to campus.
2. I often change my daily travel plans.
3. Transferring buses does not bother me.
4. Saving travel time is more important than saving money.
5. Taking the bus lengthens my commute.
6. Even if gas prices and parking costs go up, I would use my auto as a commuting mode.
7. Taking the bus gives me the opportunity to save money.
8. If the buses come often enough, I would use the bus more often.
9. If the buses arrive on time, I would use the bus more often.
10. I enjoy driving alone.
11. The bus routes and scheduling information are accurate.
12. Transit service is available where I live.
13. I feel safe at bus stops/on the bus.
14. If the buses were not overcrowded, I would use public transit more often.
15. Buses are clean enough.
16. Where I choose to live is affected by transit service availability.
17. I know where to access bus schedules and route information.
18. It is not a hassle to search for transit related information.
19. I feel more comfortable in my auto than on the buses.
20. I read books or do other stuff on the bus.
21. I enjoy interacting with others on the bus.
22. Traffic congestion is more tolerable than bus delays.
23. Driving on the congested roadway is very stressful.
24. Traffic congestion is not so bad on/around campus.
25. Driving in traffic congestion is more stressful than waiting for the bus or bus transfers.
26. I prefer transit to avoid the stress from finding a parking spot.
27. During the period of heavy snow or rain, I prefer transit over driving.
28. I enjoy spending my time on the bus reading or listening to music.
29. Regardless of adverse environment impacts, I prefer driving.
30. I see transit as an environmentally friendly travel option.
31. I am actively trying to use my car less often.
32. I have no interest in reducing my car use.
33. My friends usually take public transit.
34. My family usually takes public transit.
35. My co-workers usually take public transit.
36. I don't have a car or I don't use one to come to campus.
37. My lifestyle is dependent on having a car.
38. I don't think about my travel options; I just get in my car and go.
39. I have no other option but to drive to campus.
40. Shorter commute time is important in mode choice.
41. More flexibility in when I depart from campus is important in mode choice.
42. The ability to make stops on the way to and from campus is important in mode choice.
43. Safety from crime is important in mode choice.
44. Safety in traffic is important in mode choice.
45. Extreme weather conditions is an important consideration in mode choice.
46. Cost is important in mode choice.
47. Concern for the environment is important in mode choice.
23 attitudinal statements

1. I don't think about my travel options; I just get in my car and go
2. I have no interest in reducing my car use
3. I enjoy driving alone
4. Regardless of adverse environment impacts, I prefer driving
5. If the buses come often enough, I would use the bus more often
6. If the buses arrive on time, I would use the bus more often
7. If the buses were not overcrowded, I would use public transit more often
8. I often make other trips during my commute to campus
9. I often change my daily travel plans
10. Saving travel time is more important than saving money
11. Taking the bus lengthens my commute
12. My friends usually take public transit
13. My family usually takes public transit
14. My co-workers usually take public transit
15. I read books or do other stuff on the bus
16. I enjoy spending my time on the bus reading or listening to music
17. Transit service is available where I live
18. I know where to access bus schedules and route information
19. It is not a hassle to search for transit related information
20. Driving on the congested roadway is very stressful
21. Driving in traffic congestion is more stressful than waiting for the bus or bus transfers
22. Safety from crime is important in mode choice
23. Safety in traffic is important in mode choice
Results of the PCA

• I don't think about my travel options; I just get in my car and go
• I have no interest in reducing my car use
• I enjoy driving alone
• Regardless of adverse environment impacts, I prefer driving

PC 1: Preference of car use

• If the buses come often enough, I would use the bus more often
• If the buses arrive on time, I would use the bus more often
• If the buses were not overcrowded, I would use public transit more often

PC 2: Willingness to use transit

• I often make other trips during my commute to campus
• I often change my daily travel plans
• Saving travel time is more important than saving money
• Taking the bus lengthens my commute

PC 3: Need for flexibility/ sensitivity to time

• My friends usually take public transit
• My family usually takes public transit
• My co-workers usually take public transit

PC 4: Transit use around a traveler

• I read books or do other stuff on the bus
• I enjoy spending my time on the bus reading or listening to music

PC 5: Ability to rest or read

• Transit service is available where I live
• I know where to access bus schedules and route information
• It is not a hassle to search for transit related information

PC 6: Perceived availability of transit service/ familiarity with bus information access

• Driving on the congested roadway is very stressful
• Driving in traffic congestion is more stressful than waiting for the bus or bus transfers

PC 7: Sensitivity to congestion

• Safety from crime is important in mode choice
• Safety in traffic is important in mode choice

PC 8: Sensitivity to safety
Model Specification – Binary Logit

- The probability of being a transit user for traveler $n$ is given by the following:

$$P_n(i) = \Pr(U_n(i) \geq U_n(j))$$

Where, $U$ is the utility of the given alternative, and $i$ and $j$ are alternatives in the choice set for traveler $n$.

- $U_n(i)$ represents the utility of being a transit user for traveler $n$. There are two alternatives, $i$ and $j$ in this study: $i$ is being a transit user, $j$ is otherwise.

$$U_n(i) = \beta_i x_{ni} + \epsilon_{ni}$$

where, $U_n(i)$ and $U_n(j)$ are utility functions. $x_{ni}$ is observed variables that relates to the individual, $\beta_i$ is a vector of coefficients, and $\epsilon_{ni}$ is the random error term.

