IDENTIFYING SPATIAL GAPS IN TRANSIT ACCESSIBILITY TO ENHANCE MARKET POTENTIAL

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INTRODUCTION
- Rapid growth in population
- Increasing travel demand and congestion
- Potential solutions / alternative
  - Includes enhanced public transportation
PUBLIC TRANSPORTATION

- Efficiency depends on
  - Accessibility
  - Fare
  - Frequency
  - Travel time
  - Comfort and convenience

OBJECTIVE

- Explore features available in commercial GIS software to estimate accessibility
  - Stop, route and regional level
- Identify spatial gaps in the transit system to enhance its market potential
STUDY AREA

- City of Charlotte, North Carolina
- Charlotte Area Transit System (CATS)
  - 3,622 Transit stops
  - 80 Routes

METHODOLOGY

- Selection of variables and weights
- Spatial analysis
- Data processing
- Estimate accessibility index for
  - Each transit stop
  - Each route
  - Entire study area
METHODOLOGY

Selection of variables and weights

<table>
<thead>
<tr>
<th>Selected variables</th>
<th>Assigned weightage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemployed population</td>
<td>30</td>
</tr>
<tr>
<td>Auto ownership (0 or 1)</td>
<td>20</td>
</tr>
<tr>
<td>Population by age group</td>
<td>10</td>
</tr>
<tr>
<td>Low income group</td>
<td>30</td>
</tr>
<tr>
<td>Ethnicity</td>
<td>10</td>
</tr>
</tbody>
</table>

Spatial analysis

- Generate 0.25 mile buffer around each transit stop and along each route
- Overlay census data layer with 2008 estimates to capture potential captive riders
METHODOLOGY

Data processing

\[ U_i = \sum_j \frac{A_{ij}}{A_j} \times U_j \]

- \( U_i \): Number of unemployed in the buffer "i" around transit stop "s"
- \( U_j \): Number of unemployed in census block "j"
- \( A_{ij} \): Area of census block "j" in the buffer "i" around transit stop "s"
- \( A_j \): Area of census block "j"

METHODOLOGY

Estimating accessibility index for each transit stop

\[ A_s = 0.3 \times U_s + 0.2 \times AO_s + 0.1 \times AG_s + 0.3 \times I_s + 0.1 \times E_s \]

- \( A_s \): Accessibility index for transit stop "s"
- \( U_s \): Total unemployed in buffer for transit stop "s"
- \( AO_s \): Population with auto-ownership 0 or 1 in buffer for transit stop "s"
- \( AG_s \): Age group between 15 to 74 in buffer for transit stop "s"
- \( I_s \): Low income population (< $25,000) in buffer for transit stop "s"
- \( E_s \): Ethnicity in buffer for transit stop "s"
METHODOLOGY

Estimating the accessibility index for each transit route

- Compare using 2 methods
  - Based on calculated accessibility for each transit stop along a route
  - Based on data by generating buffer along a route

Ar,s = 0.3 *Ur,s + 0.2 *AOr,s + 0.1*AGr,s + 0.3*Ir,s + 0.1*Er,s

- Ar,s = Accessibility index for transit route “r” based on buffers around transit stops
- Ur,s = Total unemployed in dissolved buffers along transit route “r”
- AOr,s = Population with auto-ownership 0 or 1 in dissolved buffers along transit route “r”
- AGr,s = Age group between 15 to 74 in dissolved buffers along transit route “r”
- Ir,s = Low income population (< $25,000) in dissolved buffers along transit route “r”
- Er,s = Ethnicity in dissolved buffers along transit route “r”
METHODOLOGY

Estimating the accessibility index for each transit route – based on route level data

\[ A_r = 0.3 * U_r + 0.2 * AO_r + 0.1 * AG_r + 0.3 * I_r + 0.1 * E_r \]

- \( A_r \) = Accessibility index for transit route “r” based on buffer around the route
- \( U_r \) = Total unemployed in buffer for transit route “r”
- \( AO_r \) = Population with auto-ownership 0 or 1 in buffer for transit route “r”
- \( AG_r \) = Age group between 15 to 74 in buffer for transit route “r”
- \( I_r \) = Low income population (< $25,000) in buffer for transit route “r”
- \( E_r \) = Ethnicity in buffer for transit route “r”

