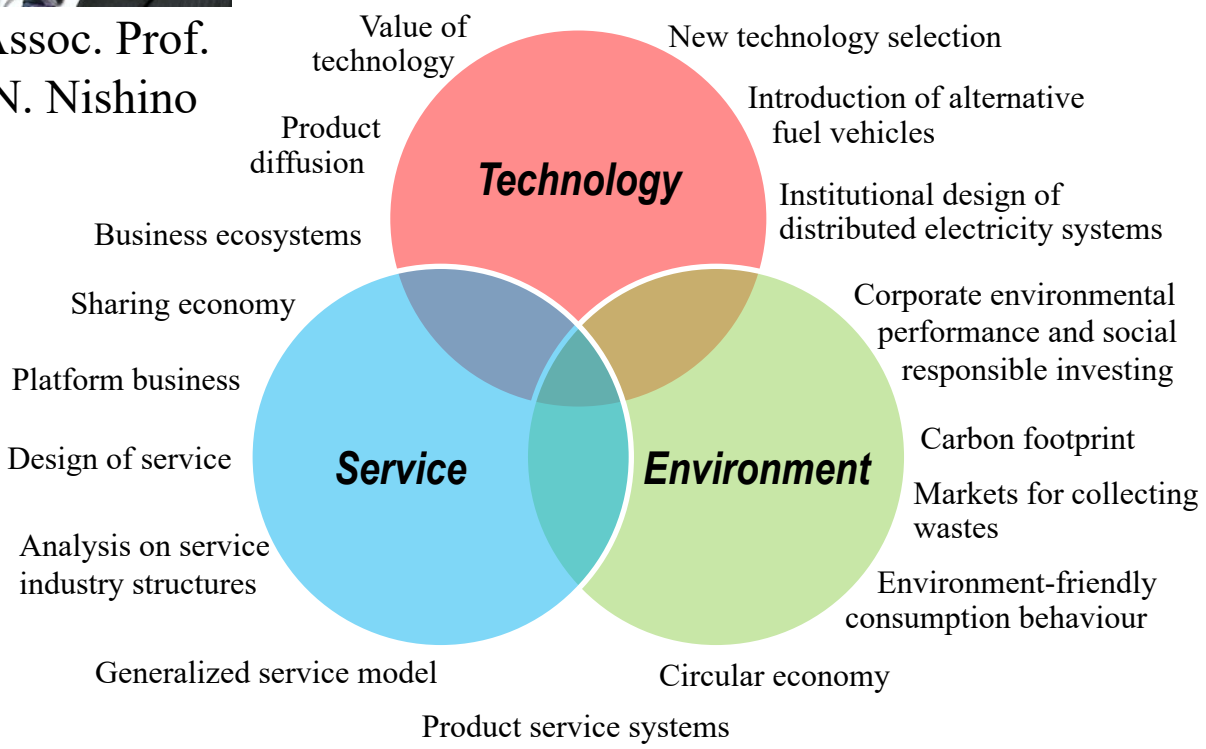
Nishino Lab

—Towards Construction of Mechanisms for Co-creative Social Systems—

Assoc. Prof.
N. Nishino

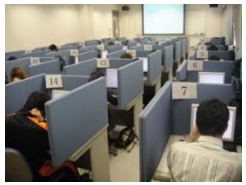
Our lab pursues theoretical mechanism for building a value-creating relation amongst society, human, and artefact

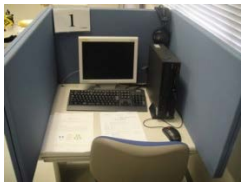
Research topics



Methodology

- **Game theory:** analyses interdependent decision-makings in a society mathematically
- **Multi-agent systems:** analyses a social system with autonomous agents by simulation, etc.
- **Economic experiments:** analyses human behaviour in a virtual economic situation under controlled lab environments





Economic experiment lab

Examples of research themes

- Design of Trading mechanisms in a distributed electricity system
- Game-theoretic modelling circular economy and circularity analysis
- Manufacturer's strategy in sharing economy

