시장경제연구 제54집 1호 (2025년) pp. 45-72

An Experimental Investigation on the Effect of Payoff Mechanisms on a Finitely Repeated Social Dilemma Game

Jinkwon Lee*

When experimenters conduct repetition in a game experiment, they usually adopt either an accumulated payoff mechanism (APM) or a random lottery payoff mechanism (RRPM) as a financial incentive. In this study, we experimentally dexamine whether the RRPM and APM induce identical behavior in a finitely repeated game experiment, where the subjects' risk attitudes do not matter under the assumption of self-interest, but may matter if a social preference (e.g., conditional cooperation) is considered. Our hypothesis states that the riskiness of payoff mechanisms can affect the subjects' strategic choices based on their risk attitudes. We found that the strategic behavior of risk-averse subjects differs between the APM and RRPM. Regression analyses confirm that the riskiness of payoff mechanisms affects subjects' strategic behavior, in relation to their risk attitudes. The results suggest that the experimenters should be cautious when choosing a payoff mechanism for finitely repeated game experiments.

Key Words: Accumulated payoff mechanism, Random round payoff mechanism, Risk attitudes, Finitely repeated social dilemma game experiment

JEL Classification: C90, C91, C92

(접수일 : 2025. 1. 20., 수정일 : 2025. 2. 4., 게재확정일 : 2025. 2. 4.)

* Professor, Department of Economics, Sogang University, Seoul, South Korea, Email: jlee22@sogang.ac.kr

Ⅰ. Introduction

In this study, we experimentally investigate whether two different payoff mechanisms widely used in repetitive experiments induce a different behavior of subjects in a simple finitely repeated social dilemma game where a unique pure subgame perfect Nash Equilibrium (NE) exists. Specifically, subjects' behavior in the game is compared under the *accumulated payoff mechanism* (APM) and the *random round payoff mechanism* (RRPM). Under APM, subjects' payoffs are accumulated through experimental rounds. Under RRPM, the payoffs of only one round, which is randomly chosen after completing the experimental session, become their final payoffs for the experiment. RRPM is believed to control a possible wealth effect.[1)]

APM is the most widely used payoff mechanism in game experiments while RRPM is widely used in individual decision-making experiments (Lee, 2008, 2004). This difference relies on the difference of the assumption on the effectiveness of subjects' risk attitudes and wealth on behavior: if there is a unique pure equilibrium in a finitely repeated game, then there is no room for a risk attitude and wealth to affect self-interested rational subjects' equilibrium behavior while there is no presumption on their risk attitudes in individual decision-making experiments. Hence, the riskiness of the payoff mechanisms does not matter at least for a finitely repeated game where a unique pure subgame

1) There is still a debate if RRPM, which is also called a random lottery incentive mechanism, could elicit a true risk or uncertainty preference which is identical to a preference for a single shot decision problem in an individual decision-making experiment. Starmer and Sugden (1991), Cubitt et al. (1998), Hey and Lee (2005a, 2005b) and Lee (2008) support that it could do so while Cox et al. (2014, 2015) and Harrison and Swarthout (2014) find that RRPM could generate a bias. For the discussion on the debate, refer to Cox and Sadiraj (2019) and Charness et al. (2019).

perfect NE exists under the self-interest and rationality assumptions: that is, it is presumed that APM and RRPM induce an identical behavior. However, what if subjects are not completely self-interested but have a degree of social preference of reciprocity (i.e., conditional cooperation)? If so, some cooperative strategies could also become an equilibrium based on players' beliefs on the others' types (Andreozzi et al., 2020; Fischbacher and Gächter, 2010; Fischbacher et al., 2001). Then, APM and RRPM could induce a different behavior because the different riskiness of the payoff mechanisms affects subjects' strategic behavior via their risk attitudes. In this case, the two payoff mechanisms cannot be regarded as a replication each other. The main concern of this study is to investigate on this issue.

There have been few studies to deal with this question yet to our knowledge. Lee (2004) investigates the same topic and finds that there is a behavioral difference between APM and RRPM in the similar game environment to ours. He also finds that the behavioral difference exists even for a stranger matching environment. However, the samples in the study were rather scarce to assure the findings. Sherstyuk et al. (2013) compare the effect of APM with RRPM in an infinitely repeated game experiment (which is induced by using a random termination), and support adopting APM based on their experimental results that RRPM could generate a present bias. However, their study cannot answer to the question of whether the riskiness of payoffs can affect a strategic behavior of players with a social preference such as reciprocity because an infinitely repeated game can have various subgame-perfect NE even under the self-interest assumption, depending on subjects' innate discount rates.

We in this paper consider a two-player repeated social dilemma game experiment where a unique subgame perfect NE exists under the usual rationality and self-interest assumptions (Lee, 2004). A novel feature of the game used in this study is that if this game is played against a random player (i.e., an individual decision-making task) the NE strategy would be the least risky and a farther strategy from the NE is both riskier and more cooperative. Then, we compare the players' strategic choices between APM and RRPM in which the expected payoffs are identical for any given strategy. That is, the payoff distribution under RRPM is a mean preserving spread of the payoff distribution under APM for any given strategy (Lee, 2004). Given the assumption of a self-interested rational players, the difference of the riskiness of the payoff distributions should not affect the players' choice of strategy: that is, their choice should approach to the NE regardless of the riskiness of payoff mechanisms and of players' risk attitudes. However, if a type uncertainty with a reciprocal preference exists, the difference of the riskiness of payoff distributions between APM and RRPM could lead to different strategic choice depending on the players' risk attitudes. For example, a risk averse conditional cooperator may be willing to exercise a cooperative strategy at initial periods with taking some risks under APM, but his or her willingness to do so would be diluted under the riskier RRPM. Therefore, there is no guarantee that RRPM and APM induce an identical behavior.

