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 2025

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(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.

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.

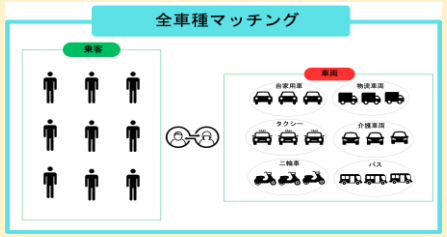
① Identification of local mobility resources
④ Development of local mobility re-design report and Japanese re-design index
⑦-9 Proposed systems and rules
⑱ Practical research (action research) and dissemination development activities to typify and identify areas utilizing local mobility resources

Integrated Theme of the Three SIP Projects

Hypothesis: To mitigate concerns and potential market contraction caused by information asymmetry in ride-sharing, disclosing drivers' biometric data and vehicle information to passengers may reduce this asymmetry and enhance user confidence.

Smart mobility platform

・Current Challenges in the Mobility Service Market
・Review of Transaction Rules for Mobility Services
・ Participation of Mobility Service Providers and Use of Biometric Data



Proposal for Service Design

Data Provision

Robotics

Utilization of Compact Biometric Monitoring Devices
Continuous collection, analysis, and AI-based processing of various vital signs such as cardiac activity and body movements in daily settings.

Model Generalization

Recommendation for bus operating expenses (subsidies)

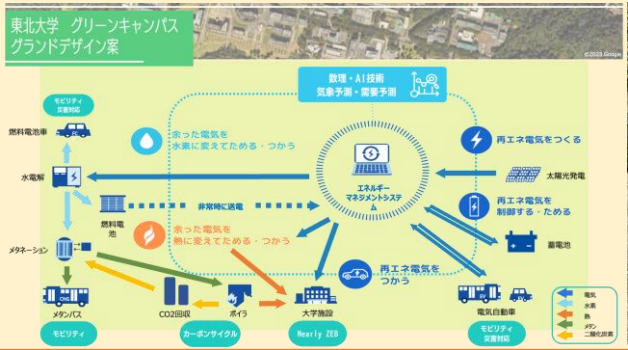
『 Comprehensive Support for Professional Drivers and Improvement of Transportation Safety Using Small Biomonitoring Devices 』

Demonstration site

Data Provision

Smart energy management

・Consideration of Matching Mechanisms
・ Construction of a forecasting model utilizing migration data and its simulation



International Cooperation

Expansion to Malaysia, Vietnam, etc.
Adaptation to local traffic

Data Strategy

Acquired vehicle information to Data Linkage WG

■ Defined Goals and Metrics for Achievement

Interim target for FY2025: Achieve GRL 4 (conceptualization of the system)

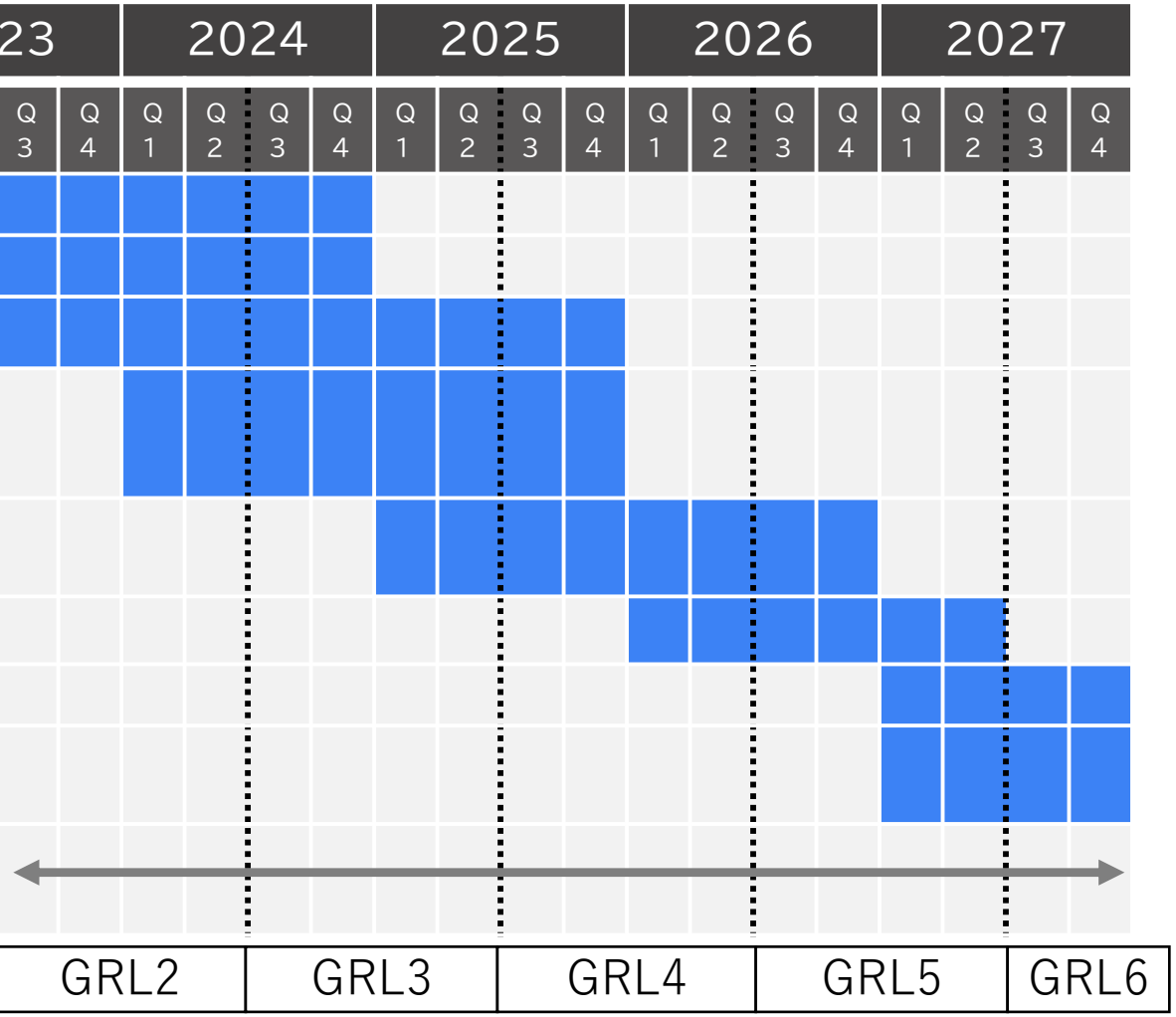
- Raising the Issue of Subsidy Systems in the Mobility Services Market (Issues of the domestic subsidy system, especially in comparison with foreign countries), Compilation of the impact of the integrity and environmental impact indicators displayed on the platform on the platform's feasibility.

