Evaluation and Application of Transit Network Directness Using Geographic Information Systems

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## Transit Performance Measure Points of View (TCRP 88)

<table>
<thead>
<tr>
<th>Performance Measure Examples</th>
<th>Community</th>
<th>Vehicle/Driver</th>
<th>Agency</th>
<th>Customer (&quot;Quality of Service&quot;)</th>
<th>Travel Time</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Delay</strong></td>
<td>• Vehicle Capacity Ratio</td>
<td>• Volume-to-Capacity</td>
<td>• Community Economic Impact</td>
<td>• Road Calls</td>
<td>• Transit Auto Travel Time</td>
</tr>
<tr>
<td>• System Speed</td>
<td>• Roadway Capacity</td>
<td>• Mobility</td>
<td>• Environmental Impact</td>
<td>• Cost Efficiency</td>
<td>• Transfer Time</td>
</tr>
<tr>
<td>• Transit Time</td>
<td>• ndash</td>
<td>• ndash</td>
<td>• ndash</td>
<td>• ndash</td>
<td>• ndash</td>
</tr>
</tbody>
</table>

**Notes:**
- **Delay** includes both system speed and travel time.
- **Vehicle Capacity Ratio** is critical for understanding the efficiency of vehicle usage.
- **Volume-to-Capacity** helps in assessing the demand on the transit system.
- **Community Economic Impact** reflects the economic benefits or costs associated with the service.
- **Environmental Impact** considers the environmental footprint of the transit service.
- **Road Calls** are important for maintaining safety and improving response times.
- **Cost Efficiency** measures the effectiveness of cost management.
- **Construction Impact** assesses the impact of construction on transit operations.
- **Vehicle Accident Rate** and **Crime Rate** are critical for safety performance.
- **Passenger Accident Rate** and **Vehicle with Safety Devices** evaluate safety measures.
- **Reliability** measures the consistency of transit service.
- **Customer Satisfaction** reflects the customer's perception of service quality.
- **Service Delays** and **Service Coverage** are important for service delivery.
- **Frequency** and **Hours of Service** are key indicators of service availability.

**Additional Notes:**
- **Economic** measures focus on financial aspects of transit service.
- **Maintenance & Construction** includes both quality and efficiency of maintenance practices.
- **Safety & Security** ensures the safety and security of passengers and employees.
- **Service Delivery** focuses on the overall delivery of transit services.
- **Availability** measures the overall availability of transit services.

**Conclusion:**
The chart illustrates various aspects of transit performance measures from different points of view, including community, vehicle/driver, agency, and customer perspectives. Each category contains specific measures that contribute to the overall performance of the transit system.
New Transit Performance Measures

- TCRP 88 report has been popular and dominant

- However, they are not very specific and general

- TCRP Synthesis J-07/Topic SA-43 (Transit Service Evaluation Standards) is in the process

- Needs for the more specific and tangible performance measures

- Needs for more detailed performance measures for auto/transit travel time
Four Transit Network Directness Measures

- **Degree of Competitiveness**: comparison between auto and transit travel times
  - Total Travel Time Degree of Competitiveness (**TTTDOCO**)
  - In-Vehicle Travel Time Degree of Competitiveness (**ITTDOCO**)

- **Degree of Circuity**: how much the transit service or network configuration can be improved
  - Total Travel Time Degree of Circuity (**TTTDOCI**)
  - In-vehicle Travel Time Degree of Circuity (**ITTDOCI**)

Then

- **Simple Average**
- **Weighted Average** (with demand size)
Examples and Analysis

Five cities in Korea were selected.