We, in this study, find that subjects' chosen strategies are significantly different between APM and RRPM: that is, the chosen strategies under RRPM are significantly closer to the unique NE than those under APM, implying that the riskier payoff distribution of RRPM may prevent subjects from exercising a riskier cooperative strategy. This supports the general results of various studies on social preferences where the backward induction and/or self-interest assumptions are violated, and then more importantly shows that the riskiness of payoff distribution and subjects' risk attitude can play a crucial role if a social preference such as a reciprocal preference is considered. Indeed, we find that subjects' risk aversion makes the strategy choice closer to the less risky NE under RRPM while subjects' risk aversion does not affect the strategy choice under APM.

In Section II, we describe that RRPM is a mean preserving spread of APM if the expected payoff is set to be identical. In Section III, the two-player simple social dilemma game used in this study is introduced. The experimental design and procedure are presented in Section IV, and the hypotheses regarding the difference in subjects' behaviors between APM and RRPM are tested using the experimental data in Section V. Conclusions are followed in Section VI.

Ⅱ. RRPM vs. APM

In this section, we describe that RRPM can be a mean-preserving spread of APM for any given decision for a general binary lottery choice task. However, the property can be easily extended to more general lottery tasks and game tasks where a player's beliefs on the other players play a role.

We here assume that a subject regards an experiment, which consists of (stationary) repetition (of an identical task), as a whole. Suppose two rounds of a choice task between $l=(x_1,p_1;x_2,p_2;x_3,p_3)$, and $r=(x_1,q_1;x_2,q_2;x_3,q_3)$, and denote the decision sequence under APM and RRPM by $d_a=\{d_t\}_{t=1}^{T}$ and $d_r=\{d_t\}_{t=1}^{T}$ where T is the number of choice rounds, respectively. Then we define RRPM being a mean preserving spread of APM if the distribution under RRPM is a mean preserving spread of that under APM for *any identical decision*, i.e., for any $d_a = d_r$. We can show that RRPM is always a mean preserving spread of APM for any identical decision. For example, consider lottery $l = \left(x_1, p_1; x_2, p_2; x_3, p_3\right)$ where $x_1 < x_2 < x_3$. If this lottery is repeated twice (i.e., *T*=2), then the payoff space under APM can be denoted by $(2x_1, p_1^2; x_1 + x_2, 2p_1p_2; x_1 + x_3, 2p_1p_3; 2x_2, p_2^2; x_2 + x_3, p_2p_3; 2x_3, p_3^2)$ while that under RRPM is $(2x_1, p_1; 2x_2, p_2; 2x_3, p_3)$.[2)] Hence, using the assumption of $x_1 < x_2 < x_3$, it is straightforward to show that the total payoff distribution under RRPM whose expected total payoff is identical to that of APM, is a mean preserving spread of that under APM (Lee, 2004). Lee (2004) also argues that this property can be easily extended to the case for *T*>2 by an induction to a finite *T* as well as *the cases for lr*(=*rl*): since the shape of the payoff distribution of APM becomes dense while the shape of the distribution of RRPM does not change as *T* becomes large, and since both APM and RRPM always have the same minimum and maximum outcomes, if RRPM is a mean preserving spread of APM when *T* is equal to 2, then RRPM should be a mean preserving spread of APM for *T*>*2*, too.

This suggests a possibility that the expected utility (EU) maximizing subjects may behave differently between these two payoff mechanisms. Indeed, Rothschild and Stiglitz (1970) and Diamond and Stiglitz (1974) suggest that there is no guarantee that RRPM induces the same individual decision-makings as APM does unless people are risk neutral or CARA. Given that many

2) Under RRPM, the payoffs can be denoted by a compound lottery, $((2x_1, p_1; 2x_2, p_2; 2x_3, p_3), \frac{1}{2}; (2x_1, p_1; 2x_2, p_2; 2x_3, p_3), \frac{1}{2})$. By using the reduction rule of compounded lotteries, it can be reduced to the single lottery $(2x_1, p_1; 2x_2, p_2; 2x_3, p_3)$.

experimental studies report that a significant number of subjects are risk averse for a typical level of laboratory stakes (e.g., Lee, 2008; Holt and Laury, 2002; Binswanger, 1980), there is a possibility that RRPM could induce a different behavior from APM if subjects are risk averse. For example, Lee (2008) finds that a background risk in initial wealth induced by the feature of RRPM can make subjects choose more risk averse alternatives than certain initial wealth under APM in an individual decision-making context. We investigate in this study if such a behavioral difference between APM and RRPM in the individual decision-making tasks could be extended to a strategic choice.

Ⅲ. Simple integer game tasks

We here introduce a two-player *simple integer game* to compare the effect of RRPM with that of APM (Lee, 2004). The basic structure of the single-shot game is as follows: each player chooses an integer number $x \in [1,10]$. Then, the payoff schedule follows:

$$\begin{array}{ll} c \cdot (m-x) & \text{if } x > y \\ \frac{c}{2} \cdot (m-x) & \text{if } x = y \\ 0 & \text{if } x < y \end{array} \qquad (1)$$

where m is the reference number preset by an experimenter, x is the integer number which a player (say, Player 1) chooses, and y is the integer number which the partner (say, Player 2) chooses. The c is a conversion rate. That is, if the number x is larger than

y, then Player 1 [2] receives $c \cdot (m-x)$ [0], and if x = y, then both Player 1 and 2 receive $c \cdot (m-x)/2$ and $c \cdot (m-y)/2$, respectively. And if x is smaller than y, Player 1 [2] earns nothing [$c \cdot (m-y)$]. Let m and c be 12 and *$1,* respectively.