Final target for FY2027: Achieve GRL6 (implementation plan)

- Final recommendations on the grant system reflecting numerical experiments including mathematical engineering perspectives

Roadmap

研究開発テーマ	実施項目
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



■ Summary of Key Findings and Insights

1） Fact-finding Survey of Local Mobility Resources

（Conducted in conjunction with SIP3 Smart Energy Project）

- Three groups of renewable energy resources available for mobility: solar power, biomass power, and others
- Consider introduction of small mobility as a mobility resource, in addition to EVs for personal use and renewable energy-derived on-demand transportation
- Data analysis of on-demand bus demonstration

2） Survey of Subsidy Programs in the Mobility Services Market

- Comprehensive survey of government and municipal subsidies for each mobility

■ Summary of Key Findings and Insights

3）Develop an actuarial economic model including subsidies in the mobility service market from a market design perspective

- Development and analysis of an economic model for matching all types of vehicles, including carrying passengers in business vehicles, and measurement of effectiveness through simulation with a view to demonstration on the Tohoku University campus
  ⇨Aiming to make policy recommendations to Article 78 of the Road Transport Law, including the design of a Japanese version of ridesharing and public ridesharing system.

（ External reports: 1 article published in the Nihon Keizai Shimbun, 1 master's thesis ）

- Mathematical model development and analysis for network operation connecting solar energy resources and electric mobility

（ External reports: Ando, Kon, Kurino, and Takahara, *IEEE WS*, 2024））

4） Integrated Theme of the Three SIP Projects

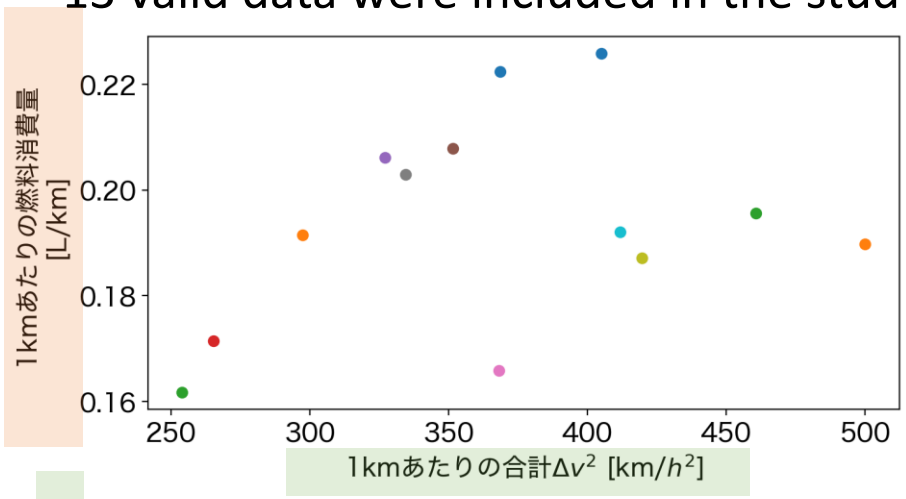
Study of the impact of publishing indicators on mobility platforms