METHODOLOGY

Estimating the accessibility index for entire study area

- Compare using 2 methods
  - Based on calculated accessibility for each transit stop in the entire study area
  - Based on data for entire study area
**METHODOLOGY**

### Estimating the accessibility index for entire study area – based on transit stops

\[ A_{e,s} = 0.3 \cdot U_c + 0.2 \cdot AO_c + 0.1 \cdot AG_c + 0.3 \cdot I_c + 0.1 \cdot E_c \]

- \( A_{e,s} \): Accessibility index for entire study area based on dissolved buffers around transit stops
- \( U_c \): Total unemployed based on dissolved buffers for entire study area
- \( AO_c \): Population with auto-ownership 0 or 1 based on dissolved buffers for entire study area
- \( AG_c \): Age group between 15 to 74 based on dissolved buffers for entire study area
- \( I_c \): Low income population (< $25,000) based on dissolved buffers for entire study area
- \( E_c \): Ethnicity based on dissolved buffers for entire study area

### Estimating the accessibility index for entire study area – based on census block level data

\[ A_{e,c} = 0.3 \cdot U_c + 0.2 \cdot AO_c + 0.1 \cdot AG_c + 0.3 \cdot I_c + 0.1 \cdot E_c \]

- \( A_{e,c} \): Accessibility index for entire study area based on census blocks
- \( U_c \): Total unemployed by census block “c”
- \( AO_c \): Population with auto-ownership 0 or 1 by census block “c”
- \( AG_c \): Age group between 15 to 74 by census block “c”
- \( I_c \): Low income population (< $25,000) by census block “c”
- \( E_c \): Ethnicity by census block “c”
ANALYSIS & RESULTS

Accessibility index for transit stops

<table>
<thead>
<tr>
<th>Accessibility Range</th>
<th>No. of Transit Stops</th>
<th>Percent of Transit Stops</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>7</td>
<td>0.5</td>
</tr>
<tr>
<td>1 to 10</td>
<td>204</td>
<td>56.7</td>
</tr>
<tr>
<td>10 to 100</td>
<td>198</td>
<td>56.7</td>
</tr>
<tr>
<td>&gt; 100</td>
<td>176</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Summary of Accessibility Index by Transit Stops

Accessibility index by route

<table>
<thead>
<tr>
<th>Accessibility Range</th>
<th>No. of Transit Routes</th>
<th>Percent of Routes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0.0</td>
</tr>
<tr>
<td>1 to 2,501</td>
<td>45</td>
<td>56.3</td>
</tr>
<tr>
<td>2,501 to 5,483</td>
<td>32</td>
<td>41.3</td>
</tr>
<tr>
<td>&gt; 5,483</td>
<td>2</td>
<td>2.5</td>
</tr>
</tbody>
</table>

Summary of Accessibility Index by Routes

<table>
<thead>
<tr>
<th>Percent Served</th>
<th>No. of Potential Captive Riders Served by Routes</th>
<th>Percent of Routes</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 to 25</td>
<td>31</td>
<td>63.8</td>
</tr>
<tr>
<td>25 to 50</td>
<td>15</td>
<td>21.3</td>
</tr>
<tr>
<td>50 to 75</td>
<td>4</td>
<td>7.5</td>
</tr>
<tr>
<td>&gt; 75</td>
<td>1</td>
<td>1.5</td>
</tr>
</tbody>
</table>

Summary of Percent of Potential Captive Riders Served by Routes
ANALYSIS & RESULTS

Area-wide accessibility index

Possible extension of existing routes to serve this area

Possible new route

Statistical analysis

<table>
<thead>
<tr>
<th>Category</th>
<th>Coefficient</th>
<th>T - Stat</th>
<th>P - Value</th>
<th>F - Stat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transit Stops</td>
<td>0.16</td>
<td>22.74</td>
<td>0.00</td>
<td>516.96</td>
</tr>
<tr>
<td>Routes</td>
<td>10.62</td>
<td>9.27</td>
<td>0.00</td>
<td>85.85</td>
</tr>
</tbody>
</table>
CONCLUSIONS

- Average accessibility index for transit stops is 105 and for routes is 2,591.
- Strong relation exists between ridership and accessibility index.
- Only 11 percent of the potential captive riders are served.