Reliability Valuation in Japan

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Contents

1. Current status of the economic appraisal of transport infrastructure in Japan
   – Current CBA guideline for road project

2. Very recent trials of measuring the economic benefit of travel time variability
   – Consideration in the practice of road project
   – Application of new approach

3. Outlook for the future studies
Legislation of CBA for Transport Infrastructure Investment in Japan

• “Law for Evaluation of Policies Implemented by Administrative Organs” (enforced on April 1, 2002)
  – Article 6: The head of an administrative organ ... shall establish a basic plan for policy evaluation on policies concerned...
  – Article 9: An administrative organ shall execute pre-evaluation concerning its jurisdiction when it sets a policy ... in order to carry out public works and/or official development assistance...

• CBA guidelines have been established since late 1990s: Road, Rail, Seaport, Airport etc.
Guidelines for the Evaluation of Road Investment Projects

- Travel time
- Vehicle cost
- Traffic safety

No details about “Reliability”!
Guidelines for the Evaluation of Road Investment Projects

The English Version of the Volume 1

May 2000
A total of “Benefit of travel time saving”
= [Total travel time cost without project]−[Total travel time cost with project ]

Total travel time cost := [Traffic volume] x [Travel time] x [Value of travel time]
Trial of Considering Reliability Benefits

- The Ministry of Land, Transport and Infrastructure (MLIT) started very recently (since 2008) the pilot study of how the benefit of travel time variability will be incorporated into the CBA practice for road projects.

\[
\text{Benefit of travel time reliability} := \left[\text{Total cost of safety margin } T \text{ without project}\right] - \left[\text{Total cost of safety margin } T \text{ with project}\right]
\]

- Total cost of “safety margin T” = (Safety Margin) x (VTT) x (Share of car drivers with schedule constraints)
Basic Idea of Applying Safety Margin Time

Before the project:
Average TT 20 min. + Safety Margin 20 min.

After the project:
Average TT 15 min. + Safety Margin 10 min.
How to Measure Safety Margin Time?

(1) Calculate $CV$ (Coefficient of Variation) of travel time distribution for the unit road length (e.g. 1 km) by using probe-vehicle & GPS technologies.

(2) Plot the relationship between average vehicle speed and $CV$ for some road sections.

(3) Calculate the average probability of not being late $X$ (estimated as 95%) from survey questionnaire.

(4) Calculate “Safety margin time per unit road length” as:

$$\text{[Average Travel Time per 1km] \times CV \times Z_X}$$

($Z_X$: $X$ percentile value of standard normal distribution)

(5) Calculate “Safety margin Time for the route” by multiplying the result of (4) and the route length.
Some Issues on this Approach

(1) Who will be benefitted from travel time reliability?
   • All travelers?  " Travelers with schedule constraints?
   • Travelers with schedule constraints who have to wait without doing any other activities?
   ⇒How can we select them from the population?

(2) How to measure the value of Safety Margin?
   • Is that the same as Value of Travel Time?
   • How do we estimate the probability of not being late?
   • Is that a single value?  Do we need to make some differentiations?

(3) Distributional assumption of travel times
   • Normal distribution: Easy to handle, but far from the actual observations.
   • Aggregation of safety margin over consecutive road links is failed, if the travel times are correlated across different road sections.
Application of Fosgerau-Karlström model to travel time data in Japan

<table>
<thead>
<tr>
<th>Tomei Intercity Expressway</th>
<th>Section (15.3 km)</th>
<th>Year</th>
<th>Period</th>
<th># of Observations (Standard car only)</th>
<th>Time of Day</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In</td>
<td>Out</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Atsugi IC</td>
<td>Yokohama Machida IC</td>
<td>2007</td>
<td>18 July to 30 Sept. [Only weekdays]</td>
<td>238,203</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>6:00 - 22:00</td>
</tr>
</tbody>
</table>
Travel Time Data Collected with ETC

Data in July 18 – September 30 [weekdays only], 2007:

Scatter Plot (238,203 Sample)
Estimated Mean & Standard Deviation of TT

Mean TT \([ \hat{\mu}(t) ] \)

Red: estimate, Green & Blue: 95% Confidence bounds

Stdev TT \([ \hat{\sigma}(t) ] \)

Time of Day (hour)
Calculation of Driver’s Total Cost

Driver’s Total Cost can be written as:
Fosgerau & Karlström (2009)

\[ EC^* = VTT \cdot \hat{\mu} + VTT \cdot \left( \frac{VTTV}{VTT} \right) \cdot \hat{\sigma} \]

\[ = RR \text{ (Reliability Ratio)} \]

Where:

\[ VTT = 62.86 \text{ (JPY/veh./min.)} \text{ ← CBA Guideline} \]

Scheduling parameters ← Small (1982)

Then, \( RR \) is calculated as:

\[ RR = \frac{VTTV}{VTT} \]

\[ = \frac{\lambda}{\eta + \omega} H \left( \Phi, \frac{\eta}{\lambda} \right) \]

\[ \approx 0.966 \]

Note: 100 JPY ≈ 1.16 USD

Cost caused by TTV occupies the significant share, particularly during peak period.
Outlook for Future Studies in Japan

1. The definition and the measurement of TTV
   - Standard deviation
   - Quartiles, Buffer Time Index or others

2. Estimation of drivers’ preference parameters used for valuing travel time reliability
   - So far, we have no any established SP survey for estimating VTT & VTTV.
   - The use of SP surveys is not common in Japan.
Thank you for your attention!