- Seoul
- Busan
- Suwon
- Seongnam
- Uijeongbu
## Characters of the Cities

<table>
<thead>
<tr>
<th>City</th>
<th>Seoul</th>
<th>Busan</th>
<th>Suwon</th>
<th>Seongnam</th>
<th>Uijeongbu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (million prs)</td>
<td>10.25</td>
<td>3.55</td>
<td>1.09</td>
<td>0.98</td>
<td>0.43</td>
</tr>
<tr>
<td>Area (Km²)</td>
<td>605.25</td>
<td>765.64</td>
<td>121.01</td>
<td>141.74</td>
<td>81.59</td>
</tr>
<tr>
<td>Population density (prs/Km²)</td>
<td>16,935</td>
<td>4,637</td>
<td>9,008</td>
<td>6,914</td>
<td>5,270</td>
</tr>
<tr>
<td>Bus passenger per day (million prs/day)</td>
<td>5.58</td>
<td>1.53</td>
<td>0.85</td>
<td>0.55</td>
<td>0.21</td>
</tr>
<tr>
<td>Subway passenger per day (million prs/day)</td>
<td>6.35</td>
<td>0.96</td>
<td>0.24</td>
<td>0.23</td>
<td>0.07</td>
</tr>
<tr>
<td>Transit demand density (prs/Km²)</td>
<td>19,710</td>
<td>3,252</td>
<td>9,008</td>
<td>5,503</td>
<td>3,432</td>
</tr>
<tr>
<td>Transit demand / Population</td>
<td>1.16</td>
<td>0.70</td>
<td>1.00</td>
<td>0.80</td>
<td>0.65</td>
</tr>
<tr>
<td>Number of zones</td>
<td>2,088</td>
<td>1,070</td>
<td>682</td>
<td>448</td>
<td>160</td>
</tr>
<tr>
<td>Number of bus routes</td>
<td>435</td>
<td>271</td>
<td>114</td>
<td>56</td>
<td>72</td>
</tr>
<tr>
<td>Number of subway routes</td>
<td>9</td>
<td>4</td>
<td>1</td>
<td>2</td>
<td>2</td>
</tr>
</tbody>
</table>
Modeling zones and transit networks of the cities

<table>
<thead>
<tr>
<th>City</th>
<th>Reality</th>
<th>Model</th>
</tr>
</thead>
<tbody>
<tr>
<td>Seoul</td>
<td><img src="seoul_reality.png" alt="Image" /></td>
<td><img src="seoul_model.png" alt="Image" /></td>
</tr>
<tr>
<td>Busan</td>
<td><img src="busan_reality.png" alt="Image" /></td>
<td><img src="busan_model.png" alt="Image" /></td>
</tr>
<tr>
<td>Suwon</td>
<td><img src="suwon_reality.png" alt="Image" /></td>
<td><img src="suwon_model.png" alt="Image" /></td>
</tr>
<tr>
<td>Seongnam</td>
<td><img src="seongnam_reality.png" alt="Image" /></td>
<td><img src="seongnam_model.png" alt="Image" /></td>
</tr>
<tr>
<td>Uijeongbu</td>
<td><img src="ujeongbu_reality.png" alt="Image" /></td>
<td><img src="ujeongbu_model.png" alt="Image" /></td>
</tr>
</tbody>
</table>
Simple Average TTTDOCO
Weighted Average TTTDOCO

The chart shows the relative frequency of various categories for different locations:

- **Seoul**
  - less than 100%: 0.00%
  - between 100% and 200%: 20.00%
  - between 200% and 300%: 40.00%
  - more than 300%: 80.00%

- **Suwon**
  - less than 100%: 0.00%
  - between 100% and 200%: 20.00%
  - between 200% and 300%: 40.00%
  - more than 300%: 80.00%

- **Busan**
  - less than 100%: 0.00%
  - between 100% and 200%: 20.00%
  - between 200% and 300%: 40.00%
  - more than 300%: 80.00%

- **Seongnam**
  - less than 100%: 0.00%
  - between 100% and 200%: 20.00%
  - between 200% and 300%: 40.00%
  - more than 300%: 80.00%

- **Uijeongbu**
  - less than 100%: 0.00%
  - between 100% and 200%: 20.00%
  - between 200% and 300%: 40.00%
  - more than 300%: 80.00%
FIGURE 3 Spatial distribution of TTTDOCO for each city
FIGURE 4 Spatial distribution of TTTDOCI for each city
Summary of the Transit Directness Measures

