Customer Satisfaction Analysis for Evaluating Winter Driving Environment

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Civil Engineering Research Institute (CERI) for Cold Region

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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

Evaluation of Road Conditions

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
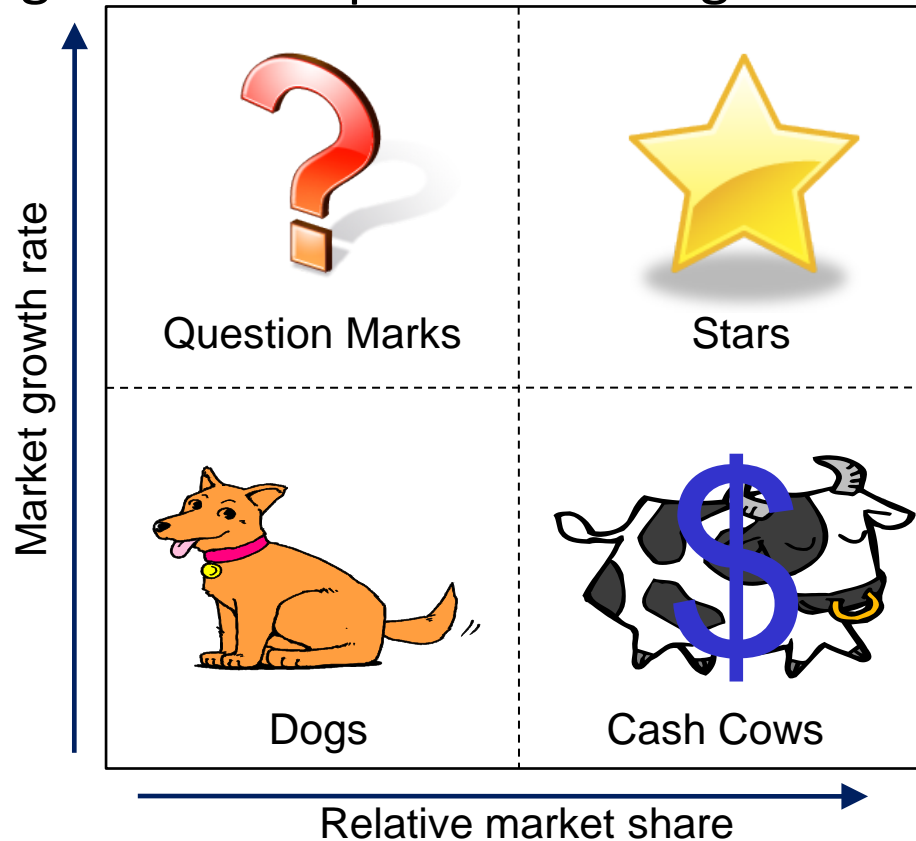

Continuous Friction Tester (CFT)

User Satisfaction Survey
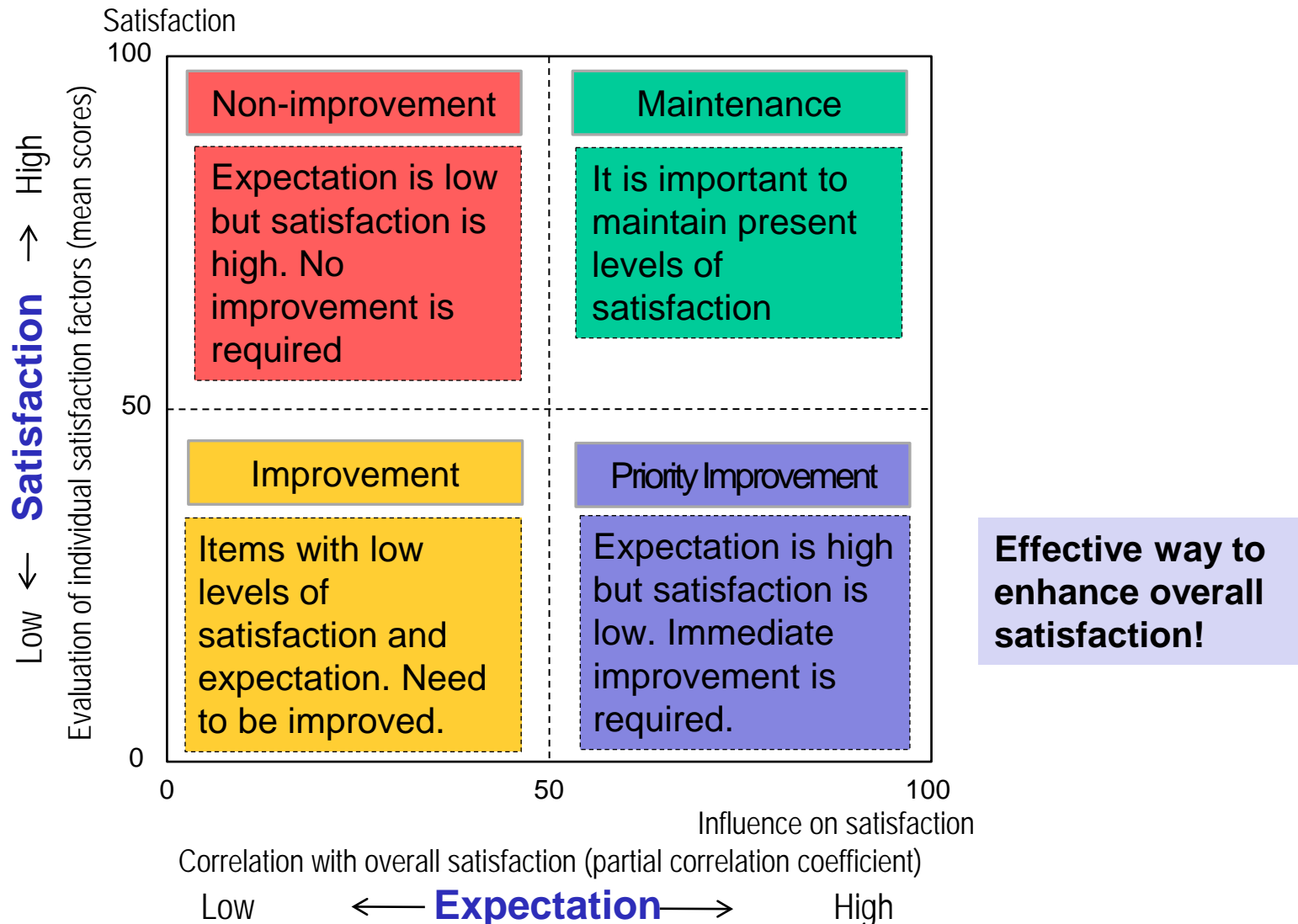
Customer Satisfaction (CS) Portfolio Analysis :