- Acquisition of occupational driver biometric and vehicle data to publish objective safety indicators on the platform
- Development and analysis of economic theory models (1 master's thesis)
- Demonstration test and basic analysis of questionnaire creation and display on a vehicle dispatch application to measure the effectiveness of displaying biometric and safety indicators of professional drivers on a platform

Gasoline vehicle and EV actual fuel consumption data analysis

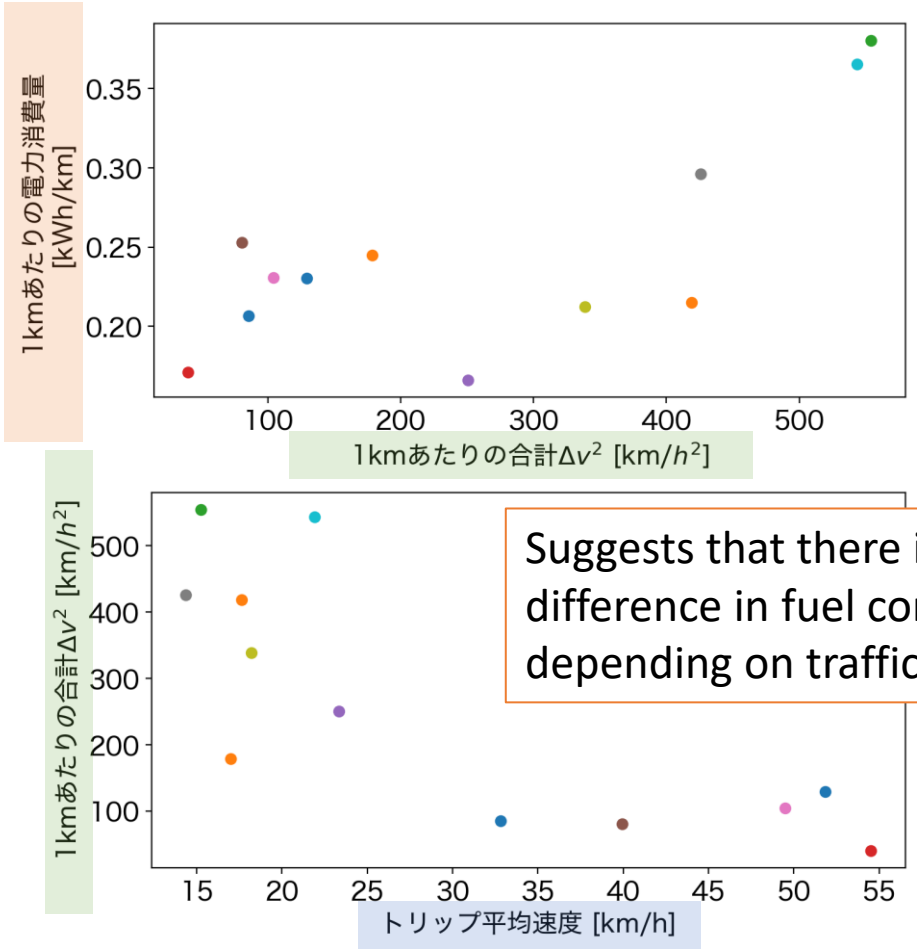
【 Gasoline on-demand bus 】

13 valid data were included in the study



【 EV Passenger Car 】

12 valid data were included in the study.



Suggests that there is a difference in fuel consumption depending on traffic behavior

：**Sum of squares of the change in speed per distance Δv (only when increasing)**

■ Report of Research Results / 3) Develop an actuarial economic model including subsidies in the mobility service market from a market design perspective

Contributed an article to Nihon Keizai Shimbun

Japanese version of ridesharing: Taxi companies take the initiative and manage the operations of regular drivers, while limiting the areas and hours of ridesharing.

- Recommendation 1: Impose rules on matching algorithms and government monitoring as a fair competition policy.
- Recommendation 2: Remove regional and time zone restrictions and impose cab priority rules on the algorithm.

