Design Science: A Prelude[†]

Tatsuyoshi Saijo*
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* Institute of Social and Economic Research, Osaka University, Ibaraki, Osaka 567-0047, Japan, E-mail address: saijo@iser.osaka-u.ac.jp.

1. Introduction

Recently, we find the rise of criticisms in the field of mechanism design, which is to design a mechanism or system for achieving social goals such as efficiency and equity in the distribution of goods and services.

First of all, there is a criticism from experimentalists. In the verification of various mechanisms using human subjects in laboratories, these designed mechanisms do not necessarily function as prescribed. This fact itself is a criticism to not only this particular field, but also extending to economics as a whole. Departing from the initial stage of surprise with why theoretically expected results cannot be observed in laboratories, we are now entering the stage of determining why they do not function and what are the essential factors involved.

Second criticism involves the presumptions in the theories themselves. Mechanism design has not paid sufficient attention to information exchanges between people, the cost of processing, and the selections of equilibrium concepts. What is questioned now is the real validity of frameworks themselves, on which the theories are nested.

This report is, through exploratory works on issues of mechanism design, to contemplate hints of new approaches to the questions: what it means to design a mechanism; how to design them; and what shall be the next step economics needs to aim for.

2. Public Goods Provision

Let us consider the theory of public goods provision. When one person watches a TV program, it does not necessarily mean that that person excludes other persons from watching the same program. Such feature of public goods is called the non-rivalness of goods and services. Yet, TV programs can be scrambled to allow only those paying to watch them. In order words, those goods and services can exclude the possibility of consumption. Those goods and services that are non-rival but excludable are called public goods.

In the textbook theory of public goods provision, there will be a free riding by the people who find it best to freely use public goods provided by others. Thus the level of public goods provision is short of a Pareto efficient level. Whether it was possible to design a mechanism to provide a Pareto efficient level of a public good or not was one

of the main unsolved problems in 1970's.

Those forerunners who challenged this question were Clarke (1971) and Groves (1973). They designed a mechanism, in which it would be best to express one's true preference of public goods regardless of other individuals' choices of strategies (i.e., satisfying *strategy-proofness* or *incentive compatibility*), although it would not be possible to attain Pareto efficiency. Their mechanism is mathematically equivalent to the second price auction in auction theory. Later, Green and Laffont (1979) designed a mechanism that can not attain Pareto efficiency, but the allocation is very close to Pareto efficient one.

Those succeeded the initial studies were the groups of researchers called mechanism designers. Groves and Ledyard (1977), Hurwicz (1979), Walker (1981), Varian (1994) and others constructed games that would make Pareto efficient level of public goods achievable. In other words, they demonstrated that the Nash equilibrium allocations of such games is Pareto efficient. At about the same time, Maskin (1977) provided necessary and sufficient conditions where the outcomes of a game coincide with a social choice correspondence, which provided theoretical background to mechanism designers.

By the time mechanism designers concluded that they could theoretically resolve the issue of public goods, Johansen (1977) contradicted their approach itself. He pointed out that the framework of preference revelation would be far from the political process of public goods provision, and there was almost no incident when public goods were provided by preference revelation. He advocated for the analysis involving political process as the true analysis of public goods provision.

Later, many mechanism designers rejected Johansen's criticism and continued designing mechanisms, which were said to provide better performance. On the other hand, others started to question their approach from viewpoints different from Johansen's.

First of all, Kagel *et al.* (1987, 1993) verified in their experimental studies of the second price auction, which is strategy-proof, that people would rarely state their true valuation. People would usually state values higher than their true values. Moreover, Attiyeh *et al.* (2000) and Kawagoe and Mori (2001) confirmed in Clarke's pivotal mechanism experiments, which is mathematically equivalent to the second price

auction, that the pivotal mechanism would not function either. They strongly questioned further study along such line.

Why strategy-proof mechanisms would not function in laboratories?   Saijo, Sjöström, and Yamato (2004) focused on the fact that most of strategy-proof mechanisms have a continuum of Nash equilibria, and considered that subjects participated in experiments might not necessarily choose dominant strategy even if that would state their true preference. In other words, which behavioral rules people would adopt would be entirely people's choice and not predetermined by researchers. They called the mechanism in which the outcomes of dominant strategy and Nash equilibria would agree as a secure mechanism and characterized it. They found that such a mechanism would hardly exist and only a special type of the Groves mechanism would be secure.

Moreover, Cason *et al.* (2004) verified the performances of secure and non-secure mechanisms using subjects in the laboratory. They found that a secure mechanism did function and a non-secure mechanism did not.

The implication of aforementioned studies is important. It is because it concerns the very existence of a field of designing strategy-proof mechanisms, in which true preference announcement is a dominant strategy. Even if a strategy-proof mechanism can be designed successfully, however the mechanism itself may not function well, at least in laboratory, unless it is secure. Needless to say, such a mechanism is not likely to be applicable in a real society. If the mechanism is secure, still the possibility of its application is nil as long as it presumes the preference announcement as a strategy. How difficult it is for people to convey even a part of their preferences has been clearly demonstrated in the vote recounting event at Florida's Bush-Gore contention during the US Presidential election in 2000. Even if a preference can be represented by a continuous function, the dimensions of all possible preferences become infinite. It is principally impossible to exchange such information without costs.

Then, will the mechanism designed by, for example, Groves and Ledyard (1977), which Nash-implements a Pareto efficient allocation, function well in a laboratory? Chen *et al.* (2004) confirmed that the Groves-Ledyard mechanism does converge to Nash equilibria after the repetition of several hundred times with the same subjects. If a mechanism requires 100 repetitions to converge to an equilibrium, it will hardly have any practical use. In addition, Hamaguchi *et al.* (2003) found through their emissions

trading experiments that the Varian mechanism, that implement a social goal subgame perfectly, would not function well either.