 - 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

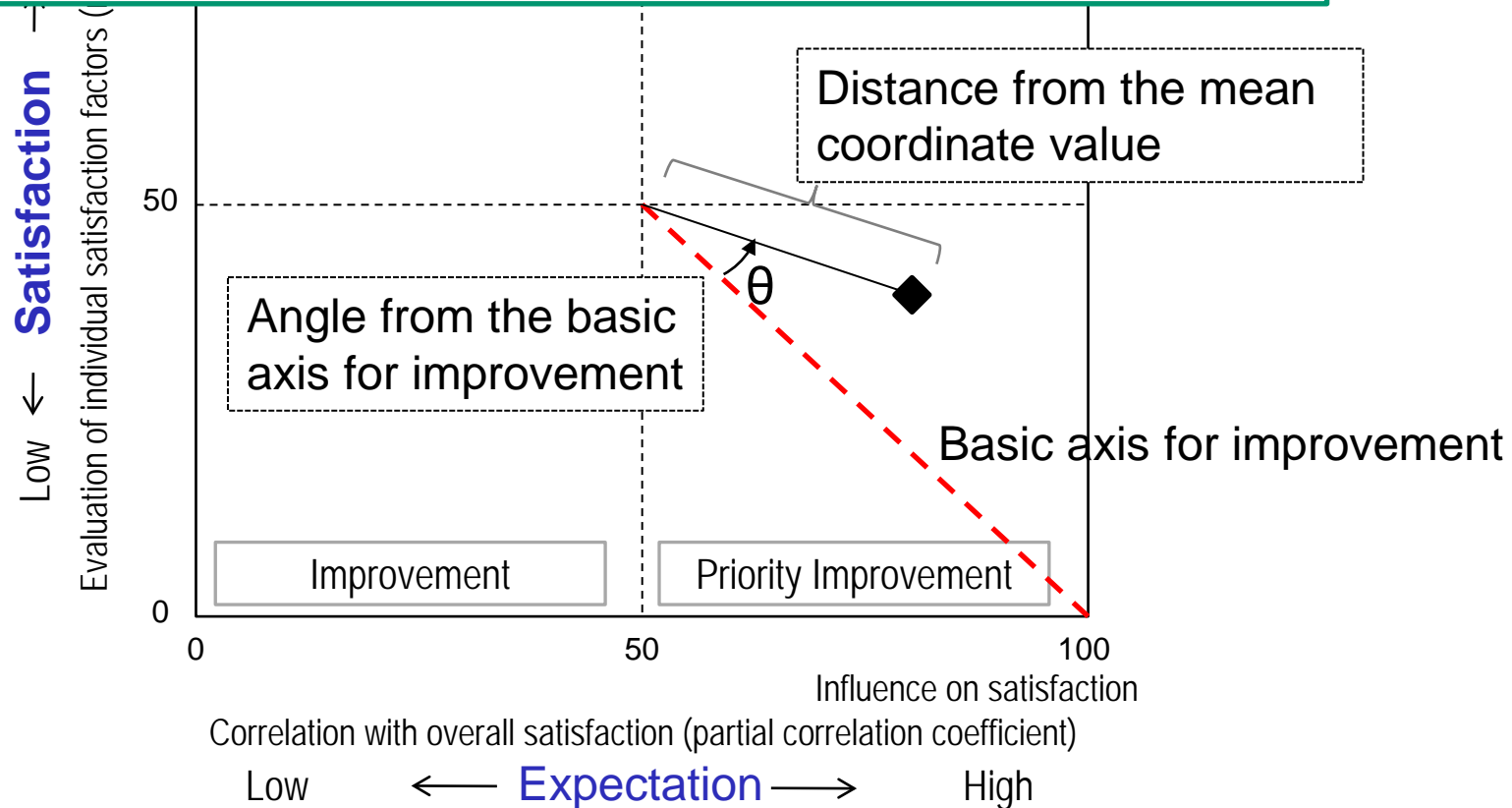- Widely used in the field of marketing to clarify user needs

Satisfaction

100

Satisfaction Low ← → High

Evaluation of individual satisfaction factors (mean scores)

Non-improvement	Maintenance
Expectation is low but satisfaction is high. No improvement is required	It is important to maintain present levels of satisfaction

50

Improvement	Priority Improvement
Items with low levels of satisfaction and expectation. Need to be improved.	Expectation is high but satisfaction is low. Immediate improvement is required.