一般ドライバーが自家用車を用いて有償で乗客を送迎する「ライドシェア」の導入が進められている。4月から導入された日本版ライドシェアは、タクシー会社が主体となって管理運営し、ライドシェアの地域と時間帯を制限するものだ。既存のタクシー業界とライドシェアの共存を目指している。本稿では、より利用者に配慮した公共交通の制度設計を提言したい。

まず重要なのは、目標実現型の制度設計だ。これまでのライドシェア解禁を巡る議論は、手段の議論に終始し、実現したい公共交通の姿が見えない。望ましい交通の姿は、比較的安価な運賃で、待つことなく、安全に出発地から目的地までほぼ直行できるといったも

くりの・もりみつ　73年生まれ。ピッツバーグ大博士（経済学）。専門はマーケットデザイン

きた・ひでゆき　54年生まれ。京都大学工学博士。専門は交通システム工学

地域交通の危機 打開できるか ㊦

栗野盛光
慶応義塾大学教授

喜多秀行
神戸大学名誉教授

ライドシェア、制度設計が鍵

Nihon Keizai Shimbun
Economic Classroom,
April 30, 2024 morning edition

- In FY24, develop a theoretical model for institutional design of the ridesharing market
- In FY25, conduct a more detailed simulation analysis and evaluation of the Japanese version of ridesharing and make policy recommendations

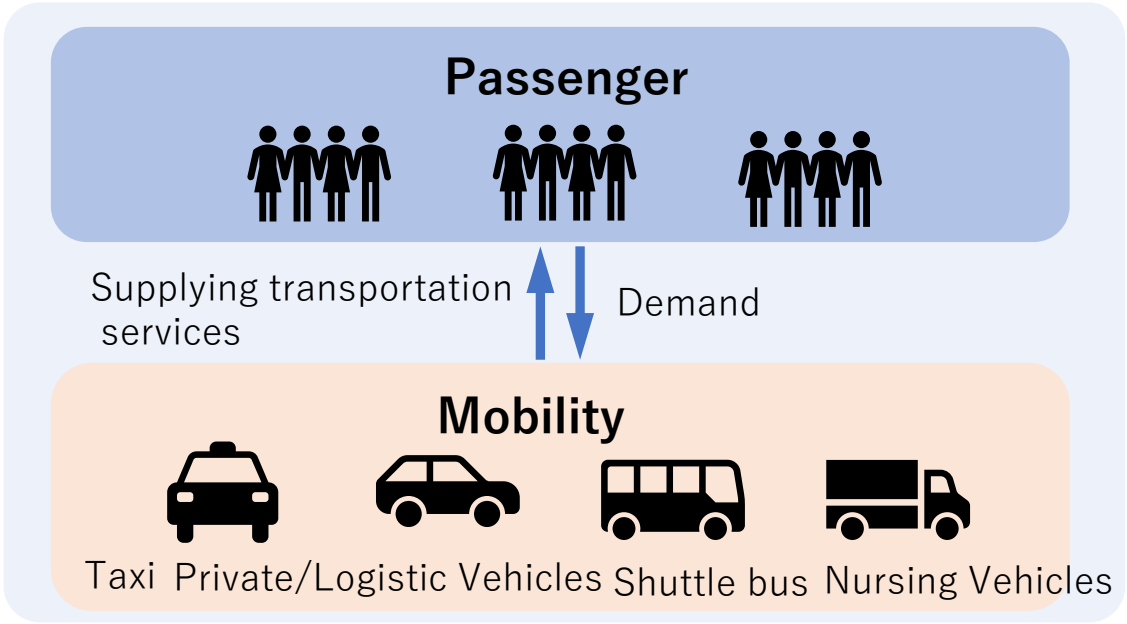
■ Report of Research Results / 3) Develop an actuarial economic model including subsidies in the mobility service market from a market design perspective

Establish a model for matching all vehicle types in the mobility services market (including ride-sharing and public/business vehicles)

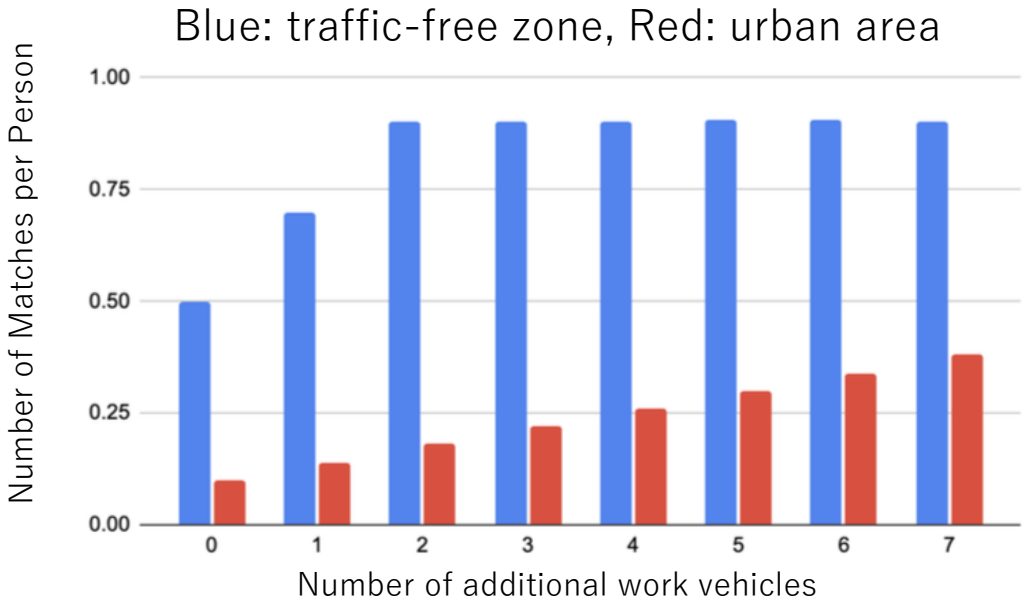
- Proposed algorithm to find fares and matching endogenously
- This research result achieves matching stability and efficiency (overall optimum)

