FY2023 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

Principal Investigator:
Tohoku University

March 2024

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Project Overview

(Cars, buses, trains, trucks, motorcycles, bicycles, etc.)
- Services by driving oneself
- Cab dispatch service
- Transportation services to and from nursing care facilities.

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.

Objective

From the perspective of market design, we will examine the design of a system of mobility service markets and platforms that handle mobility service markets, aiming to design a system that maximizes the use of mobility resources and meets the demand for mobility services in the region. Furthermore, we will verify the validity of the system through a data-based mathematical engineering approach.

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

Project Overview / R&D Roadmap

Business Item	FY2023				FY2024				FY2025				FY2026				FY2027			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
① Survey of local mobility resources			→	→	→	→	→	→	→											
② Survey of subsidy programs in the mobility service market			→	→	→	GRL2	→	→	→											
③ Research on the impact of publishing indicators on mobility platforms			→	→	→	→	→	→	→	→	→	→	→							
④ Development of a mathematical economic model with subsidies in the mobility service market based on a market design perspective					→	→	→	→	→	→	→	→	→							
⑤ Analysis of Mobility Services Market Model and Evaluation of Subsidy Programs based on a market design perspective									→	→	→	→	→	→	→	→	→			
⑥ Numerical experiments based on mathematical engineering													→	→	→	→	→	→	→	
⑦ Research on subsidy system reflecting numerical experiments																	→	→	→	→
⑧ Contribute to diagnostic guidelines and mobility re-design reports as an implementation plan																	→	→	→	→
GRL Achievement			GRL2				GRL3				GRL4				GRL5				GRL6	

Project Overview / Achievement Targets

① **Survey of local mobility resources** (Tohoku University) → *GRL2 achieved*
Survey mobility resources around Tohoku University campus.

② **Survey of subsidy programs in the mobility service market** (Tohoku University and Keio University) → *GRL2 achieved*
Survey and organize subsidy systems of all ministries and some local governments.

③ **Research on the impact of publishing indicators on mobility platforms** (Tohoku University) → *GRL3 achieved*
Research the effect on users by displaying safety indicators and environmental impact indicators on the platform.

④ **Development of a mathematical economic model with subsidies in the mobility service market based on a market design** (Keio University) → *GRL3 achieved*
Survey the subsidy system and the previous literature, and develop a mathematical economic model based on them.

⑤ **Analysis of Mobility Services Market Model and Evaluation of Subsidy Programs based on a market design perspective** (Keio University) → *GRL4 achieved*
Analyze and evaluate the efficiency, fairness, and incentive conditions of various subsidy programs based on the mathematical economic model constructed.

⑥ **Numerical experiments based on mathematical engineering** (Tohoku University) → *GRL5 achieved*
Identify the impact of subsidies on the mobility service market through numerical experiments based on mathematical and economic models.

⑦ **Research on subsidy system reflecting numerical experiments** (Keio University) → *GRL6 achieved*
Evaluate the results of numerical experiments based on market design.

⑧ **Contribute to diagnostic guidelines and mobility re-design reports as an implementation plan** (Tohoku University) → *GRL6 achieved*
Contribute by providing a mathematical engineering and economic rationale to the installation plan that reflects market design and mathematical analysis.

Achievement Goals

Targets for FY2025

Address issues regarding the subsidy system in the mobility services market (especially issues related to the domestic subsidy system, including comparisons with foreign countries).
Compile the impact of safety indicators and environmental impact indicators displayed on platforms on the viability of platforms.

Final goal for FY2027

Finalize recommendations on how the subsidy system should be designed, based on numerical experiments, including mathematical engineering perspectives.

Research Report / Whole

1) **Survey of local mobility resources**
   - Renewable energy resources available for mobility
   - Mobility resources using renewable energy resources
   - Network models that connect renewable energy resources and mobility resources
2) **Survey of subsidy programs in the mobility service market**
   - Understanding the various subsidies by mobility, purpose, etc.
   - Identification of the subsidy delivery hierarchy, such as central and local governments.
   - Proposed ride-sharing platform
3) **Research on the impact of publishing indicators on mobility platforms**
   - Construction and analysis of a theoretical model

Research Report / 1） Survey of local mobility resources

Objective area：Campuses in Tohoku University

Features：
- Vast campus area
- Significant elevation differences due to mountainous terrain
- Four separate campuses located throughout the city

➡ High demand for mobility services

Collaboration with the SIP3 Smart energy management system(SEMS):
Considering the introduction of renewable energy (solar power generation), the installation of charging facilities, and the introduction of new mobility options.

