Accessibility: The Land Use-Transportation Link
Day 5
11.953

Content
- Review of Introductory Assignment
- Accessibility: History and Definitions
- Types of Accessibility Measures
- Example Applications
- Accessibility: Indicator or Variable?
- Practical Uses of Accessibility Measures

Introductory Assignment
- Defining Neighborhoods
  - Primarily Physical: 10
  - Physical-Social-Economic: 9
  - "Other"
    - "Daily/Weekly Patterns": 2
    - Variations in concept of "nearness"
- Example characteristics
  - "atmosphere", housing stock age/type, activity types, aesthetics
  - "walkability"
  - Clear boundaries: physical, monuments, street patterns
  - "status"

Introductory Assignment

<table>
<thead>
<tr>
<th>Neighborhood Summaries</th>
<th>Perimeter (m)</th>
<th>HAs</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>16</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Mean</td>
<td>2827.75</td>
<td>51.83</td>
<td>128.08</td>
</tr>
<tr>
<td>Median</td>
<td>2642.00</td>
<td>35.98</td>
<td>88.90</td>
</tr>
<tr>
<td>Minimum</td>
<td>1227</td>
<td>8</td>
<td>21</td>
</tr>
<tr>
<td>Maximum</td>
<td>6383</td>
<td>224</td>
<td>553</td>
</tr>
</tbody>
</table>

Your 'hoods: Relative Locations

Source: www.mass.gov/mgis
Journey to Work Mode Choice
(as reported in Census, 2000; courtesy of Mikel Murga)
Physical Characteristics of “Relevance”
- “Neighborhood”
  - Parking, Transit Access
  - Traffic Calming
  - Density
  - Street Width, Streetscape, NMT Networks, Mix Uses
- Regional Setting, Access to Jobs

Non-Physical Characteristics & Future Factors

Non-Physical Characteristics
- Student populations
- Family Life-cycle
- Vehicle Costs

Future Factors
- Public Transport Networks
- Automobile Costs
- “Culture”

Defining Accessibility
- “extent to which the land-use and transportation systems enable (groups of) individuals to reach activities or destinations”
  (Geurs and van Wee, 2004; p. 128)

Accessibility = Function of:
(transportation system, land use patterns, the individual characteristics of firms and people, the overall quality of “opportunities” available, the communications system)

Accessibility: Contributing Elements

<table>
<thead>
<tr>
<th>Elements</th>
<th>Effect on Accessibility (all else equal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transportation</td>
<td>Improved with more links, faster or cheaper service</td>
</tr>
<tr>
<td>Spatial distribution of “opportunities”</td>
<td>Improved if proximity of opportunities is increased</td>
</tr>
<tr>
<td>Individual (personal/firm) characteristics</td>
<td>Improved with physical, mental, economic ability to take advantage of opportunities</td>
</tr>
<tr>
<td>Quality of opportunities</td>
<td>Improved with more, or better, opportunities within same distance/time</td>
</tr>
</tbody>
</table>

Derived from BTS, 1997

Accessibility and Human Development

<table>
<thead>
<tr>
<th>Sen’s Concept</th>
<th>Meaning</th>
<th>Link to Accessibility/Mobility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionings</td>
<td>Everything that an individual may wish to be or do (to “flourish” as human beings)</td>
<td>Potential trip purposes (work, school, shopping, etc.)</td>
</tr>
<tr>
<td>Capabilities</td>
<td>Freedom to achieve the “functionings” that individuals have reason to choose</td>
<td>The land use-transportation system directly influences an individual’s ability to realize trip purposes and combinations of trip purposes</td>
</tr>
</tbody>
</table>