Three Characteristics of Researches in Nishino Lab

1. "**Theoretical**" research

2. Understanding "**human decision-making**"

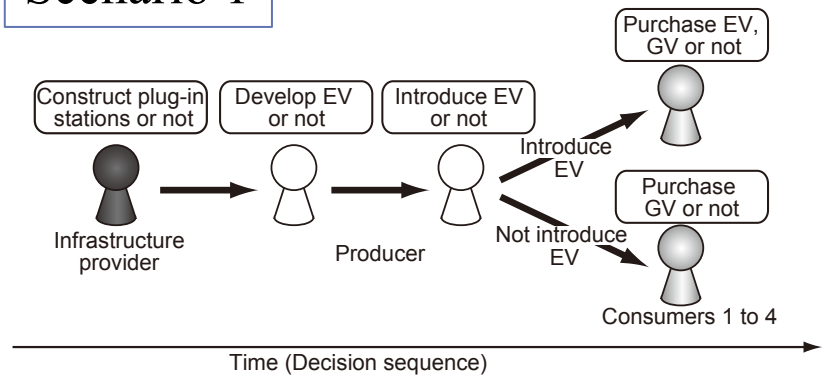
3. A viewpoint of "**synthesis**"

1. Theoretical research

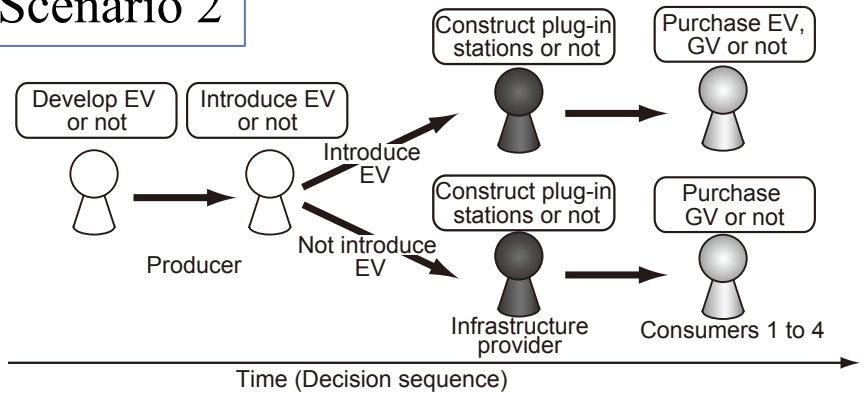
Research example: Social system structure in developing/introducing electric vehicles

Manufacturers, infrastructurers and consumers are interdependent, and its relation is modeled game-theoretically.