0

0   50   100

Influence on satisfaction

Correlation with overall satisfaction (partial correlation coefficient)

Low   ←— **Expectation** —→   High

Effective way to enhance overall satisfaction!

IMprovement necessity Factor (IMF)

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= Modified exponent × Distance from coordinates (50, 50)

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

Distance from the mean coordinate value

Angle from the basic axis for improvement

θ

Basic axis for improvement

Improvement

Priority Improvement

Satisfaction Low ⟸

Evaluation of individual satisfaction factors (

50

0

0   50   100

Influence on satisfaction

Correlation with overall satisfaction (partial correlation coefficient)

Low   ⟵ Expectation ⟶   High

Driving Test

Test day:
 - autumn of 2009
 - winter of 2010

Test route:
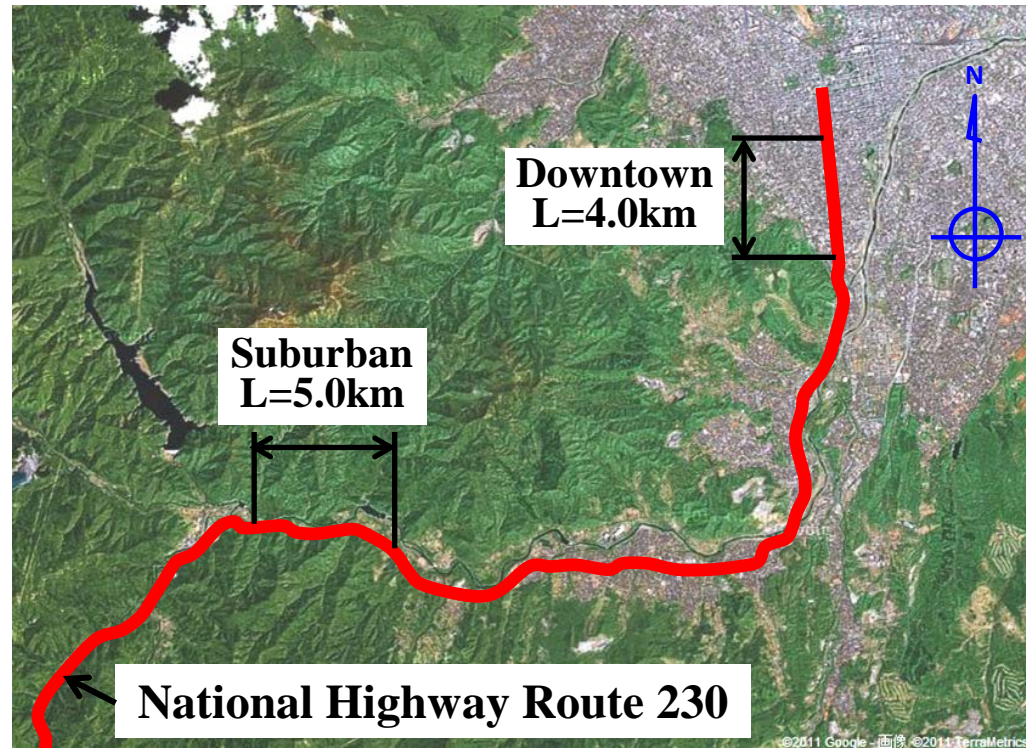 National Highway Route 230

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

Case study route map

Weather conditions

	Date	Weather	Air temperature (°C)		
			Lowest	Highest	Average
Autumn	Nov. 26, 2009	Cloudy	2.9	5.8	4.1
Winter	Jan. 15, 2010	Mostly sunny	-8.7	-3.8	-6.5