Additional criticism concerning the mechanism design involves a tacit assumption concerning the public goods provision. Conventionally, mechanism designers assume tacitly that people should participate in the mechanism they designed. In other words, people *must* participate in it. What the non-excludability of public goods implies is that people will do free riding without participating in the mechanism. Saijo and Yamato (1999) proved that, considering this factor, it would be impossible to design a mechanism in which every people participates. The issue of public goods provision has not been resolved in theories. Those challenging the issue of impossibility are young researchers such as Yu (2001), Sameshima (2003), Shinohara (2003 and 2004), Healey (2004) and so on. Cason *et al.* (2002) and Cason *et al.* (2004) conducted experiments on this issue.

However, these criticisms have not provided solution to the question of how to design a system for providing public goods. This is because the circumstances assumed for models are far from the reality. Of course, the results of public goods provision model as idealtypus has significance, but to continue designing mechanisms by creating theoretical models in ignorance of how public goods have been provided in our society will be problematic.

In our society, public goods are not always improvided for or short supplied. For example, what we found during the 1980's and 1990's was rather the excess provision of public goods. Being aware of the fact that public goods could be short supplied if left alone, our ancestors tried on various methodologies to secure the provision of public goods, such as the "common land" to prevent the tragedy of the commons. It is certainly important to analyze these means, but have we conducted a thorough analysis on the decision making in public goods provision in this modern Japanese society?

Whether national level or community level, the decision making processes for public goods provision are normally structured as follows. First, bureaucrats are to prepare a draft of public goods provision policy. Then they announce the contents of the draft to relevant regional residents and hold public hearing meeting, in which mostly those people opposing the draft will likely participate and exercise strong influence over the

revision of draft. Bureaucrats determine the strength and direction of the opposition opinions at the public hearing meeting, revise the draft, and resubmit to another public hearing meeting. Once this step is settled, bureaucrats submit the revised draft to the Council, which members are selected by bureaucrats and usually consisted of not only the experts of relevant public goods, but also prominent persons or stakeholders relevant to the introduction of the said public goods. Occasionally, some individuals of prominence or academic standing not residing in the region may become the Council members for the purpose of maintaining the neutrality. The Council reports to a Community leader such as a mayor or a governor, and the leader will acknowledge the result and move to implement the public goods provision project.

The study of such decision-making process has just begun in recent years. However, unless the public goods provision process undertaken today is fully analyzed, it is not possible to compare it with the mechanism proposed by mechanism designers. It is necessary to identify the pros and cons of each mechanism through comparison at least in theories. In order to adopt a mechanism that is theoretically more preferable than the current system, it is necessary to provide favorable results in laboratories, and in cases studies of other countries, other regions, or in the past. To sum up, mechanism designers incline to confine themselves in academic ivory tower and fail to propose mechanisms that can be alternatives to the existing systems.

3. Designing a Mechanism for Global Warming Mitigation

As the second example, let us consider the designing of a domestic system to prevent global warming under the UNFCCC's Kyoto Protocol. Once the Kyoto Protocol enters into effect, Japan, for example, will have a GHG emissions cap at 94% of 1990 emissions for 5 years from 2008 to 2012. If the actual emissions do not exceed this cap, Japan will have the options to either bank the difference between the cap and actual emissions to be used after 2013, or to sell them to other countries. If the actual emissions exceed the cap, on the other hand, it must purchase emissions reduction from other countries.

To achieve such targets, there are various potentially conceivable systems. Discussed below is the review of several approach designs so to identify economically correct approaches and to contemplate on what should be done to the new field of design science. In the designing of systems discussed below, I will try to approach problems through exaggerated profiling of systems' characterization, rather than through minute

examination of details.

Upon designing systems, various indexes can be applied for different approaches of assessment. Economists may stress "economic efficiency" to minimize GHG reduction costs. On the other hand, from the viewpoint of absolute compliance with Kyoto targets, the first priority will undoubtedly be the "compliance" of the Kyoto targets. From the viewpoint of attaining as much GHG reduction as possible, rather than mere compliance with the Kyoto targets, then the system must aim for global "environmental" conservation.

There is no single incentive to encourage people to achieve such targets. Those in emissions trading business will certainly recommend emissions trading, without even considering the "economic efficiency." Bureaucrats involved in policy-making to promote energy saving technologies or vested interests at the back of such policy will advocate "environmental conservation" in order to secure budgets for such policy, rather than "economic efficiency" or "compliance." I have no intention to discuss "good or bad" of incentives. Important point here is that researchers responsible in creating "design science" have not contemplated fully on past incentives as demonstrated below.

Researchers of expertise in strategy-proofness will think of a game to state GHG reduction technology without questioning. This means that each entity is to state a reduction technology function, but it is easy to show that the true technology function announcement will not be the best way. Moreover, if the mechanism is a Clarke type though sacrificing efficiency, they will show that the true technology function announcement is the dominant strategy. As discussed in the previous section, researchers in this field will not likely analyze who shall collect information by what methods, how such information is processed and in what way the distribution of reductions to each country can be determined. Those involved in policy-making will likely consider such proposal as a thing in the air.

Mechanism designers will undoubtedly demonstrate that they can design a mechanism to achieve efficiency. For instance, the Varian mechanism will enable the achievement of Kyoto target through sub-game perfect equilibrium. As in the case of strategy proofness, however, problem of information processing will not be addressed. There is much unnaturalness embraced in mechanisms designed by mechanism designers

such as the Varian mechanism. For example, in a numerical statement game, if all but one state the same numerical value, then the agent not stating that value will have penalties. Sometimes, there may be a designer who will design a mechanism to enable the confiscation of all the assets of this agent. If one loses all the assets by failed speculation in a futures market, then one has only oneself to blame. However, why is it that one merely providing information different from others has to receive penalty? What is the legal basis to put penalty to such an entity? Still, mechanism designers continue designing mechanisms without questioning the "unnaturalness" of their mechanisms. Empirical researchers, on the other hand, verify that such mechanisms will not function as prescribed. It is deemed that policy-makers will not seriously consider such mechanisms as an alternative.