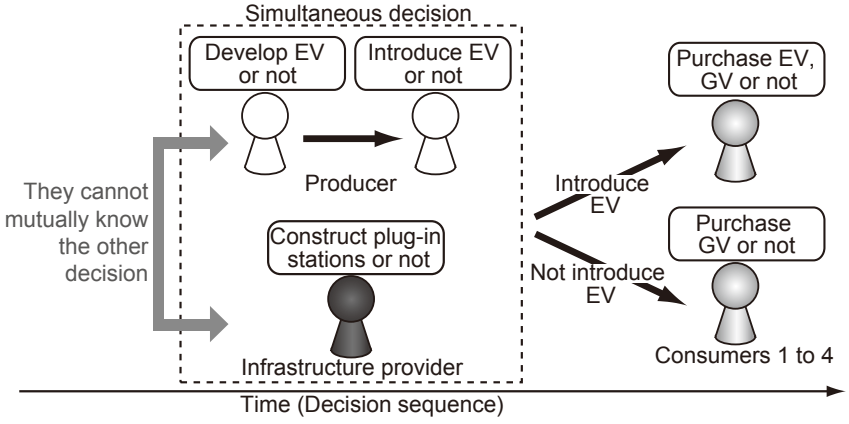
Scenario 1



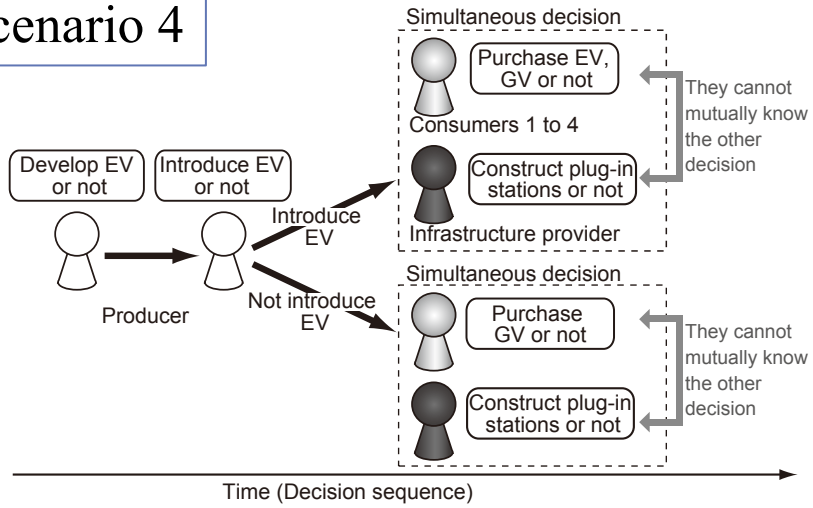
Scenario 2



Scenario 3



Scenario 4



Theoretical formulation

Manufacturer

Profit function : $\Pi_p = \left(\sum_{j \in J} p_j q_j \right) - c_p,$

- p_j: Price of vehicle j
- q_j: Sales quantity of vehicle j

where $c_p = \left(\sum_{j \in J} c_j^F + c_j^V q_j \right) + RD + c^R, \quad J = \{EV, GV\}$

- c_j^F: Fixed cost for production of j
- c_j^V: Variable cost for production of j, which is reduced depending on RD: $c_j^V = c_j^V(RD)$
- RD: R&D Cost for EV
- c^R: Environmental tax: $c^R = c^R(q_{GV})$

Infrastructurer

Profit function : $\Pi_I = f_1(q_{EV}^{long}) + f_2(q_{EV}^{short}) - c^I + S^I,$

- q_{EV}^{long}: The number of long-drive consumers
- q_{EV}^{short}: The number of short-drive consumers
- c^I: Fixed cost for plug-in station construction
- S^I: Subsidy from government

Consumers:

