FY2025 Results Report

# Strategic Innovation Program (SIP) Phase 3 / Building a Smart Mobility Platform, Economic and Mathematical Engineering Research by Market Design for the Smart Mobility Platforms

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March 2026

# ■ Table of Contents

# Background

There are a variety of mobility resources in the region, and mobility services are provided for the movement of people and goods using mobility resources.

Currently, the use of mobility is often dictated by entry regulations and subsidies.
→The subsidy for buses makes it possible to maintain the route. The size of the subsidy also determines the number of services. It is questionable whether mobility is being provided in accordance with the actual conditions of the area.

There are mobility resources in the region that have potential for use, such as cabs and school/caregiver shuttle buses, by making effective use of them, mobility services are expected to become more convenient and efficient.

# Purpose

**Optimizing Mobility Resources Through Market Design**
**•Institutional Design for Mobility Service Markets and Platform Management**
**•Regional Institutional Design Aligned with Mobility Service Demand**
**•Validation via Data-Driven Mathematical Engineering Approaches**

# Project Overview / Issues to be work

## **Economic study of market design that brings easier service provision of smart mobility services**

Expected to be applied in the validation process for diagnostic guidelines and in the analysis process for mobility re-design reports.
Organize and specifically apply the concept of market design.

**Based on the results, support efforts to work on the following sub-issues.**

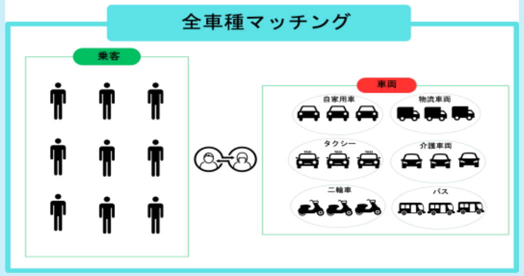
① Identification of local mobility resources
④ Development of  local mobility re-design report and Japanese re-design index
⑦-9 Proposed systems and rules
⑱ Practical research (action research) and dissemination development activities to typify and identify areas utilizing local mobility resources

# ■ Three-Task Collaboration Theme

Hypothesis: **To avoid the anxiety arising from information asymmetry in ride-sharing and the resulting market contraction, can disclosing drivers' biometric and vehicle data to passengers break the information asymmetry and provide a sense of security?**

### Smart Mobility Platform

・Survey of current mobility-market issues
・Organize mobility-service transaction rules
・Operator participation & biometric measurement




Service design proposal

Data provision

### Robotics

・Use of compact biometric monitoring devices
・Continuously collecting various vital data such as cardiac activity and body movement, then analyzing and AI-processing it


Generalization of the model

Bus subsidy recommendations

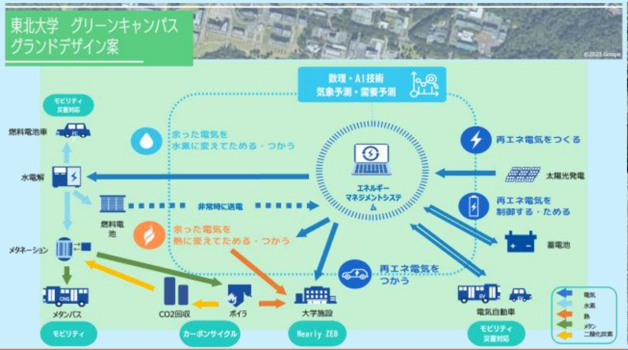
"Compact biometric monitoring devices for comprehensive driver support & safer transport"

Provision of demonstration test sites

Data provision

### Smart Energy Mgmt: market design & eco-driving

・Consideration of matching mechanisms
・Predictive models using mobility data & simulation




**International collaboration**
**Malaysia, Vietnam, etc.**
**Adaptation to local transport**

**Data strategy**
Acquired vehicle information to the Data Collaboration WG

# ■ Project Overview / Target Goals

## 2025 interim goal: Achieve GRL4 (conceptualization of the system)

- Raise issues on the subsidy system in the mobility service market (especially challenges of Japan's domestic subsidy system, including comparison with overseas); compile the impact of safety and environmental-load indicators shown on the platform on the platform's viability

## 2027 final goal: Achieve GRL6 (implementation plan)

- Compile final recommendations on the ideal form of the subsidy system, reflecting numerical-computation experiments grounded in mathematical-engineering perspectives

# ■ Roadmap

| 研究開発テーマ | 実施項目 | 2023 | | | | 2024 | | | | 2025 | | | | 2026 | | | | 2027 | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 | Q1 | Q2 | Q3 | Q4 |
| ⑧ | 地域モビリティ資源の実情調査 | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | |
| | モビリティサービス市場における補助金制度調査 | | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | | | | | |
| | モビリティプラットフォームでの指標公開による影響の研究 | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | |
| | マーケットデザインの観点からモビリティサービス市場における補助金を含めた数理経済モデルの作成 | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | |
| | マーケットデザインの観点からモビリティサービス市場モデルを分析して、補助金制度を評価 | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| | 数理工学的見地による数値計算実験 | | | | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | | |
| | 数値計算実験を反映した補助金制度のあり方研究 | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ |
| | 導入計画としての診断ガイドラインやモビリティ・リ・デザイン・レポートへの貢献 | | | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ |
| ①,④,⑦,⑱ | ⑧の成果を基に取組をサポート | | | ← | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― | ― | → |
| | | | | GRL2 | | | | GRL3 | | | | GRL4 | | | | GRL5 | | | | GRL6 | |

# ■ FY2025 Research Achievement Report / Overall

**1) Research on the impact of disclosing indicators on the mobility platform**

**2) Development of a mathematical economic model including subsidies in the mobility service market from a market-design perspective**

**3) Analysis of the mobility service market from a market-design perspective to evaluate the subsidy system**

**4) Smart-energy cross-task collaboration: Demonstration of energy-efficiency evaluation for low-speed/constant-speed EVs**