If Player 2 were a random player, it is easy to show that a risk-neutral Player 1 would choose 6, that a risk-averse Player 1 would choose a number above 6, and that a risk-loving Player 1 would choose a number below 6. Moreover, the more risk averse the subject is, the higher number she would choose because a higher number implies a safer but lower expected payoff. In this way, we can systemize the relationship between a player's risk attitudes and the player's chosen strategy in this game against nature.[3)]

If each player is paired with any other player, then this task becomes a two-player social dilemma game whose unique Nash Equilibrium of this game is that both players choose 10: that is, (10, 10) will be a unique NE of this game under the assumptions of the common rationality and the self-interest. An important feature of this game is that there is always a negative relationship between a winning probability of a strategy and a payoff from the strategy. Hence, the payoff at the NE of (10, 10) is relatively small while the NE always guarantees a payoff more than zero with certainty. Indeed, the NE is the least risky strategy with a low payoff. On the contrary, the unique NE (10, 10) is Pareto dominated by other symmetric outcomes including (1, 1) which is the Pareto optimal strategy in this game. The Pareto optimal strategy (1,1) is the riskiest with a high payoff and cannot be an equilibrium under the assumption of rationality and self-interest

---

3) For more details for this feature in the individual decision-making context, see Lee (2008).

because since choosing 1 is a dominated strategy.[4] However, this fact may affect the stability of the NE when the game is repeated with the same partner if we allow a player to be reciprocal (i.e., conditional cooperator). These features make this integer game a social dilemma game.

When this game is repeated with the same partner, this game has a unique pure subgame perfect NE of choosing (10, 10) at every period established by iteratively eliminating dominated strategies under the usual rationality and self-interest assumptions.[5] This means that there is no room for risk attitudes and/or payoff riskiness to enter if the self-interest assumption holds. However, risk attitudes and payoff riskiness would affect subjects' choices as soon as we throw the common knowledge of self-interest assumption out. Indeed, in the absence of the assumption, a closer integer to the subgame perfect NE of 10 becomes a less risky strategy with a low payoff while a closer integer to 1 becomes riskier cooperative strategy with a high payoff.

Different payoff mechanisms may induce different risky decision environments as shown in the previous section and hence affect a subject's choice if the subject is risk averse. If we assume a distribution of the probabilistic beliefs across subjects, then we could attribute a different choice behavior between payoff mechanisms to a difference in the effects of the riskiness of the payoff mechanisms on risk-averse subjects' strategic behaviors.

This consideration predicts that risk-neutral subjects' behavior

---

4) Note that reciprocity and reputation building would be appropriate for a continuing relationship (e.g., so called partner treatment) while altruism would be appropriate for both partner and stranger treatments.

5) This game resembles the tournament game used by Merlo and Schotter (2003, 1999), the traveller's dilemma game (Capra et al., 2002, 1999), the p-beauty contest game with variable payoffs (Nagel, 1999) and Bertrand duopoly in this respect.

will not be different between APM and RRPM even if the self-interest assumption is thrown out. However, risk-averse subjects would differently behave under RRPM since RRPM increases riskiness of the payoff distribution. Given that many studies report that the risk averse tend to behave more risk aversely as the payoff riskiness increases (e.g., Strobl, 2022; Beaud and Willinger, 2015; Lee, 2008; Harrison et al., 2007), we predict that risk averse players, if they are not completely self-interested, tend to take a less risky strategy under RRPM than under APM. That is, the chosen integer under RRPM will be higher than that under APM. For example, consider a risk averse conditional cooperator. Given the type uncertainty, he or she may try to begin with a riskier and cooperative low integer at initial periods. However, the incentive for these trials at initial periods should be weaker under RRPM than under APM.

Therefore, we need to separately measure subjects' risk attitudes for our purpose. For the purpose, we elicit subjects' risk attitudes using Holt and Laury (2002) mechanism (hereafter HL task) before the two-player integer game task, as explained with more details in the next section. We can relate those risk attitudes to the chosen numbers in the integer game.[6]

Ⅳ. Experimental design

This experiment was implemented in a computerized environment using the z-Tree software (Fischbacher (1999)) in SEE (Sogang Experimental Economics) laboratory of Sogang University in South

6) That is, if the integer game were played against nature, the higher number which is closer to 10, could correspond to the higher switch point (i.e., more risk averse) in HL task.

Korea. The participants were undergraduates and postgraduates of the university. The design of the experiment is summarized in 〈Table 1〉. Four sessions were run with 14 subjects each. Hence, the total number of subjects was 56. Each session consists of two tasks: the HL task to elicit subjects' risk attitudes, and the repeated two-player simple integer game task. We call the former *Task 1* and the latter *Task 2*. Task 2 followed Task 1, and consisted of 10 periods with the partner matching.

〈Table 1〉 Experimental Design

	Number of Subjects	Task 1	Number of Periods for Task 2	Payoff mechanism for Task 2	Matching for Task 2
APM	28	HL	10	APM	Partner
RRPM	28	HL	10	RRPM	Partner

Note: HL is the Holt and Laury task to elicit subjects' risk attitudes and implemented before Task 2.

The treatment variable was related to only Task 2. We kept an identical treatment of HL task in Task 1 in all the four sessions. The treatment variable was the payoff mechanism used in Task 2: we used APM in two sessions and RRPM in two sessions. The final monetary rewards for Task 2 with the APM were simply the sum of monetary payoffs over all periods of Task 2. Since our purpose is to compare the effect of RRPM with that of APM, it was necessary to equate the expected payoffs between RRPM and APM. Hence, the final monetary rewards for Task 2 with the RRPM were 10 times the monetary payoff in one period chosen at random after subjects completed the session. We call the former

APM groups and the latter *RRPM groups*. Subjects were informed all the relevant information before the start of the session.

Each subject's (potential) earnings for Task 2 at each period were computed according to the formula (1) in the previous section. In our actual experiment, we used the set of numbers {2, 4, 6, 8, 10, 12, 14, 16, 18, 20} for x and y, 26 for m, and 200 KRW for c in order to avoid the 'flat payoff problem' argued by Harrison (1994, 1989). Note, however, that this modification does not lead to a different interpretation for the experimental results. Thus, the unique subgame perfect NE in our experiment is (20, 20) while the Pareto optimum is achieved at (2, 2).