Utility function: $U_{i,j} = R_{i,j} - p_j + S_j,$

where $R_{i,j} = R^* - t_1(r_j, r_i^*) - t_2(sa_j, sa_i^*) - t_3(m_j, m_i^*)$

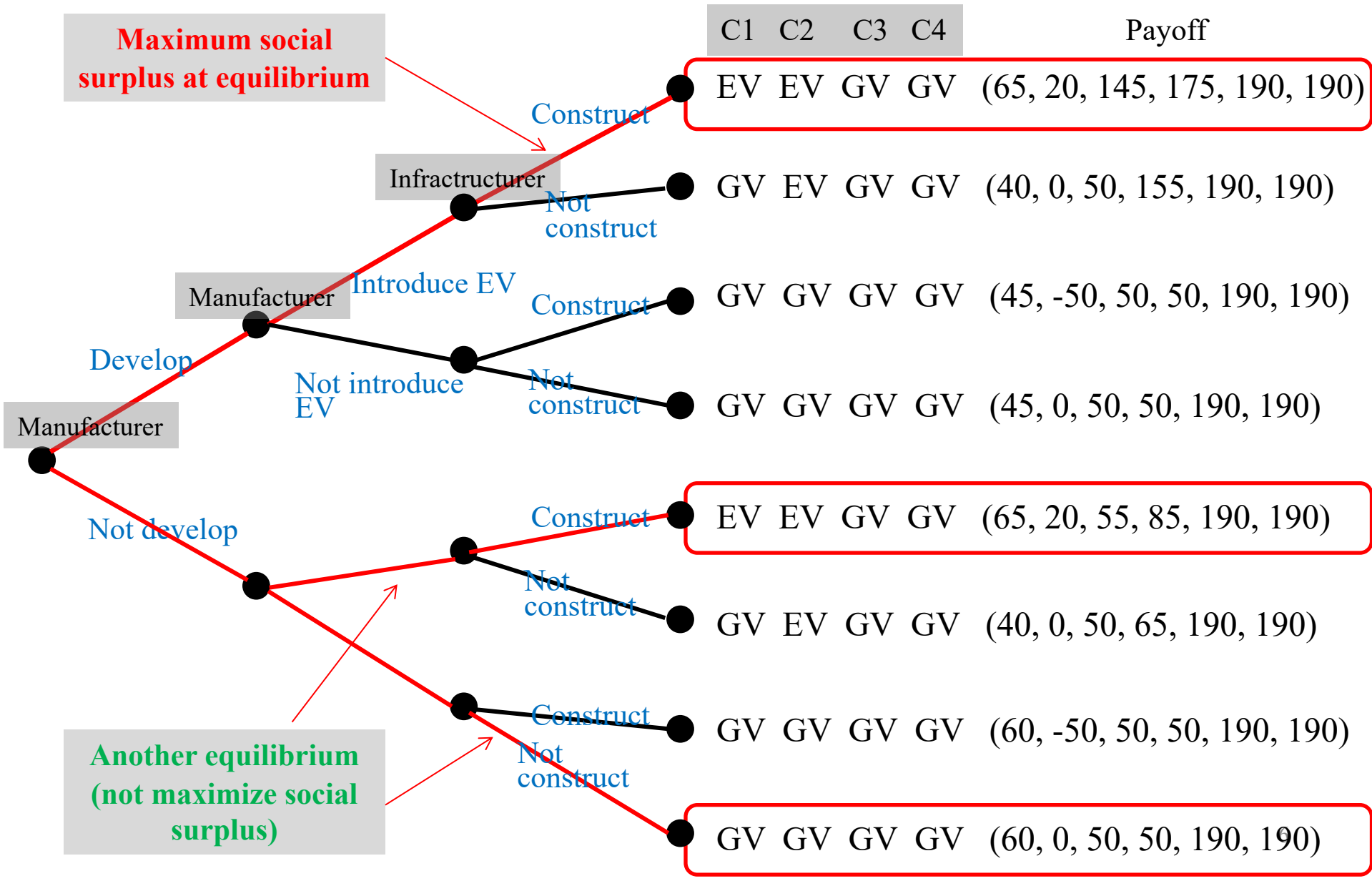
Disutility from preference mismatch

- r_j: Mileage per charge/fuel tank
- sa_j: Infrastructure convenience
- m_j: Fuel/electricity consumption

- $R_{i,j}$: reservation price
- p_j : price for vehicle j
- S_j : Subsidy for vehicle j

$$t_i(x,y) = \begin{cases} \alpha_i(y-x) & (\text{if } x < y) \\ 0 & (\text{if } x \geq y) \end{cases}$$

Theoretical equilibrium of scenario 4



Game theory is a basis

- The theory can describe a structure of social systems from a decision-making point of view and also provide clear theoretical outcomes.

- Although unrealistic assumptions like rationality, complete information, and common knowledge are sometimes imposed, the theory can catch the fundamental factors that a social system has in reality.

- Theoretical solution (equilibrium) can be regarded as a state in an ideal situation.

- We analyze how a social system works in reality by understanding the theoretical equilibrium.

2. Understanding human decision-making

Experiments with Human Subjects

- In the experimental laboratory, a virtual socio-economic system is constructed to analyze subjects' decision-making behavior.
- This experiment method is based on experimental economics methodology (V. Smith 1976, 1982):
  - Experiments are designed to examine a particular theory or an economic system.
  - Such a laboratory environment is used to satisfy controlled conditions.
  - Subjects are promised to be paid a monetary reward according to payoff earned in experiments.