Of course, the well known economic tools in the field are carbon tax and emissions trading. According to the standard textbooks, both approaches are said to bring the efficient compliance of the Kyoto target. Let us first examine the carbon tax, which many researchers recommend. Actually, no one knows what can be the rate of carbon taxes that can achieve how much of the target. Moreover, even if carbon tax is imposed, its rate cannot be changed easily, since such changes need the approval of the Diet. The fact that laboratory experiment has not yielded any proper rate of carbon tax to enable Kyoto target achievement, as explained in Akai, Kusakawa *et al.* (2004), indicates the difficulty of complying with the Kyoto target through carbon tax. In other words, carbon tax, though efficient, is not fit to achieve a pre-fixed target. As shown here, a proposal not contemplating on political restrictions will not be justifiable.

How about emissions trading? According to the standard textbooks, emissions trading also enables efficient achievement of a fixed target. In other words, it can provide both efficiency and compliance. However, according to the empirical study by Akai, Kusakawa, *et al.* (2004), there can be non-textbook cases if any uncertainties of emissions reduction investments.

4. Framework of Design Science

How one needs to design a system with no precedents, such as the case of domestic system design for global warming? No well functioned mechanism can be designed, if only relying on the approaches in a specific field. What is needed is to design various alternatives by setting multiple number of assessment criteria, and using multiple approaches. As discussed in the previous section, the mechanisms designed by current

mechanism designers are not likely to become alternatives.

When developing various alternatives for domestic mechanism design to prevent global warming, one must consider designing a system that can incorporate characteristics unique to Japan and non-existent in other countries (such as almost total reliance on imports of fossil fuels, difficultly to comply with the Kyoto target, and so on). Instead of relying on a sole approach, we must consider the combination of multiple methodologies. Also, it is necessary to develop new methodologies, rather than solely relying on the conventional ones. This is where researchers can exhibit their originalities. If one alternative is inferior to other alternatives in the light of every assessment criteria, then that cannot be an alternative. Thus, what would remain are only those alternatives that cannot totally surpass other alternatives. Such an attempt was made by Akai, Okagawa, Kusakawa, *et al.* (2004). However, there have been almost no studies that squarely address the issue of incentives for various stakeholders in the process of policy decision making. Amazingly, economists including environmental economists hardly ever study the comparison of systems, and merely propose a system they consider preferable, or introduce systems of other countries.

If multiple alternatives remain as theoretical proposals, then they cannot become truly adoptable proposals. Verification is needed to determine whether each proposal can exhibit theoretically prescribed performance or not by using various methodologies. Also needed to implement is the verification of measurement models and numerical calculation models such as applied general equilibrium model, proof of each system in laboratories using subjects, and confirmation of a system or similar system of the past or in other countries, through the survey of their successes and failures.

After these processes, the proof of each proposal's performance should be implemented, and any problems likely to be arisen should be solved. Then, coming would be the works to submit and to verify new proposal or revisions of existing proposals.

Even if a good proposal is made, it can be wasted unless the Council takes it up as its agendum. If the proposal is not compatible with incentives for stakeholders or bureaucrats at the back of the Council, then the proposal will not be accepted. Also important is the process of letting policy-makers understands various proposals. For instance, not many people understand the "marginal concept," which is a common

knowledge for economist, or comprehend the meaning of "economic efficiency" and "dead weight loss."

Preferable system will be to establish a center to design systems and policies independent of bureaucrats, rather than the system for bureaucrats to expend national budget to a Council set for each issue and to consign studies to think tanks and universities of the private sector. Policy makers will be exposed to competition with systems and policies recommended by external research institutes. Of course, the Council style policy-making process itself will become an important research subject for such centers.

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Design Science A Prelude

The Experimental Economics Week in Honor of Dr. Vernon L. Smith Kyoto Sangyo University

December 17, 2004

Tatsuyoshi Saijo
ISER, Osaka University

Goal: Build up a Scientific Framework for Designing Institutions

Example: Public Good Provision

1. **Choice of Equilibrium Concepts**
   Is Incentive Compatibility enough?

2. **Theoretical Framework**
   Is the current framework of mechanism design all right?

3. **Research Methodology**
   What should be the framework for "Design Science"?

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1. Choice of Equilibrium Concepts Is Incentive Compatibility enough?

1. Applicability Problem
Is there any incentive compatible (or strategy-proof) mechanism used in a real economy? Are we the worst sales people? Or, don't we have enough confidence to sell them?

2. Negative Experimental Evidence
Very few subjects reveal their true valuations
• Second price auction experiments: Kagel, Harstad, and Levin (1987), Kagel and Levin (1993) , Harstad (2000)
• Pivotal mechanism experiments: Attiyeh, Franciosi, and Isaac (2000) and Kawagoe and Mori (2001)

What's wrong?

One explanation:
Confusion due to the complexity of the mechanism and the non-transparency of the dominant strategy

Saijo, Sjöström and Yamato (2004): go beyond this explanation.

**How will behavior deviate from the dominant strategy equilibrium?**

A look at equilibrium structures to identify systematic (rather than random) deviations from the dominant strategy equilibrium

Multiple "Bad" Nash equilibria Exist!

Example 1: Second Price Auction (Vickrey, 1961)
Agent 1 (true value= **7**) and Agent 2 (true value= **5**)
The highest bidder pays the second highest bid.