For Task 2, each subject in a group of two players simultaneously chose a number among the 10 numbers. After they chose their numbers, feedback was given. In the APM sessions, the feedback included the subject's own chosen number, the other player's chosen number, the subject's cash earnings in that period, and the accumulated earnings up to that period. In the RRPM session, the feedback included the subject's own chosen number, the other player's chosen number, and the subject's potential earnings in that period. The earnings in each period in the RRPM session were 'potential' because the final cash earnings would be 10 times the subject's potential earnings in a period randomly chosen after the subject completed the session.

For Task 1, HL task was used before Task 2 in all four sessions. Hence, there was no difference in Task 1 between the treatment groups. Since Task 1 is an individual decision-making task, there was no need for a matching treatment too. The used HL task is presented in 〈Table 2〉, and this setting has been used in some previous studies (e.g., Lee, 2016a, 2016b).

〈Table 2〉 HL task (Task 1)

Choice ques-tions	Lottery L	Lottery R	E(L)-E(R)	Constant relative risk aversion coefficient (r)
1	(₩14500, 1/10; ₩10000, 9/10)	(₩25200, 1/10; ₩1300, 9/10)	₩6760	r〈-1.66
2	(₩14500, 2/10; ₩10000, 8/10)	(₩25200, 2/10; ₩1300, 8/10)	₩4820	-1.66〈r〈-0.93
3	(₩14500, 3/10; ₩10000, 7/10)	(₩25200, 3/10; ₩1300, 7/10)	₩2880	-0.93〈r〈-0.49
4	(₩14500, 4/10; ₩10000, 6/10)	(₩25200, 4/10; ₩1300, 6/10)	₩940	-0.49〈r〈-0.15
5	(₩14500, 5/10; ₩10000, 5/10)	(₩25200, 5/10; ₩1300, 5/10)	-₩1000	-0.15〈r〈0.15
6	(₩14500, 6/10; ₩10000, 4/10)	(₩25200, 6/10; ₩1300, 4/10)	-₩2940	0.15〈r〈0.43
7	(₩14500, 7/10; ₩10000, 3/10)	(₩25200, 7/10; ₩1300, 3/10)	-₩4880	0.43〈r〈0.72
8	(₩14500, 8/10; ₩10000, 2/10)	(₩25200, 8/10; ₩1300, 2/10)	-₩6820	0.72〈r〈1.05
9	(₩14500, 9/10; ₩10000, 1/10)	(₩25200, 9/10; ₩1300, 1/10)	-₩8760	1.05〈r〈1.51
10	(₩14500, 10/10; ₩10000, 0/10)	(₩25200, 10/10; ₩1300, 0/10)	-₩10700	r〉1.51

In the HL task, we estimate the subjects' degree of risk aversion by asking them to choose between two pair-wise lotteries. Each subject must choose between Lottery L or Lottery R for each of the 10 questions, as shown in 〈Table 2〉. For example, in the case of Question 1, Lottery L offers a 10% chance to win 14,500 KRW and a 90% chance to win 10,000 KRW, while Lottery R offers a 10% chance to win 25,200 KRW and a 90% chance to win 1,300 KRW. Subsequently, the probability of the higher payoff increases by 10%, and the probability of the lower payoff decreases by 10%, which generates the remaining questions, resulting in a total of 10 choice questions. Therefore, in each question, Lottery L will always be less risky than Lottery R, and the degree of risk aversion of the participant can be measured by which question they switch to Lottery R. For example, a very strongly risk loving subject will choose Lottery R from the first question and continue to choose it until the last question, while a risk-neutral subject will choose

Lottery L for the first item, continue with Lottery L until the fourth question, and then switch to Lottery R at the fifth question and keep R for the remainder. A risk-averse participant will choose Lottery L for the first question, continue with Lottery L until the fifth question, and then switch to Lottery R at some point after the fifth question and continue to choose Lottery R for the remainder. The first question in which the participant switches to Lottery R is defined as the "switch point," and it corresponds to the interval of the subject's degree of risk aversion. Therefore, the more risk-averse the subject, the higher the switch point. In this study, the switch point of each subject will be used to represent the subjects' risk attitudes. Using a utility functional, we can specify this range and better understand the relationship between the switch point and the risk aversion range. For example, using the common CRRA (constant relative risk aversion) utility function, $u(w)=\frac{w^{1-r}}{1-r}$, the range of risk aversion can be estimated from the choice data. When r is 0, we set $u(w)=\ln w$. Here, it can be easily shown that if r is less than 0, the subject is risk-averse, if equal to 0, they are risk-neutral, and if greater than 0, they are risk-loving. Using this CRRA utility function, we can calculate the range of risk aversion represented by the switch point from Lottery L to Lottery R, and the results are shown in the last column of 〈Table 2〉. For example, a subject whose switch point is 1 has a risk aversion coefficient less than -1.66, meaning they are very risk-loving. A risk-neutral participant has a switch point of 5, while risk-averse subjects have a switch point higher than 5, depending on their degree of risk aversion. What should be noted here is that subjects with consistent preferences should switch only once. In other words, a choice with two or more switch points such as LLLRRRLRRR is inconsistent. Additionally, rational subjects should choose Lottery

R in the 10th question, regardless of their degree of risk aversion, and the final 10th question can also be used as a test of the subjects' 'rationality.' Therefore, through these consistency checks, inconsistent choices, which violate rationality, can be filtered out in the analysis.

After the whole experiment is implemented, one question is randomly selected for Task 1, and the chosen lottery for the question is played. Based on the result, the corresponding realized payoff is paid for Task 1.

A subject's final cash earnings for the experiment were the sum of his or her cash earnings for Task 1 and for Task 2. Each session took about one hour to be completed on average, and subjects' average earnings were 29,060 KRW for the whole experiment.