- Binary logit function can be written as follows:

$$P_n(i) = \frac{1}{1 + e^{\beta(x_{nj} - x_{ni})}}$$
## Model results

### Base case: being a non-transit user

<table>
<thead>
<tr>
<th>Variable</th>
<th>Model 1</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef.</td>
<td>z stat.</td>
<td>Marginal Effect</td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.583</td>
<td>1.31</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Socioeconomic variables (undergraduate student is the base case)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faculty</td>
<td>-1.833</td>
<td>-3.58</td>
<td>-42.1</td>
<td></td>
</tr>
<tr>
<td>Staff</td>
<td>-2.238</td>
<td>-7.18</td>
<td>-48.4</td>
<td></td>
</tr>
<tr>
<td>Graduate student</td>
<td>-1.261</td>
<td>-3.99</td>
<td>-30.5</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>0.329</td>
<td>1.44</td>
<td>7.1</td>
<td></td>
</tr>
<tr>
<td>Ethnicity (non_white)</td>
<td>0.361</td>
<td>1.19</td>
<td>7.7</td>
<td></td>
</tr>
<tr>
<td><strong>Service</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bus stops (within 0.25 miles)</td>
<td>-0.245</td>
<td>-0.65</td>
<td>-5.8</td>
<td></td>
</tr>
<tr>
<td><strong>Locations (1-5 miles is the base case)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than a mile</td>
<td>-0.903</td>
<td>-2.89</td>
<td>-33.9</td>
<td></td>
</tr>
<tr>
<td>6 miles to 10 miles</td>
<td>0.114</td>
<td>0.35</td>
<td>2.6</td>
<td></td>
</tr>
<tr>
<td>11 miles to 15 miles</td>
<td>0.393</td>
<td>0.96</td>
<td>8.3</td>
<td></td>
</tr>
<tr>
<td>More than 15 miles</td>
<td>-0.419</td>
<td>-0.76</td>
<td>-10.0</td>
<td></td>
</tr>
<tr>
<td><strong>Principal Components</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC 1: Preference of car use</td>
<td>-0.199</td>
<td>-2.20</td>
<td>-5.7</td>
<td></td>
</tr>
<tr>
<td>PC 2: Willingness of transit use</td>
<td>0.275</td>
<td>3.10</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td>PC 3: Need for flexibility/ Sensitivity to time</td>
<td>-0.284</td>
<td>-3.15</td>
<td>-9.5</td>
<td></td>
</tr>
<tr>
<td>PC 4: Transit use around a traveler</td>
<td>0.165</td>
<td>1.98</td>
<td>5.0</td>
<td></td>
</tr>
<tr>
<td>PC 5: Ability to rest or read</td>
<td>0.293</td>
<td>3.29</td>
<td>8.3</td>
<td></td>
</tr>
<tr>
<td>PC 6: Perceived availability of transit service/ familiarity with bus</td>
<td>0.126</td>
<td>1.32</td>
<td>3.5</td>
<td></td>
</tr>
<tr>
<td>information access</td>
<td>0.137</td>
<td>1.41</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>PC 7: Sensitivity to congestion</td>
<td>-0.215</td>
<td>-2.19</td>
<td>-7.7</td>
<td></td>
</tr>
<tr>
<td>PC 8: Sensitivity to safety</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number of observations (N)</strong></td>
<td>533</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Initial Log likelihood</strong></td>
<td>-359.4324</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Final Log likelihood</strong></td>
<td>-265.95233</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bolded coefficients are significant at the 95% level and italicized coefficients are significant at the 90% level. For marginal effects, the probability of being a transit user is calculated at means for continuous variables and at zero for dummy variables. The probability of being a transit user at means is 64.5%.
Step 1
Attitudes

New Attitudinal Components

Analysis of Effects of New Attitudinal Components on Transit Use

Step 3
Effects of New Attitudinal Components & New Neighborhood Types on Transit Use

Step 2
Land Use & Built Environment Characteristics

New Neighborhood Types

Analysis of Effects of New Neighborhood Types on Transit Use
Study Area
Built Environment Variables

- Population Density
- Employment Density
- Housing Density
- Median Age of Structures
- Percentage of Single Family Housing
- Intersection Density