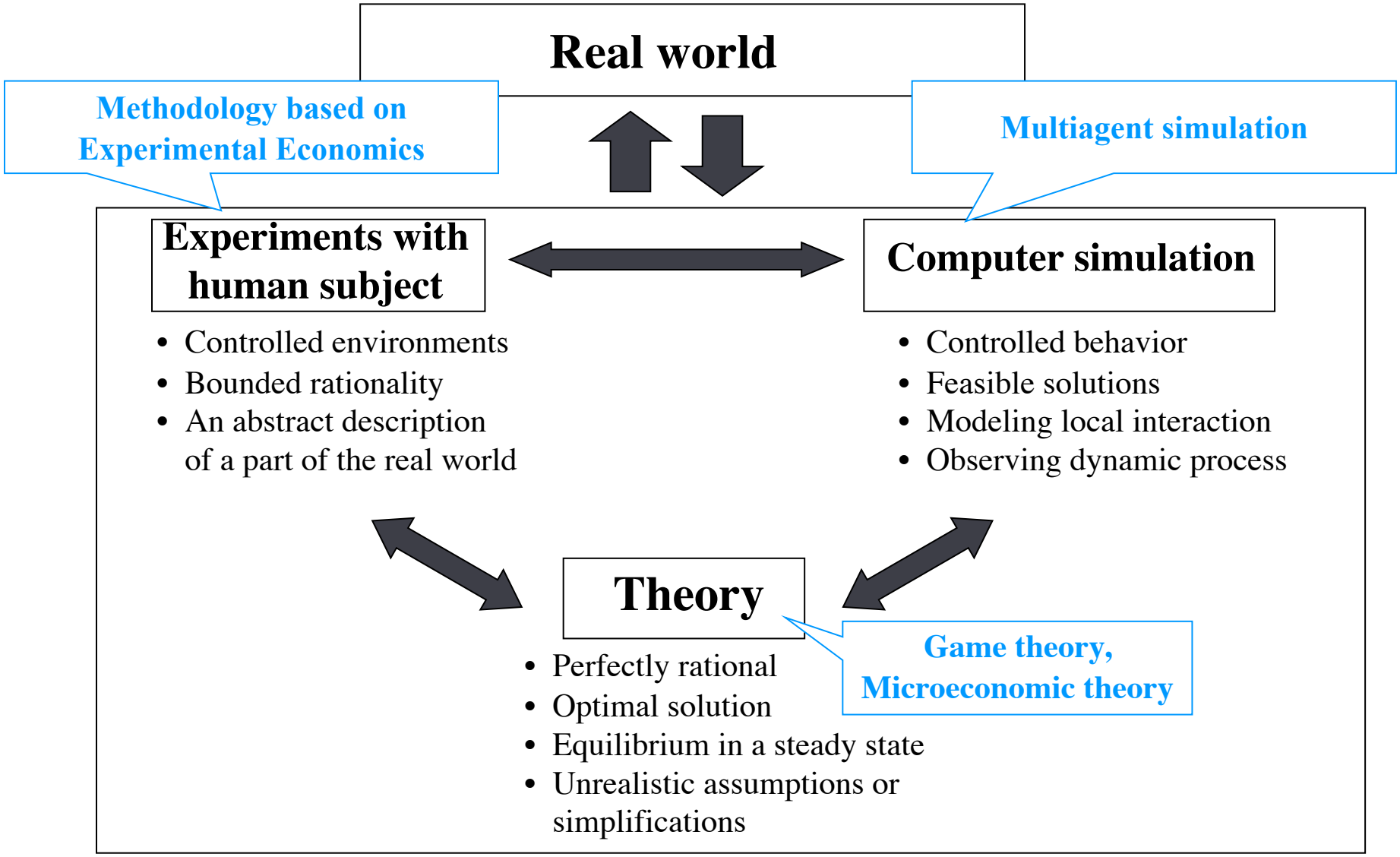
Fig. An experimental desk

Fig. Experimental laboratory

This method can give us …

- **Deep analysis on actual human behavior**
- **Elucidation of mechanism on decision-making structure with humans**
- **Assessment of result reproducibility**