Inspired by Sen (1998)
### Types of Accessibility Measures

<table>
<thead>
<tr>
<th>Measure Type</th>
<th>Examples</th>
<th>Suitability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infrastructure-Based</td>
<td>Travel speeds by different modes; operating costs; congestion levels</td>
<td>Weak - only reflect level of throughput, no explicit land-use component</td>
</tr>
<tr>
<td>Location-Based</td>
<td>Distance measures (e.g., cumulative opportunities); potential measures (e.g., gravity-based measures)</td>
<td>Okay/Good - normally derived for some spatially aggregated unit, can represent stratified population segments</td>
</tr>
<tr>
<td>Person-Based</td>
<td>Space-time prisms</td>
<td>Good - measured at the individual level, according to temporal constraints</td>
</tr>
<tr>
<td>Utility-Based</td>
<td>Random utility-based measures (i.e., from discrete choice models or the doubly constrained entropy model)</td>
<td>Good - based on microeconomic benefit (utility) for individuals or stratified population segments</td>
</tr>
</tbody>
</table>


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### Gravity-based Measures

- Theoretical origins in physics.
- Improvement over distance-based measures, partly because they attempt to better reflect travel behavior realities through their functional form, generally:

  \[ A_i = \sum_j W_j f(c_{ij}, \beta) \]

  where:
  - \( W_j \) represents the opportunities available in a given zone \( j \).
  - \( f(c_{ij}, \beta) = \exp(-\beta c_{ij}) \) = impedance between zones \( i \) and \( j \).
  - \( c_{ij} \) represents the travel cost/distance between zones \( i \) and \( j \); and
  - \( \beta \) is a travel cost sensitivity parameter.
  - generally enters as a negative exponential function
  - the accessibility measure clearly is highly sensitive to this parameter.
  - Should come from empirical analysis

### Gravity-based Measures

- Can be derived for an area (zone) and/or groups of people
- Fairly straightforward calculation based on readily available data
- Can be adapted to account for competition for opportunities at the destination
  - e.g., when the number of job opportunities is limited at given site (Shen, 1998)


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### “Person-based” or “Constraints-based” Measures

- Origins in Hagerstrand’s (1970) time-space framework
  - aims to capture temporal and spatial constraints
  - i.e., both distance (between themselves and potential activities) and available time (to engage in activities).
- Theoretically appealing
- Some applications
- Data-intensive
  - e.g., require information on people’s activities and time budgets
- Computationally burdensome


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### Utility-Based Accessibility

- Can reflect individual preferences
  - Consistent with Sen’s “human freedoms” perspective
  - Based on the individual’s actual choice set
- Directly linked to traditional measures of consumer surplus
  - Based in microeconomic theory (Williams, 1977; Small and Rosen, 1981)
- Derived from discrete choice models
  - With a long tradition of application in transportation system analyses

Source: Allen et al., 1993; BTS, 1997.
Utility-Based Accessibility: 
the Logit Model

\[ U_{jn} = V(z_{jn}, s_{jn}, \beta) + \epsilon_{jn} \]

\[ P_{n}(i) = \frac{e^{\mu y_{ni}}}{\sum_{j=1}^{m} e^{\mu y_{ji}}} \]

Utility-Based Accessibility: 
The “Logsum” and Nested Logit

\[ P_{d}(m) = P_{n}(m|d) P_{n}(d) \]

“Logsum” at “the root” represents composite benefit (“Expected Maximum Utility”) of the entire choice process

1.2. Destination Choice
Disturbance term = \( \epsilon_{d} \)
Scale parameter = \( \mu_{d} \)

1.1. Mode Choice
Disturbance term = \( \epsilon_{m} \)
Scale parameter = \( \mu_{m} \)

Social Accessibility Levels
Female Adult, Evaluated at Mean Relevant Characteristics for Income Category

Recreational Accessibility Levels
Male Adult, Evaluated at Mean Relevant Characteristics for Income Category

Relative Decline in Recreational Accessibility
Middle Income Female
Average Relative Decline in Female Accessibility

“Utility-based” Measures

- Theoretically appealing
  - Basis in behavioral theory and welfare economics
- Not immediately and easily convertible into meaningful and understandable units
  - Convertible into currency, time, but cumbersome
- Assumes utility linear with respect to income
  - Nonpresence of income effect
- Still travel-biased measures
  - Cannot immediately account for non trip-based accessibility (e.g., not traveling; trip-chaining)