K-means Cluster Analysis
## Results of the Cluster Analysis

<table>
<thead>
<tr>
<th>Variables</th>
<th>Cluster 1</th>
<th>Cluster 2</th>
<th>Cluster 3</th>
<th>Cluster 4</th>
<th>Cluster 5</th>
<th>Cluster 6</th>
<th>Cluster 7</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population Density (persons/sq. mi)</td>
<td>11488.5</td>
<td>7785.4</td>
<td>4529.7</td>
<td>3213.8</td>
<td>2052.6</td>
<td>1857.7</td>
<td>284.1</td>
<td>2301.2</td>
</tr>
<tr>
<td>SD</td>
<td>7014.6</td>
<td>1692.8</td>
<td>890.5</td>
<td>3761.8</td>
<td>710.5</td>
<td>1386.7</td>
<td>322.9</td>
<td>2892.1</td>
</tr>
<tr>
<td>Employment Density (persons/sq. mi)</td>
<td>9898.3</td>
<td>2450.6</td>
<td>1403.0</td>
<td>31323.7</td>
<td>983.6</td>
<td>5114.0</td>
<td>244.5</td>
<td>2341.6</td>
</tr>
<tr>
<td>SD</td>
<td>3706.3</td>
<td>1767.9</td>
<td>879.0</td>
<td>2925.8</td>
<td>731.0</td>
<td>2009.6</td>
<td>405.9</td>
<td>5934.6</td>
</tr>
<tr>
<td>Housing Density (house/sq. mi)</td>
<td>5207.9</td>
<td>3481.1</td>
<td>1738.3</td>
<td>1651.2</td>
<td>900.3</td>
<td>1301.0</td>
<td>192.6</td>
<td>1042.7</td>
</tr>
<tr>
<td>SD</td>
<td>2103.2</td>
<td>1222.0</td>
<td>787.4</td>
<td>893.1</td>
<td>560.1</td>
<td>930.0</td>
<td>232.9</td>
<td>1269.4</td>
</tr>
<tr>
<td>Intersection Density</td>
<td>240.4</td>
<td>165.4</td>
<td>104.2</td>
<td>303.1</td>
<td>57.7</td>
<td>90.1</td>
<td>12.8</td>
<td>67.6</td>
</tr>
<tr>
<td>SD</td>
<td>168.9</td>
<td>84.4</td>
<td>64.2</td>
<td>145.6</td>
<td>39.1</td>
<td>86.1</td>
<td>19.7</td>
<td>90.4</td>
</tr>
<tr>
<td>Median Age of Structures</td>
<td>57.3</td>
<td>56.2</td>
<td>44.5</td>
<td>41.8</td>
<td>32.8</td>
<td>41.3</td>
<td>33.1</td>
<td>37.7</td>
</tr>
<tr>
<td>SD</td>
<td>5.6</td>
<td>11.5</td>
<td>14.4</td>
<td>12.5</td>
<td>13.5</td>
<td>15.5</td>
<td>9.8</td>
<td>14.1</td>
</tr>
<tr>
<td>Percent Single Detached House</td>
<td>27.1</td>
<td>47.1</td>
<td>60.3</td>
<td>3.5</td>
<td>63.3</td>
<td>41.6</td>
<td>79.1</td>
<td>64.3</td>
</tr>
<tr>
<td>SD</td>
<td>12.7</td>
<td>21.3</td>
<td>20.3</td>
<td>4.5</td>
<td>21.2</td>
<td>20.4</td>
<td>19.2</td>
<td>26.3</td>
</tr>
<tr>
<td>Number of TAZs</td>
<td>37</td>
<td>116</td>
<td>303</td>
<td>64</td>
<td>401</td>
<td>110</td>
<td>774</td>
<td>1805</td>
</tr>
<tr>
<td>Number of Respondents</td>
<td>362</td>
<td>371</td>
<td>405</td>
<td>12</td>
<td>263</td>
<td>130</td>
<td>97</td>
<td>1640</td>
</tr>
</tbody>
</table>

- **Cluster 1**: Urban high-density & Mixed-use neighborhoods
- **Cluster 2**: Urban high-density & residential neighborhoods
- **Cluster 3**: Urban medium-density & Residential neighborhoods
- **Cluster 4**: Central Business District (CBD)
- **Cluster 5**: Urban low-density & Residential neighborhoods
- **Cluster 6**: Urban low-density & Mixed-use neighborhoods
- **Cluster 7**: Suburban low-density & Single-family neighborhoods
Results of the Cluster Analysis

Central Business District (CBD): Cluster 4

Urban Area: Cluster 1, 2, 3, 5, 6

Suburban Area: Cluster 7
## Model results

**Base case: being a non-transit user**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coef.</th>
<th>z stat.</th>
<th>Marginal Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>1.188</td>
<td>4.20</td>
<td></td>
</tr>
</tbody>
</table>

**Socioeconomic vars (undergraduate student -base case)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coef.</th>
<th>z stat.</th>
<th>Marginal Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faculty</td>
<td>-1.780</td>
<td>-4.03</td>
<td>-41.0</td>
</tr>
<tr>
<td>Staff</td>
<td>-2.241</td>
<td>-7.99</td>
<td>-50.8</td>
</tr>
<tr>
<td>Graduate student</td>
<td>-1.001</td>
<td>-3.63</td>
<td>-22.0</td>
</tr>
<tr>
<td>Female</td>
<td>0.163</td>
<td>0.81</td>
<td>2.8</td>
</tr>
<tr>
<td>Ethnicity (non-white)</td>
<td>0.447</td>
<td>1.66</td>
<td>7.1</td>
</tr>
</tbody>
</table>

**Locations (1-5 miles is the base case)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coef.</th>
<th>z stat.</th>
<th>Marginal Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than a mile</td>
<td>-0.625</td>
<td>1.88</td>
<td>-12.9</td>
</tr>
<tr>
<td>6 miles to 10 miles</td>
<td>-0.205</td>
<td>-0.64</td>
<td>-3.9</td>
</tr>
<tr>
<td>11 miles to 15 miles</td>
<td>-0.105</td>
<td>-0.27</td>
<td>-1.9</td>
</tr>
<tr>
<td>More than 15 miles</td>
<td>-0.461</td>
<td>-0.90</td>
<td>-9.2</td>
</tr>
</tbody>
</table>