⇨ Possible evaluation of subsidy system, Japanese version of ridesharing, and public ridesharing (recommendation to Article 78 of Road Transport Law)

Structure of all matching models

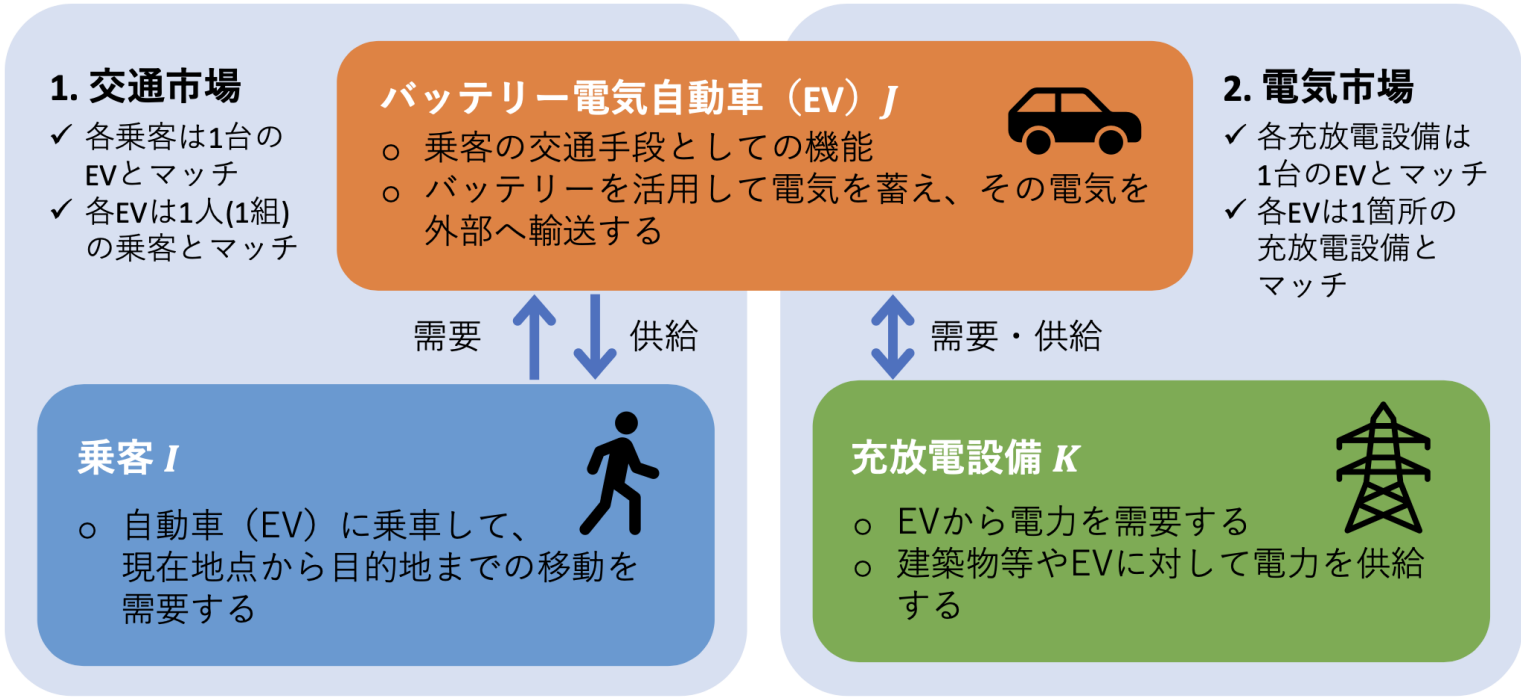


Suggests that the addition of operational vehicles will be more efficient and improve the number of matches in the more traffic-free areas.



