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【研究ノート】

Estimation of Exit Behaviors :

Panel Data Analysis of an Experiment with Intergroup Mobility

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Key Words

Estimation, Exit Behaviors, Free Riding, Laboratory Experiment

1 Introduction

Modern societies enjoy increasing mobility in such areas as job changes, accommodation changes and immigration. Conversely there is the free-riding problem, manifested in shirking in workplaces and a collapse of social norms.

According to the "folk theorem" of the repeated prisoners' dilemma game, there is a relation between these two phenomena: mobility has negative effects on cooperation. Where there is no mobility, players continue to interact with each other in a fixed group or society. They know that free-riding will have harmful effects on their future payoffs. In situations where there is mobility, however, players can cut relationships with other members of their group. As mobility increases, players care less about the harmful effects of free riding.

Conversely, there are positive effects of mobility on cooperation in the coordination game (Dieckmann 1999, Bhaskar and Vega-redondo 2004, Oechssler 1997). In the well-known coordination game, there exist both a Pareto-efficient equilibrium and a risk-dominant but inefficient equilibrium. In the risk-dominant equilibrium there is an advantage to risk taking. The decrease in a player's payoff that arises from making an error in the risk-dominant equilibrium is less than in the Pareto-efficient equilibrium. The risk-dominant but inefficient equilibrium is selected under various conditions (Kandori et al. 1993, Ellison 1993, Young 1998). If, however, there is a choice to move into another group, the Pareto efficient equilibrium may be preferred over the risk dominant equilibrium. The logic is very simple. Players in the inefficient group can exit in order to change the action from the inefficient one to the efficient one.

The logic in the coordination game does not apply directly in the social/prisoners' dilemma game. In the coordination game, all players wish to change to the efficient action, so that the action of players who are moving into a group is desirable for players who are in that group. On the other hand, in the social/prisoners' dilemma game, the non-cooperators aim to

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enjoy free riding by moving into another group. Because of these free riders, the cooperators in the group do not continue to cooperate. Consequently, the Pareto efficient equilibrium is not supported by mobility.

In the social/prisoners' dilemma game, the cooperators and the non-cooperators both move. However, if there are differences in moving behavior between them, it is possible that the best use of differences allows us to distinguish the cooperators from the non-cooperators in a social/prisoners' dilemma game[1]. Less attention has been paid to actual moving behavior in the social/prisoners' dilemma game. There is a need for empirical work to estimate this. The exception is Ehrhart and Keser (1999).

Ehrhart and Keser (1999) examines cooperation and exit behavior. However, they use the Spearman rank correlation coefficient. With this technique, an environment that subjects face is not sufficiently controlled. Here, we use several variables in estimation formula in order to control an environment faced by subjects[2].

There is a drawback with the index of cooperation used by Ehrhart and Keser (1999), in which the ratio of decisions to cooperate to all decisions is calculated. In their cooperation index, exogeneity is not assured. We therefore construct the cooperation index from the first five rounds, after which the estimation period begins. Hence the cooperation index is predetermined. Also, if we interpret our index as a proxy of cooperativeness of subjects, the errors-in-variables problem arises and the exogeneity of the index is not assured. Hence our examination focuses on the effect of an individual's previous experience. Our index is adequate because there is a correlation between our cooperation index and the cooperation rate in the previous five rounds. The index is good information to predict the cooperation behavior in the future[3].

In addition, our research relates to a series of papers in changes of job (Taniguchi and Oura 2005, Kobayashi 2005, Akiyoshi 2005) in which questionnaire surveys are conducted and the consistent results are found, that is, cooperators tend to change jobs. Free riding in workplace has been examined and it is categorized as one variant of withholding effort (Albanese and Fleet 1985, Kidwell and Bennett 1993). Taniguchi and Oura (2005), Kobayashi (2005), Akiyoshi (2005) are extensions of their researches. Our research has the following advantages over them: First, in estimations, we can use the predetermined variables and the relation of cause and effect is clearer in this sense. Second, our data is based on actions that were observed objectively, on the other hand, in questionnaire surveys, data is based on self-assessment information. Of course, our model is too simple in comparison with the questionnaire surveys. Hence each of them complements each other.