**Clusters (Cluster 2: Urban high-density & Old residential neighborhoods is the base case)**

<table>
<thead>
<tr>
<th>Cluster</th>
<th>Coef.</th>
<th>z stat.</th>
<th>Marginal Effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cluster 1: Urban high-density &amp; Mixed-use neighborhoods</td>
<td>-0.741</td>
<td>-2.27</td>
<td>-15.7</td>
</tr>
<tr>
<td>Cluster 3: Urban medium-density &amp; Residential neighborhoods</td>
<td>-0.682</td>
<td>-2.21</td>
<td>-14.3</td>
</tr>
<tr>
<td>Cluster 5: Urban low-density &amp; Residential neighborhoods</td>
<td>-0.877</td>
<td>-2.09</td>
<td>-18.9</td>
</tr>
<tr>
<td>Cluster 6: Urban low-density &amp; Mixed-use neighborhoods</td>
<td>-1.113</td>
<td>-2.56</td>
<td>-24.8</td>
</tr>
<tr>
<td>Cluster 7: Suburban low-density &amp; Single-family neighborhoods</td>
<td>-1.991</td>
<td>-1.97</td>
<td>-45.7</td>
</tr>
</tbody>
</table>

**Number of observations (N)** | 533   |
**Initial Log likelihood**      | -359.4324 |
**Final Log likelihood**        | -306.49029 |

Bolded coefficients are significant at the 95% level and coefficients in italics are significant at the 90% level. For marginal effects, the probability of being a transit user is calculated at zero for dummy variables. The probability of being a transit user at means is 76.6%.
Step 1
Attitudes

New Attitudinal Components

Analysis of Effects of New Attitudinal Components on Transit Use

Step 2
Land Use & Built Environment Characteristics

New Neighborhood Types

Analysis of Effects of New Neighborhood Types on Transit Use

Step 3
Effects of New Attitudinal Components & New Neighborhood Types on Transit Use
Model Specification

Model 1: *attitudinal factors* and socio-demographics

Model 2: *the built environment* & socio-demographics

Model 3: *attitudinal factors, the built environment* & socio-demographic variables
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.357</td>
<td>1.29</td>
<td>1.188</td>
<td>4.20</td>
<td>0.851</td>
<td>2.56</td>
</tr>
<tr>
<td><strong>Socioeconomic variables</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(undergraduate student is the base case)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Faculty</td>
<td>-1.841</td>
<td>-3.59</td>
<td>-1.780</td>
<td>-4.03</td>
<td>-1.932</td>
<td>-3.65</td>
</tr>
<tr>
<td>Graduate student</td>
<td>-1.270</td>
<td>-4.03</td>
<td>-1.001</td>
<td>-3.63</td>
<td>-1.378</td>
<td>-4.24</td>
</tr>
<tr>
<td>Female</td>
<td>0.331</td>
<td>1.45</td>
<td>0.163</td>
<td>0.81</td>
<td>0.293</td>
<td>1.27</td>
</tr>
<tr>
<td>Ethnicity (non-white)</td>
<td>0.361</td>
<td>1.19</td>
<td>0.447</td>
<td>1.66</td>
<td>0.371</td>
<td>1.19</td>
</tr>
<tr>
<td><strong>Locations</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(1-5 miles is the base case)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than a mile</td>
<td>-0.914</td>
<td>-2.93</td>
<td>-0.625</td>
<td>1.88</td>
<td>-0.632</td>
<td>-1.76</td>
</tr>
<tr>
<td>6 miles to 10 miles</td>
<td>0.158</td>
<td>0.49</td>
<td>-0.205</td>
<td>-0.64</td>
<td>0.227</td>
<td>0.62</td>
</tr>
<tr>
<td>11 miles to 15 miles</td>
<td>0.491</td>
<td>1.30</td>
<td>-0.105</td>
<td>-0.27</td>
<td>0.683</td>
<td>1.53</td>
</tr>
<tr>
<td>More than 15 miles</td>
<td>-0.274</td>
<td>0.55</td>
<td>-0.461</td>
<td>-0.90</td>
<td>-0.003</td>
<td>0.00</td>
</tr>
<tr>
<td>PC 1: Preference of car use</td>
<td>-0.197</td>
<td>-2.17</td>
<td>-0.204</td>
<td>-2.22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC 2: Willingness of transit use</td>
<td>0.265</td>
<td>3.04</td>
<td>0.252</td>
<td>2.85</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC 3: Need for flexibility/ Sensitivity to time</td>
<td>-0.280</td>
<td>-3.11</td>
<td>-0.252</td>
<td>-2.78</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC 4: Transit use around a traveler</td>
<td>0.167</td>
<td>2.01</td>
<td>0.172</td>
<td>2.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC 5: Ability to rest or read</td>
<td>0.293</td>
<td>3.29</td>
<td>0.297</td>
<td>3.32</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC 6: Perceived availability of transit service/</td>
<td>0.121</td>
<td>1.27</td>
<td>0.100</td>
<td>1.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>familiarity with bus information access</td>
<td>0.140</td>
<td>1.44</td>
<td>0.159</td>
<td>1.61</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC 7: Sensitivity to congestion</td>
<td>-0.213</td>
<td>-2.18</td>
<td>-0.194</td>
<td>-1.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PC 8: Sensitivity to safety</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Neighborhoods</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>(High-density, old is the base case)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>High-density, mixed use</td>
<td>-0.741</td>
<td>-2.27</td>
<td>-0.814</td>
<td>2.28</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium density, residential</td>
<td>-0.682</td>
<td>-2.21</td>
<td>-0.564</td>
<td>-1.59</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low density, residential</td>
<td>-0.877</td>
<td>-2.09</td>
<td>-0.731</td>
<td>-1.49</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low density, mixed use</td>
<td>-1.113</td>
<td>-2.56</td>
<td>-0.946</td>
<td>-1.97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Suburban low density, single family</td>
<td>-1.991</td>
<td>-1.37</td>
<td>-0.980</td>
<td>-1.13</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Number of observations (N)</strong></td>
<td>533</td>
<td></td>
<td>533</td>
<td></td>
<td>533</td>
<td></td>
</tr>
<tr>
<td>Initial Log likelihood</td>
<td>359.4324</td>
<td></td>
<td>359.4324</td>
<td></td>
<td>359.4324</td>
<td></td>
</tr>
<tr>
<td>Final Log likelihood</td>
<td>266.1624</td>
<td></td>
<td>306.49029</td>
<td></td>
<td>261.85128</td>
<td></td>
</tr>
</tbody>
</table>