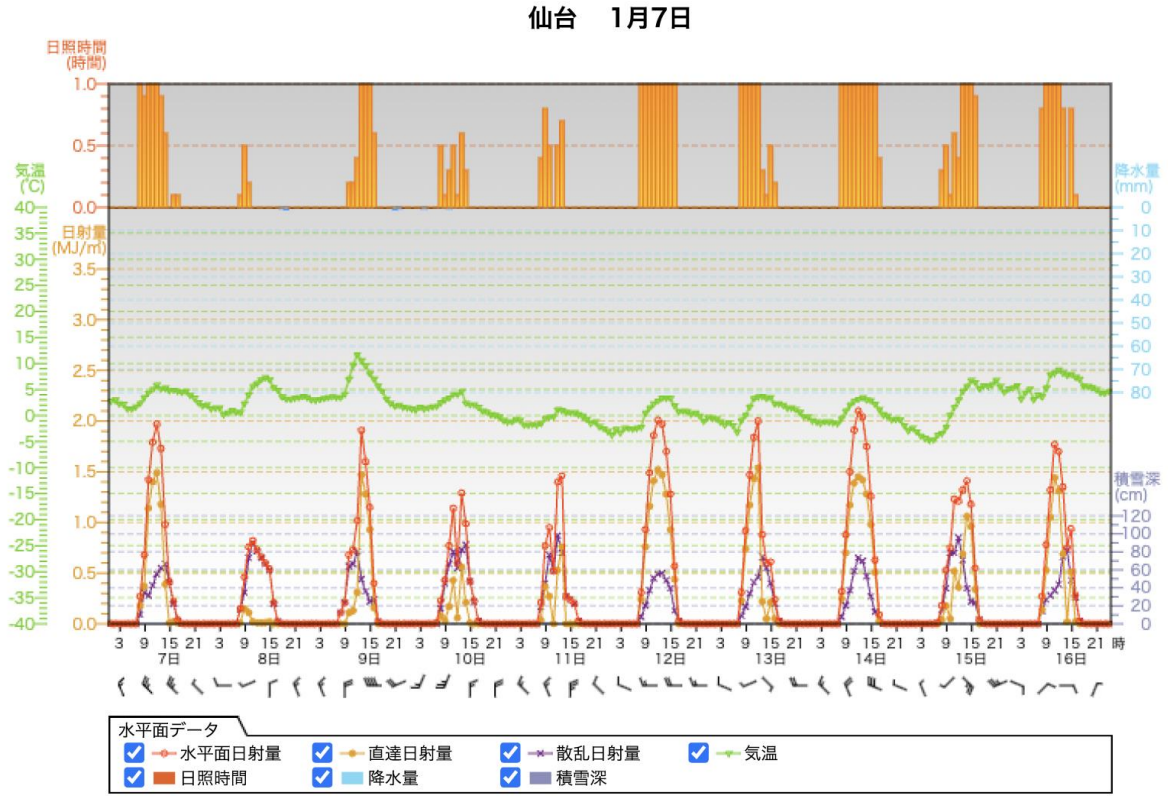
Data to be acquired @SEMS project

- Mobility demand of university members (e.g., current usage data of on-campus buses)
- Utilization data of introduced mobility, probe data, and data related to environmental impact
- Data on changes in awareness due to the introduction of new mobility options

Aim to create a showcase of safe and environmentally friendly mobility services on the university campus.

Research Report / 1） Survey of local mobility resources

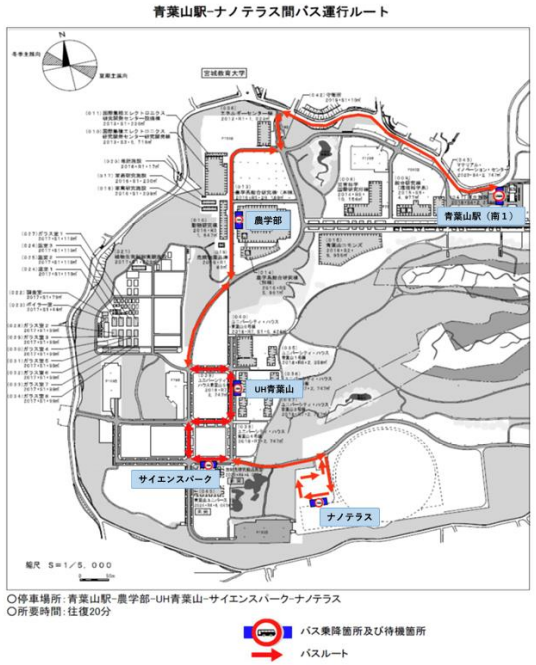
- Regarding the existing mobility services on Tohoku University's campus,
  - From the perspective of energy management, we have begun collecting data to integrate renewable energy, primarily solar power generated on campus, with existing mobility services. This includes verifying the performance data of the solar panels already installed on campus.



