

Non-Excludable Public Good Experiments

By

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(0) Prelude

Saijo, T. and H. Nakamura, "The 'Spite' Dilemma in Voluntary Contribution Mechanism Experiments," *Journal of Conflict Resolution*, Vol. 39 (3), pp. 535-560, 1995.

Ito, M., T. Saijo, and M. Ueda, "The Tragedy of the Commons Revisited," *Journal of Economic Behavior and Organization*, Vol. 28 (3), pp. 311-335, 1995.

(1) Theory

Tatsuyoshi Saijo and Takahiko Yamato, "A Voluntary Participation Game with a Non-Excludable Public Good," *Journal of Economic Theory*, Vol. 84, pp. 227-242, 1998.

T. Saijo and T. Yamato, "Voluntary Participation in the Design of Non-excludable Public Goods Provision Mechanisms" ISER DP 559, 2001.

(2) Experiment in Japan

Tatsuyoshi Saijo, Takehiko Yamato, Konomu Yokotani, and Timothy Cason, "Non-Excludable Public Good Experiments," *Games and Economic Behavior*, Vol. 49-1, pp. 81-103, 2004.

(3) Comparison between Japan and the US

Timothy N. Cason, Tatsuyoshi Saijo, and Takehiko Yamato, "Voluntary Participation and Spite in Public Good Provision Experiments: An International Comparison," *Experimental Economics*, Vol. 5, pp. 133-153, 2002.

(4) Summary Paper

T. Saijo, "Spiteful Behavior in Voluntary Contribution Mechanism Experiments," forthcoming in *Handbook of Experimental Economics* (Rothschild, Charles R. Plott and Vernon L. Smith (Eds), Elsevier Science)

1. The Universal Principle

Economic activities can be approximately explained by the consequence of a model consisting of selfish agents, regardless of time and place.

David Hume, 1739:

"Now as we seldom judge of objects from their intrinsic value, but form our notions of them from a comparison with other objects; it follows, that according as we observe a greater or less share of happiness or misery in others, we must make an estimate of our own, and feel a consequent pain or pleasure. **The misery of another gives us a more lively idea of our happiness, and his happiness of our misery.** The former, therefore, produces delight; and the latter uneasiness."

(in *A Treatise of Human Nature: Being an Attempt to Introduce the Experimental Method of Reasoning into Moral Subjects, Book II Of the Passions*)

Hume: People care about how they are doing relative to others.

Take **SPITEFUL** actions to decrease the happiness of others.

Might result in outcomes that are socially inferior to outcomes arising from the interaction of purely self-interested individuals.

However,

- **Spitefulness leads to greater cooperation** in a new public good provision experiment.
- Casts doubt on fundamental assumptions of human nature underlying the universal principle.

2. The Free Rider Problem

* Public good: Everybody can use the good or service simultaneously - TV programs, Police, Global warming etc.

* The Free Rider Problem:

It is impossible to achieve socially desirable allocation in public goods economies (Samuelson (1954) etc.)

* Can we overcome the Free Rider Problem?

* Mechanism Design Approach

Design an institution (or mechanism) to achieve a desirable allocation with public goods

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!??>>

3. 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

• 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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• Saito-Yamato (JET, 1999):
 Participation is a choice variable for agents

An impossibility theorem:

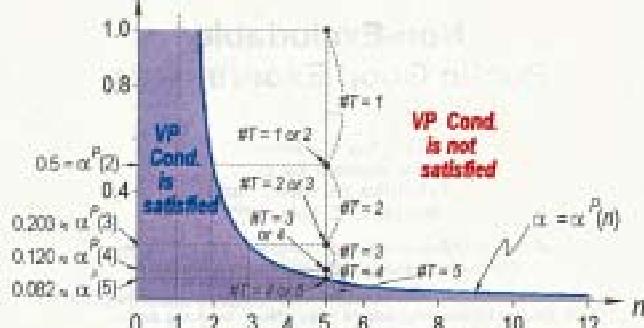
It is **impossible** to design a mechanism in which everyone has an incentive to participate.

Example: Consider any mechanism that is Pareto efficient.
 Everybody has the same utility function:

$$U_i^{\alpha}(x_i, y) = x_i^{\alpha} y^{1-\alpha}$$

where x is a private good and y a public good (the smaller alpha is, then the more public good is preferred).