Theory says: both agents should announce their true value since telling the true value is a dominant strategy.
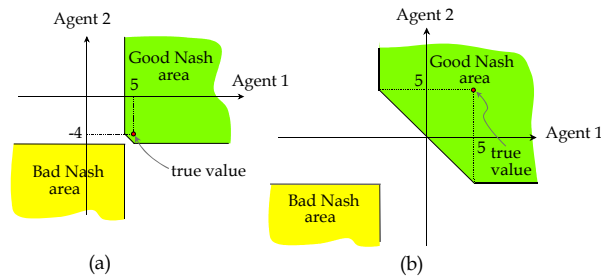

Agent 1's Best Response

Agent 2's Best Response
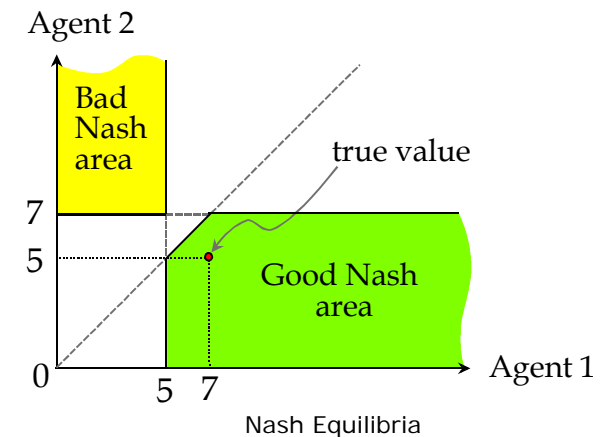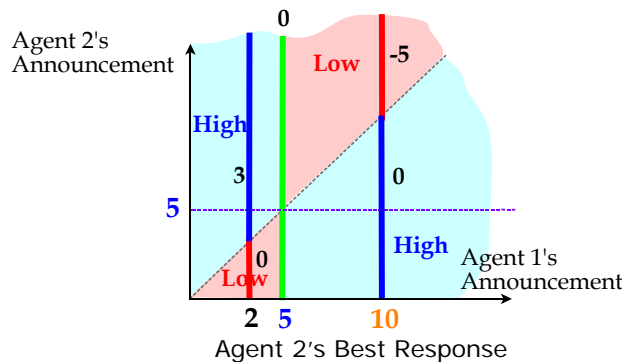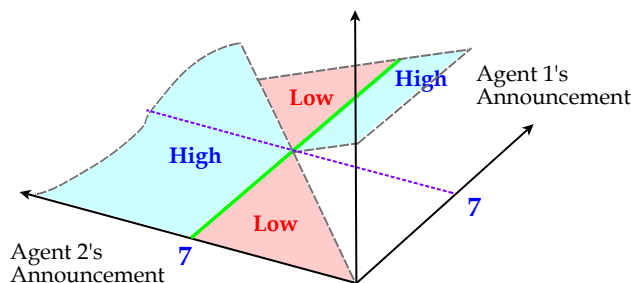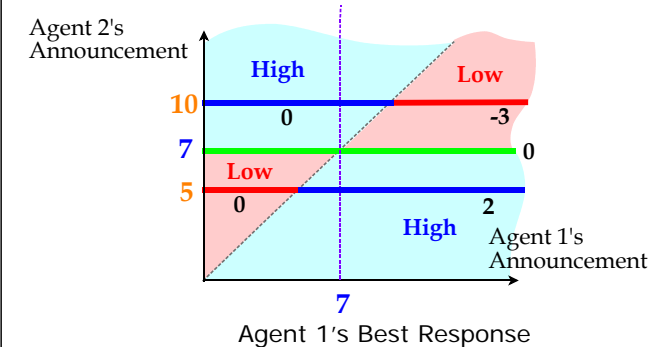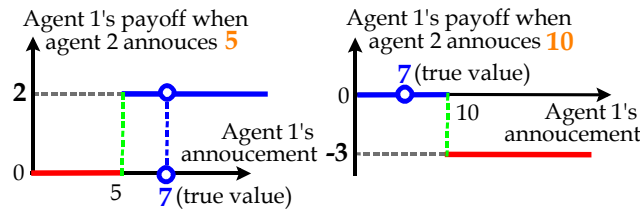
Nash Equilibria

Example 2: Pivotal Mechanism (Clarke, 1971)

(a)   (b)

1. About a half region of strategy space is Nash equilibria.
2. One-fourth is **bad** Nash equilibria.

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A Solution:

• Simultaneously implement a social choice function (SCF) in dominant strategies *and* Nash equilibria to exclude "bad" Nash equilibria equilibria
= **Secure Implementation**

Why not just Nash implementation to exclude Bad Nash?

• Mechanisms designed for Nash implementation may not work well in experiments.

• The strategic uncertainty: In the absence of a dominant strategy, a player's best response depends on the other players' choices, which may be hard to predict.

$\Rightarrow$ the failure to coordinate on a Nash equilibrium.

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• Neither dominant strategy implementation nor Nash implementation provides a robust foundation for practical implementation.

• We consider secure implementation in order to
(i) get the advantages of dominant strategies (strategic uncertainty is not important);
(ii) avoid the possibility that the players may play "bad" Nash equilibria.
(all Nash equilibria should yield a socially optimal outcome)

Note: secure implementation = multiple (more than double) implementation in dominant strategy equilibria, Nash equilibria, and all refinements of Nash equilibria
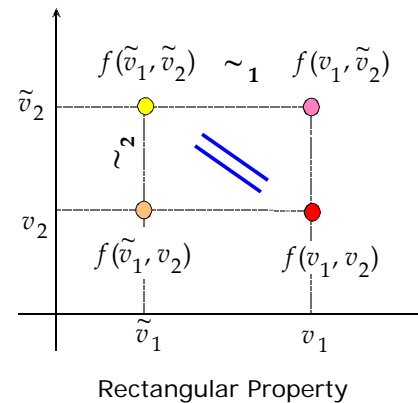
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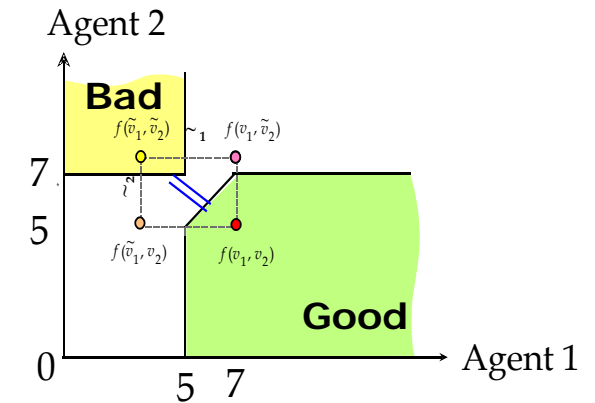## Secure Implementation in Public Good Economies: Saijo, Sjöström and Yamato (2004)

Secure implementability
$\Rightarrow$ dominant strategy implementability
$\Rightarrow$ incentive compatibility
(**Revelation Principle,** Gibbard, 1973)

Another condition is necessary for secure implementation.