Example of collected data (Reference data for generation potential) Source: Created from NEDO Solar Radiation Database Browsing System.

Research Report / 1） Survey of local mobility resources

- No transportation services had been introduced on the new Aobayama Campus of Tohoku University.
  - As a result of the survey, sufficient transportation services were introduced in April 2024 with the start of campus bus operations, meeting current mobility needs. Therefore, the goal is to coexist with the existing services by introducing a complementary mobility service, rather than an alternative one.
  - On the other hand, the current campus bus service, while operational, has room for improvement in terms of supply capacity and convenience due to the vastness of the campus and significant elevation differences caused by the mountainous terrain. Additionally, from the perspective of the potential for time-variant mobility demand, there could be issues related to fairness and convenience. Therefore, it is necessary to design a mobility platform that allows for the introduction of new on-demand BEV buses and small electric mobility options to coexist with the existing campus bus service, while also ensuring safety. A demand survey is planned for the near future.



■青葉山駅 → ナノテラス
to NanoTerasu

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■ナノテラス → 青葉山駅
to Aobayama Sta.

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Example of a fixed-route service on Tohoku University's Aobayama Campus: Campus bus operation route and timetable (excerpt)

Cite from: (https://www.bureau.tohoku.ac.jp/shisan/campusbus/aobayamashuttlebus.html)

Research Report / 1） Survey of local mobility resources

- Regarding the existing mobility services and the utilization of renewable energy on campus,
  - We conducted a network simulation using consensus dynamics to explore the feasibility of multiple operations for mobility and energy, focusing on the network of distributed solar power generation facilities and electric vehicles that can be charged at these locations, functioning as mobile batteries. This study was carried out in collaboration with the SEMS project.