Finally we make some comments on a relationship with social statistics. By the definition of Nozawa (1996), social statistics deals with qualitative aspect of social phenomena, supplies and analyzes data, taking account of social characteristics and relationship. Experimental economics also takes account of social characteristics and relationships. In experiments, social relationships and repetition are reproduced. Data is created from such a social characteristics and it is analyzed. Hence experimental economics is included in broadly-defined social statistics. It should be noted that this argument is not new but it has argued since 1930s. Tosaka (1935) points out that statistics and experiment have common property of obtaining materials for scientific analysis. Utsumi (1988) says that a refinement of Tosaka's statements and developing a new methodology is important issues to address[4].

From the viewpoint of social statistics, some questions are expected. We reply to them in advance. First, we did not collect subjects with random sampling. In experiment economics, the incentive to make decisions properly is important. In order to do so, subjects have to understand the rule of game and they have to be sensitive to the reward in the game. But adults who left school more than a decade do not familiar with the learning abstract rules. Those who have a job are less sensitive to the reward because they get enough money from their jobs. One or two thousand yen does not attract them. Hence random sampling is not a best method for experimental economics.

Second, sample size is small in comparison with other surveys in social statistics fields. Of course, it is important to repeat similar experiments to make our results more robust. On the other hand, comparing with other researches in experimental economics, our sample size is standard one. For example, there are 90 subjects in Ehrhart and Keser (1999), 216 subjects in Orbell and Dawes (1993).

Although there are some relevant reasons, we admit our results are limited from the viewpoint of above criticisms. To improve these points remains as future topics.

In section 2 we outline the experimental design. Section 3 reports the estimations and the results for exit behavior. Section 4 presents conclusions.

2 Experimental Design

Our experiment consisted of ten sessions, utilizing 170 students in 4 Japanese universities in or near Tokyo. There are 17 subjects in a session. Seats were assigned to them by lottery in a large room with no partitions. They were connected by computers on a local area network, and made decisions by clicking their mouse anonymously. All information about the game was shown on a laptop computer display to each subject.

2.1 Structure of the game

The game was designed as follows:

1. at the start, subjects were assigned randomly to one of four groups by computer. Each group had four or five subjects.
2. at a single stage, they played a social dilemma game within their groups.
3. in a round, they repeated five stages and then had an option to move to another group.
4. in a session, ten rounds were repeated.

In total, subjects played the social dilemma game for 50 stages, with nine chances to exit (Figure 1). It took about 45 minutes to complete 50 stages. Subjects did not know when the session would finish.

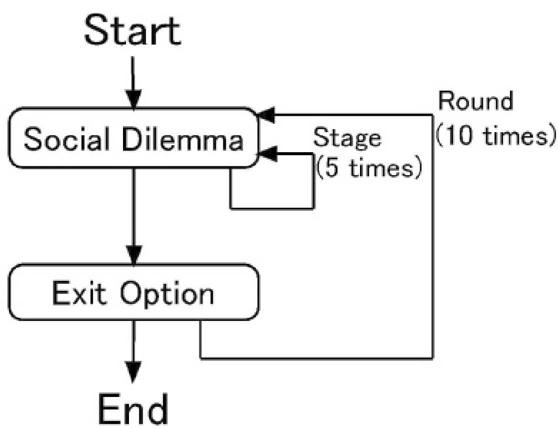

Figure 1 Structure of Experiment

2.2 Social Dilemma Game at Each Stage

At each stage, subjects received 20 yen as a resource[5)]. They decided whether to provide it to their group as an investment ("cooperation" or "C") or to keep it ("non-cooperation" or "N").

The rate of return depended on group size. Let n denote the number of all members in a group and let m be the number of providers in the group.

In multiple-player groups ($n \geq 3$), the investment was multiplied by 2. The payoff function, $U(\cdot)$, is defined as follows:

$$U(C) = 40\frac{m}{n}, \qquad U(N) = 40\frac{m}{n} + 20.$$

In two-player groups ($n = 2$), the investment was multiplied by 1.5:

$$U(C) = 30\frac{m}{2} = 15m, \quad U(N) = 30\frac{m}{2} + 20 = 15m + 20.$$

In single-player groups ($n = 1$), the return was equal to the investment because there were no "social" effects:

$$U(C) = U(N) = 20.$$

These payoff functions satisfy Dawes (1980)'s conditions of social dilemmas, apart from the single-player groups.