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Benefit of Travel Time Saving for Roads

A total of “Benefit of travel time saving”
= [Total travel time cost without project]−[Total travel time cost with project ]

Total travel time cost := [Link traffic volume] x [Link travel time] x [Value of time]

(1) VOT by vehicle types

<table>
<thead>
<tr>
<th>Vehicle types</th>
<th>VOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Passenger cars</td>
<td>62.86</td>
</tr>
<tr>
<td>Buses</td>
<td>519.74</td>
</tr>
<tr>
<td>Passenger cars (Including buses)</td>
<td>72.45</td>
</tr>
<tr>
<td>Small trucks</td>
<td>56.81</td>
</tr>
<tr>
<td>Ordinary trucks</td>
<td>87.44</td>
</tr>
</tbody>
</table>

(2) Items contained in VOT

(a) Human opportunity cost
   • Monetary value of saved time allowing more time to work and/or leisure

(b) Vehicle opportunity cost
   • Monetary value of saved time allowing better use of vehicles

(c) Freight opportunity cost
   • Monetary)value of saved time allowing better use of vehicles

(Unit: JPY/minute/vehicle)

100 JPY ≈ 1.16 USD
APPENDIX 1: VOT APPLIED IN JAPAN
Economic Evaluation of Urban Rail Projects

- **Users’ economic benefit** :=
  - Benefit of travel time savings
  - Traffic safety benefit (reduction of traffic accidents)
  - Benefit of improvement in comfort (transfer time, on-board congestion etc.)

- (Details) Benefit of travel time savings
  - Benefit definition: Consumer surplus (rule-of-half)
  - Value of time: no unified criteria
    (mixing of wage-rate approach and behavioral approach)
APPENDIX 2:  
TRIAL CALCULATION OF SOCIAL COST CAUSED BY TRAIN DELAY IN TOKYO
Now Train Delays Occur Very Frequently in Tokyo Metropolitan Area

- 130 lines and 1,800 stations
- 500 million daily passengers

Train delays (knock-on delays) are becoming common!
Example of Train Delay in Tokyo
Social Cost Caused by Train Delays

1. Delay from the scheduled departure time
   ⇒ Increase in passengers’ waiting time
2. Delay from the scheduled on-board travel time
   ⇒ Increases in passengers’ travel time
3. Decrease in train frequencies
   ⇒ Increase in on-board congestion
4. Increase in passengers’ safety margin to avoid being late for the schedule
Marginal Social Costs Caused by Train Delays

Iwakura (2009)

<table>
<thead>
<tr>
<th>Route choice model (Yai et al 1997)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>VOT for Waiting Time:</td>
<td>45 JPY/min.</td>
</tr>
<tr>
<td>VOT for In-Vehicle Time:</td>
<td>25 JPY/min.</td>
</tr>
<tr>
<td>Cost for Congestion Ratio:</td>
<td>8-12 JPY/10%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Departure-time choice model (Iwakura &amp; Harada 2005)</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost of Schedule Delay Early:</td>
<td>7 JPY/min.</td>
</tr>
</tbody>
</table>

100 JPY ≈ 1.16 USD
# Trial Calculation of Social Cost Caused by Train Delays in Tokyo

Iwakura (2009)

## Scenario of each passenger

<table>
<thead>
<tr>
<th>Event</th>
<th>Social Cost / person</th>
</tr>
</thead>
<tbody>
<tr>
<td>Delay of train departure time: +1min.</td>
<td>45 JPY/person</td>
</tr>
<tr>
<td>Increase in time: +2min. (35⇒37min.)</td>
<td>54 JPY/person</td>
</tr>
<tr>
<td>Decrease in freq.: -1 (29⇒28/hour)</td>
<td>8 JPY/person</td>
</tr>
<tr>
<td>Increase in congestion: +6% (170⇒176%)</td>
<td></td>
</tr>
<tr>
<td>Depart early from home: 10min.</td>
<td>70 JPY/person</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>175 JPY/person</strong></td>
</tr>
</tbody>
</table>

## Scenario of population

<table>
<thead>
<tr>
<th>Event</th>
<th>Social Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Daily passengers: 500 million people</td>
<td>218 billion JPY/year</td>
</tr>
<tr>
<td>Annual working days: 250 days</td>
<td>1,800 bil.</td>
</tr>
</tbody>
</table>

100 JPY ≈ 1.16 USD