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Rectangular Property

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Theorem 1 (Saijo-Sjöström-Yamato (2004)). *An SCF is securely implementable if and only if it satisfies incentive compatibility and the rectangular property.*

Theorem 2 (Saijo-Sjöström-Yamato (2004)).
(i) *For any mechanism implementing an efficient SCF in dominant strategy equilibria, the set of Nash equilibrium outcomes is strictly larger than that of dominant strategy equilibrium outcomes if the number of public project choices is finite.*
(ii) *Assuming that preferences are single-peaked and the choice of public project is continuous, incentive compatible and efficient SCF's are securely implementable by Groves-Clarke mechanisms.*

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The Experiment: Cason, Saijo, Yamato and Sjöström (2004)
(i) The pivotal mechanism (Treatment P) and
(ii) a Groves-Clarke mechanism with single-peaked preferences (Treatment S).

Two sessions with 20 subjects for each treatment

Use payoff tables: Context-free experiments!

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Procedures
(i) A pair plays the game and the pairings were determined in advance by experimenters so as not to pair the same two subjects more than once ("strangers").
(ii) No subject knew the payoff table of the other type.
(iii) No explanation regarding the rules of the mechanisms or how the payoff tables were constructed.
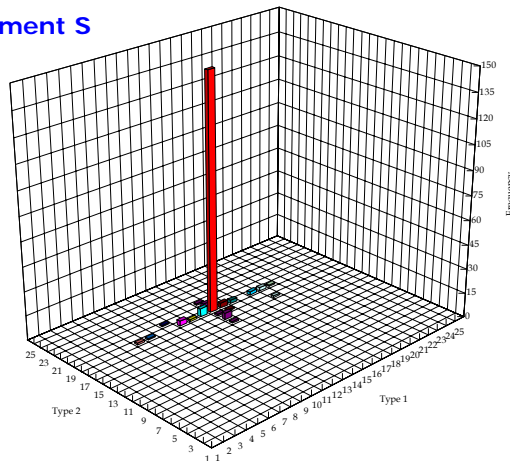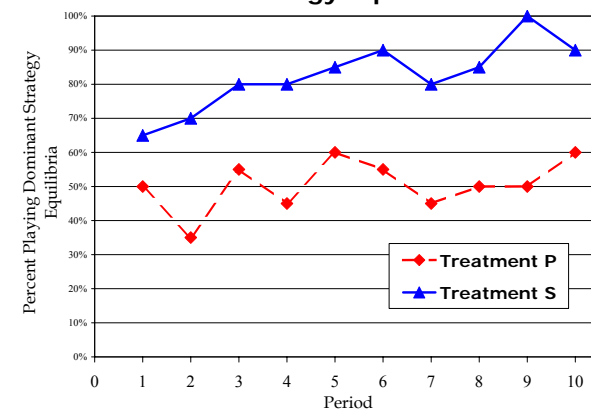(iv) Eight periods in Japan and ten periods in the U.S.

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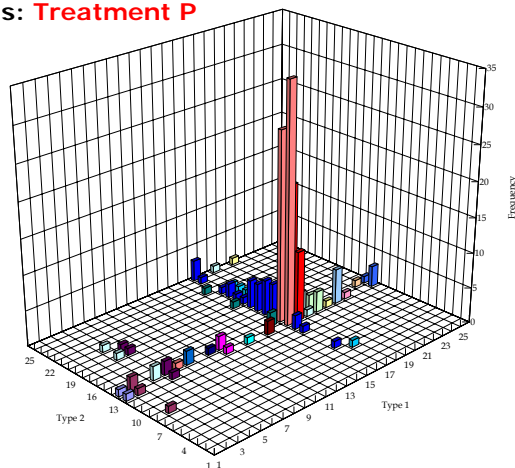
Treatment S

Rates that Pairs Play Dominant Strategy Equilibria

- Treatment P
- Treatment S

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The Problems

1. **The class of secure social choice functions is very thin** => **impossibility results**

2. **Johansen Critiques:**
   (a) The framework of preference revelation is far from the political process of public goods provision.
   (b) Almost no incident when public goods were provided by preference revelation.

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2. Theoretical Framework
Is the current framework of mechanism design all right?

The Groves and Ledyard mechanism (1977)
The Walker Mechanism (1981)
The Hurwicz Mechanism (1979) and others

constructed mechanisms to achieve a socially desirable allocation.

The Free-Rider Problem is solved!?

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Fundamental difficulties in mechanism design in economies with public goods

- Previous mechanism design including Groves-Ledyard, Walker, Hurwicz and almost all mechanisms assume that everyone MUST participate in a mechanism.

⇓

- Ignore NON-EXCLUDABILITY of a public good: non-participants can enjoy the public good provided by participants

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- **Examples:**
- **<International Treaties>**
- The Kyoto Protocol on climate change (1997) to reduce green house gas emissions: the U.S. signed the protocol, but decided not to ratify it

- **<Public Fee to public goods>**
- NHK's Public Broadcasting Fee in Japan no penalty without paying the fee

What would happen if we consider voluntary participation?

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- **Saijo and Yamato** (*JET*, 1999):
Participation is a choice variable for agents

An impossibility theorem:
It is impossible to design a mechanism in which everyone has an incentive to participate.

- **Experiments**
  Cason, Saijo and Yamato (*Exp. Econ.*, 2002)
  Cason, Saijo, Yamato and Yokotani (*GEB*, 2004)

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The Voluntary Contribution Mechanism: A two agent game where each agent decides to contribute her money for constructing a public good.