A social system is considered as a decision-making model and studied by an integral approach



Research example: Proposal of seat auction mechanism in theater service

Current theater service

- In most theaters, price is fixed
- Price is not different even if the movie title is different

Price should be determined depending on content's quality and seats

Utilizing mechanism design theory, we propose a new mechanism:
- Price determination auction by **VCG mechanism**
- Matching by considering seat preference based on **Gale-Shapley mechanism**

Proposed mechanism

Consumers send the information of bidding price and preferred seats

(1) Price determination

M units of one kind are sold through auction. The *M* highest bidders win at the price that the (*M*+*1*)-th highest bidder sets

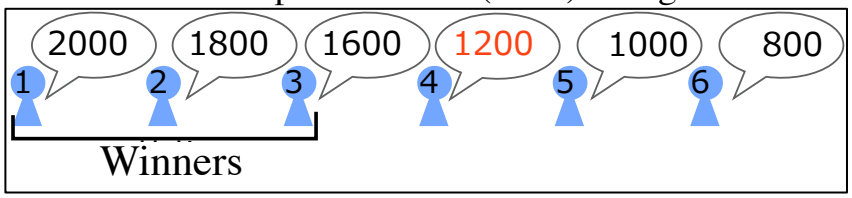
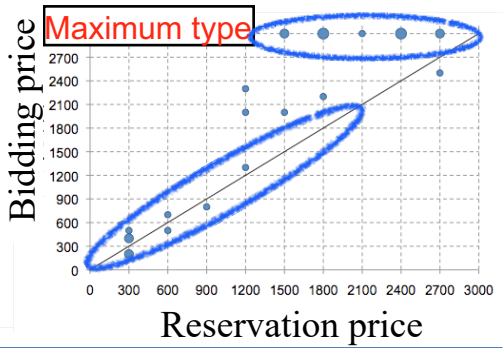


Fig. A case of ***M***=3 (The three winners purchase at price of 1200

(2) Seat matching

Higher bidders have higher priority to be matched with preferred seats

Results of human subject experiments



Experiments are conducted to extract strategies, and then multiagent simulations with such strategies are run in order to evaluation the proposed mechanism.

Simulation results

- The proposed mechanism outperforms fixed-price mechanism in terms of social surplus.
- Efficient allocation can be realized.

3. A viewpoint of synthesis

Analysis and Synthesis

Understanding Nature

Structure/ Action

Direct Problem
Analysis

Inverse Problem
Synthesis

Function/ Demand

Creating Artifacts

What is "synthesizing a social system"?