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)
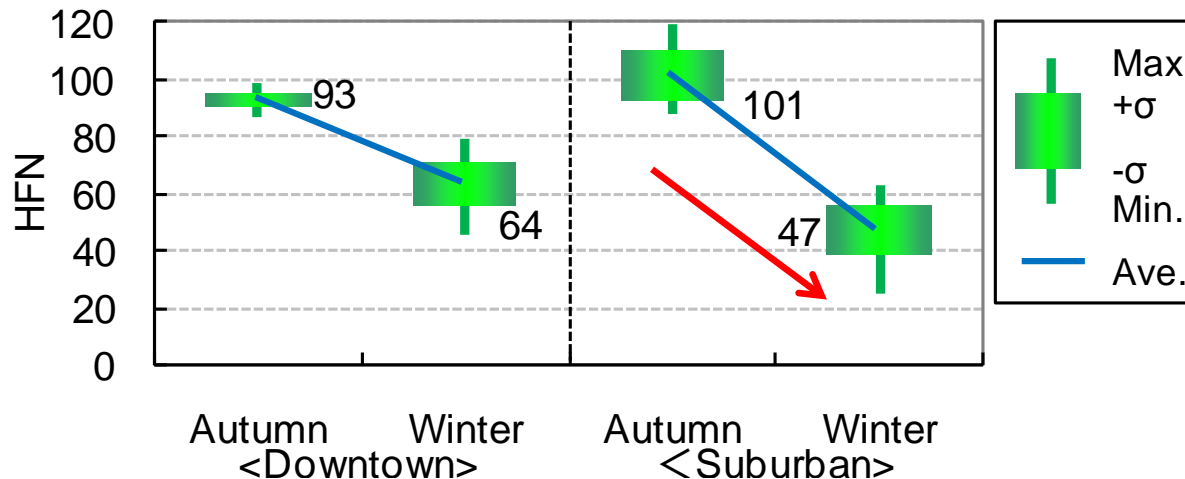

Test vehicle

Questionnaire completion

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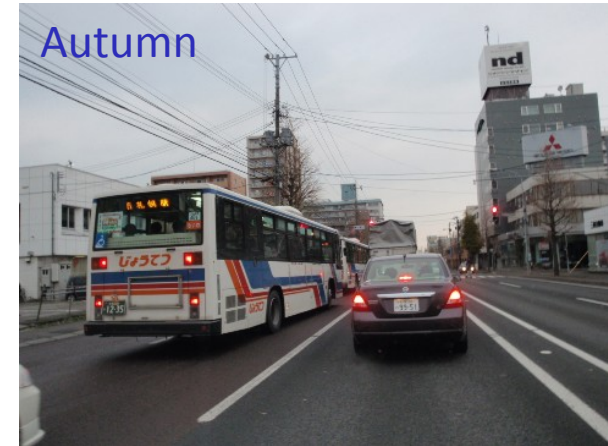
Road surface condition (visual assessment):
- Autumn: Dry
- Winter: Downtown; ice, slush and wet
          Suburban; ice or compacted-snow

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

Autumn

Winter

Road surface conditions on the test days

	Max +σ
	-σ Min.
	Ave.

Road surface conditions (HFN values) on the test days
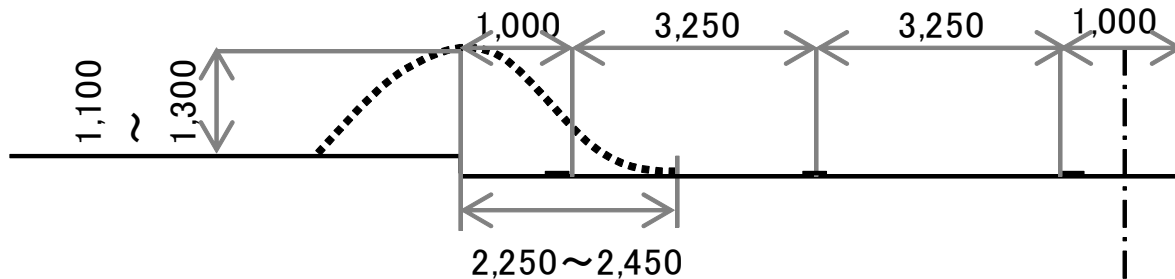
Road Conditions

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.

Snow piles in the downtown area

Dimensions of snow piles in the downtown area

- Suburban area

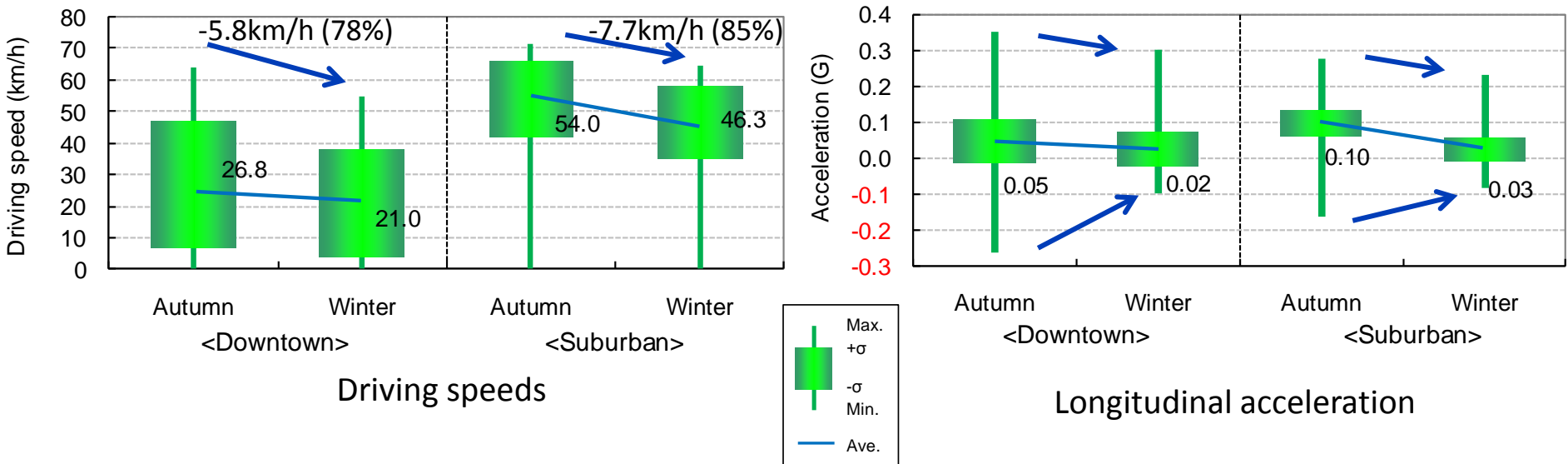Snow piles were observed only on bridge sections

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.