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Equilibria of a Pareto efficient mechanism when voluntary participation is allowed.

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<A new free-rider problem again?>

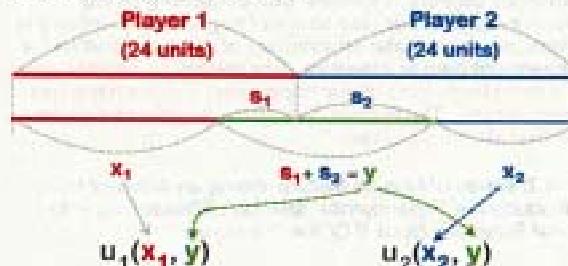


<Experiments with human subjects!>



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

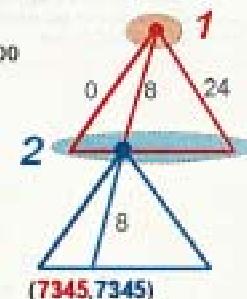


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• Represent the VCM by a Game Tree

$$u_1(x_1, y) = \frac{0.47 \cdot 0.53 \cdot 4.45}{50} + 500$$

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



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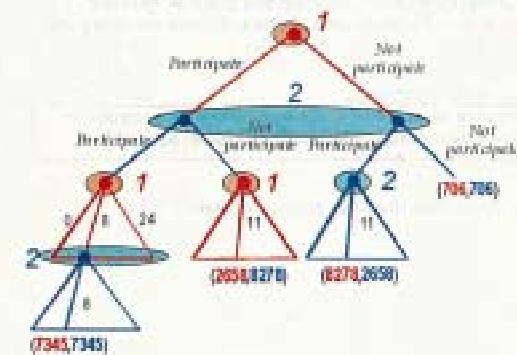
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1	808	1187	1373	1647	1315	2333	2423	2613	2814	2994	3018	3031
2	2186	2462	1764	2072	2374	2656	2753	3129	3237	3413	3452	3485
3	2384	2886	2313	2575	2902	3062	3443	3678	3821	3925	3951	3983
4	2011	2485	2187	3166	3508	3817	4078	4282	4422	4488	4483	4250
5	2578	2610	2432	2621	4183	4267	4762	4950	5064	5201	5055	4723
6	3044	3710	4211	4380	4342	4272	4818	5481	5765	5771	5548	5248
7	4008	4529	5005	5493	5812	6112	6228	6678	6883	6943	6714	5905
8	4264	5487	5944	6294	6776	7027	7349	7348	7265	7024	6763	6285
9	5907	6475	6994	7452	7778	8542	8535	8071	8208	8273	7856	7003
10	7035	7614	8130	8541	8897	9133	9057	9148	9050	8824	8139	7444
11	8278	8873	9364	9690	10109	10306	10394	10338	10173	9898	9492	8769
12	9450	10256	10750	11142	11408	11369	11389	11483	11242	10877	10360	9791

Best Responses

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Year	1	2	3	4	5	6	7	8	9	10	11	12
0	706	871	1012	1297	1596	1779	2003	2219	2398	2523	2638	2648
1	808	1187	1373	1647	1315	2333	2423	2613	2814	2994	3018	3031
2	2186	2462	1764	2072	2374	2656	2753	3129	3237	3413	3452	3485
3	2384	2886	2313	2575	2902	3062	3443	3678	3821	3925	3951	3983
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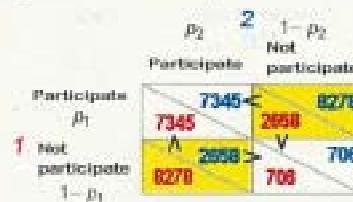
• Adding a Participation Stage



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- Looking at the Participation Decision -> A Hawk-Dove Game
- Not a prisoner's dilemma game



The set of Nash equilibria

$\{(p_1, p_2); (1,0), (0,1), (0.68, 0.68)\}$

Evolutionarily stable strategy $p_1 = 0.68$

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- Evolutionarily Stable Strategy Equilibrium (or John Maynard Smith Equilibrium)

Consider a game with identical players and pairwise interactions

$r_i(p_i, p_j)$: agent i 's expected payoff when i uses strategy p_i and $j \neq i$ uses strategy p_j