## ■ Research Achievement Report / 1) Impact of disclosing indicators on the mobility platform

Conducted 6 surveys of passengers and drivers in Japan and Malaysia

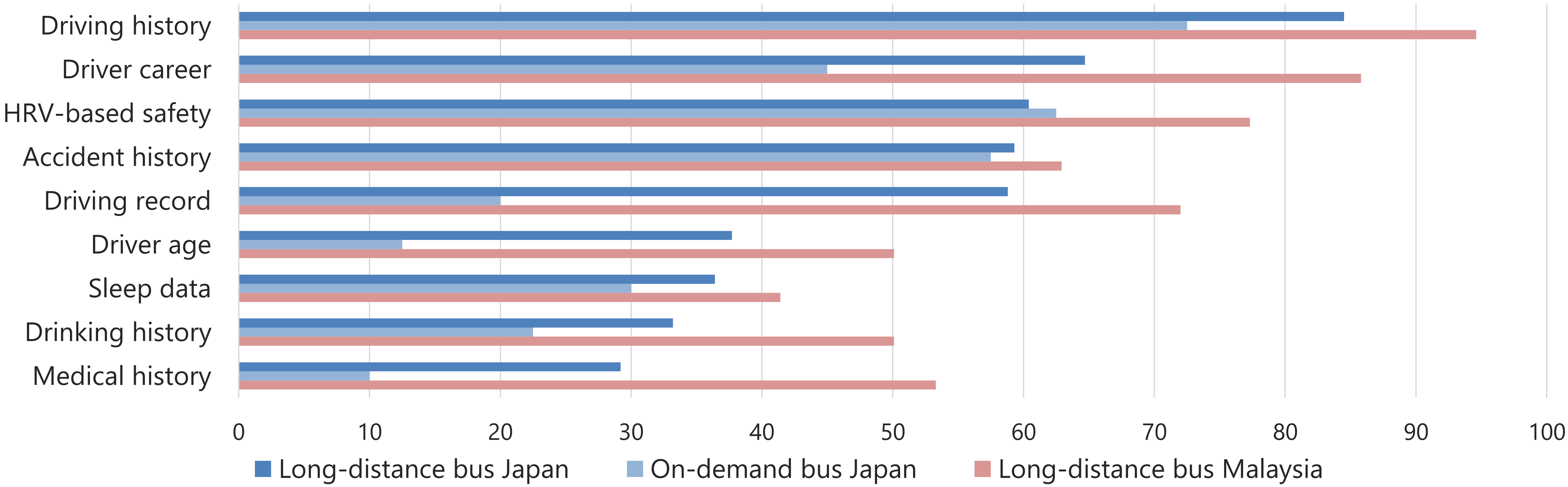
➡ For passengers: surveyed information needs and changes in reassurance/trust from information display

➡ For drivers: surveyed psychological burden from information disclosure and reluctance to disclose

| No. | Survey respondents | Target region | Target bus system | Valid responses |
|---|---|---|---|---|
| 1 | Passenger | Japan | Long-distance bus | 3,539 |
| 2 | Passenger | Malaysia | Long-distance bus | 353 |
| 3 | Passenger | Japan | On-demand bus | 30 |
| 4 | Driver | Japan | Long-distance bus | 10 |
| 5 | Driver | Malaysia | Long-distance bus | 10 |
| 6 | Driver | Japan | On-demand bus | 10 |