Driving speeds

Longitudinal acceleration

CS Portfolio Analysis Results (Downtown)

- 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.
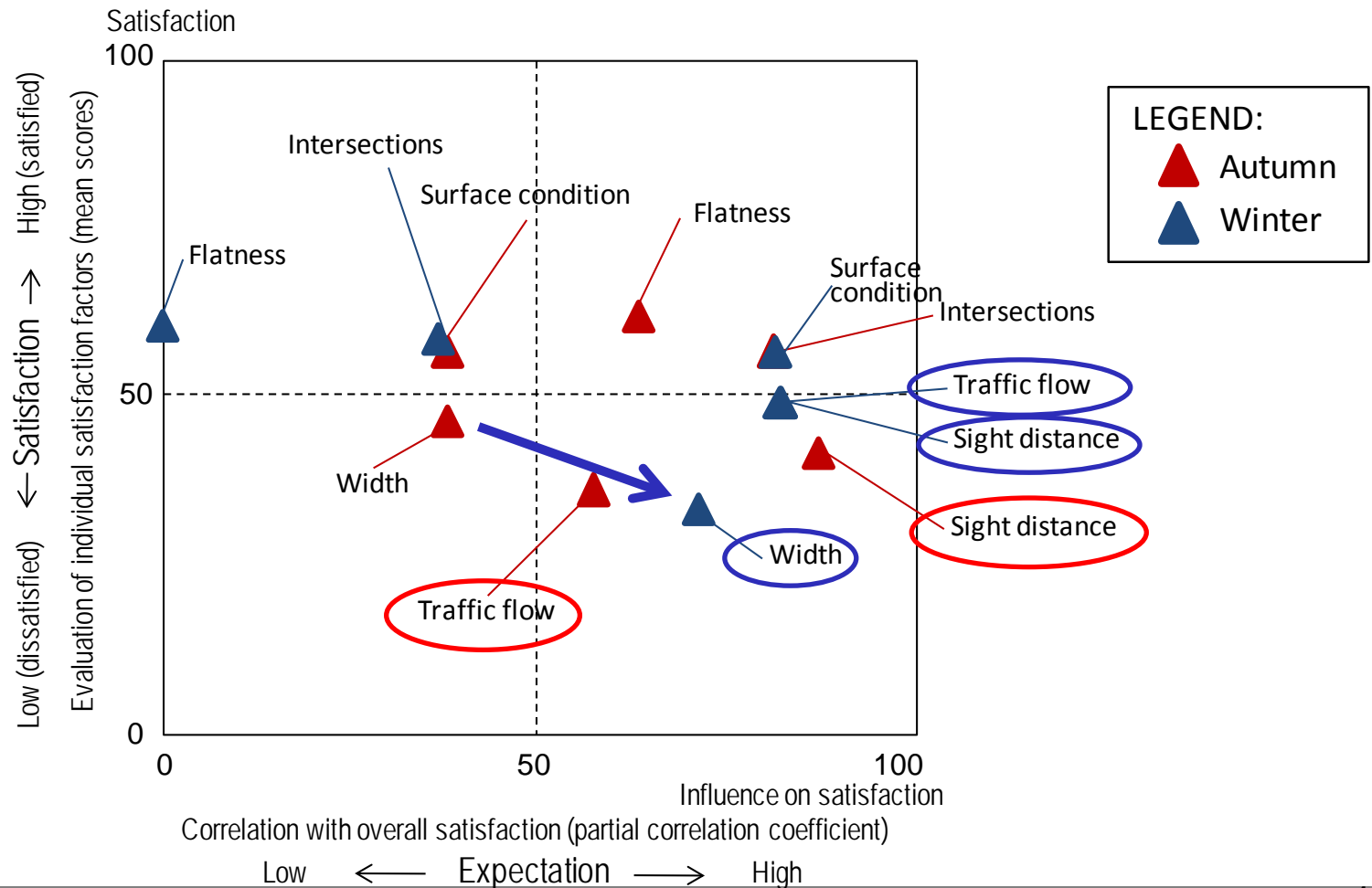
CS Portfolio Analysis Results (Suburban)