V. Experimental results

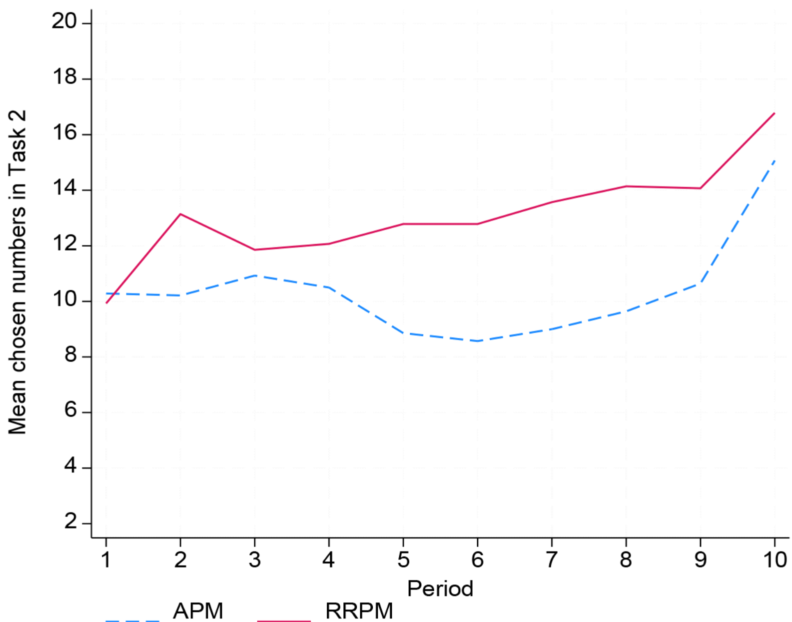
Before we analyze the results of this experiment, it would be helpful to summarize our hypotheses to be tested.

Hypothesis 1) In the simple two-player integer game (i.e., in Task 2), RRPM makes the decision environment riskier than APM does. Thus, APM and RRPM could induce a different strategic behavior. Especially, RRPM will induce a less risky strategic decision closer to the subgame perfect NE than APM does.

Hypothesis 2) The difference in strategic behavior between APM and RRPM groups depends on subjects' risk attitudes. That is, the effect of subjects' risk attitudes on the strategic behavior is more prevalent under RRPM than under APM.

1. The effect of payoff mechanisms

Our main concern in this section is in whether or not the payoff mechanisms induce different behaviors. The mean numbers chosen for Task 2 by each treatment group is shown in ⟨Figure 1⟩ and ⟨Table 3⟩. Both APM and RRPM groups seem to eventually move toward the subgame perfect NE, but the degree of convergence is clearly different between RRPM and APM. The mean chosen numbers are higher for RRPM than APM in most periods, resulting in a higher overall mean chosen number of 13.11 in RRPM than 10.37 in APM. This difference is statistically significant by the two-sided Wilcoxon rank-sum test (p=0.002). It is also notable that the final period effect of converging the NE is stronger in the APM than in RRPM. Hence, this result supports Hypothesis 1.



⟨Figure 1⟩ Mean chosen numbers for Task 2 in APM and RRPM treatments

〈Table 3〉 Mean Chosen Numbers for Task 2

	Period											
Treatment	1	2	3	4	5	6	7	8	9	10	Overall	p-value
APM	10.29 (4.29)	10.21 (6.34)	10.93 (8.05)	10.50 (8.23)	8.86 (8.15)	8.57 (7.93)	9.00 (8.08)	9.64 (7.99)	10.64 (7.77)	15.07 (6.38)	10.37 (7.39)	0.002
RRPM	9.93 (4.29)	13.14 (4.75)	11.86 (6.07)	12.07 (6.59)	12.79 (7.00)	12.79 (7.06)	13.57 (7.15)	14.14 (7.49)	14.07 (7.28)	16.79 (4.77)	13.11 (6.37)	

Note. Here the unit of observation is the mean numbers of a two-player group at each period. Standard deviation in the parentheses. A two-sided Wilcoxon rank-sum test is used for the p-value.

We can conjecture that this difference comes from two different paths. First, a direct effect due to the payoff mechanisms may explain it. Second, an indirect effect of the payoff mechanisms on subjects' strategic consideration may also explain it. Of course, the direct and indirect effects may be compounded.

Our hypotheses conjecture that if subjects are assumed not to have a common knowledge of self-interest but to have a reciprocal preference, then subjects' beliefs on their partners' type and hence their risk attitudes may affect their strategic choices. If other conditions are equal, then risk-averse subjects will be more reluctant to take a riskier cooperative strategy under RRPM than under APM. On the contrary, risk-neutral subjects' strategic behavior may not be much affected by the different riskiness of payoff mechanisms. Hence, the results would suggest that the payoff mechanisms may affect subjects' strategic behavior especially for risk averse subjects. To check this, we need information on subjects' risk attitudes elicited in Task 1.

2. Categorising risk attitudes from Task 1

Using the HL task, we can elicit and categorize 56 subjects' risk attitudes. Among them, 40 (71.5%) were risk averse, 12 were risk neutral (21.4%), and 4 were risk loving (7.1%). This categorization generates qualitatively similar results to those of previous experimental studies: that is, there exist a significant proportion of risk averters even for low stakes. For example, Holt and Laury (2002) report that the percentage of risk averse is 65%, risk neutral is 26%, and risk loving is 8% for low real stakes. The number of risk-averse subjects under RRPM sessions is 19 and that under APM sessions is 21. The numbers of risk neutral subjects under RRPM and APM sessions are 6 and 5, respectively. There were 1 and 3 risk loving subjects under APM and RRPM, respectively, and 1 subject made an inconsistent choice. The inconsistent choice was excluded from the analyses.

It is important that we assure the random allocation of subjects to the treatments in terms of their risk attitudes. For the purpose, we run the interval regression based on the CRRA intervals specified in 〈Table 2〉, controlling some demographic variables as well as Big Five personality traits.[7] The results are presented in 〈Table 4〉, and confirm that subjects' risk attitudes are not significantly different between APM and RRPM. While the gender differences in risk attitudes and the effect of personalities on risk attitudes are not the main concerns of this study, we find that although males tend to have a lower risk aversion than females, it is not statistically significant, and that openness trait is negatively correlated with risk attitudes.