Survey for passengers

Q. Which information about the driver would you like to know? (multiple answers allowed)

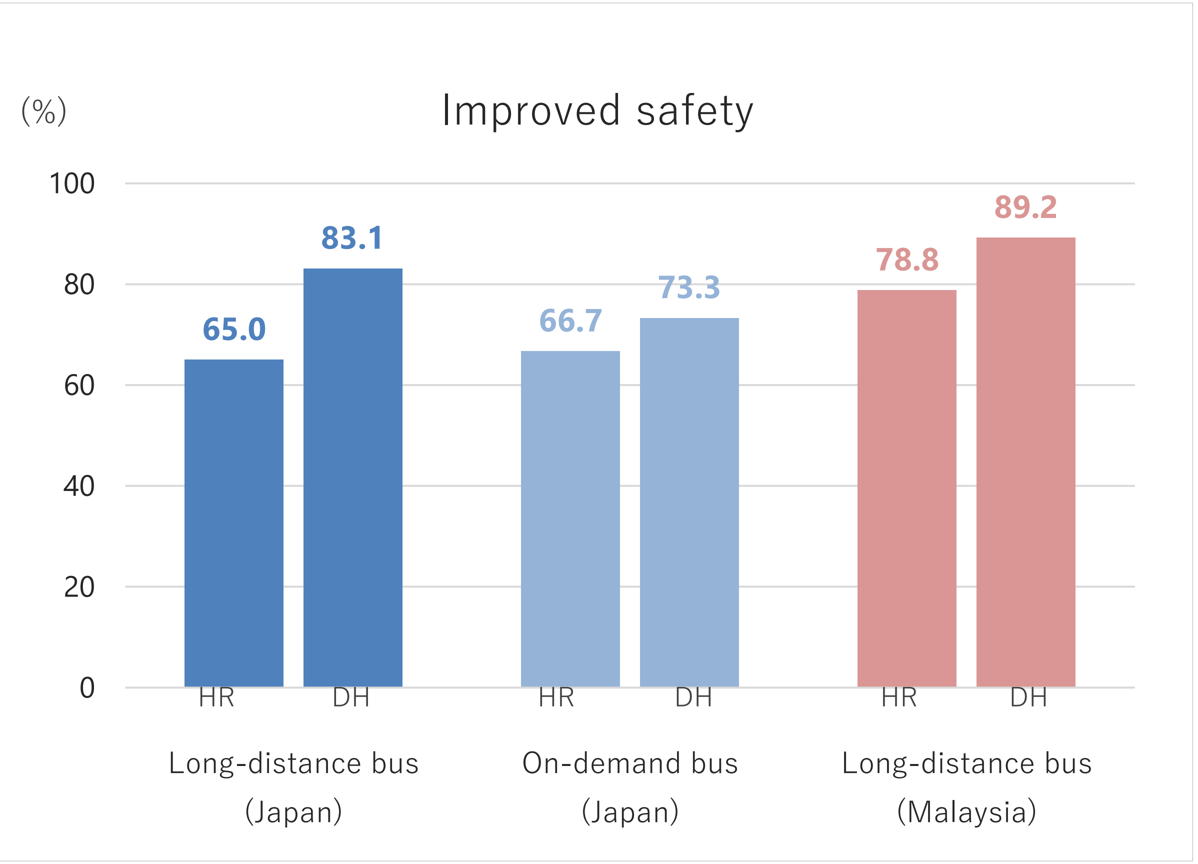


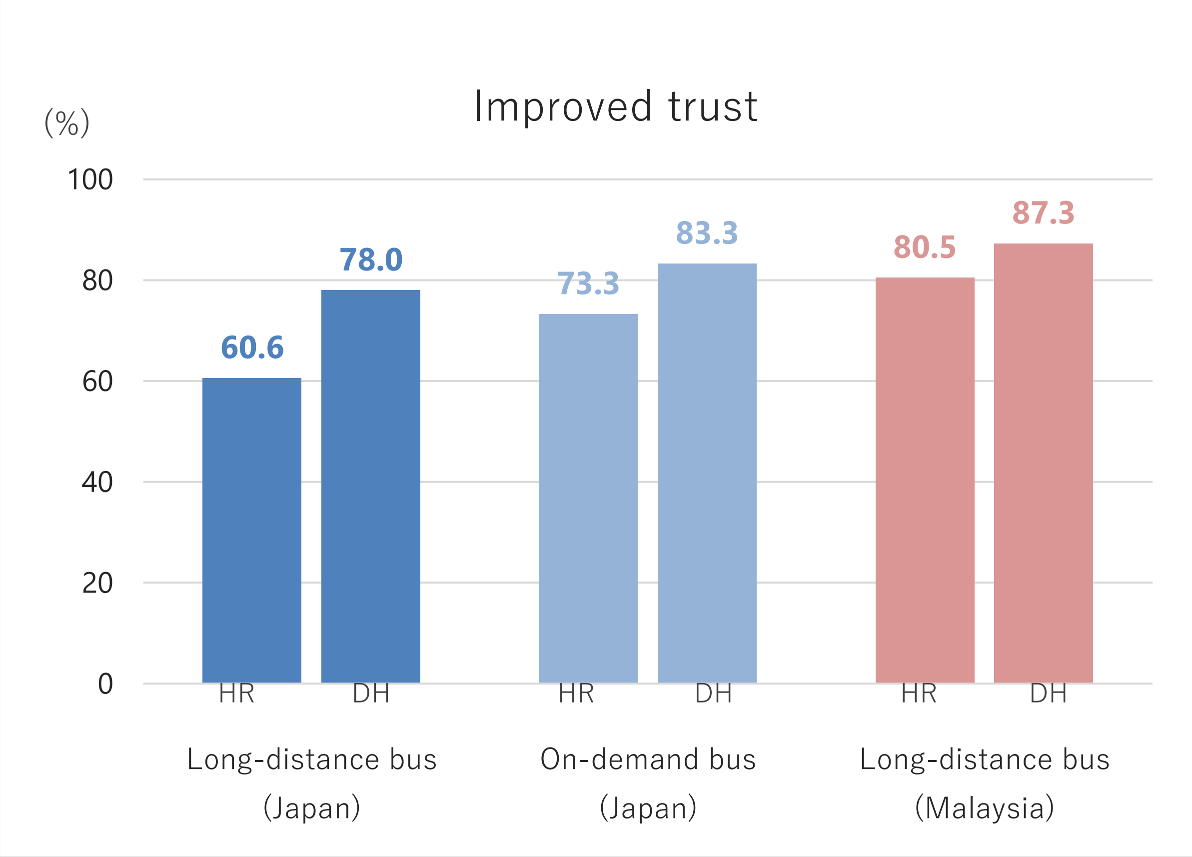

Passengers in both Japan & Malaysia have high info needs; driving history ranks highest.