**Bolded coefficients are significant at the 95% level and coefficients in italics are significant at the 90% level**
Research Questions & Answers

1) Do attitudes toward public transit affect public transit use? If so, how do attitudes affect people’s transit use?

2) Does the built environment affect public transit use? If so, how does the built environment influence people’s transit use?

3) Do the attitudinal factors, neighborhood types or a combination of both explain the resulting transit use better?

Attitudes are strongly associated with transit choice. If attitudes are not taken into consideration, the effects of built environment and infrastructure provision will be over-estimated.
Future Directions

• Collect panel data that examines the effects of land-use change while keeping the respondent specific characteristics constant.
  • Panel data collected with changes to built environment
  • Panel data where respondents move

• Develop survey questionnaire to reflect people’s attitudes toward residential neighborhood environments.

• Extend to other travel modes.

• Comparative studies using similar data from different campuses.
INTEGRATED LAND-USE & TRANSPORTATION MODELS
Linking Land-Use & Travel in Ohio

• Develop a user-friendly modeling tool to develop forecasts based on different land use, transportation and policy scenarios.

• Enhance the existing Land Allocation model developed by MORPC (Mid-Ohio Regional Planning Commission)
  • Land allocation model gives forecasts of future land development under different scenarios.

• Add a transportation component to be able to forecast the implications of future land-use and infrastructure decisions on the resulting travel patterns.

• Study funded by Ohio Department of Transportation. Co-PI: Prof. Steven I. Gordon.
Why Look at Household Travel?

- Household travel accounts for the vast majority (over 80%) of miles traveled on US roadways and three-quarters of the CO₂ emissions from mobile sources (FHWA, 2009).

- The carbon footprint of daily travel =
  - f (types of vehicles, fuel efficiency, number of miles traveled).

- There is need to improve our understanding of the links between the land use, transportation policies and individual/household travel behavior to develop sound policies and investment decisions.

- The technological innovations alone will not be enough to reach targeted reductions in emissions, as the projected increase in vehicle miles traveled will outpace the advances in fuel economy and lower carbon fuels.
Land Allocation Component

- Allocate population and employment
  - Region divided into 40 acre cells
  - Cells characterized by current land-use and factors that would influence future development
  - Factors used to create score that dictates which cells would develop first
  - Development capped by regional growth control forecast
# Major Score Categories

- **Economic development factors**
  - Cell in one of several economic development districts
- **Infrastructure availability**
  - Availability of sewer, water, recreation, transportation
- **Environmental limitations**
  - Constraints related to conservation areas, floodplains, slopes, etc.
- **Nuisance limitations**
  - Airport noise, quarries, landfills, wastewater treatment plants

## Examples:

<table>
<thead>
<tr>
<th>Category</th>
<th>Feature</th>
<th>Long description</th>
<th>Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Econ Dev</td>
<td>TIF</td>
<td>Majority of grid in Tax Increment Financing (TIF) district</td>
<td>8</td>
</tr>
<tr>
<td>Econ Dev</td>
<td>CRA</td>
<td>Majority of grid in Community Reinvestment Area (CRA)</td>
<td>5</td>
</tr>
<tr>
<td>Environ</td>
<td>Forests</td>
<td>More than 25% of grid with land cover of forest</td>
<td>-4</td>
</tr>
<tr>
<td>Environ</td>
<td>Streams (1/4 mile)</td>
<td>Majority of grid within 1/4 mile of rivers and streams</td>
<td>-4</td>
</tr>
<tr>
<td>Environ</td>
<td>Wellhead Zone 5-year</td>
<td>Majority of grid in Ohio EPA modeled 5-Year Wellhead Zone related to ground water wells</td>
<td>-4</td>
</tr>
<tr>
<td>Environ</td>
<td>High Slope (&gt;24 %)</td>
<td>Majority of grid has slope greater than 24% in soil survey data</td>
<td>-4</td>
</tr>
<tr>
<td>Environ</td>
<td>Upstream from water in-take</td>
<td>Majority of grid in Ohio EPA defined Corridor Management Zone (CMZ) related to surface water intakes</td>
<td>-6</td>
</tr>
<tr>
<td>Environ</td>
<td>Ground Reservoirs</td>
<td>Majority of grid within 1/4 mile of ground reservoirs</td>
<td>-2</td>
</tr>
</tbody>
</table>
Transportation Component

