Customer Satisfaction Analysis for Evaluating Winter Driving Environment

16th International Road Weather Conference
Helsinki, Finland, 23-25 May 2012

Civil Engineering Research Institute (CERI) for Cold Region
Naoto Takahashi, Ph. D., P.E
Tetsuya Takada
Makoto Kiriishi
Roberto Tokunaga, Ph. D.
Introduction

- Unfavorable road conditions during winter
  - traffic congestion, traffic accidents
  - lower drivers’ satisfaction
- Need to find ways of improving the appropriateness and efficiency of winter road maintenance to improve drivers’ satisfaction

How the deterioration of road conditions affects user satisfaction and driving behavior?

To evaluate winter driving environments by simultaneously carrying out

**Evaluation of road conditions**
- Dimensions of snow piles, Friction number

**Driving test**
- Driving behavior, User satisfaction survey
Dimensions of snow piles on road shoulders:
- The height and width of snow piles were measured using photos taken from the sidewalk.

Road surface friction:
- Continuous Friction Tester (CFT)
- Measures the axial force on a test tire offset by 1 - 2 degrees from the direction of travel
- Measures friction continuously
- Friction value determined by CFT (Halliday Friction Number: HFN) is between 0 and 100
Customer Satisfaction (CS) Portfolio Analysis:
- Based on the product portfolio method proposed by Boston Consulting Group (BCG)
- Rank business units (or products) on BCG matrix
- Tool for viewing a business portfolio at a glance
Customer Satisfaction Portfolio Analysis

- Widely used in the field of marketing to clarify user needs

Evaluation of individual satisfaction factors (mean scores)

Satisfaction

0 50 100

Influence on satisfaction

Low Expectation High

Non-improvement

Expectation is low but satisfaction is high. No improvement is required

Maintenance

It is important to maintain present levels of satisfaction

Improvement

Items with low levels of satisfaction and expectation. Need to be improved.

Priority Improvement

Expectation is high but satisfaction is low. Immediate improvement is required.

Correlation with overall satisfaction (partial correlation coefficient)

Low → Expectation → High

Effective way to enhance overall satisfaction!
**IMprovement necessity Factor (IMF)**

\[
\text{IMprovement necessity Factor (IMF)} = \text{Modified exponent} \times \text{Distance from coordinates (50, 50)}
\]

\[
= \left( \frac{90^\circ - \text{angle from boundary line}}{90} \right) \times \sqrt{(x - \bar{x})^2 + (y - \bar{y})^2} \quad , (\bar{x}, \bar{y}) = (50, 50)
\]
Driving Test

Test day:
- autumn of 2009
- winter of 2010

Test route:
National Highway Route 230

Test section:
- Downtown area
- Suburban area

Test subjects:
- 10 non-professional drivers in their 30s and 40s
- Drive on a daily basis
- Annual driving distances; 10,000 to 20,000 km

Weather conditions

<table>
<thead>
<tr>
<th></th>
<th>Date</th>
<th>Weather</th>
<th>Air temperature (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Lowest</td>
<td>Highest</td>
</tr>
<tr>
<td>Autumn</td>
<td>Nov. 26, 2009</td>
<td>Cloudy</td>
<td>2.9</td>
</tr>
<tr>
<td>Winter</td>
<td>Jan. 15, 2010</td>
<td>Mostly sunny</td>
<td>-8.7</td>
</tr>
</tbody>
</table>
Driving Test

**Test vehicle:**
- Sedan-type car with 1,500 cc engine

**Driving behavior:**
- Driving speed, longitudinal acceleration

**Satisfaction survey:**
- Immediately after the driving test
- Asked to indicate their levels of satisfaction on a five-point Likert scale (1; dissatisfied, 2; somewhat dissatisfied, 3; neither satisfied nor dissatisfied, 4; somewhat satisfied, 5; satisfied)
  - Overall satisfaction
  - Road surface condition
  - Traffic flow
  - Road surface flatness
  - Road width
  - Sight distance
  - Intersections (starting and stopping)
Study Results

Road surface condition (visual assessment):
- Autumn: Dry
- Winter: Downtown; ice, slush and wet
  Suburban; ice or compacted-snow

Road surface condition (Friction value):
- Road surface was particularly slippery in the suburban area.

Road surface conditions on the test days
Road Conditions

**Snow piles:**
- **Downtown**
  - Height: 1.1m to 1.3m
  - Narrowed the road by 1.25 m to 1.45 m (1.35 m on average).
  - The road width was, on average, 79% of the 6.50 m value seen in autumn.

- **Suburban area**
  - Snow piles were observed only on bridge sections
Driving Behavior

Driving speeds:
The average driving speeds in winter were 5.8km/h and 7.7km/h lower in the downtown and suburban areas.