A strategy p_i^* is an ESS if for every strategy p_i ,

a) $r_i(p_i^*, p_j) \geq r_i(p_i, p_j)$ and

b) $r_i(p_i^*, p_j^*) = r_i(p_i, p_j^*) \Rightarrow r_i(p_i^*, p_j) > r_i(p_i, p_j)$

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5. Experimental Design

Tsukuba and Tokyo Metro in Japan

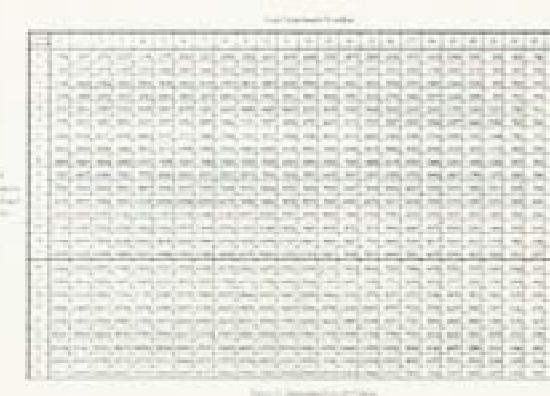
USC and Purdue in the US

Treatment A: Every subject must participate in investment

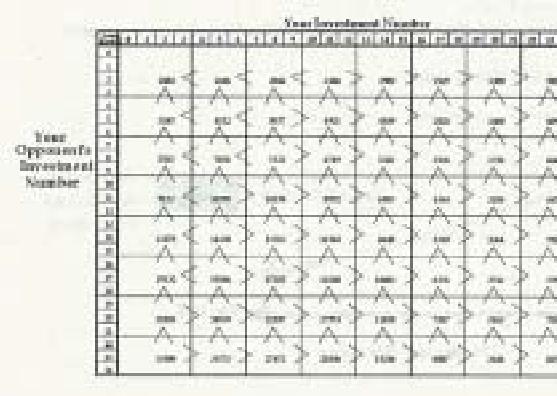
- 20 subjects
- 2 subjects make a pair (10 pairs)
- No communication
- Each subject does not know who is your opponent
- 15 periods
- No subject faces the same subject twice or more
- Every subject knows that every subject has the same payoff table
- A pair knows the investment decision each other, but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

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

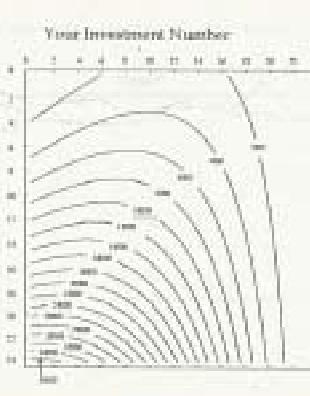
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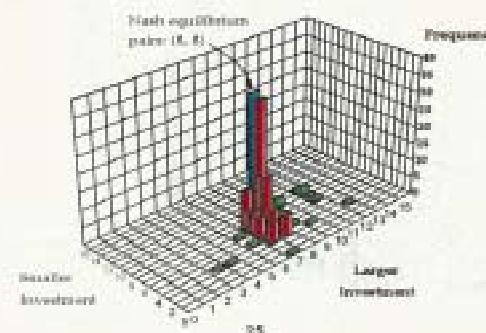
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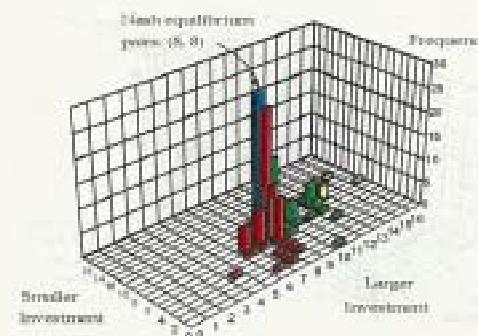
6. Results

Treatment A: Tsukuba



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Treatment A: USC



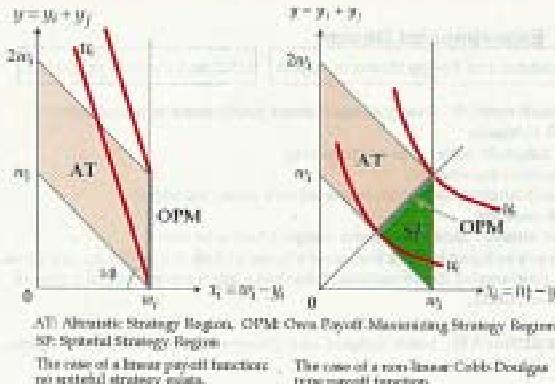
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Treatment A: USC