- Transit Information
- Outputs of the land allocation model: Distribution of employment & households
- Census Data: Household Characteristics
- Transportation Model: Auto Trip Ends at TAZ level
- Transportation Model: Trip Distances at TAZ level
- Vehicle Miles Traveled (VMT) at TAZ level

Outputs of the land allocation model:
- Distribution of employment & households
- Transportation Model: Auto Trip Ends at TAZ level
- Transportation Model: Trip Distances at TAZ level
- Vehicle Miles Traveled (VMT) at TAZ level
Approach

• Given a land allocation scenario:
  • How many auto-trips will be generated?
  • What will be the mean trip length?
  • What will be the resulting VMT?

• Data:
  • Household travel surveys across OH.
    • Approximately 23,000 households
    • Over 200,000 trips
  • Census
  • Transit Agencies

• Two transportation models
  • Auto trip ends at TAZ level
  • Auto trip distances at TAZ level
Percentage of Auto Trips

Source: Household Travel Surveys
## Auto Trip Ends

<table>
<thead>
<tr>
<th>City</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akron</td>
<td>16,261</td>
<td>11,706</td>
<td>215</td>
</tr>
<tr>
<td>Canton</td>
<td>14,339</td>
<td>13,417</td>
<td>133</td>
</tr>
<tr>
<td>Cincinnati</td>
<td>16,894</td>
<td>12,998</td>
<td>432</td>
</tr>
<tr>
<td>Cleveland</td>
<td>23,485</td>
<td>17,140</td>
<td>460</td>
</tr>
<tr>
<td>Dayton</td>
<td>14,154</td>
<td>13,336</td>
<td>296</td>
</tr>
<tr>
<td>Lima</td>
<td>10,888</td>
<td>10,236</td>
<td>50</td>
</tr>
<tr>
<td>Mid-Ohio</td>
<td>19,745</td>
<td>22,903</td>
<td>412</td>
</tr>
<tr>
<td>Mansfield</td>
<td>10,521</td>
<td>10,184</td>
<td>63</td>
</tr>
<tr>
<td>Non-metro</td>
<td>11,403</td>
<td>15,157</td>
<td>1,127</td>
</tr>
<tr>
<td>Springfield</td>
<td>10,555</td>
<td>9,194</td>
<td>66</td>
</tr>
<tr>
<td>Steubenville</td>
<td>5,708</td>
<td>7,225</td>
<td>66</td>
</tr>
<tr>
<td>Toledo</td>
<td>17,514</td>
<td>15,134</td>
<td>175</td>
</tr>
<tr>
<td>Youngstown</td>
<td>14,762</td>
<td>14,534</td>
<td>165</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>15,427</td>
<td>16,123</td>
<td>3,660</td>
</tr>
</tbody>
</table>

Source: Outputs of the Ohio Statewide Model
# Mean Trip Length (Auto Trips - miles)

<table>
<thead>
<tr>
<th>City</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Akron</td>
<td>7.45</td>
<td>3.69</td>
<td>210</td>
</tr>
<tr>
<td>Canton</td>
<td>6.65</td>
<td>2.83</td>
<td>131</td>
</tr>
<tr>
<td>Cincinnati</td>
<td>7.30</td>
<td>3.33</td>
<td>426</td>
</tr>
<tr>
<td>Cleveland</td>
<td>7.19</td>
<td>3.58</td>
<td>429</td>
</tr>
<tr>
<td>Dayton</td>
<td>7.54</td>
<td>4.82</td>
<td>285</td>
</tr>
<tr>
<td>Lima</td>
<td>6.95</td>
<td>2.44</td>
<td>47</td>
</tr>
<tr>
<td>Mid-Ohio</td>
<td>8.38</td>
<td>5.44</td>
<td>359</td>
</tr>
<tr>
<td>Mansfield</td>
<td>7.40</td>
<td>5.53</td>
<td>63</td>
</tr>
<tr>
<td>Non-metro</td>
<td>9.23</td>
<td>5.82</td>
<td>897</td>
</tr>
<tr>
<td>Springfield</td>
<td>6.91</td>
<td>2.35</td>
<td>64</td>
</tr>
<tr>
<td>Steubenville</td>
<td>8.05</td>
<td>3.83</td>
<td>60</td>
</tr>
<tr>
<td>Toledo</td>
<td>6.36</td>
<td>3.32</td>
<td>172</td>
</tr>
<tr>
<td>Youngstown</td>
<td>6.21</td>
<td>2.74</td>
<td>164</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>7.83</td>
<td>4.65</td>
<td>3,307</td>
</tr>
</tbody>
</table>

Source: Household Travel Surveys
Census Data: Household Characteristics

Outputs of the land allocation model: Distribution of employment & households

Transportation Model: Auto Trip Ends at TAZ level

Transportation Model: Trip Distances at TAZ level

Vehicle Miles Traveled (VMT) at TAZ level

Transit Information
Auto Trip Rates

- Estimate auto trip rates at TAZ level as a function of:
  - Number of households
  - Retail employment
  - Industrial employment
  - Office employment
  - Other employment
  - Availability of transit