7) For the details of the interval regression method for CRRA intervals, refer to Lee (2016b).

〈Table 4〉 Interval regression for Task 1 based on CRRA intervals

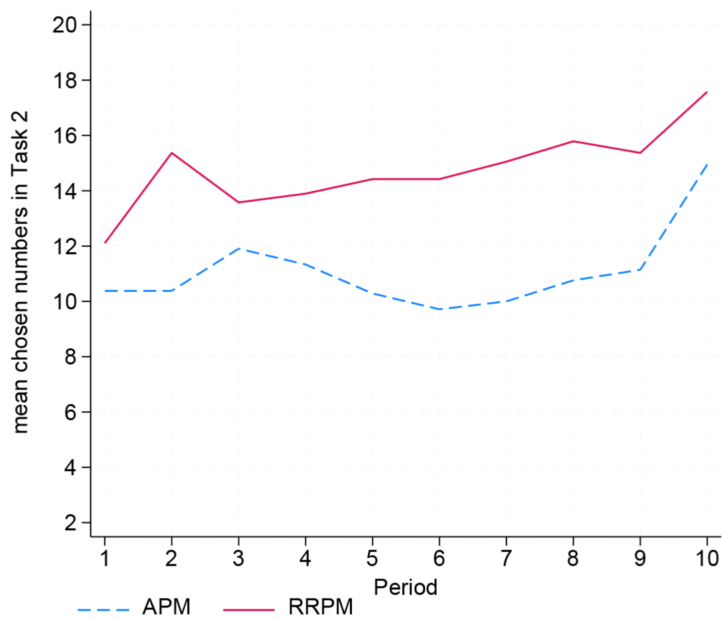
	Interval regression based on CRRA intervals in Task 1		
Payoff Mechanism (APM=1, RRPM=0)	0.108 (.142)	0.111 (0.142)	0.139 (0.141)
Gender (Male=1, Female=0)	-	-0.066 (0.149)	-0.055 (0.154)
Major (Economics=1, Others=0)	-	-0.001 (0.208)	-0.059 (0.228)
Extraversion	-	-	0.034 (0.051)
Agreeablness	-	-	-0.046 (0.094)
Conscientiousness	-	-	0.010 (0.063)
Emotional stability	-	-	0.013 (0.065)
Openness	-	-	-0.105* (0.058)
Constant	0.448*** (0.101)	0.485*** (0.130)	0.910 (0.621)
Log-likelihood	-107.42	-107.32	-105.57

Note. The dependent variable is the interval of CRRA coefficients for Task 1.
***, **, * represents 1%, 5%, 10% significance level, respectively.

3. Risk attitudes and payoff mechanisms

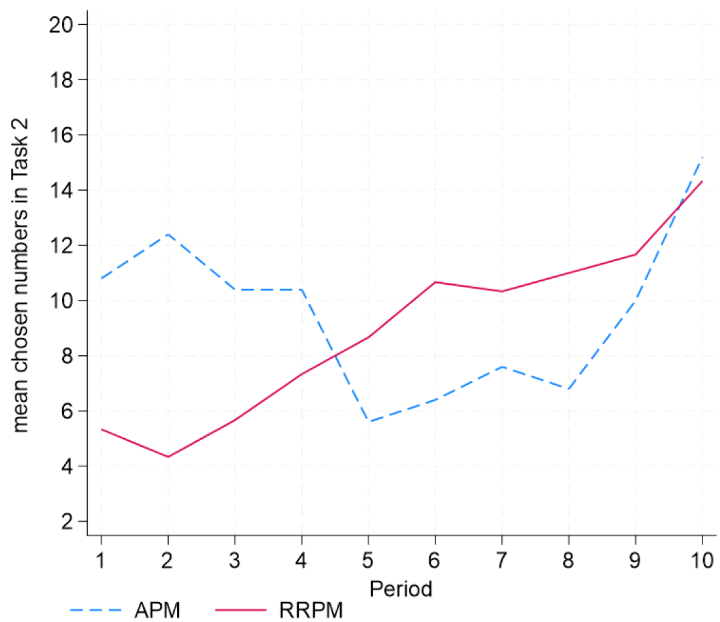
In this section we test *Hypothesis 2)*. To test this hypothesis, we first analyze risk-averse subjects' behavior and risk-neutral subjects' behavior for Task 2 separately. We can do this by using our categorization of subjects' risk attitudes obtained from the results of Task 1.

We compare choices for Task 2 under APM with those under RRPM for the risk averse. As we have seen, the number of risk-averse subjects was 21 under APM sessions and 19 under RRPM sessions. The mean numbers through periods are compared in 〈Figure 2〉. It is clear that the mean numbers are larger under RRPM than under APM for risk-averse subjects through whole periods. Indeed, the overall chosen mean numbers in APM and RRPM are 11.09 and 14.76, respectively, and this difference is significant at 10% level by the two-sided Wilcoxon rank-sum test (p= 0.093). This implies that risk-averse subjects' choice behavior is significantly affected by the riskiness of a payoff mechanism: risk-averse subjects tend to choose higher numbers, which are safer and closer to the NE, for Task 2 under RRPM than under APM.



〈Figure 2〉 Mean chosen numbers in Task 2 for the risk averse

If *Hypothesis 2* is right, risk-neutral subjects should not be affected by the payoff mechanisms. The number of risk-neutral subjects was 5 under APM and 6 under RRPM. Their mean numbers for Task 2 are shown in 〈Figure 3〉. Though there seems to exist a difference during initial periods between APM and RRPM, the difference becomes to reverse as periods proceed, resulting in the overall indifference in the chosen mean numbers. Mann-Whitney test confirms this: the difference of the overall means of the chosen numbers (i.e., 9.56 for APM and 8.93 for RRPM) between APM and RRPM is not significant (p=0.619). Because the sample sizes for risk-neutral subjects are quite small, our results may not represent a general tendency. It would be, though, worth reporting the result since the behavioral difference between risk-averse subjects and risk-neutral subjects is quite sharp between the payoff mechanisms.