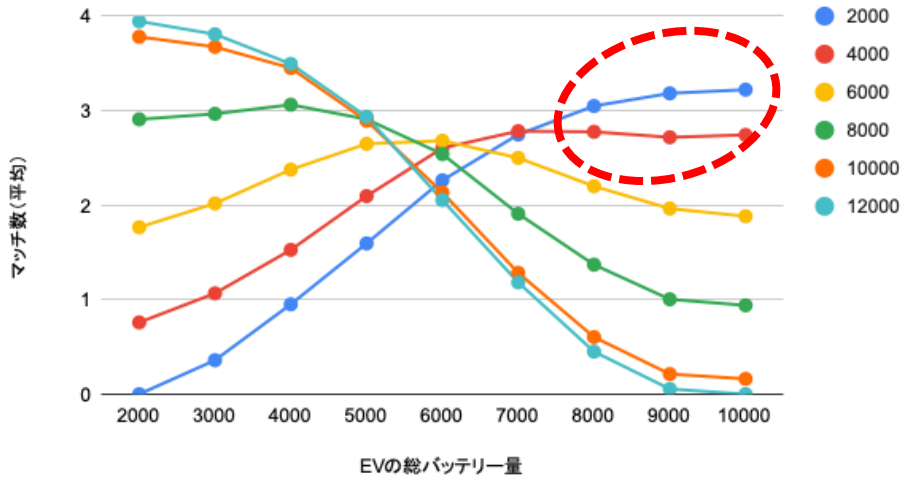
■ Report of Research Results / 3) Develop an actuarial economic model including subsidies in the mobility service market from a market design perspective

- Build an economic model of energy and mobility sector coupling
  "Coordinating Electric Vehicles: Impacts on Mobility-Service and Electricity Markets,"
  Ando, Kon, Kurino and Takahara, in *2024 IEEE International Conference on Big Data (BigData)*, 2024, pp. 3838-3846.
- Matching in the transportation and electricity markets, and an algorithm to simultaneously determine mobility and electricity rates to achieve stability and efficiency (overall optimum).



✓ Confirm V2G contribution when total battery capacity of EVs is high and total battery capacity of charging and discharging facilities is low

表. EVと充放電設備の平均マッチ数（電力調整EV）



*Number of matches: Number of pairs in which one EV and one charging/discharging facility transfer power.

- After FY2025, simulation of the algorithm will be conducted for the Tohoku University campus, the demonstration site.
- To be presented at the CIRP International Conference in Italy

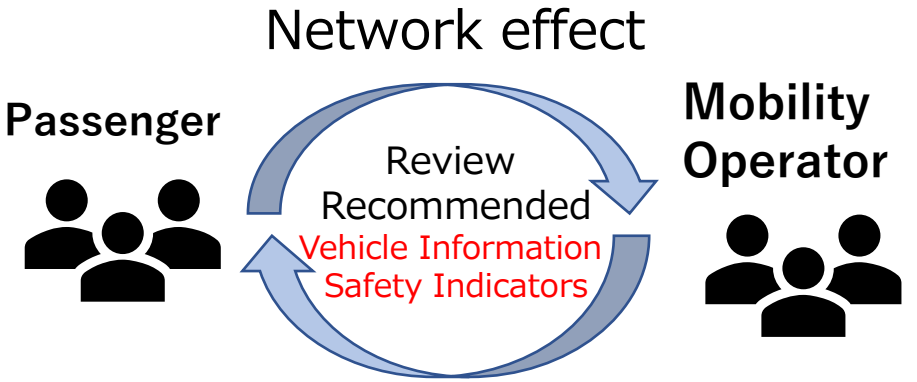
■ Report of Research Results / 4)

3–Project Collaboration (S.M. – S.E. – ROBOTICS)
Study of the impact of publishing indicators on mobility platforms.

Results from theoretical research

Confirmation that presenting safety indicators results in higher passenger wellbeing and network effects

- Drivers with high safety indicators are matched with passengers
- Building a game-theoretic model in which drivers compete for passengers by investing in safety
  - Drivers have different safety competencies and this competence is determined by private information
  - Driver safety investment determines the level of safety indicators



Experimental study

Measurement of driver biometric and vehicle information and acquisition of questionnaires in preparation for release of indicators
Target: Intercity buses (Japan, Malaysia, Vietnam) and on-demand buses (Japan and Malaysia)

User survey

- Indicator is confirmed or not
- Need for indicator display
- Sense of security/change in trust due to release of indicators
- Range of indicators you want to know about

Amount of Data
3,650 cases：Domestic intercity bus
40：Domestic on-demand bus
386：Overseas on-demand bus

Driver survey

- Driving awareness brought about by the release of indicators
- Receptivity to public disclosure of indicators

Amount of data
10 cases： Domestic intercity bus
10： Domestic on-demand bus
10： Overseas on-demand bus

Drivers' vital infomration

- ECG
- Heart rate

Amount of data(2 weeks)
71 cases：Domestic intercity and on-demand bus
89：Overseas intercity and on-demand

Vehicle information

- latitude/longitude
- Velocity
- Fuel consumption

Amount of data(2 weeks)
85 cars： Domestic intercity and on-demand bus
28： Overseas intercity and on-demand