## ■ Research Achievement Report / 1) Impact of disclosing indicators on the mobility platform

Survey for passengers

Q. Does displaying heart-rate(HR) and driving-history(DH) information improve your safety and trust?

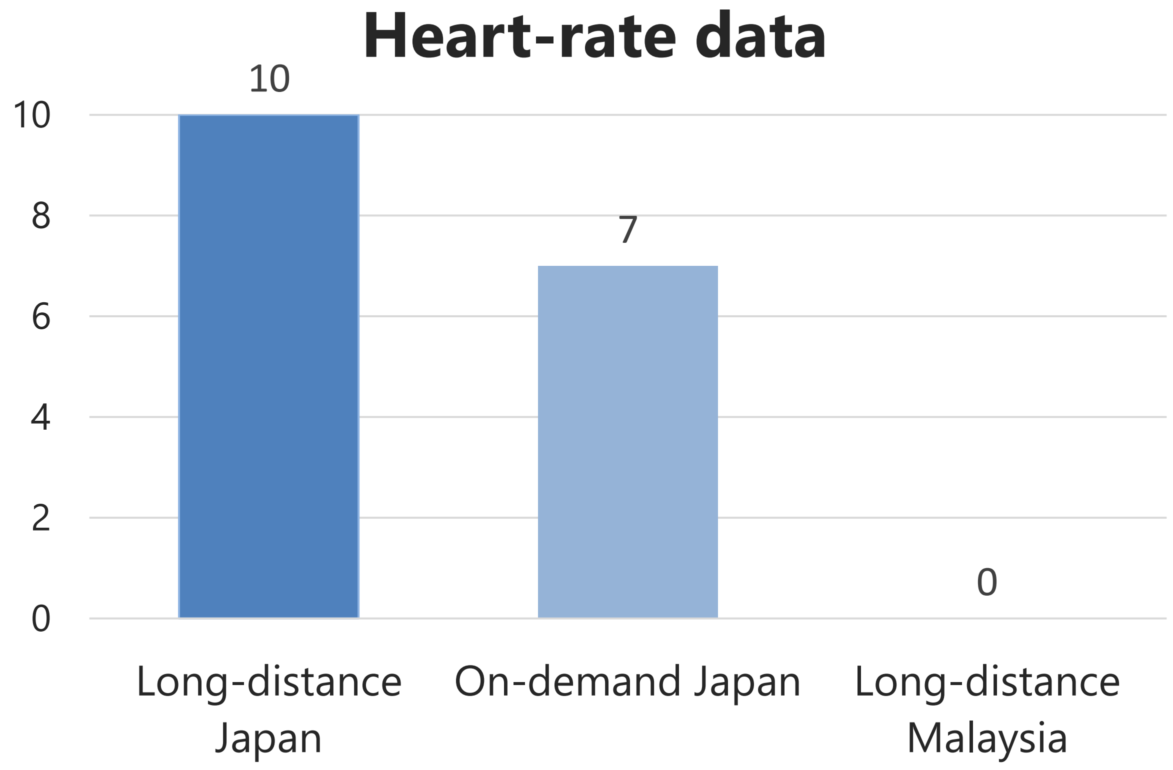


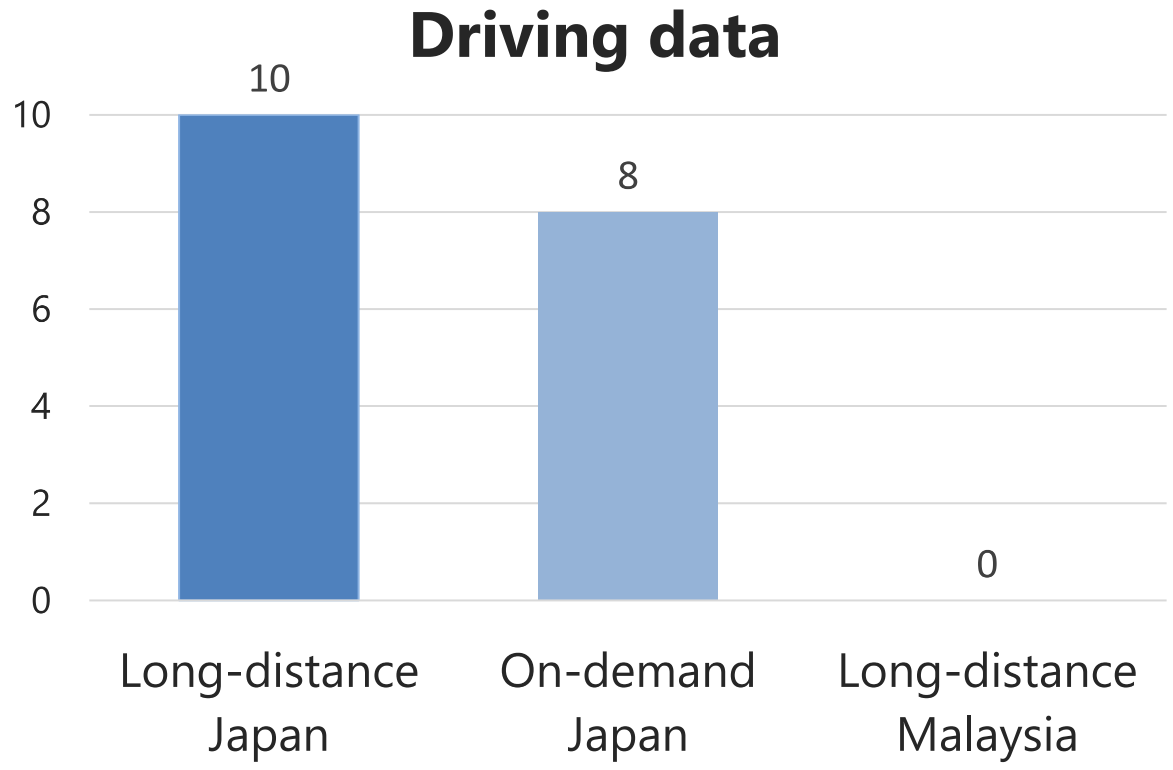




Both heart-rate and driving-history data contribute to greater safety and trust.
Driving-history data raised safety and trust more than heart-rate data.

Survey for drivers

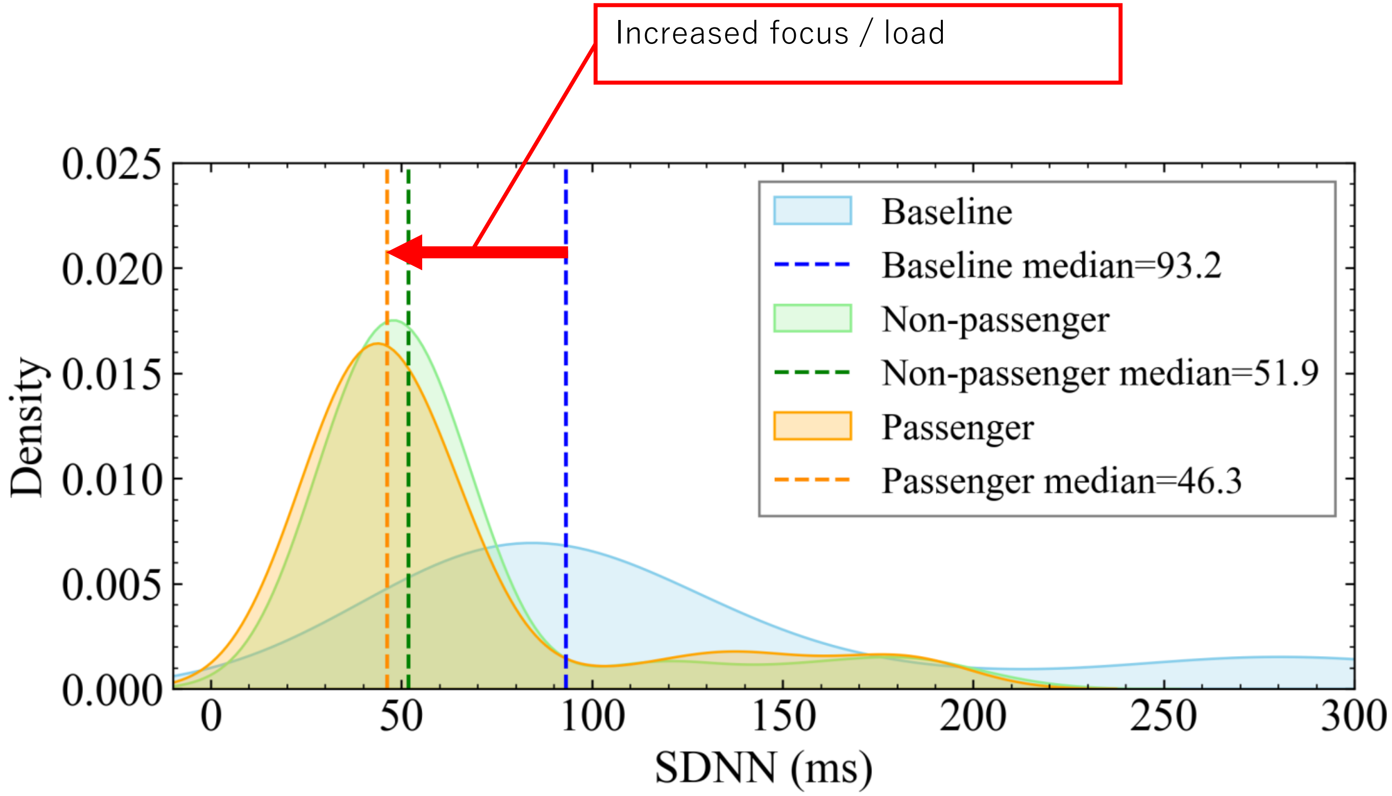
Q. Do you feel stress when heart-rate / driving information is shown to passengers?