- 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.
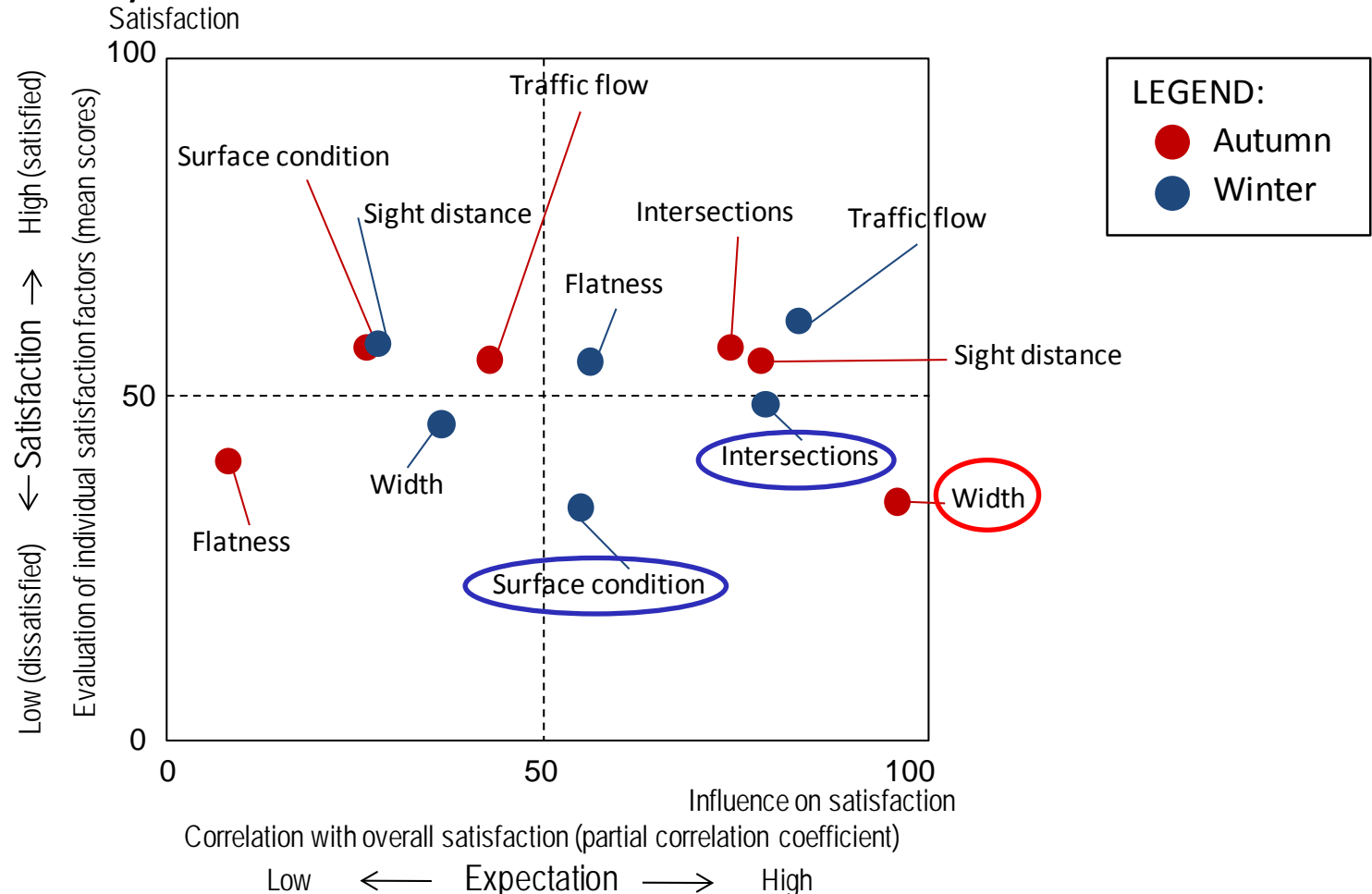
Changes in Road Condition, Driving Behavior and IMF

- 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	Driving 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.
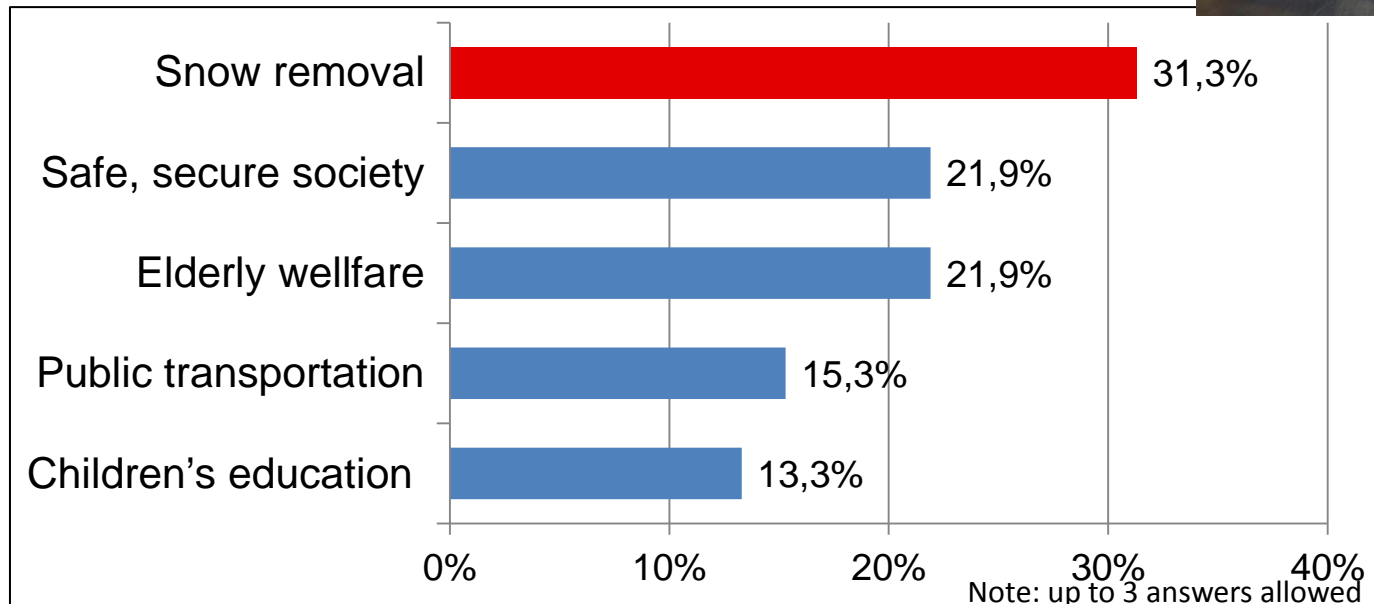
Thank you for your attention