Player 1 (24 units)   **Player 2** (24 units)

s_1 s_2

x_1 $s_1 + s_2 = y$ x_2

$u_1(x_1, y)$ $u_2(x_2, y)$

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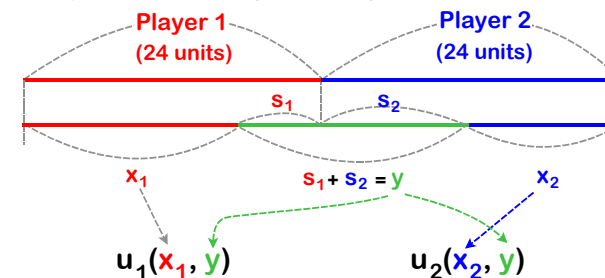
• **Represent the VCM by a Game Tree**

$$u_i(x_i, y) = \frac{(x_i^{0.47} y^{0.53})^{4.45}}{50} + 500$$

Nash Equilibrium:
$(s_1, s_2) = (8,8)$

1

0   8   24

2

8

(7345,7345)

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s_1

s_2

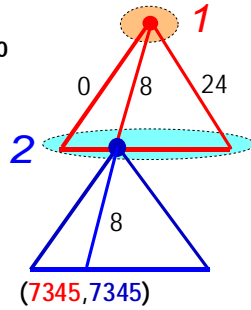| Your Payoff	0	1	2	3	4	5	6	7	8	9	10	11	12
0	706	871	1072	1297	1536	1775	2003	2210	2386	2523	2615	2658	2648
1	905	1127	1379	1647	1919	2183	2427	2641	2816	2944	3019	3039	3001
2	1186	1465	1764	2072	2374	2658	2913	3129	3297	3411	3465	3456	3385
3	1554	1888	2232	2575	2902	3202	3463	3675	3831	3925	3952	3911	3801
4	2017	2401	2787	3160	3508	3817	4078	4281	4420	4488	4483	4403	4250
5	2578	3010	3432	3831	4193	4507	4762	4950	5064	5101	5057	4934	4733
6	3244	3718	4171	4590	4960	5272	5515	5681	5766	5765	5677	5504	5249
7	4018	4529	5008	5440	5812	6115	6339	6478	6526	6481	6343	6114	5800
8	4904	5447	5944	6383	6751	7038	7237	7340	7345	7250	7056	6765	6385
9	5907	6475	6984	7422	7779	8043	8209	8271	8225	8073	7816	7458	7007
10	7031	7616	8130	8561	8897	9132	9257	9270	9168	8951	8624	8193	7664
11	8278	8873	9384	9800	10109	10306	10384	10339	10173	9886	9482	8970	8359
12	9653	10250	10750	11142	11416	11567	11589	11480	11242	10877	10390	9791	9090

Best Responses

28

Slide 29

• **Adding a Participation Stage**

1

Participate   *Not participate*

2

Participate   *Not participate*   *Participate*   *Not participate*

(706,706)

1   1   2

0   8   24   11   11

2

8

(7345,7345)   (2658,8278)   (8278,2658)

29

Slide 30
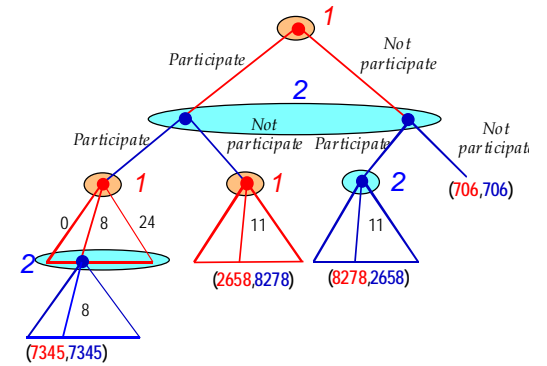
• **Looking at the Participation Decision** ⇒ A Hawk-Dove Game ⇐ Not a prisoner's dilemma game

2

p_2 $1 - p_2$

Participate   **Not participate**

1   **Participate** p_1 7345 < 8278 ; 7345 , 2658

Not participate $1 - p_1$ 2658 > 706 ; 8278 , 706

The set of Nash equilibria
$\{(p_1, p_2): (1,0), (0,1), (0.68, 0.68)\}$
Evolutionarily stable strategy $p_i = 0.68$

• **Evolutionarily Stable Strategy Equilibrium (or John Maynard Smith Equilibrium)**

30

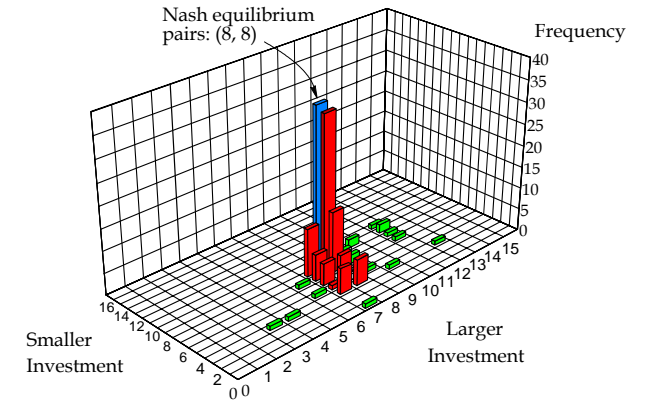## Slide 31

• **Experimental Design**

| Tsukuba & Tokyo Metro in Japan | USC & Purdue in the US |

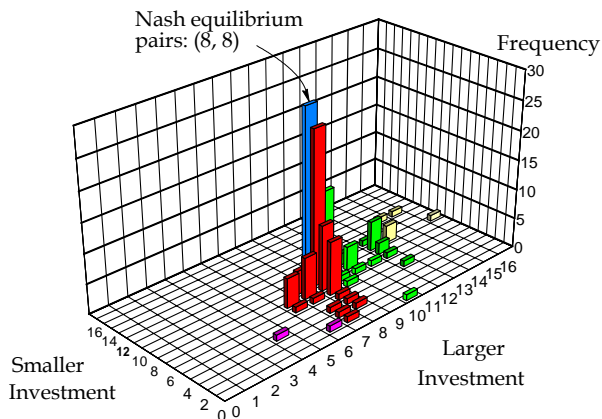**Treatment A**: Every subject must participate in investment.
• 20 subjects
• 2 subjects make a pair (10 pairs)
• No communication
• Each subject does not know who is your opponent
• 15 periods
• No subject faces the same subject twice or more
• Every subject knows that every subject has the same payoff table
• A pair knows the investment decision each other, but this info is not in public.