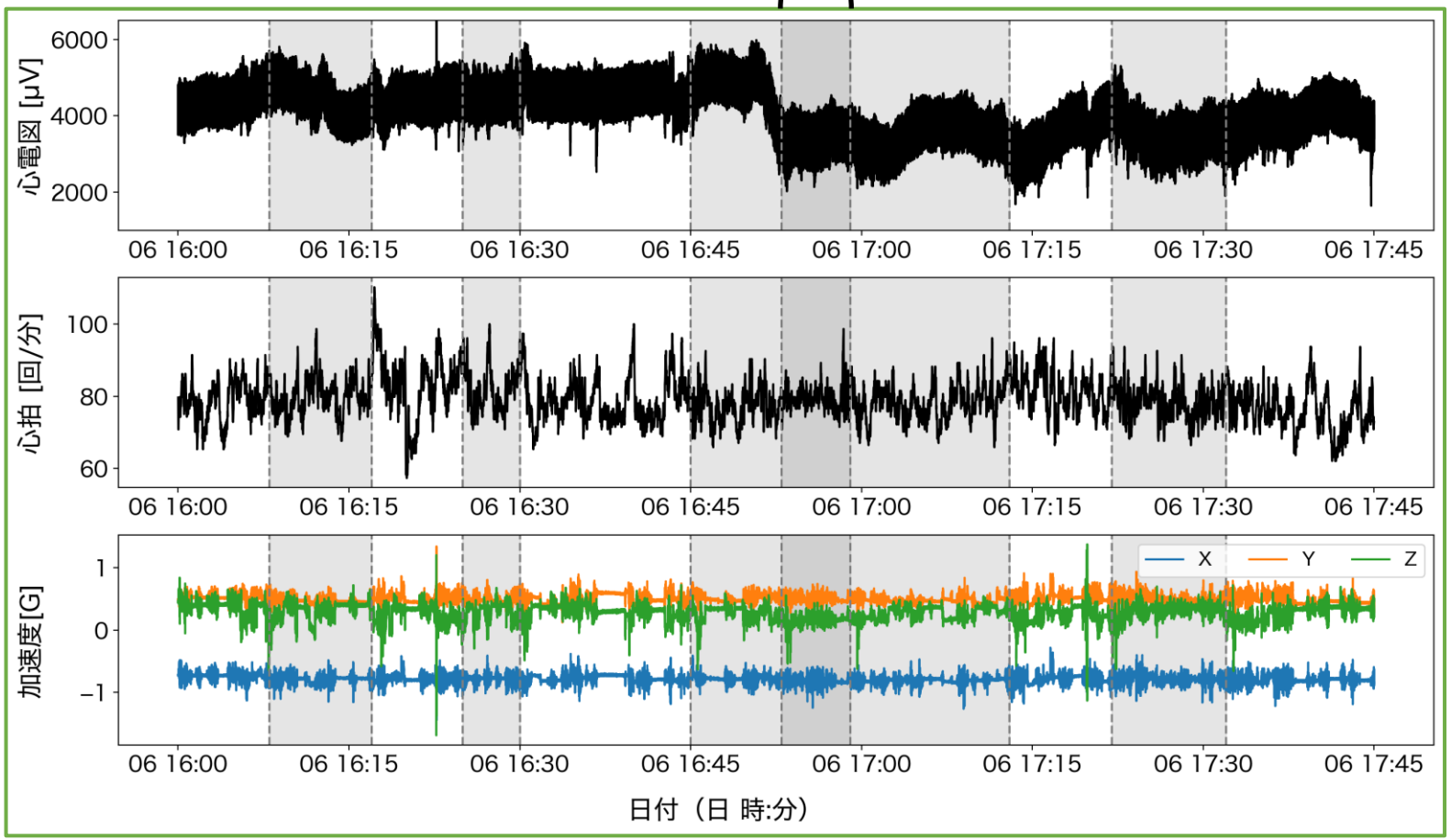
Recognized by the Ethics Committee of the Graduate School of Medicine, Tohoku University (half year of audit)

After 2025 Vehicle data and biometric data: Consider deployment to Tohoku University campus at the demonstration site.

[Fukushima Ward, Osaka City]
Demonstration example of an on-demand bus

Rideshare

Reservation Period



Changes between the driver's physical condition and vehicle driving conditions to be analyzed (currently being demonstrated in Malaysia and Vietnam)

*To verify the (causal) relationship between carbon neutrality, driver mental and physical health, and traffic safety by multiplying the driver's biometric data

■ International collaboration study S. M./S. E collaboration theme

＜ Key Issues for smart mobility ＞

(Correction of the Road Traffic Act Enforcement Order 2024
Correction of the Enforcement Order September 2026)

Zone３０・Zone３０plus

Re-design of the legal speed reduction from 60km/h to 30km/h on all domestic roads in Japan