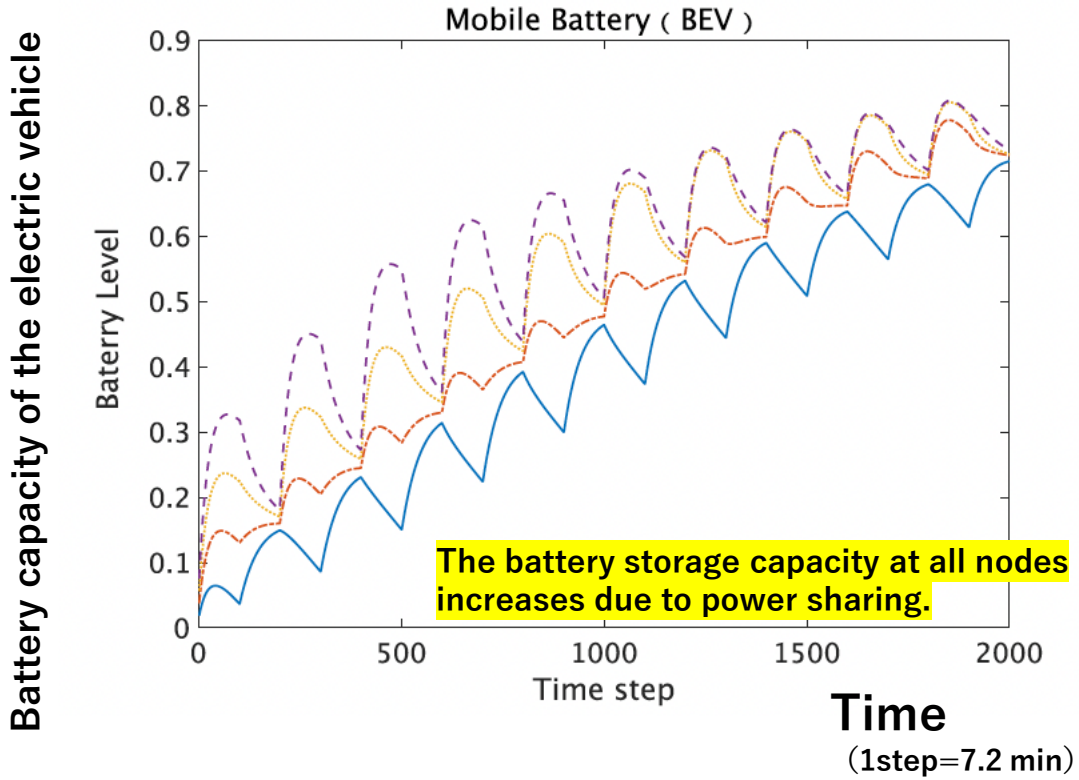


Figure: Progression of Electric Vehicle Battery Storage Capacity

- We present a simulation study of a network where the distributed solar power facilities across the university, for example, in four different areas, are treated as nodes. This study examines the power generation at each node, the charging of electric vehicle batteries within each area, and the model for power sharing between nodes.
- The integration of battery EVs, which facilitate power sharing, ensures the stability and continuity of power supply across the entire network.

$$\frac{dx_i}{dt} = \Sigma_{j \in N_i} k(x_j - x_i)$$

Model of Power Sharing Between Node i and Neighboring Node j
Variable x represents the battery storage capacity of electric vehicles at the node.

[Watahiki+ 2022]

Research Report / 2) Survey of Subsidy Programs in the Mobility Services Market

Subsidy problems for mobility

1. Subsidy system is complicated

□ Many subsidies with unknown total budgets
□ Application procedures and documents are many and complicated
□ Difficult to find out about subsidy programs
→The relationship of responsibility between the national and local governments is blurred due to incomplete fiscal decentralization.
→The intention is to provide implicit relief because visible relief may cause a backlash from taxpayers.

2. Many grants are purpose-specific and business-oriented

□ Unrestricted subsidies : lead to efficient resource allocation in line with the diverse needs of local residents

□ Restricted subsidies : Inefficient and prone to institutional rigidity
→ Benefits of subsidies for users
1) Households can choose transportation more freely
2) Subsidies can be focused on vulnerable transportation users in need
3) Incentives are created for companies to improve their services.
□On the other hand, user-oriented subsidies are few and difficult to reach the public.

Subsidy Problem for Mobility: Examples of Restricted Use

- **Subsidy for aid to children in rural areas (Ministry of Education, Culture, Sports, Science and Technology: 2.15 billion yen budget for FY2023)**
  The government subsidizes a part of the cost of mobility for commuting to school paid for by the local government.

Availability to purchase a school bus for use during the morning and evening commute to and from school.

But, Use of school buses for purposes other than subsidized projects (welfare transportation, cargo transportation, etc.) may result in the revocation of the subsidy decision.

Mobility inefficiency occurs due to lack of availability

Aiming for effective use of mobility by easing conditions

Examples of easing of restrictions:
<Kushima City, Miyazaki Prefecture>
Community organizations that provide support for the elderly (e.g., shopping) during daytime hours when school buses are not in use can use the buses at the request of residents.

Research Report / 2) Survey of Subsidy Programs in the Mobility Services Market

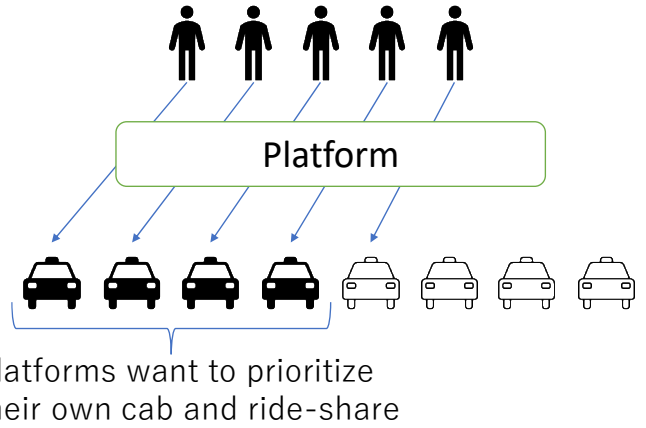
Proposal for a ride-sharing platform

(To be published in the Nihon Keizai Shimbun "Keizai Kyoshitsu" at the end of April 2024 by Professor Emeritus Hideyuki Kita of Kobe University and Professor Morimitsu Kurino of Keio University (subcontracting organization))