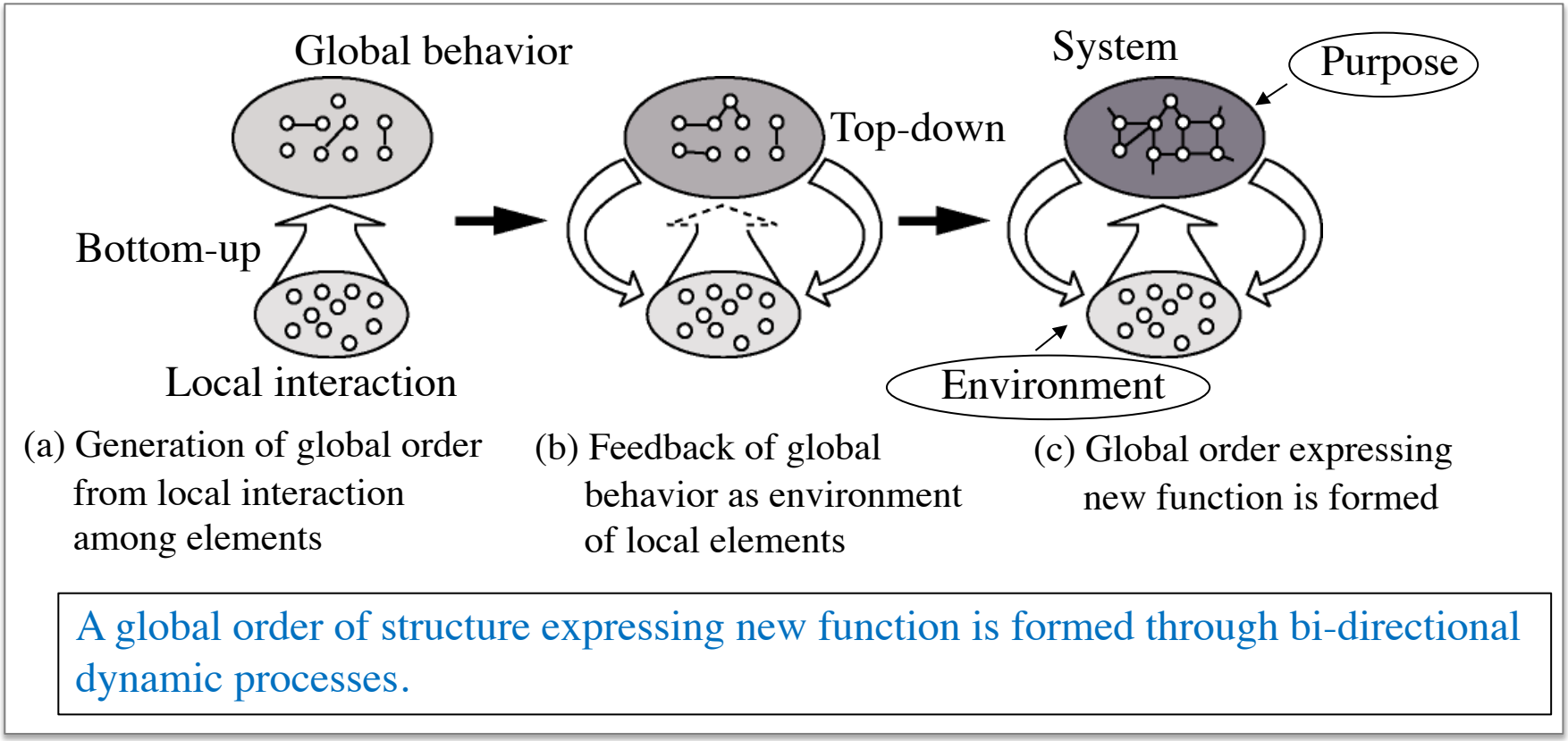


Fig. Concept of emergence —From Local Simplicity to Global Complexity—

A society is an emergent system, so we synthesize (design) a component that determines interaction among entities through emergent process ⇨ **Institution (mechanism)**

Research example: Proposal of mechanism of distributed electricity trade for households

Distributed electricity trade in our study

This study targets the market of electricity trade where households can join. Households play a role of electricity consumers as well as electricity producers.

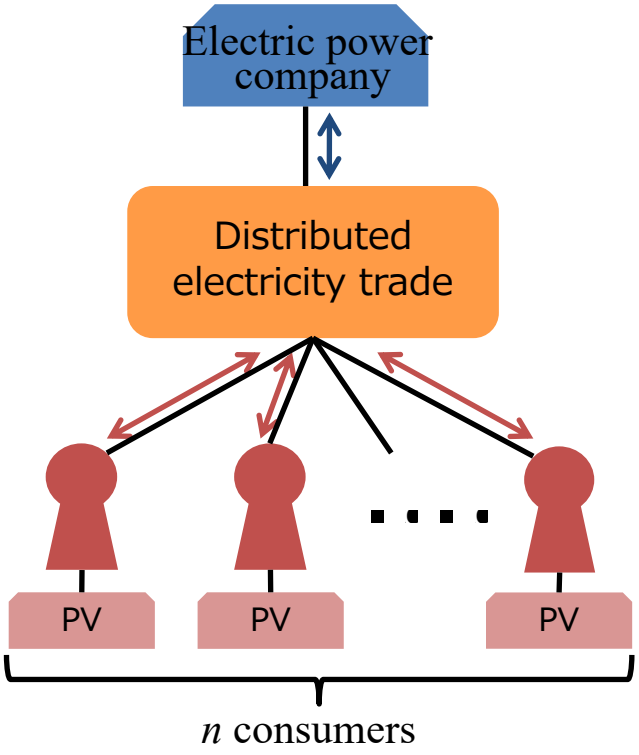


Fig. Model structure

Four mechanisms are proposed and evaluated by economic experiments and simulation