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- Need to find ways of improving the appropriateness and efficiency of winter road maintenance to improve drivers' satisfaction

Category	Percentage
Snow removal	31,3%
Safe, secure society	21,9%
Elderly wellfare	21,9%
Public transportation	15,3%
Children's education	13,3%

0%   10%   20%   30%   40%

Note: up to 3 answers allowed

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

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To improve drivers' satisfaction

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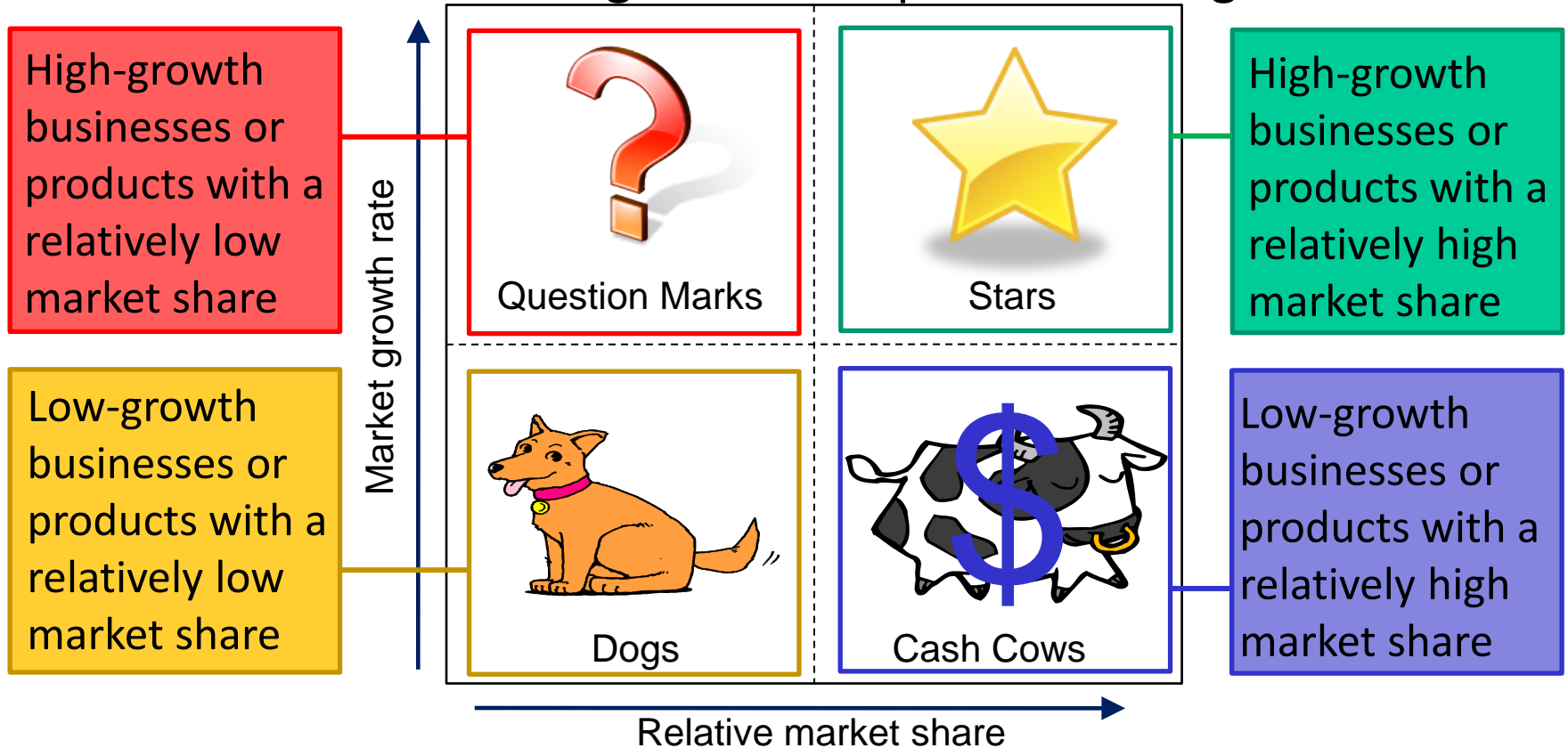- Dimensions of snow piles on road shoulders
- Friction number