Japanese ride-sharing

The cab company is the main operator, and they manages the operations of the general driver fleet and limiting ride-sharing areas and hours

Proposal 1: Fair competition policy, imposing rules on algorithms and monitoring by the government



*Concerns about the current system

1. Matching algorithm determines the match.
   →The driver's income depends on the algorithm.
2. No platformer publishes its algorithm.
3. If there is some cab company on the platform,
   platform may arbitrarily select some cab companies and customers

Incentive to create own platform: High → **Platform disruption**

Research Report / 2) Survey of Subsidy Programs in the Mobility Services Market

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Proposal 2: Remove area and hours restrictions on ridesharing and impose taxi-priority rules on the algorithm.

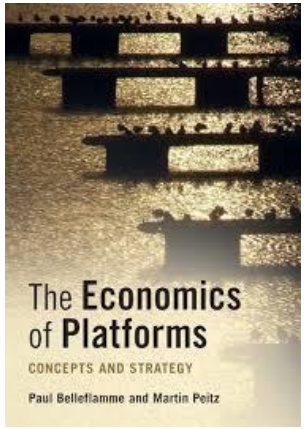
1. In Japanese ride-sharing, the government determines regions and time zones based on data collected from the platformer.
   - Such restrictions based on long-term forecasts cannot cope with short-term demand changes, resulting in inefficiencies

     Short-term demand changes: rainfall, snowfall, rail delays and cancellations, events, etc.
2. Impose rules on the platform to make it adopt an algorithm that gives priority to cab drivers when drivers belonging to a cab company and regular drivers are available.
   - Cab companies do not lose customers in the absence of ridesharing and receive brokerage commissions and other revenues from ride-sharing drivers.
   - If ride-sharing drivers are not earning enough money, the algorithm may consider adjusting the dispatch ratio between cab companies and ride-sharing.

Research Report / 3) Study of the impact of publishing indicators on mobility platforms

Economic study on the disclosure of metrics on platforms

Literature review



「**The Economics of Platforms**」(Belleflamme and Peitz, 2021)
This book delves into the economics behind platforms, providing an explanation of network effects, direct and indirect externalities, pricing, and platform design strategies based on theory, empirical evidence, and case studies.

The Role of Platforms

Enabling interactions between users and creating network effects from these interactions.
Examples of common mobility platforms:

- Highway bus reservation systems (bus companies × passengers)
- Ride-sharing apps (taxi drivers × passengers)

However, users do not consider network effects when making decisions,
interactions are less likely to be organized.
→ It is necessary for a third-party intermediary to find a way to internalize the network effects.

Research Report / 3) Study of the impact of publishing indicators on mobility platforms

The key to a successful platform is <u>to create a network effect</u>

Network effect

A phenomenon in which the value of a product or service increases as the number of users of the product or service increases.

e.g. E-commerce site: As the number of buyers increases, the number of sellers also increases, which in turn attracts more buyers, creating a virtuous cycle.

Digital technology increases the likelihood of meeting platform requirements

Significant reduction of transaction costs for users

E.g., search, matching, screening, contract, trust, reservation management

Intermediaries can more actively manage network effects and add or reallocate value through price and non-price means

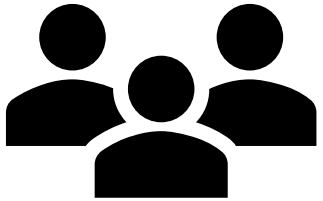
Research Report / 3) Study of the impact of publishing indicators on mobility platforms

This project will develop and analyze a theoretical model.

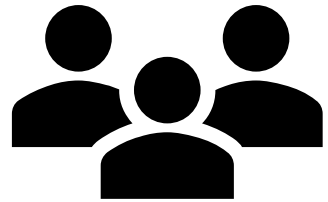
Examining indicators of network effect in mobility platforms.

our project

passenger



mobility providers



Based on the literature review, the following will be promoted in FY2024,
- Propose a safety index based on multimodal data
- Economic modeling and verification of network effects

This paper includes the results of Cross-ministerial Strategic Innovation Promotion Program (SIP) 3rd Phase, “Development of Smart Mobility Platform” promoted by Council for Science, Technology and Innovation, Cabinet Office. (Project Management Agency : New Energy and Industrial Technology Development Organization (NEDO) (Project Code JPNP23023))