Subjects were given an instruction and informed of this structure before the game. They were also asked to complete two confirmation tests to verify that they understood the structure. Solutions were also provided by an instructor after the tests.

At the beginning of each stage, each subject saw on his/her computer display: all of his/her past decisions and payoffs in the current round; each group's size; each group's average payoffs at the previous stage and those in the current round; his/her total payoff.

After making each decision, a subject was given the following information: the number of providers in his/her group, his/her own decision, and payoff at that stage.

2.3 Exit Option in the Round

After five stages, the subjects were simultaneously offered an exit option. The subjects decided which group to join in the next round; they could choose to stay in the same group.

Subjects who chose another group had to pay moving costs. We considered three distinct conditions: high moving costs, low costs, and no costs. The cost function, $Cost(\cdot)$, is defined as follows:

$Cost(E) = 50, \quad Cost(S) = 0$ in high cost condition,
$Cost(E) = 20, \quad Cost(S) = 0$ in low cost condition,
$Cost(E) = Cost(S) = 0$ in no cost condition,

where E denotes "Exiting", and S "Staying".

At the decision making to exit (or not), each subject saw on the computer display: all group's average payoffs at each stage in the current round, each group's size and his/her total payoff earned in the current round, all group's average payoffs in the current and all past rounds.

2.4 Total Payoffs

In summary, each subject earned a payoff in the session as follows:

$$\sum_{t=1}^{50} U(a_t) - \sum_{s=1}^{9} \mathrm{cost}(b_s),$$

where $a_t \in \{C, N\}$ and $b_s \in \{E, S\}$ in each period $t \in \{1, \cdots, 50\}$, and $s \in \{1, \cdots, 9\}$.

Subjects knew that they would receive a monetary reward (in yen) equal to the payoff they earned in their session[6)].

3 Difference in Exit Behavior

3.1 Descriptive Statistics of Sessions

Table 1 sets out descriptive statistics of sessions. At the macro level, we confirm that the

Table 1 Descriptive Statistics of Sessions

		Cooperation Rate		Mobility Rate		Payoffs (yen)	
session	moving cost	Mean	(S.D.)	Mean	(S.D.)	Mean	(S.D.)
1	50	0.349	(0.209)	0.203	(0.180)	1236.5	(171.9)
2	50	0.360	(0.184)	0.203	(0.116)	1228.2	(113.8)
3	50	0.256	(0.181)	0.209	(0.201)	1145.0	(181.7)
4	50	0.268	(0.178)	0.131	(0.116)	1203.9	(142.4)
5	20	0.295	(0.161)	0.327	(0.145)	1217.1	(111.8)
6	20	0.296	(0.207)	0.216	(0.210)	1223.7	(102.5)
7	20	0.395	(0.224)	0.281	(0.162)	1331.8	(199.3)
8	20	0.286	(0.163)	0.268	(0.166)	1218.8	(88.1)
9	0	0.288	(0.231)	0.693	(0.181)	1261.8	(100.1)
10	0	0.416	(0.186)	0.654	(0.178)	1381.2	(138.3)
All sessions		0.320		0.318		1244.8	

The unit is the individual subject.

mobility rates differ significantly with differing moving costs[7]. The cooperation rates does not show such significant differences, however. A parallel paper, Kobayashi et al. (2005), investigates the macro behavior more closely. Below, we focus on individual behavior patterns (micro level analysis).

3.2 Data and Variables

A player has fifty chances to cooperate or not, and nine chances to exit from a group (or not) in a session. To define an index of cooperation, we divide a sequence of data into two periods. This is done in order to generate a predetermined variable for cooperation. The first period consists of the first 5 rounds in which there are 25 opportunities to cooperate and five opportunities to exit[8]. We then calculate the ratio of the number of choices of cooperation to all 25 decisions. If the subject belongs to a one-subject group then decisions are excluded, since choice is indifferent between cooperation and non-cooperation. This index is based on actual behavior rather than potential attitudes about cooperation[9]. We call this measure an "individual cooperation index."