引用　警察庁

＜Theme＞

Traffic volume assessment around Zone 30 areas

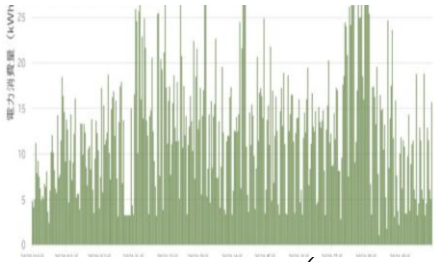
Digital
Sandbox

《 Predicted traffic congestion
in the vicinity 》

＜ Working with SmartEnergy ＞

《 Energy Consumption Forecast 》

Simulate energy consumption fluctuations in and out of the area



Hours　（Output Image）

Energy Assessment

・ Impact of increase/decrease in area of the target area
・ Impact of traffic congestion around the area
Energy Perspective Assessment Methodology
Recommendations

Collaboration between Western countries with advanced zoning systems and Japan promoting digital evaluation

Appendix

Subsidy Issues for Mobility

1. **Subsidy system is complicated**
   □ There are many subsidies for which the total budget amount is unknown
   □ Many application procedures and application documents are complicated
   □ It is difficult to research the subsidy system
   → The relationship of responsibility between the national and local governments is ambiguous due to incomplete fiscal decentralization
   → Intention to provide relief implicitly due to the possibility that visible relief may cause taxpayers' protests
2. **Many subsidies are purpose-specific and targeted to businesses**
   □On the other hand, there are few user-oriented subsidies, which are difficult to reach the public.
   →Advantages of user-oriented subsidies
   ①Households can choose transportation more freely
   ②Subsidies can be focused on vulnerable transportation users in need
   ③Incentives are created for companies to improve their services
3. **Numerous subsidies have limited use.**
   □Subsidies with limited use: Inefficient and prone to institutional rigidity
   □Unlimited use: Leads to efficient resource allocation in line with the diverse needs of local residents

Subsidy Issues for Mobility: Examples of Limited Use

- **Subsidy for aid for children in remote areas (Ministry of Education, Culture, Sports, Science and Technology: 2.15 billion yen budget for FY2023)**

  This program supports smooth compulsory education in remote areas by partially subsidizing local governments for school buses, boats, and long-distance commuting costs.

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

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

Mobility inefficiencies occur due to lack of availability

Can we make effective use of mobility by easing conditions?

Examples of relaxed conditions:
＜Kushima City, Miyazaki Prefecture＞
Used by a community-based organization that supports the elderly (shopping, etc.) during daytime hours when school buses are not in use, in response to requests from residents
＜Kurobe City, Toyama Prefecture＞
Used as a shuttle bus for community events (marathons) held on weekends when school buses are not in use Kurobe City, Toyama Prefecture

■ Research Report / 2) Subsidy Program Study in the Mobility Services Market

- This project item included a comprehensive survey of subsidy programs related to mobility.

表 3.1: 自家用車に対する補助金

番号	官庁名・地方自治体名	種類	補助率	補助対象経費	限度額	予算総額	対象事業者	目的別	事業者向け
1	環境省[1]	車両	2 分の 1	工事費	-	-	自動車運送事業者	○	○
2	国土交通省[2]	機器	3 分の 1	購入費	-	-	自動車運送事業者	○	○
3	国土交通省[3]	機器	2 分の 1	購入費	80 万円	-	自動車運送事業	○	○
4	国土交通省[4]	コンサルティング	3 分の 1	コンサルティング活用に要する経費	100 万円	-	自動車運送事業	○	○
5	経済産業省[5]	車両	-	購入費	20～230 万円	約 900 億円	個人・法人等	○	△
6	経済産業省[6]	実証・支援	3 分の 2	-	1000 万～1.5 億円	15.6 億円	民間団体等	○	○
7	東京都[7]	車両	-	購入費	20～110 万円	-	個人・事業者	○	△

表 3.2: タクシーに対する補助金

番号	官庁名・地方自治体名	種類	補助率	補助対象経費	限度額	予算総額	対象事業者	目的別	事業者向け
8	環境省[15]	車両	5 分の 1～3 分の 1	購入費	600～1000 万円	7.35 億円	タクシー事業者	○	○
9	国土交通省[16]	観光産業	2 分の 1	環境整備費	1000 万～3000 万円	-	タクシー事業者	○	○
10	国土交通省[17]	燃料	価格高騰分	購入費	-	-	タクシー事業者	○	○
11	東京都[18]	機器	個人:10 分の 9, 法人:2 分の 1	購入費・工賃	個人:9 万円, 法人: 台数× 5 万円	-	タクシー事業者	○	○
12	東京都三鷹市[19]	支援	個人:30,000 円, 法人:28,000 円 × 車両台数	事業活動	法人:100 万円	-	個人事業主／法人	○	○
13	沖縄県[20]	燃料	価格高騰分	購入費	-	78895 千円	レンタカー事業者	○	○

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))