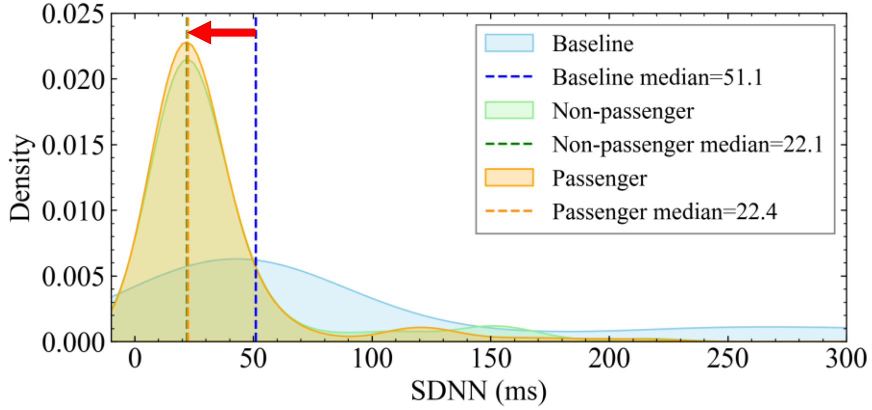




In Japan, disclosure caused significant stress for drivers.
In Malaysia, disclosure was not felt as stress at all.

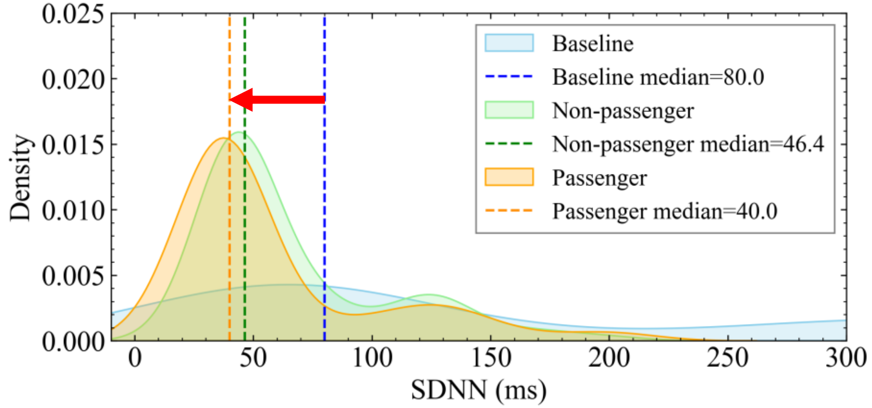
# Change in SDNN while driving




Driver 1-1




Driver 1-2




Driver 1-3

SDNN was widely distributed when stopped, but peaked at small values while driving.
→ This indicates the potential to detect driving load from heart-rate variability.

## ■ Research Achievement Report / 1) Impact of disclosing indicators on the mobility platform

1. Passengers seek safety-related information that evokes the driver's safe driving; when these needs are met, safety and trust improve.
   ➡ Resolving information asymmetry can foster safety and trust.

2. Passengers tend to seek multiple pieces of safety-related information, with safety and trust as fundamental elements.
   ➡ This suggests that “safety” may be a multifaceted concept.

3. Drivers feel a psychological burden about disclosing their own information (Japan).
   ➡ Drivers' cooperation is essential for information disclosure. Incentive design (intrinsic and extrinsic motivation) is key to easing the gap in disclosure acceptance between passengers and drivers.

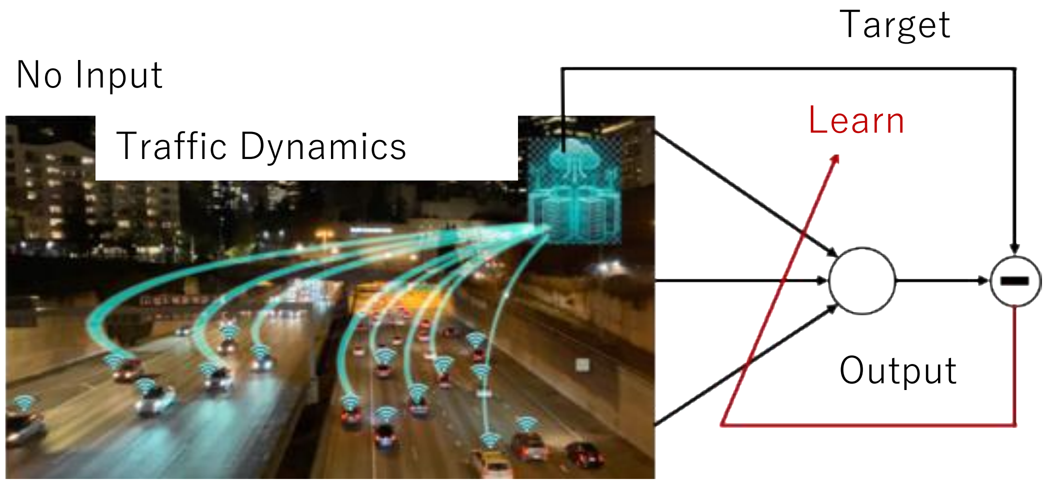
# ■ Research Achievement Report / 1) Impact of disclosing indicators on the mobility platform