Driving test
- Driving behavior: Driving speed, Longitudinal acceleration
- User satisfaction survey: Customer Satisfaction portfolio analysis

User Satisfaction Survey

Customer Satisfaction (CS) Portfolio Analysis :

- Based on the product portfolio method proposed by Boston Consulting Group (BCG)
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- Serve as a tool for viewing a business portfolio at a glance

High-growth businesses or products with a relatively low market share	Question Marks	Stars	High-growth businesses or products with a relatively high market share
Low-growth businesses or products with a relatively low market share	Dogs	Cash Cows	Low-growth businesses or products with a relatively high market share

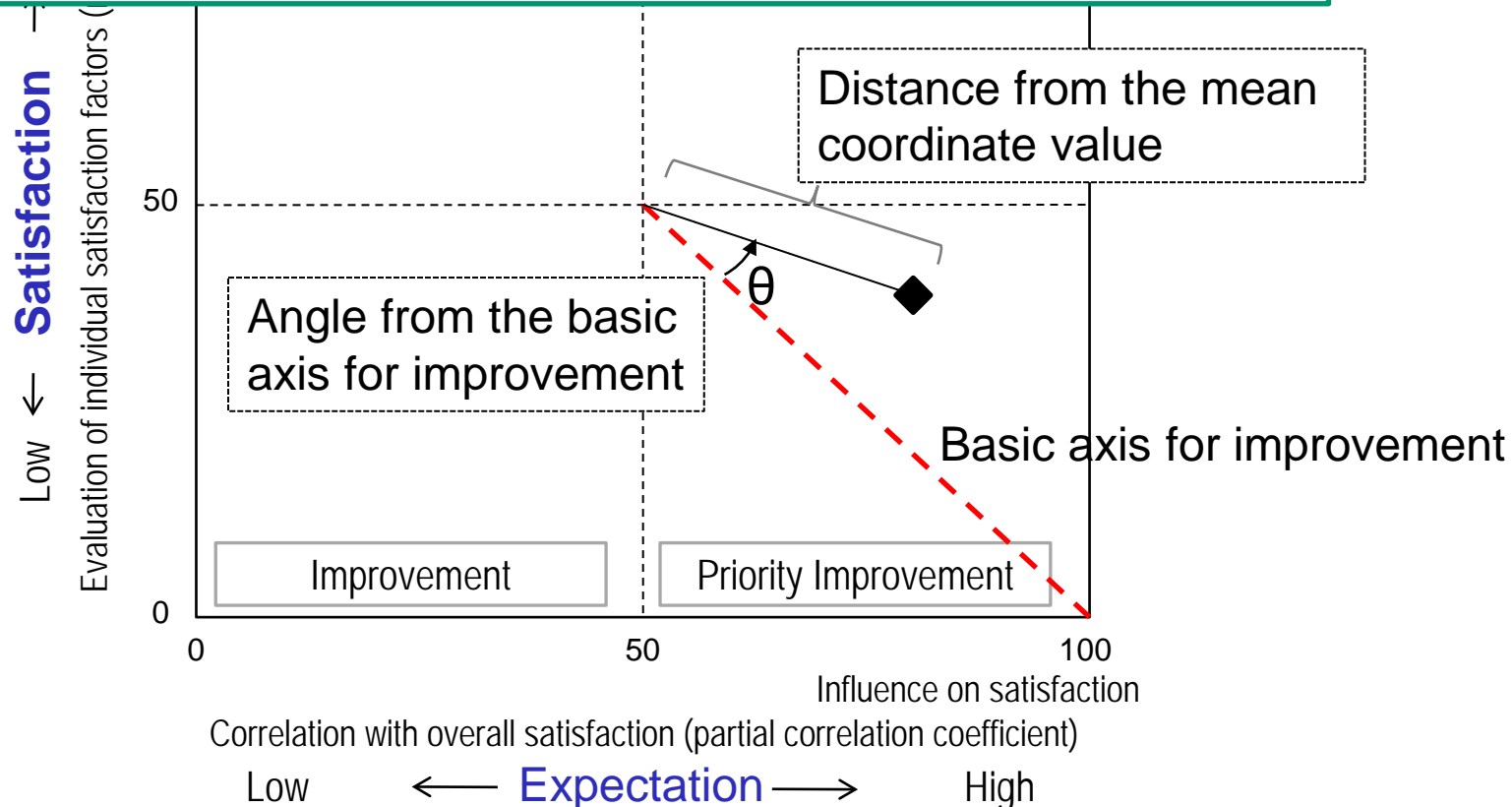Market growth rate

Relative market share

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Basic axis for improvement

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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)

■ Satisfied   ■ Somewhat satisfied   ■ Neither satisfied nor dissatisfied   ■ Somewhat dissatisfied   ■ Dissatisfied

< Autumn, Downtown >

< Autumn, Suburban >

< Winter, Downtown >

< Winter, Suburban >