The second period is the last 5 rounds in which there are 25 opportunities to cooperate and 4 opportunities to exit[10]. With this data, we estimate the exit behavior of individuals. There are ten sessions in which 17 subjects are included, so that the sample size for estimation is $4 \times 17 \times 10 = 680$. We construct an "exit variable" which takes value one if a subject exits a group, and is otherwise 0.

We also construct other variables. The first is a "cooperation rate of others in the group," which is the group's mean cooperation rate excluding the subject concerned in the round under consideration. Suppose, for example, that there are four subjects in a group, and the cooperation rate of Subject 1 is 0.4, the cooperation rate of Subject 2 is 0.6, the cooperation rate of Subject 3 is 0.2 and the cooperation rate of Subject 4 is 0.3. For Subject 2, the "cooperation rate of others in the group" is $(0.4 + 0.2 + 0.3)/3 = 0.3$.

A second variable is the payoffs of the other groups in the current round[11]. We call this variable "other groups' payoffs".

Using these variables, we examine three hypotheses:

- H1: The low "cooperation rate of others in the group" induces subjects to exit.
- H2: The high difference between the "individual cooperation index" and the "cooperation rate of others in the group" induces subjects to exit.
- H3: The other groups' information is a significant factor in exiting behavior.

These hypotheses can be paraphrased as follows. First, subjects care about the *absolute* level of cooperation of their group members. If the level of cooperation is low, a subject wishes to leave the group. Second, if one can obtain data about individual cooperation actions, this is significant information. The difference between an individual's own previous cooperation level and the current realized cooperation level of others has an effect on exit behavior. This is because the subject cannot tolerate the gap between his/her intended cooperation level and the realized cooperation level. Subjects care about their *relative* cooperation level, compared to others. Third, subjects care about information from other groups. This is because such information is important for choosing a group in exit options.

Under these hypotheses, we take the "exit variable" as a dependent variable. Explanatory variables are the "cooperation rate of others in the group", the differences between the "individual cooperation index" and the "cooperation rate of others in the group", and "other groups' payoffs".

Finally, we comment on the data set. We first add the dummy variables for the 50-yen-cost and 0-yen-cost conditions. Second, we omit the "exit variable" for the exits from single and two subject groups, because the formula for payoffs in single and two subject groups are different and the "cooperation rate of others in the group" cannot be calculated in a single-subject group.

3.3 Estimation and Results

In our models, the dependent variable is the "exit variable," which is binary data, and there are individual effects. To estimate parameters we use the probit model with random effects specification for panel data.

To compare different formulae, we consider three different models. In model 1, the absolute cooperation level of others (the "cooperation rate of others in the group") and the relative cooperation level (the difference between the "individual cooperation index" and the "cooperation rate of others in the group") are included. In models 2 and 3, each one of these two is included.

Estimated results are summarized in Table 2. In this table we use abbreviations as follows, Dif: The difference between the "individual cooperation index" and the "cooperation rate of others in the group"; CRO: Cooperation Rate of Others in one's group; OGP: Other Group's Payoff; D50: Dummy for 50 yen Moving Cost; D0: Dummy for 0 yen Moving Cost.

Table 2 Decision on Exits

Dependent Variable: Exit Variable (random effects probit regressions)

	Mldel 1		Model 2		Model 3	
Independent Variables	Coefficients	(p-value)	Coefficients	(p-value)	Coefficients	(p-value)
Constant	−2.457	(0.002)**	−2.201	(0.005)**	−2.721	(0.000)**
Dif	0.794	(0.022)*			1.244	(0.000)**
CRO	−1.022	(0.047)*	−1.812	(0.000)**		
OGP (Max)	0.013	(0.469)	0.012	(0.533)	0.019	(0.293)
OGP (Mid)	0.041	(0.110)	0.041	(0.121)	0.042	(0.099) +
OGP (Min)	0.022	(0.534)	−0.026	(0.472)	0.011	(0.748)
D50	−0.471	(0.006)**	−0.477	(0.007)**	−0.436	(0.010)**
D0	1.449	(0.000)**	1.496	(0.000)**	1.395	(0.000)**
LR test (zero slope)		0.000**		0.000**		0.000**
LR test (no rand. eff.)		0.007**		0.003**		0.012*
Pseudo R^2		0.167		0.160		0.161

Number of observations = 620, Number of groups = 169
** significant at 1% level, * at 5% level, + at 10% level

From Table 2, we obtain the following results:

- Result 1: Hypothesis 1 (H1) is accepted because "CRO" is negative and significant.
- Result 2: Hypothesis 2 (H2) is accepted because "Dif" is positive and significant.
- Result 3: Hypothesis 3 (H3) is rejected because none of "OGP (Max, Mid, Min)" is significant.