〈Figure 3〉 Mean chosen numbers in Task 2 for the risk neutral

The results imply that the payoff mechanisms seem to affect risk-averse subjects' strategic consideration rather than risk neutral subjects. Indeed, the results of regression analyses, where some demographic and feedback variables are controlled, confirms that there is a clear difference in subjects' chosen numbers between APM and RRPM, and moreover that subjects' risk attitude is a critical factor to generate the difference. The results are presented in 〈Table 5〉. The second column shows the results of the random effect GLS. It shows that the subjects' strategic reactions to their partners' decision are more sensitive in APM than in RRPM. More importantly, the chosen numbers in Task 2 significantly increase with subjects' risk aversion under RRPM (1.405) while they are rather constant (-0.184) and not significantly different from 0 under APM.[8] This result clearly supports our *Hypothesis 2*. The third column checks the robustness of those results using the random effect Tobit because the chosen numbers in Task 2 have the minimum of 2 and the maximum of 20, and the main results do not qualitatively change.

These results altogether support our hypotheses that the difference between APM and RRPM is due to the difference of their riskiness affecting risk-averse subjects' strategic behavior, depending on the subjects' degree of risk aversion. That is, RRPM induces risk-averse subjects to behave more risk aversely and hence the increased riskiness affects subjects' strategic consideration when they interact with the same partner through several periods. Then, an incentive by which a risk-averse subject attempts to do

8) The effect of risk aversion on the chosen numbers in Task 2 under APM can be estimated as "the coefficient of Switch point in Task 1" plus "the coefficient of the interaction term Payoff Mechanism * Switch point in Task 1" because the coefficient of the interaction term is the difference of the slopes for Switch point in Task 1 between APM and RRPM. Hence, the value is 1.405-1.589=-0.184 and not significantly different from 0 (p=0.547).

experimentation with a risky strategy will be lower under RRPM than under APM. Indeed, the results in this study would suggest that a more articulate theory may still need to be developed for understanding the relationships between riskiness on payoff mechanisms, risk attitudes and various strategic considerations.[9)]

〈Table 5〉 Regression results on the chosen numbers in Task 2

Dep. Variable = chosen number in Task 2	RE GLS	RE Tobit
Payoff Mechanism (APM=1, RRPM=0)	7.096* (3.870)	17.422 (11.406)
Period	0.288** (0.116)	1.081*** (0.312)
Gender (Male=1, Female=0)	-2.006* (1.017)	-4.097 (2.829)
Major (Economics=1, Others=0)	-0.559 (0.910)	-0.735 (3.077)
Partner's lagged chosen number	0.452*** (0.056)	0.685*** (0.143)
Payoff Mechanism * Partner's lag chosen number	0.216** (0.084)	0.563** (0.218)
Switch point in Task 1	1.405*** (0.407)	3.440*** (1.114)
Payoff Mechanism * Switch point in Task 1	-1.589*** (0.536)	-3.854** (1.659)
Constant	-2.325 (2.735)	-19.565** (7.902)
R^2 or pseudo log-likelihood	0.603	-774.61

Note. Clustered standard errors at the level of matching groups in parentheses. Four risk loving subjects are excluded. ***, **, * represent 1%, 5%, 10% significance level, respectively.

9) For example, Burton and Sefton (2004) hints that the payoff mechanism could matter even in a game where a dominant strategy equilibrium exists (e.g., prisoner's dilemma, linear public good game) by a concept of strategic uncertainty.

Ⅵ. Conclusions

We, in this study, find that subjects' behaviors in a two-player simple integer game task, which is a social dilemma game, are different due to the difference of the riskiness of the used payoff mechanism (say, APM versus RRPM). This result supports that people may not be completely self-interested and then that the riskiness of payoffs can affect their strategic choices, depending on their risk attitudes. That is, risk averse subjects are more sensitive in their strategic behavior to the riskiness of payoff mechanisms than the risk neutral even if the game theoretical prediction based on the self-interest assumption does not allow such a difference.

While there are still many cases where both APM and RRPM are interchangeably used for experimentally testing an identical game theoretical prediction (e.g., Charness et al., 2016 and their references), our results suggest that even in a finitely repeated game experiments where subjects' belief about the others and risk attitudes seemingly do not matter under the self-interest assumption, comparing experimental results from an experiment where APM is used with those from the other experiment where RRPM is used, could lead to a misleading conclusion. Hence, experimenters should be cautious when they choose a payoff mechanism for an experiment and compare results from experiments whose payoff mechanisms are different. That is, there is no guarantee that the results should be invariant if they used an identical payoff mechanism. Moreover, the results in this study suggest that we would need a more articulate theory to clarify the relationships between riskiness on payoff mechanisms, risk attitudes and various strategic considerations.

References

1. Andreozzi, L., P. Matteo Ploner, and A. S. Saral(2020), “The stability of conditional cooperation: beliefs alone cannot explain the decline of cooperation in social dilemmas,” *Scientific Reports*, 10, 13610.
2. Beaud, M., and M. Willinger(2015), “Are people risk vulnerable?,” *Management Science*, 61(3), 624-636.
3. Binswanger, H.P.(1980), “Attitudes Toward Risk: Experimental Measurement in Rural India,” *American Journal of Agricultural Economics*, 62, 395-407.
4. Burton, A., and M. Sefton(2004), “Risk, Pre-play Communication and Equilibrium,” *Games and Economic Behavior*, 46, 23-44.
5. Capra, M., J.K. Goeree, R. Gomez, and C.A. Holt(1999), “Anomalous Behavior in Traveler’s Dilemma?,” *American Economic Review*, 89(3), 678-690.
6. Capra, M., J.K. Goeree, R. Gomez, and C.A. Holt(2002), “Learning and Noisy Equilibrium Behavior in an Experimental Study of Imperfect Price Competition,” *International Economic Review*, 43(3), 613-636.
7. Charness, G., U. Gneezy, and B. Halladay(2016), “Experimental methods: Pay one or pay all,” *Journal of Economic Behavior and Organizations*, 131, 141-150.
8. Cox, J., and V. Sadiraj(2019), “Incentives,” in *Handbook of Research Methods and Applications in Experimental Economics*, Schram, A. and A. Ule (eds.), Glos: Edward Elgar.
9. Cox, J., V. Sadiraj, and U. Schmidt(2015), “Paradoxes and mechanisms for choice under risk,” *Experimental Economics*, 18(2), 215-250.
10. Cox, J., V. Sadiraj, and U. Schmidt(2014), “Asymmetrically dominated choice problems, the isolation hypothesis and random incentive mechanism,” *Plos ONE*, 9(3), e90742.
11. Cubitt, R. P., C. Starmer, and R. Sugden(1998), “On the Validity of the Random Lottery Incentive System,” *Experimental Economics*,

1, 115-131.