Treatment B: each subject can choose whether she participates in investment or not

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Slide 32

Result: Treatment A at Tsukuba

Nash equilibrium pairs: (8, 8)

Frequency

Smaller Investment

Larger Investment

32

Slide 33

Result: Treatment A at USC

Nash equilibrium pairs: (8, 8)

Frequency

Smaller Investment

Larger Investment

33

Slide 34

• **Spiteful Behavior**

s_1

s_2

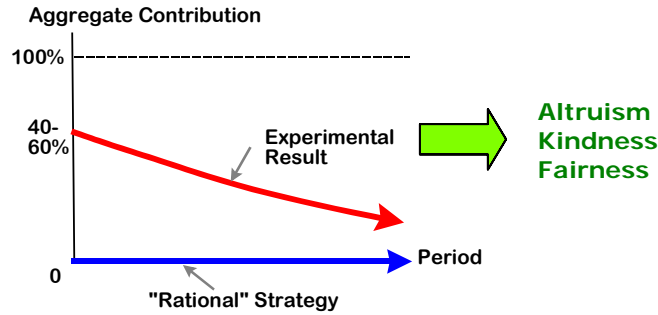| Your Payoff	0	1	2	3	4	5	6	7	8	9	10	11	12
0	706	871	1072	1297	1536	1775	2003	2210	2386	2523	2615	2658	2648
1	905	1127	1379	1647	1919	2183	2427	2641	2816	2944	3019	3039	3001
2	1186	1465	1764	2072	2374	2658	2913	3129	3297	3411	3465	3456	3385
3	1554	1888	2232	2575	2902	3202	3463	3675	3831	3925	3952	3911	3801
4	2017	2401	2787	3160	3508	3817	4078	4281	4420	4488	4483	4403	4250
5	2578	3010	3432	3831	4193	4507	4762	4950	5064	5101	5057	4934	4733
6	3244	3718	4171	4590	4960	5272	5515	5681	5766	5765	5677	5504	5249
7	4018	4529	5008	5440	5812	6115	6339	6478	6526	6481	6343	6114	5800
8	4904	5447	5944	6383	6751	7038	7237	7340	7345	7250	7056	6765	6385
9	5907	6475	6984	7422	7779	8043	8209	8271	8225	8073	7816	7458	7007
10	7031	7616	8130	8561	8897	9132	9257	9270	9168	8951	8624	8193	7664
11	8278	8873	9384	9800	10109	10306	10384	10339	10173	9886	9482	8970	8359
12	9653	10250	10750	11142	11416	11567	11589	11480	11242	10877	10390	9791	9090

Your Payoff	7	8
7	6478 < 6526	
8	7340 < 7345	

Assume that the other player chooses 8.
Choose 7 rather than 8
Reduce own payoff from 7345 to 7340 (5 units)
The other player reduces from 7345 to 6526

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Slide 35

Treatment A: No participation decision

Nash

USC

Tsukuba

Average Investment

Period

35
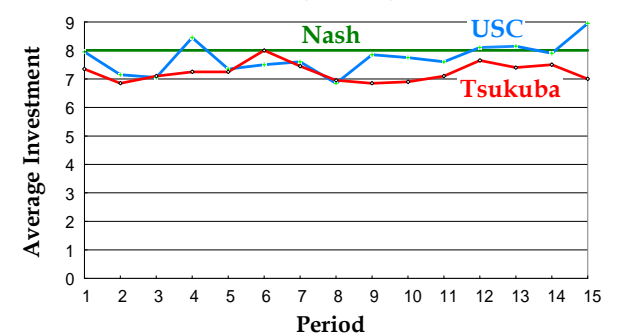
Stylized Facts in Linear Indifference Curve Public Good Experiments

Aggregate Contribution

100%
40-60%
0

Experimental Result

Altruism Kindness Fairness

"Rational" Strategy — Period

36

2
68% Participate — Not 32% participate

Participate 68%
1 Not participate 32%

	7345		8278
7345		2658	
	2658		706
8278		706	

| 46% | 22% |
| 22% | 10% |

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Result: Treatment B at Tsukuba

(8,8) Frequency

Smaller Investment — Larger Investment

The best response pairs when the opponents did not participate

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Result: Treatment B at USC

(8,8) Frequency

Smaller Investment — Larger Investment

The best response pairs when the opponents did not participate
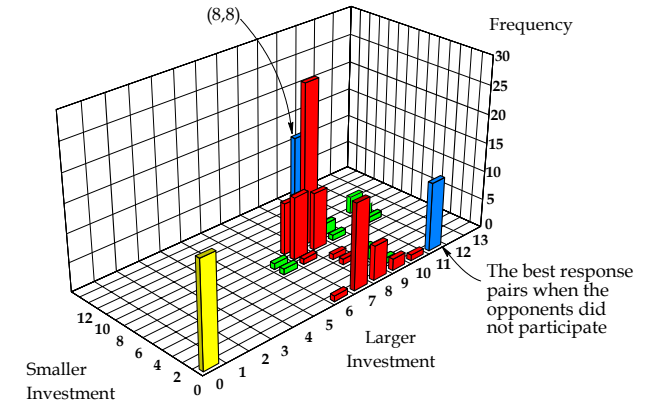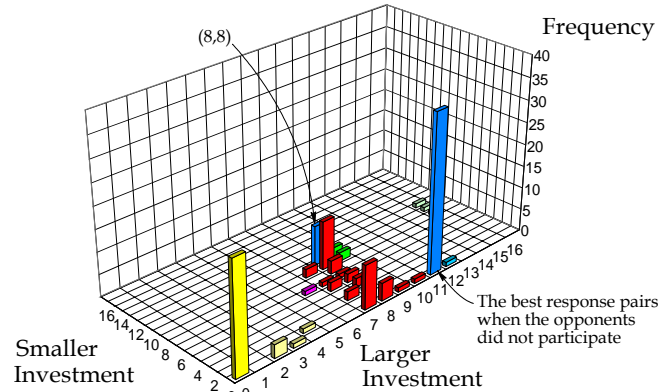
39