From these results, subjects care about the information concerning their own group mainly. One of the reasons is that the information concerning other groups is less reliable than the information concerning their own group.

The "individual cooperation index" is assembled from the first five rounds. We can calculate the same index in the last five rounds. For these two indexes, we have the following result:[12)]

- Result 4: There is a positive correlation between the "individual cooperation index" and the same index in the last five rounds; the correlation coefficient is 0.689[13)].

Hence, the "individual cooperation index" comprises useful information for predicting future cooperation behavior.

4 Conclusion

We have investigated the factors that influence the decision to exit. Our estimated results are summarized as follows. Subjects care about the absolute level of cooperation of others. If this is low, subjects tend to exit (Result 1). Also, past experience about cooperation comprises useful information for exit behavior. The greater is the difference between one's own past cooperation level and the current cooperation level of others, the higher is the probability that subjects exit to other groups (Result 2). Furthermore, one's own past cooperation level and subsequent cooperation level show high correlation (Result 4). It can be interpreted that subjects with high previous cooperation level are cooperators. Hence cooperators tend to exit to other groups given the same cooperation level of others. This is because Result 1's effect is same to both cooperators and non-cooperators but Result 2's effect is larger in cooperators than in non-cooperators. Our results are consistent with Ehrhart and Keser (1999)'s one, but our methods are more rigorous.

We can draw an important practical lesson from these observations. The cooperators exit from the groups before the groups' cooperation rates decrease very much. After the cooperators have left, the non-cooperators begin to exit. Therefore, to achieve higher cooperation rates, it is important to create new groups and enclose the cooperators in the early stages.

Notes

1) Concerning sorting effects, see also Orbell and Dawes (1993) and Bohnet and Kubler (2005), Hayashi (1993).
2) Under a traditional experimental methodology, an environment is controlled rigorously by a experimental design. On the other hand, it is important to reproduce exact situation examined. In this paper, the repetition of the social dilemma with intergroup mobility is reproduced.
3) Of course, if the group size is different, the marginal benefit from cooperation is different. We also set up an adjusted cooperation index. Adjustment proceeds by taking into account that for lower marginal benefit, the index about cooperation is more weighted; details are given in Appendix 1 of working paper version of this paper, Fujiyama et al. (2007). It turns out that the adjustment is small effect in practice, and does not improve pseudo-R^2 of the estimation. See also Table 3 and Result 4 in Fujiyama et al. (2007).
4) Concerning this issue, see also Fujiyama (2007).
5) 110 yen was about one U.S. dollar at the time of the experiment.
6) In fact they would receive 1,000 yen as a minimum reward, even if their earnings were less than 1000 yen. They did not know this in advance.
7) According to the Kruskal-Wallis test, there are differences between the three conditions at the 5% significance level. The test value is 7.875 ($>$5.991).
8) We also change the length of the first and second periods and estimate the exit behavior. However, with this modification, basic results do not change. See Appendix 2 of working paper version of this paper, Fujiyama et al. (2007).
9) This kind of measurement is used in Ehrhart and Keser (1999).
10) In the last round, there is no opportunity to exit.
11) If there is an empty group in a current round (no subject is in the group), we take 20 yen as the predicted payoff for the group. This is because 20 yen is the neutral value in our experimental design.
12) The correlation coefficient between the "individual cooperation index" in the first one round and in the last 9 rounds is 0.621. The correlation coefficient between the "individual cooperation index" in the first two round and in the last 8 rounds is 0.683. The correlation coefficient between the "individual cooperation index" in the first three round and in the last 7 rounds is 0.674. The correlation coefficient between the "individual cooperation index" in the first four round and in the last 6 rounds is 0.691. In all cases, a high correlation is found.
13) This relation is statistically significant at 1% level.

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