## Development of demand-forecasting AI for the mobility platform

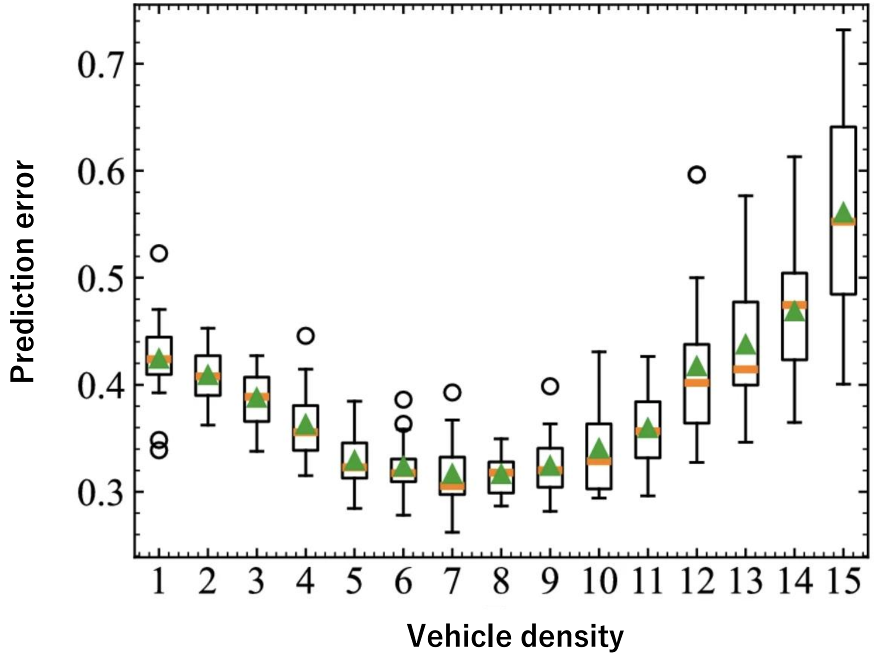
[Fukuzaki+,2025]

**RTRC**

Road Traffic
Resevoir
Computing




- **Collects road-traffic vehicle movements as data**
- **Achieves prediction using only simple computation**
- **Uses real-world physical patterns, enabling low-energy computation**




**It was found that prediction performance is maximized just before congestion occurs.**

# Built a mathematical economic model using principal–agent theory

| Variable | Definition / Description |
|---|---|
| Effort level $a_k$ | Choose $a_1$(high effort) or $a_0$(low effort). |
| Success probability $p_k$ | Success probability under effort $a_k$. Assume $p_1 > p_0$. |
| Outcome profit $\pi_i$ | Profit excluding subsidies. $\pi_S$(success) $\geq \pi_F$(failure). |
| Reward $\omega_i$ | $\omega_i = \pi_i + s_i$. Final amount received according to the outcome. |
| Disutility of effort $d_k$ | Cost associated with effort. Assume $d_1 > d_0$. |

Definition of expected reward: $E(\omega|a_k) = p_k\omega_s + (1 - p_k)\omega_F - d_k$

# Formula for the feeder-subsidy amount (modeling the current system)

$$S_i = \begin{cases} min\left\{\frac{1}{2}|\pi_i|, \beta\right\} & (\pi_i < 0) \\ 0 & (\pi_i \geq 0) \end{cases}$$

- Deficit ($\pi_i < 0$): half the deficit is covered (upper limit $\beta$)
- Surplus ($\pi_i \geq 0$): subsidy is 0 — not paid

# Formulation of the optimization problem

$$min_{\beta \geq 0} \quad p_1 s_S + (1 - p_1) s_F$$

IRF $$p_1(\pi_S + s_S) + (1 - p_1)(\pi_F + s_F) - d_1 \geq u$$

ICF $$p_1(\pi_s + s_S) + (1 - p_1)(\pi_F + s_F) - d_1 \geq p_0(\pi_S + s_S) + (1 - p_0)(\pi_F + s_F) - d_0$$

SR $$s_i = \begin{cases} min\left\{\frac{1}{2}|\pi_i|, \beta\right\} & (\pi_i < 0) \\ 0 & (\pi_i \geq 0) \end{cases}$$

# Analyzed the subsidy system under three scenarios

## Case 1: Large deficit

**Subsidy is a "fixed amount"**

The deficit is so large it has reached the upper limit. Even if effort reduces the deficit slightly, the subsidy does not decrease, so there is a reason to make an effort.

Motivation: Medium

## Case 2: Normal deficit

**Subsidy is a "fixed rate"**

A rule that covers half the deficit. Reducing the deficit through effort also reduces the subsidy by that amount, so motivation is lowest.