12. Fischbacher, U.(1999), "z-Tree: Zurich Toolbox for Readymade Economic Experiments: Experimenter's Manual," Working Paper, No.21, Institute for Empirical Research in Economics, University of Zurich.
13. Fischbacher, U., and S. Gächter(2010), "Social preferences, beliefs, and the dynamics of free riding in public goods experiments," *American Economic Review*, 100(1), 541-556.
14. Fischbacher, U., S. Gächter, and E. Fehr(2001), "Are people conditionally cooperative? Evidence from a public goods experiment," *Economics Letters*, 71(3), 397-404.
15. Harrison, G.W.(1989), "Theory and Misbehavior of First Price Auctions," *American Economic Review*, 79, 749-762.
16. Harrison, G.W.(1994), "Expected Utility Theory and the Experimentalists," *Empirical Economics*, 19, 223-253.
17. Harrison, G.W., and J. T. Swarthout(2014), "Experimental payment protocols and the bipolar behaviorist," *Theory and Decision*, 77(3), 423-438.
18. Harrison, G.W., J.A. List, and C. Towe(2007), "Naturally occurring preferences and exogenous laboratory experiments: a case study of risk aversion," *Econometrica*, 75(2), 433-458.
19. Hey J. D., and J. Lee(2005a), "Do Subjects Separate (or Are They Sophisticated)?" *Experimental Economics*, 8, 233-265.
20. Hey J. D., and J. Lee(2005b), "Do Subjects Remember the Past?" *Applied Economics*, 37, 9-18.
21. Holt, C.A., and S.K. Laury(2002), "Risk Aversion and Incentive Effects," *American Economic Review*, 92(5), 1644-1655.
22. Lee, J.(2016a), "The Effect of Personality Traits on Hypothetical Bias in Risk Attitudes," *Journal of the Korean Data Analysis Society*, 18(1), 281-293.
23. Lee, J.(2016b), "Gender Difference in Risk Attitudes and Personality Traits-An Experimental Study," *Journal of Humanities and Social Sciences*, 17(1), 565-588.

24. Lee, J.(2008), "The effect of the background risk in a simple chance improving decision model," *Journal of Risk and Uncertainty*, 36, 19-41.

25. Lee, J.(2004), "Essays on Financial Incentive Mechanisms Under Repetition in Economics Experiments," Ph.D thesis, The University of York.

26. Merlo, A., and A. Schotter(1999), "A Surprise-Quiz View of Learning in Economic Experiments," *Games and Economic Behavior*, 28, 25-54.

27. Merlo, A., and A. Schotter(2003), "Learning by Not Doing: An Experimental Investigation of Observational Learning," *Games and Economic Behavior*, 42, 116-136.

28. Nagel, R.(1999), "A Survey on Experimental Beauty Contest Games: Bounded Rationality and Learning," in *Games and Human Behavior: Essays in Honor of Amnon Rapoport*, Budescu, D.V., I. Erev, and R. Zwick (eds.), NJ: Lawrence Erlbaum Associates.

29. Sherstyuk, K., N. Tarui, and T. Saijo(2013), "Payment schemes in infinite-horizon experimental Games," *Experimental Economics*, 16, 125-153.

30. Starmer, C., and R. Sugden(1991), "Does the Random Lottery Incentive System Elicit True Preferences? An Experimental Investigation," *American Economics Review*, 81, 971-978.

31. Strobl, R.(2022), "Background risk, insurance and investment behaviour: Experimental evidence from Kenya," *Journal of Economic Behavior and Organization*, 202, 34-68.

국문초록

유한 반복 사회적 딜레마 게임 실험에서의 보상 메커니즘 효과에 대한 실험 연구

이진권*

반복게임 실험에서는 일반적으로 참가자 보상을 위해 누적 보상 메커니즘(APM) 또는 무작위 복권 보상 메커니즘(RRPM)이 사용된다. 본 연구에서는 이기적 선호 가정 하에서는 위험기피도가 균형 전략에 영향을 미치지 않지만 사회적 선호(예: 조건부 협조선호)가 존재하는 경우에는 위험기피도가 균형 전략에 영향을 미치는 유한 반복게임 실험을 통해 RRPM과 APM이 동일한 행동을 유도할 수 있는지를 살펴본다. 우리의 가설은 보상 메커니즘의 위험성이 피험자의 위험태도에 따라 전략적 선택에 영향을 미칠 수 있다는 것이다. 연구 결과, 위험회피적인 피험자들의 전략적 행동이 APM과 RRPM에서 차이를 보였다. 또한, 보상 메커니즘의 위험성이 피험자의 위험태도에 따라 전략적 행동에 영향을 미친다는 것이 확인되었다. 이러한 결과는 유한 반복게임 실험의 보상 메커니즘에 대한 신중한 선택이 필요함을 제시한다.

핵심주제어: 누적 보상 메커니즘, 무작위 복권 보상 메커니즘, 위험태도,
유한반복 사회적 딜레마 게임 실험
JEL Classification: C90, C91, C92

* 서강대학교 경제학과 교수, Email: jlee22@sogang.ac.kr