◆**Deman-Supply based mechanism**

Electricity is traded at price and quantity that balances demand and supply

◆**Residual electricity based mechanism**

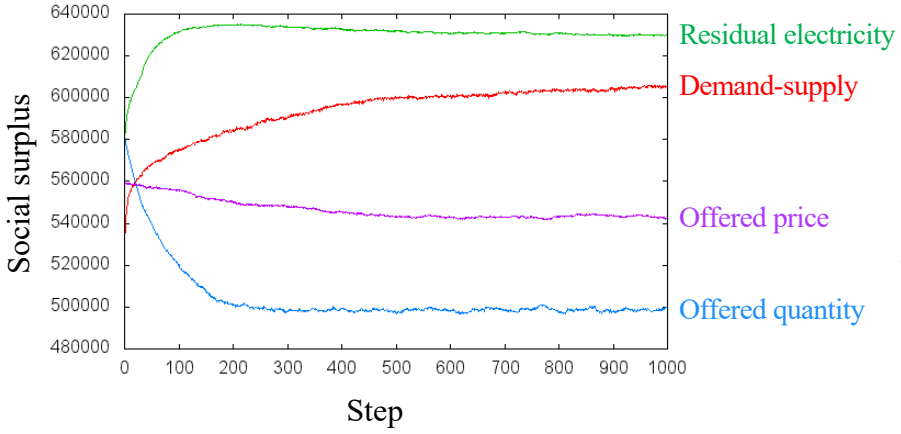
Only residual electricity is traded

◆**Offered price based mechanism**

Low price bidders have priority to trade electricity

◆**Offered quantity based mechanism**

Low quantity bidders have priority to trade electrisity



Experimental Results:
Residual electricity base mechanism demonstrates the highest social surplus

Past themes of master thesis

List of past master theses

FY 2011

- Efficient mechanism in electricity trade considering interconnection line constraints
- Modeling Japanese animation industries and analysis of its structure

FY 2012

- Application of biform game to technology management: A case of the steel industry
- Analysis of modular technology strategy in the automotive industry
- A study on matching mechanism of marathon participants

FY 2013

- Categorization of ebook industries and analysis by game theoretic approach
- Value of modular technology in the automotive industry
- A Data Mining Approach to NBA Playoffs Prediction Based on Player Ability Evaluation

FY 2014

- Mechanism of electricity trade considering three area interconnection line constraints
- A game theoretic analysis of product development strategy under heterogeneities of producer technology and consumer preference
- Categorization of service business based on value creation model and its application to the retail industry

List of past master theses (Cont'd)

FY 2015

- Analysis of consumers choice behavior on menu with field experiment
- Effects of information uncertainty and social preference on stock price
- Emergent process of business ecosystem with multi-agent simulation
- Comparison business structure of rail passenger transportation industries

FY 2016

- A study on mechanism of service provision with economic experiments
- Theoretical mechanism of service systems with empirical data: A case of the beauty salon industry

FY 2017

- Availability of physical distance as a service metrics
- Development of service design support simulator considering empirical characteristics

FY 2018

- Development of similar function in case-based decision theory toward empirical application
- Constructing a service model of restaurant industries and simulation of different employee's pay systems
- Recommendation algorithm considering diversity of lifestyle and preference

FY 2019

- Relationship between employee's health and stock price: An approach by economic experiments
- Intrinsic motivation alternation according to activity progress: A Lego building laboratory experiment
- Reward design in data analytics competition to induce continuous efforts