<table>
<thead>
<tr>
<th>City</th>
<th>Seoul</th>
<th></th>
<th>Busan</th>
<th></th>
<th>Suwon</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>simple</td>
<td>weighted</td>
<td>simple</td>
<td>weighted</td>
<td>simple</td>
<td>weighted</td>
</tr>
<tr>
<td>TTTDOCO</td>
<td>197 %</td>
<td>186 %</td>
<td>268 %</td>
<td>267 %</td>
<td>221 %</td>
<td>210 %</td>
</tr>
<tr>
<td>ITTDOCO</td>
<td>145 %</td>
<td>136 %</td>
<td>202 %</td>
<td>199 %</td>
<td>162 %</td>
<td>155 %</td>
</tr>
<tr>
<td>TTTDCI</td>
<td>110 %</td>
<td>101 %</td>
<td>152 %</td>
<td>150 %</td>
<td>125 %</td>
<td>112 %</td>
</tr>
<tr>
<td>ITTDCI</td>
<td>75 %</td>
<td>66 %</td>
<td>103 %</td>
<td>99 %</td>
<td>86 %</td>
<td>74 %</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>City</th>
<th>Seongnam</th>
<th></th>
<th>Uijeongbu</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>simple</td>
<td>weighted</td>
<td>simple</td>
<td>weighted</td>
</tr>
<tr>
<td>TTTDOCO</td>
<td>290 %</td>
<td>278 %</td>
<td>336 %</td>
<td>333 %</td>
</tr>
<tr>
<td>ITTDOCO</td>
<td>213 %</td>
<td>200 %</td>
<td>254 %</td>
<td>252 %</td>
</tr>
<tr>
<td>TTTDCI</td>
<td>163 %</td>
<td>147 %</td>
<td>187 %</td>
<td>182 %</td>
</tr>
<tr>
<td>ITTDCI</td>
<td>112 %</td>
<td>97 %</td>
<td>128 %</td>
<td>126 %</td>
</tr>
</tbody>
</table>
## Rankings of the Cities for the Important Measures

<table>
<thead>
<tr>
<th>Measure</th>
<th>Seoul</th>
<th>Busan</th>
<th>Suwon</th>
<th>Seongnam</th>
<th>Uijeongbu</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>Area</td>
<td>2</td>
<td>1</td>
<td>4</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Population density</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Transit demand density</td>
<td>1</td>
<td>5</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Transit demand / Population</td>
<td>1</td>
<td>4</td>
<td>2</td>
<td>3</td>
<td>5</td>
</tr>
<tr>
<td>Number of bus route</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>Transit directness measures</td>
<td>1</td>
<td>3/4</td>
<td>2</td>
<td>4/3</td>
<td>5</td>
</tr>
</tbody>
</table>
General Results of the Analysis

- First, mostly transit ridership (transit demand / population) depends on transit network directness.

- Second, to attract more transit riders, the weighted averages of the transit network directness measures should be meaningfully lower than the simple averages of the transit network directness. That means transit routes must be more direct where large transit demands exist.

- Third, transit network is more direct in cities with higher population density.
Conclusions

- The shape of the transit network is usually affected by the demand size.
- At the same time, the shape of the transit network affects the transit demand size as well.
- So, the relationship between the shape of the transit network and the demand size is complicated, but it is also worth investigating.
- Indeed, many other factors affect transit demand, so it may not be proper to connect the transit network directness and the transit demand size.
- However, as discussed, transit travel time is an important factor for mode choice, so it is still meaningful to find the relationship between transit demand size and transit network directness.
Conclusions

- The developed methodology can be used to analyze any cities and their transit networks.

- Transit agencies can have a better understanding of their transit network directness visually, and they can improve the transit network configuration where the transit network directness is poor.
Current and Future Research

- Relationship between transit network directness and socioeconomic factors
  - Real estate values
  - Real estate value changes
  - Crime rate
  - Number of trips
  - Car ownership
  - Household income
  - Etc...

- Transit network directness analysis for cities in US
Thank you!!

&

Any questions??