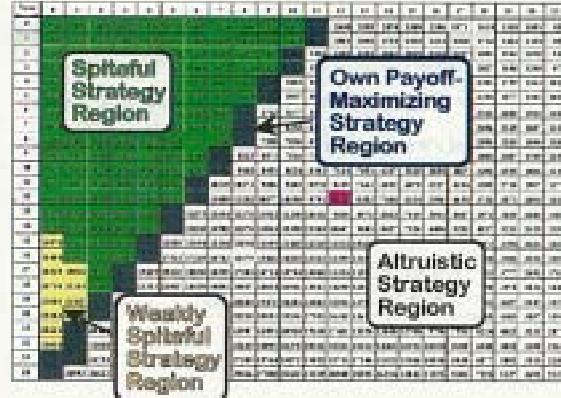
Player	0	1	2	3	4	5	6	7	8	9	10	11	12
0	7345	8278	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345
1	8278	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345
2	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345
3	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868
4	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345
5	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868
6	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345
7	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868
8	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345
9	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868
10	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345
11	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868
12	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345	2868	7345

Assume that the other player chooses 8. Choose 7 rather than 8. Reduce own payoff from 7345 to 6478 (5 units). The other player reduces from 7345 to 6526

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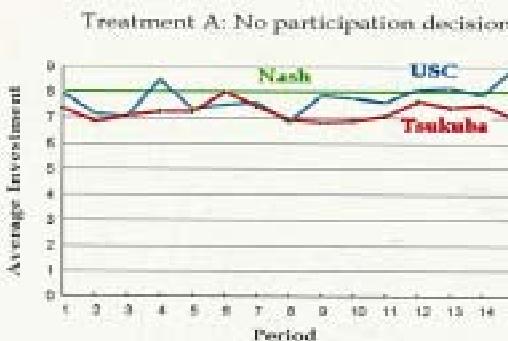


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Classification of Strategies and the Data

Treatment A	Number of cells (%)	Data
Own-maximizing	4.2%	42-48%
Spiteful	22.4%	44-50%
Altruistic	73.4%	8-12%

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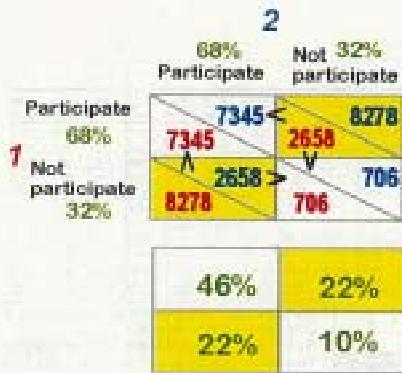


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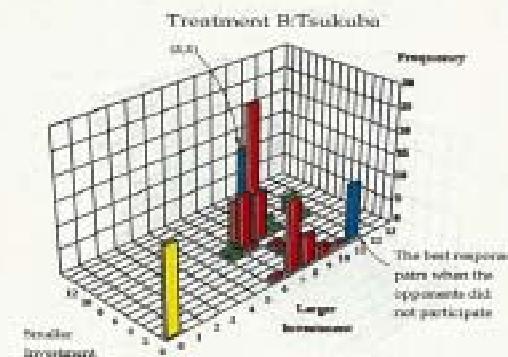
Stylized Facts in Linear Indifference Curve Public Good Experiments



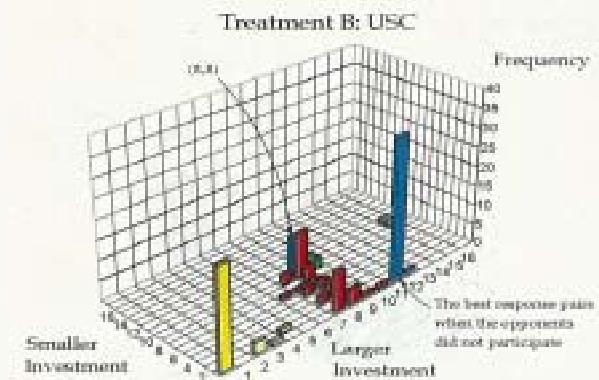
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Observation 1 (Treatment A):

- (a) Regarding the mean investment per subject, the Nash equilibrium prediction is supported in the USC data, but not the Tsukuba data.
- (b) For the Tsukuba data, the mean investment in all rounds is less than the Nash equilibrium investment and cannot be identified as the Nash equilibrium investment.