Motivation: Low(Trap)

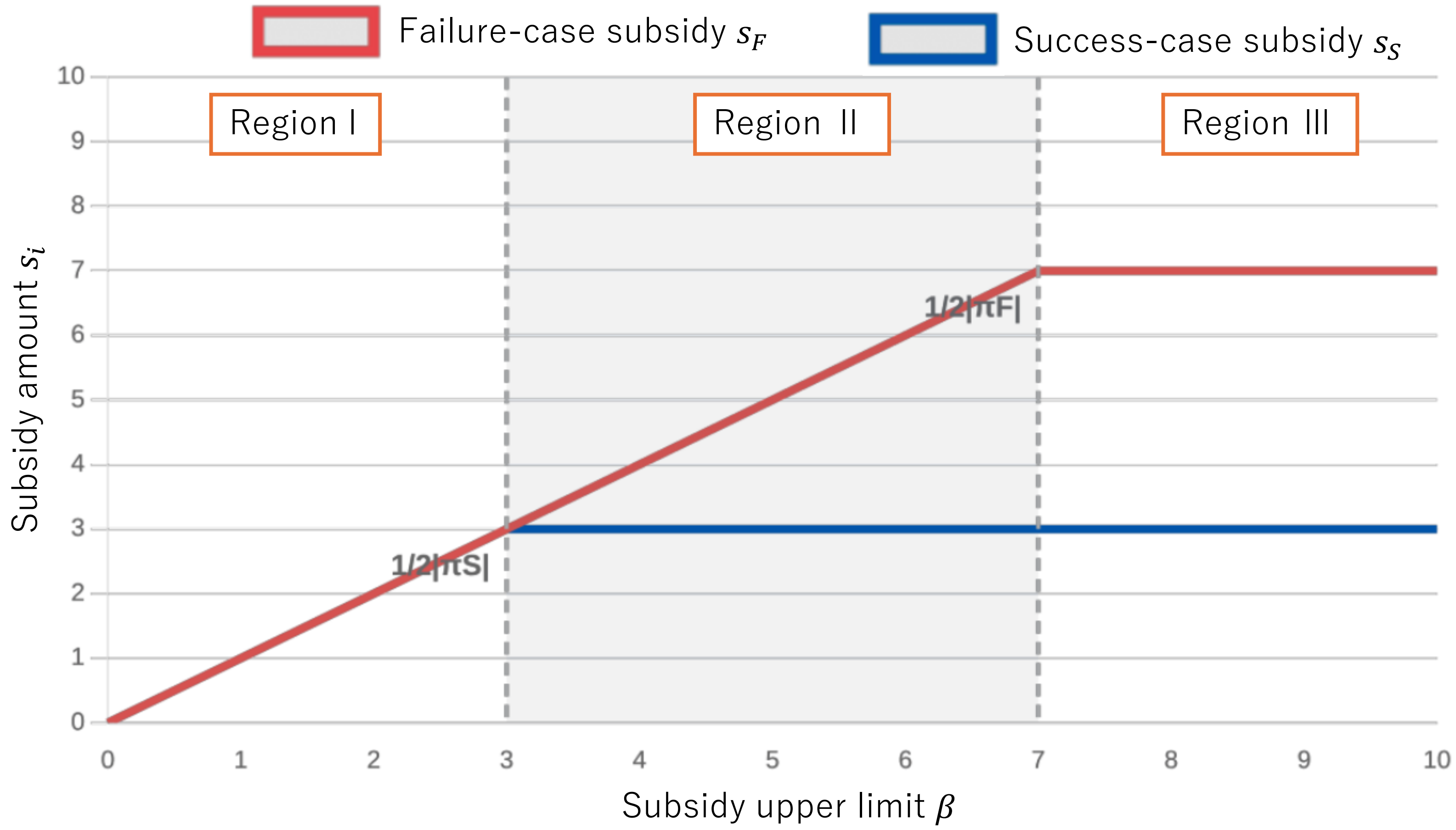
## Case 3: Surplus

**Subsidy is "none"**

Operating at a profit on its own. Increasing profit through effort means it all stays in hand, so motivation is highest.