- Separate models for metro and non-metro areas
- Dependent variable: Number of auto trips generated at each TAZ.
## Auto Trip Ends – Metro Areas

**Dependent variable= Number of auto trip ends**

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>t stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td>8.553</td>
<td>149.57</td>
</tr>
<tr>
<td>Retail employment</td>
<td>9.597</td>
<td>43.99</td>
</tr>
<tr>
<td>Industry employment</td>
<td>1.770</td>
<td>19.75</td>
</tr>
<tr>
<td>Office employment</td>
<td>1.606</td>
<td>7.39</td>
</tr>
<tr>
<td>Other employment</td>
<td>1.259</td>
<td>7.44</td>
</tr>
<tr>
<td>Retail X transit availability</td>
<td>-2.175</td>
<td>-8.69</td>
</tr>
<tr>
<td>Office X transit availability</td>
<td>-0.466</td>
<td>-2.05</td>
</tr>
<tr>
<td>Other X transit availability</td>
<td>-0.483</td>
<td>-2.74</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of observations</td>
<td></td>
<td>2533</td>
</tr>
<tr>
<td>$R^2$</td>
<td></td>
<td>0.9718</td>
</tr>
<tr>
<td>Adjusted $R^2$</td>
<td></td>
<td>0.9717</td>
</tr>
</tbody>
</table>
Auto Trip Ends – Nonmetropolitan Areas

Dependent variable= Number of auto trip ends

<table>
<thead>
<tr>
<th></th>
<th>Coefficient</th>
<th>t stat.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Households</td>
<td>7.744</td>
<td>75.5</td>
</tr>
<tr>
<td>Retail employment</td>
<td>10.985</td>
<td>47.48</td>
</tr>
<tr>
<td>Industry employment</td>
<td>2.264</td>
<td>17.59</td>
</tr>
<tr>
<td>Office employment</td>
<td>3.810</td>
<td>18.34</td>
</tr>
<tr>
<td>Other employment</td>
<td>2.319</td>
<td>14.36</td>
</tr>
</tbody>
</table>

Number of observations  1,127
R²                        0.9851
Adjusted R²               0.9850
Census Data:
Household Characteristics

Outputs of the land allocation model:
Distribution of employment & households

Transit Information

Transportation Model: Auto Trip Ends at TAZ level

Vehicle Miles Traveled (VMT) at TAZ level

Transportation Model: Trip Distances at TAZ level

Census Data: Household Characteristics
Trip Distances

• Dependent variable: $ln\ (trip\ distance)$

• Variables of interest:
  • TAZ characteristics (employment & population).
  • Household characteristics at the TAZ level
  • Job – Household index within 15 minute travel time of the TAZ.
    • Measures balance between employment and households. Ranges from 0 to 1. It is equal to 0 if only households or employment present; to 1, when there is 1 job per household.
    • Job – Household index = 
      \[
      1 - \frac{|employment - households|}{employment + households}
      \]
# Trip distance model: $\ln(\text{distance})$

<table>
<thead>
<tr>
<th></th>
<th>Coef.</th>
<th>t</th>
<th>Elasticities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Household size</td>
<td>0.0816</td>
<td>1.87</td>
<td>0.208</td>
</tr>
<tr>
<td>Household income (in $10k)</td>
<td>-0.0591</td>
<td>-6.22</td>
<td>-0.255</td>
</tr>
<tr>
<td>Vehicles per household driver</td>
<td>0.3815</td>
<td>8.04</td>
<td>0.721</td>
</tr>
<tr>
<td>Retail density</td>
<td>3.50E-05</td>
<td>-2.83</td>
<td>0.009</td>
</tr>
<tr>
<td>Industry/office/other density</td>
<td>6.86E-06</td>
<td>5.06</td>
<td>0.009</td>
</tr>
<tr>
<td>Household density</td>
<td>-0.0002</td>
<td>-12.06</td>
<td>-0.093</td>
</tr>
<tr>
<td>Job-Household index</td>
<td>-0.2427</td>
<td>-2.39</td>
<td>-0.187</td>
</tr>
<tr>
<td>Akron</td>
<td>-0.0546</td>
<td>-1.61</td>
<td>-5.310</td>
</tr>
<tr>
<td>Canton</td>
<td>-0.2313</td>
<td>-5.20</td>
<td>-20.646</td>
</tr>
<tr>
<td>Dayton</td>
<td>-0.0954</td>
<td>-2.97</td>
<td>-9.097</td>
</tr>
<tr>
<td>Lima</td>
<td>-0.1917</td>
<td>-2.74</td>
<td>-17.441</td>
</tr>
<tr>
<td>Mansfield</td>
<td>-0.2148</td>
<td>-3.52</td>
<td>-19.333</td>
</tr>
<tr>
<td>Non-metro</td>
<td>-0.1292</td>
<td>-4.69</td>
<td>-12.122</td>
</tr>
<tr>
<td>Springfield</td>
<td>-0.1591</td>
<td>-2.64</td>
<td>-14.713</td>
</tr>
<tr>
<td>Steubenville</td>
<td>-0.1219</td>
<td>-1.90</td>
<td>-11.474</td>
</tr>
<tr>
<td>Toledo</td>
<td>-0.1879</td>
<td>-4.84</td>
<td>-17.134</td>
</tr>
<tr>
<td>Youngstown</td>
<td>-0.2725</td>
<td>-6.62</td>
<td>-23.855</td>
</tr>
<tr>
<td>Constant</td>
<td>1.6489</td>
<td>13.33</td>
<td></td>
</tr>
</tbody>
</table>