* Spiteful Behavior

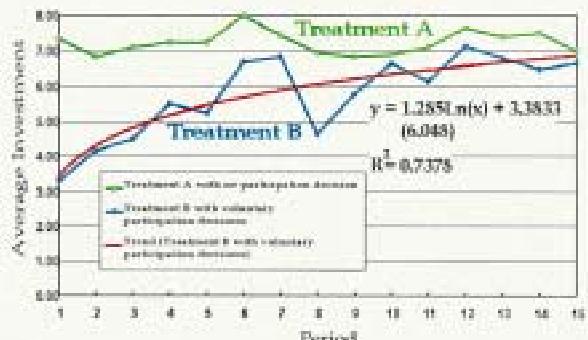
User ID	1	2	3	4	5	6	7	8	9	10	11	12
1	706	1070	1071	1081	1088	1076	1085	1078	1086	1073	1089	1048
2	1093	1127	1179	1191	1098	1108	1103	1081	1018	1048	1039	1051
3	1188	1488	1794	1973	1371	2088	1209	1207	1411	1483	1658	1888
4	1044	1088	1191	1179	1082	1021	1045	1018	1015	1042	1012	1023
5	1051	1081	1079	1083	1081	1073	1081	1089	1089	1083	1083	1058
6	1078	1018	1031	1031	1082	1087	1082	1088	1071	1081	1031	1032
7	1094	1118	1171	1206	1086	1071	1015	1081	1088	1071	1081	1048
8	1029	1058	1069	1082	1071	1039	1076	1038	1011	1014	1038	1038
9	1004	1047	1044	1036	1081	1088	1007	1045	1038	1038	1038	1038
10	1071	1079	1081	1079	1088	1089	1071	1073	1014	1068	1027	1027
11	1056	1081	1081	1081	1088	1088	1079	1088	1088	1081	1079	1058
12	1033	1028	1076	1104	1107	1107	1102	1102	1087	1087	1087	1058

The best response when the other player does not participate = 11.
 Choose 7 rather than 11.
 Reduce own payoff from 1088 to 1016 (448 units)
 The other player reduces from 1088 to 1048 (656 units)

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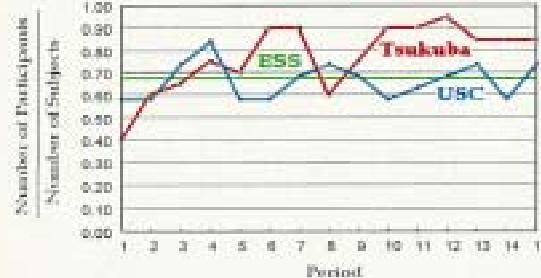
Classification of Strategies and the Data

Treatment B When just one participated	The number of cells	Data
Own-maximizing	1/25	30.0%
Spiteful	11/25	44.4%
Altruistic	13/25	0.7%



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Participation decisions



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Tsukuba Data

1 Not participate	Participate	2 Not participate
	7345	8278
1 Not participate	2058	706
	8278	706

TRANSMISSION

1 Not participate	Participate	2 Not participate
	6494	5315
1 Not participate	2349	706
	5315	706

The Original Game

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

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USC Data

1 Not participate	Participate	2 Not participate
	7345	8278
1 Not participate	2058	706
	8278	706

The Original Game

1 Not participate	Participate	2 Not participate
	7167	7279
1 Not participate	2400	706
	7279	706

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

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Observation 2 (Treatment B):

- (a) Regarding the participation ratio, the ESS prediction is supported in the USC data, but not the Tsukuba data.
- (b) For the Tsukuba data, the participation ratio rises as round advances and the average investment in the final round in Treatment B is very close to that in Treatment A.
- (c) It seems that the source of cooperation is not altruism or kindness but is spiteful behavior of subjects.
- (d) This spiteful behavior eventually leads to more efficient public goods contributions for Tsukuba subjects than for USC subjects.

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