• Spiteful Behavior s₁

Your Payoff	0	1	2	3	4	5	6	7	8	9	10	11	12
0	706	871	1072	1297	1536	1775	2003	2210	2386	2523	2615	2658	2648
1	905	1127	1379	1647	1919	2183	2427	2641	2816	2944	3019	3039	3001
2	1186	1465	1764	2072	2374	2658	2913	3129	3297	3411	3465	3456	3385
3	1554	1888	2232	2575	2902	3202	3463	3675	3831	3925	3952	3911	3801
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11	8278	8873	9384	9800	10109	10306	10384	10339	10173	9886	9482	8970	8359
12	9653	10250	10750	11142	11416	11567	11589	11480	11242	10877	10390	9791	9090

s_2

The best response when the other player does not participate = 11.
Choose 7 rather than 11
Reduce own payoff from 2658 to 2210 (448 units)
The other player reduces from 8278 to 4018 7345 to 6526

See also **Saijo & Nakamura** (*J. Conflict R.*, 1995),
Ito, Saijo and Une (*JEBO*, 1995), &
Brandts, Saijo & Schram (*Public Choice*, 2004)

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Participation decisions

Number of Participants / Number of Subjects

ESS Tsukuba USC

Period
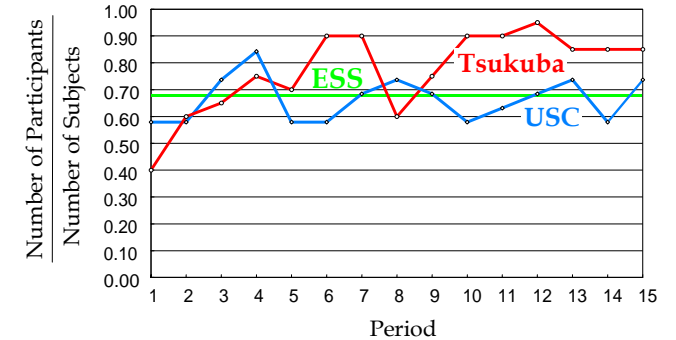
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Tsukuba Data

2
Participate — Not participate

Participate
1 Not participate

	7345		8278
7345		2658	
	2658		706
8278		706	

The Original Game

TRANSMUTATION

2 Participate — Not participate

Participate
1 Not participate

	6494		5315
6494		2349	
	2349		706
5315		706	

Average values of payoff data up to round 5 Treatment B, Tsukuba

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USC Data

2
Participate — Not participate

Participate
1 Not participate

	7345		8278
7345		2658	
	2658		706
8278		706	

The Original Game

2 Participate — Not participate

Participate
1 Not participate

	7167		7279
7167		2400	
	2400		706
7279		706	

Average values of payoff data up to round 5 Treatment B, USC

43

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3. Research Methodology What should be the framework for "Design Science"?

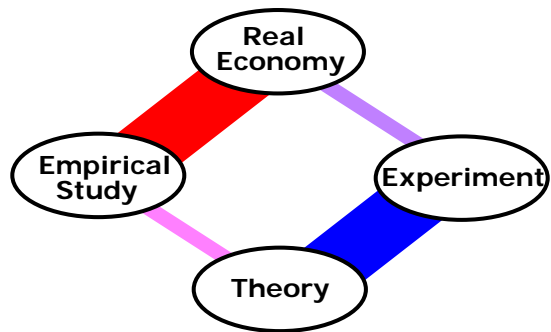**A describer's point of view:**
   Experimentalists are optimistic

A designer's point of view:
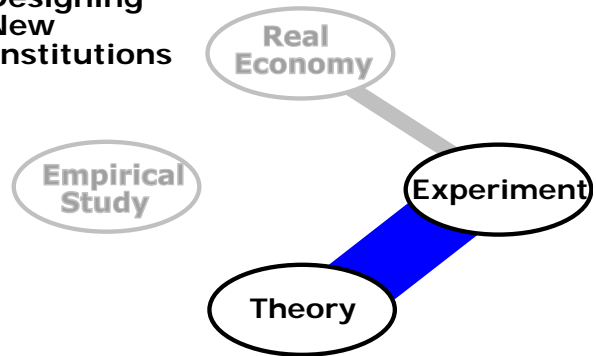   Experimentalists are pessimistic

Example: Design mechanisms to attain the goal of the Kyoto Protocol in order to mitigate global warming such as carbon tax, emissions trading and so on.
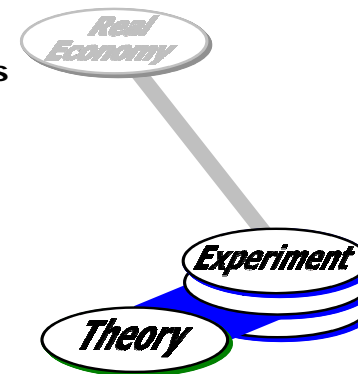
44

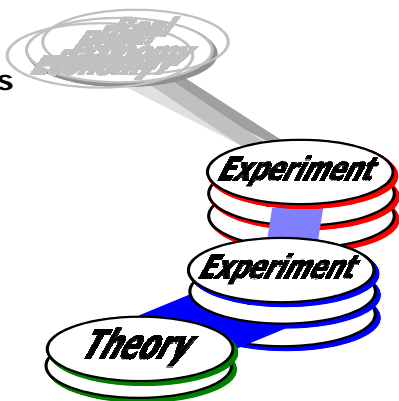45

Designing New Institutions

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Designing New Institutions

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Designing New Institutions

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New Questions

1. **What elements should we include in theories and experiments?**

2. **How far should we conduct the experiments?**

3. **How much should we rely on theories?**

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Tatsuyoshi Saijo

Institute of Social and Economic Research

Osaka University

6-1 Mihogaoka

Ibaraki, Osaka 567-0047

Japan

saijo@iser.osaka-u.ac.jp

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