Longitudinal acceleration:
- The absolute value was small in winter
- Drivers accelerated and put the brakes more carefully in winter.
Correlation with overall satisfaction (partial correlation coefficient)

- Autumn: Low travel speed have resulted in low satisfaction with traffic flow.
- Winter: Drivers felt dissatisfied with the reduction in effective road width by snow piles.
- Autumn; Low satisfaction with width is considered to result from reduced road width in tunnels and on bridges.
- Winter; Reduced satisfaction with surface conditions and intersections was caused by low friction number.

**CS Portfolio Analysis Results (Suburban)**

- Autumn: Low satisfaction with width is considered to result from reduced road width in tunnels and on bridges.
- Winter: Reduced satisfaction with surface conditions and intersections was caused by low friction number.
Changes in Road Condition, Driving Behavior and IMF

- Decrease rate (DR): magnitude of the change
- Difference in IMF value: priority of improvement.

- Downtown:
  - IMF difference was the greatest for width, followed by surface condition.
  - The DR for the HFN was greater than that for width, but the IMF difference for width was the greatest from the viewpoint of driver’s satisfaction.
  - Friction values fell to 64, but still within the acceptable level?

- Suburban area:
  - HFN showed a decrease of 53%, & IMF difference for surface condition was the greatest

- Driving speeds and acceleration rates decrease in winter, but the relation between the changes in road conditions and that in driving behavior is unclear

| Changes in road condition, driving behavior and IMF in autumn and winter |
|---|---|---|---|---|---|---|---|---|---|
| Road condition DR | Driving behavior DR | Difference in IMF |
| Width | HFN | Speed | Acceleration | Surface condition | Traffic flow | Flatness | Width | Sight distance | Intersections |
| Downtown | 21% | 31% | 22% | 60% | 23.7 | 4.6 | -31.9 | 30.4 | -7.1 | -24.1 |
| Suburban | 0% | 53% | 14% | 70% | 28.8 | 18.3 | 15.7 | -38.7 | -27.5 | 7.5 |
Conclusions & Future Study

Study Results

Driving behavior:
- Driving speeds and acceleration rates decrease in winter.
- It remained unclear whether these changes in driving behavior were caused by the deterioration of road surfaces or by the narrowed road width due to the snow piles.

Customer satisfaction survey:
- Results corresponding to the characteristics of changes in driving environments were attained
- Subjective evaluation can be an effective tool for the assessment of driving environment and the identification of factors for improvement.

Future Study
- drivers’ experience & characteristics affect user satisfaction.
- Need to conduct further studies involving subjects with a wider range of driving backgrounds in a variety of road conditions.
Thank you for your attention
Introduction

- Unfavorable road conditions during winter
  - traffic congestion, traffic accidents
- Lower drivers’ satisfaction
- Need to find ways of improving the appropriateness and efficiency of winter road maintenance to improve drivers’ satisfaction

Measures and policies that need to be improved (opinion poll conducted by Sapporo city)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Snow removal</td>
<td>31.3%</td>
</tr>
<tr>
<td>Safe, secure society</td>
<td>21.9%</td>
</tr>
<tr>
<td>Elderly welfare</td>
<td>21.9%</td>
</tr>
<tr>
<td>Public transportation</td>
<td>15.3%</td>
</tr>
<tr>
<td>Children’s education</td>
<td>13.3%</td>
</tr>
</tbody>
</table>

Note: up to 3 answers allowed
Introduction

To improve drivers’ satisfaction

How the deterioration of road conditions affects user satisfaction and driving behavior?

To evaluate winter driving environments by simultaneously carrying out ...

Evaluation of road conditions
- Dimensions of snow piles on road shoulders
- Friction number

Driving test
- Driving behavior: Driving speed, Longitudinal acceleration
- User satisfaction survey: Customer Satisfaction portfolio analysis
Customer Satisfaction (CS) Portfolio Analysis:
- Based on the product portfolio method proposed by Boston Consulting Group (BCG)
- Rank business units (or products) on BCG matrix
- Serve as a tool for viewing a business portfolio at a glance

High-growth businesses or products with a relatively low market share

Low-growth businesses or products with a relatively low market share

High-growth businesses or products with a relatively high market share

Low-growth businesses or products with a relatively high market share
Improvement Necessity Factor (IMF)

- Determine improvement priority

Correlation with overall satisfaction (partial correlation coefficient)

Influence on satisfaction

Evaluation of individual satisfaction factors (mean scores)

Basic axis for improvement

Improvement Necessity Factor (IMF) = Modified exponent \times \text{Distance from coordinates (50, 50)}

= \left( \frac{90^\circ - \text{angle from boundary line}}{90} \right) \times \sqrt{(x - \bar{x})^2 + (y - \bar{y})^2} \quad , (\bar{x}, \bar{y}) = (50, 50)
Drivers’ satisfaction

Winter: Downtown; 60% somewhat dissatisfied with **road width** (stem from the reduction in road width caused by snow piles)

Suburban; 50% dissatisfied with **surface condition** (as a result of slippery road surface)