Motivation: High

# Upper limit β vs. the subsidy vector




**Region I**

$\beta \leq \frac{1}{2}|\pi_S|$

$s_S = s_F = \beta$

**No incentive**

**Region II (controllable)**

$\frac{1}{2}|\pi_S| < \beta < \frac{1}{2}|\pi_F|$

$s_S = \frac{1}{2}|\pi_S| s_F = \beta$

Subsidy gap arises; controllable

**Region III**

$\beta > \frac{1}{2}|\pi_F|$

$s_i = \frac{1}{2}|\pi_i|$

Cannot be controlled via the upper limit

# Conditions for the incentive-compatibility constraint to hold in each region

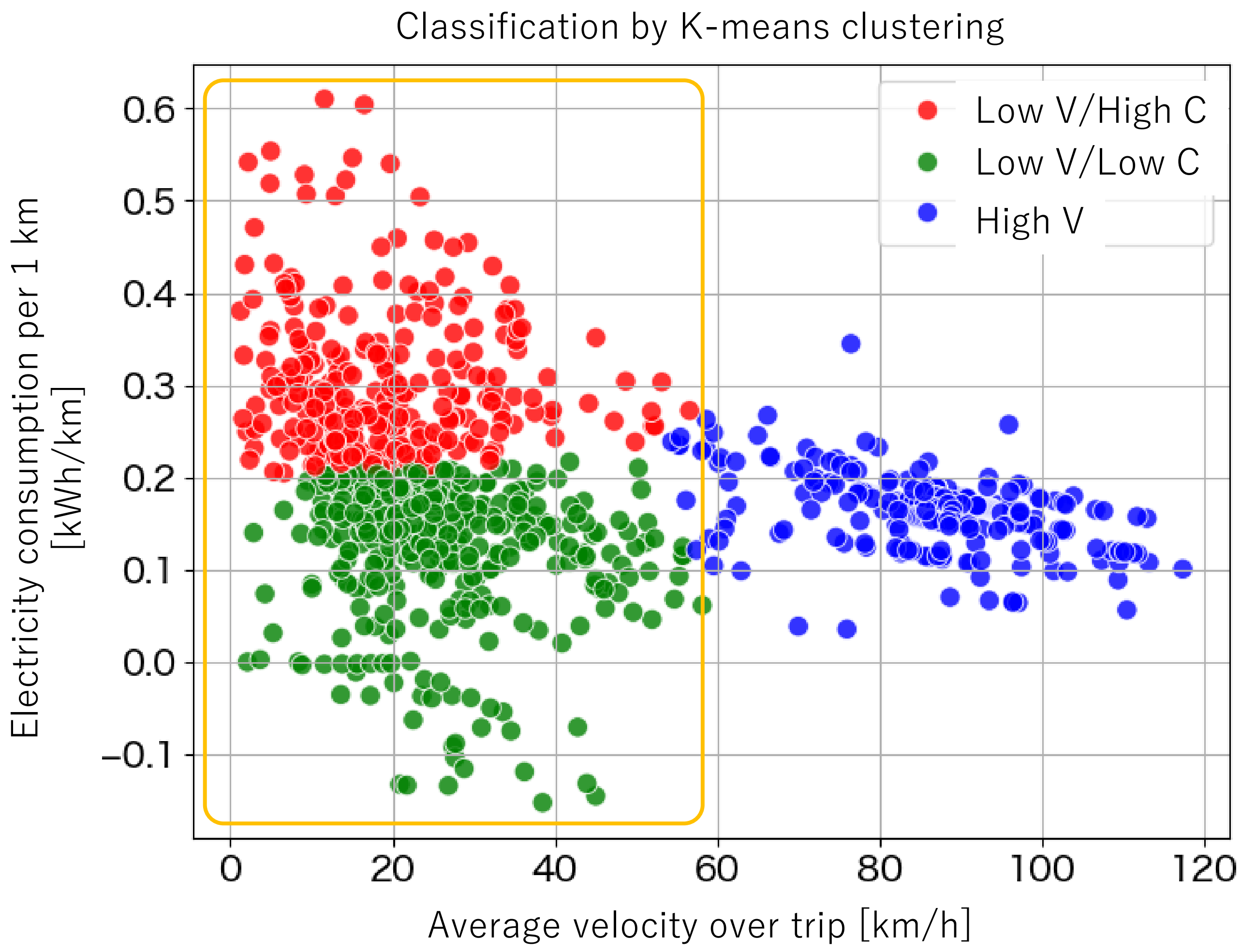
| Analysis region | Necessary and sufficient condition (transformation of ICF) | Government control |
|---|---|---|
| **Region I** (large deficit) | $\pi_S - \pi_F \geq \frac{d_1 - d_0}{p_1 - p_0}$ | **Cannot be controlled** (does not include $\beta$) |
| **Region II** (normal deficit) | $\frac{1}{2}[(\pi_S + \lvert\pi_S\rvert) - (\pi_F + \beta)] \geq \frac{d_1 - d_0}{p_1 - p_0}$ | **Controllable!** (can be adjusted via $\beta$) |
| **Region III** (small deficit) | $\frac{1}{2}(\pi_S - \pi_F) \geq \frac{d_1 - d_0}{p_1 - p_0}$ | **Cannot be controlled** (does not include $\beta$) |

- Region I and III : whether incentives are met depends on 'luck' (difference in outcome profit)
- Region II only: the government, by appropriately setting the upper limit β, can intentionally elicit operators' effort

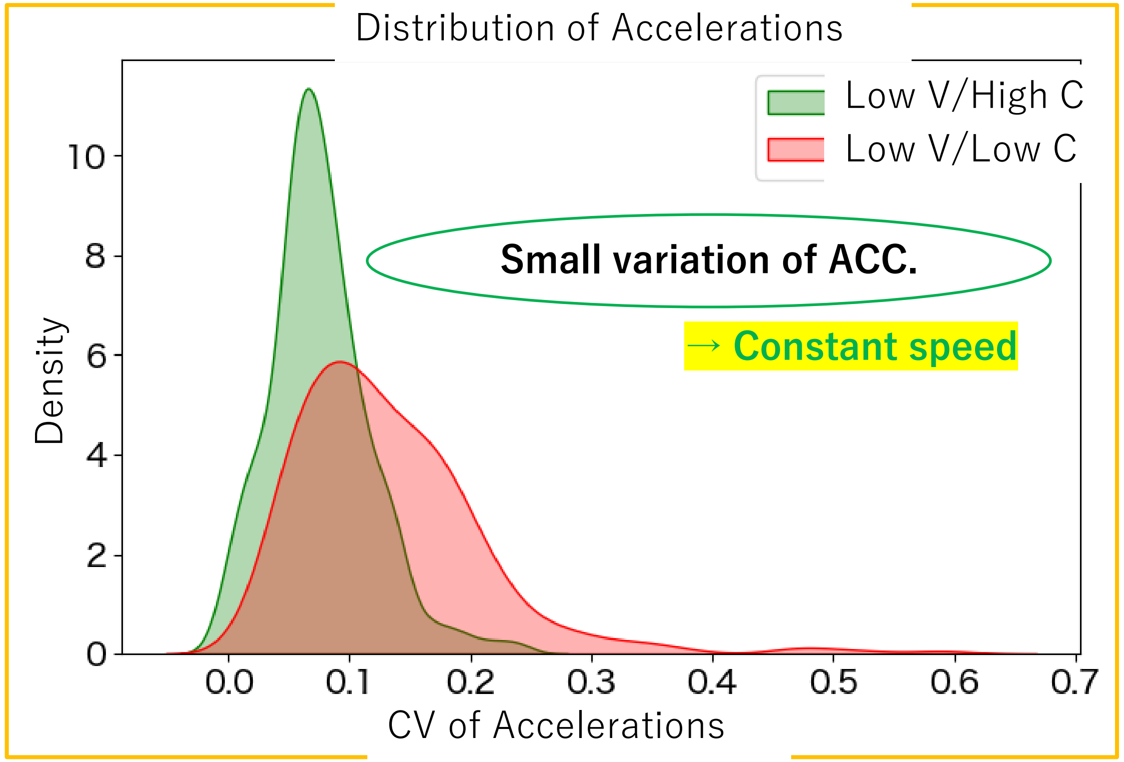
## ■ Research Achievement Report / 4) Smart-energy link: EV low/constant-speed driving

### ■ Tohoku University EV official-vehicle data analysis

Split a total of 871 km of trips into 1 km segments and classified driving patterns




Compare the acceleration-variation distribution per trip




Low/constant speed, low fuel
Acceleration variation suppressed →
Positioned as safe, low-consumption driving

This report includes results from "Cross-ministerial Strategic Innovation Promotion Program (SIP) Phase 3 / Building of a Smart Mobility Platform," promoted under the Council for Science, Technology and Innovation of the Cabinet Office (research-promotion agency: New Energy and Industrial Technology Development Organization (NEDO); management number: JPNP23023).