$N = 2878$,  
Adjusted $R^2 = 0.19$
Scenarios of Development

- **Scenario 1**
  - Continuation of current trends over forecast period (2000 – 2035)
  - Constrained by forecasts of 2035 household and employment forecasts

- **Scenario 2**
  - Site specific impacts of two potential major employment sites
  - Calculation of impacts on trips in directly impact TAZs and those adjacent

- **Scenario 3**
  - Higher density development of residential areas in Mid-Ohio to reflect possible changes in energy and housing costs
  - Modest reversal of decline trends in the central counties of other Ohio regions to reflect recovery of the economy over the long term

- **Scenario 4**
  - Scenario 3 impacts with increases in transit availability
## Mid-Ohio Region
### 2000 vs. 2035 Comparison (Base Case)

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th>2035</th>
<th>Change</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Num of hh</td>
<td>707,979</td>
<td>901,808</td>
<td>193,829</td>
<td>27.38</td>
</tr>
<tr>
<td>Num of jobs</td>
<td>867,548</td>
<td>1,119,444</td>
<td>251,896</td>
<td>29.04</td>
</tr>
<tr>
<td>Office jobs</td>
<td>365,221</td>
<td>451,054</td>
<td>85,833</td>
<td>23.50</td>
</tr>
<tr>
<td>Retail jobs</td>
<td>197,758</td>
<td>257,390</td>
<td>59,632</td>
<td>30.15</td>
</tr>
<tr>
<td>Industry jobs</td>
<td>158,904</td>
<td>206,063</td>
<td>47,159</td>
<td>29.68</td>
</tr>
<tr>
<td>Other jobs</td>
<td>145,665</td>
<td>184,480</td>
<td>38,815</td>
<td>26.65</td>
</tr>
<tr>
<td>Number of trips</td>
<td>4,249,042</td>
<td>5,450,601</td>
<td>1,201,558</td>
<td>28.28</td>
</tr>
<tr>
<td>VMT</td>
<td>26,846,612</td>
<td>37,636,168</td>
<td>10,789,556</td>
<td>40.19</td>
</tr>
<tr>
<td>Trip distance</td>
<td>6.32</td>
<td>6.90</td>
<td>0.58</td>
<td>9.26</td>
</tr>
</tbody>
</table>
Results for Central Ohio: Current trends vs. Scenario 3 (higher densities)

Scenario Results in Reduction in VMT by over 1.9 million

Central Ohio VMT Differences with Higher Density Residential

Legend

VMT Differences

-105654.585 - -78400.4564
-78400.4564 - -28254.5035
-28254.5034 - -12406.9397
-12406.9396 - -3932.95163
-3932.95162 - 3150.17228
3150.17229 - 18452.0622
Current Project: Adding New Components

1. Decline:
   • A better understanding of the impacts of declines in population & employment

2. Vehicle choice:
   • The carbon footprint of daily travel =
     \[ f \text{(types of vehicles, fuel efficiency, number of miles traveled).} \]
   • 2009-2010 Cincinnati Metropolitan Area Household Travel Survey
   • 2012-2013 Greater Cleveland Household Travel Survey
   • Vehicle Types:
     • Passenger car
     • Passenger truck (SUV, pickup truck & van)
Variables of Interest

• Socio-demographics:
  • Primary drivers’ characteristics
  • Household characteristics
  • TAZ level characteristics

• Transit access

• Built environment (TAZ level)
  • Job-Population Balance Index
  • Employment density
  • Population density
  • Percent single detached housing
  • Intersection density
Results for Central Ohio: Current trends vs. Scenario 3 (higher densities)

Central Ohio VMT Differences with Higher Density Residential

Scenario Results in Reduction in VMT by over 1.9 million

Legend

VMT Differences
-105654.585 - -78400.4565
-78400.4564 - -28254.5035
-28254.5034 - -12406.9397
-12406.9396 - -3932.95163
-3932.95162 - 3150.17228
3150.17229 - 18452.0622
Concluding Remarks

• Two different projects at different scales
  • Individual
  • Local/regional
• The common thread: Forecasting future patterns under changing socio-economic, land-use and built environment scenarios.

• The ultimate goal is on supporting social and economic activities in complex urban systems by providing effective and responsive infrastructure and services that adapt and evolve with the ever-changing environments.
Ongoing Research

• Collecting data on bicycle trips (origins, destinations and route choices) through a cell phone app to model trip generation & distribution to aid in bicycle infrastructure decisions (proposal recently funded, NEXTRANS).

• Na Chen (PhD Candidate)
  • Activity space and built environment

• Yu-Jen Chen (PhD Candidate)
  • Joint versus individual tours & trip chains: Implications for VMT

• Michael Blau (MSc – just graduated)
  • Autonomous vehicles and infrastructure preferences for non-motorized modes
THANKS!

Questions?