Payment schemes in random-termination experimental games*

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Abstract

We consider payment schemes in experiments that model infinite-horizon games by using random termination. We compare paying subjects cumulatively for all periods of the game; with paying subjects for the last period only; with paying for one of the periods, chosen randomly. Theoretically, assuming expected utility maximization and risk neutrality, both the cumulative and the last-period payment schemes induce preferences that are equivalent to maximizing the discounted sum of utilities. The last-period payment is also robust under different attitudes towards risk. In comparison, paying subjects for one of the periods chosen randomly creates a present-period bias. Experimentally, we find that the cumulative payment appears the best in inducing long-sighted behavior.

Key words: economic experiments; infinite-horizon games; random termination

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1 Motivation

Significant attention in experimental research is recently paid to dynamic infinite-horizon settings. Such settings have been used to study asset markets (Camerer and Weigelt 1993), growth models (Lei and Noussair 2002), games with overlapping generations of players (Offerman et al. 2001), and infinitely-repeated games (Dal Bo 2005). To model infinite-horizon games with discounting, experimental researchers use the random termination method: given that a period is reached, the game continues to the next period with a fixed probability p. Experimental research shows that the random termination method is indeed more successful in representing infinite-horizon games than continuing a game for a finite, known or unknown to subjects, number of periods (Offerman et al. 2001; Dal Bo 2005).

The infinite-horizon models assume that the subjects maximize the infinite sum of their discounted payoffs across periods, and thus call for paying the subjects cumulatively for all periods. Indeed, such cumulative payment schemes are used in all studies cited above. However, the cumulative payment has two limitations. First, a random-termination game that continues into the next period with probability p is theoretically equivalent to an infinite-horizon game with the discount factor p only under the assumption of risk neutrality. Risk aversion may invalidate the cumulative payment scheme, at least theoretically. Second, a possible concern for researchers is that large variations in the actual number of periods realized under random termination may result in large variations in cumulative payments to subjects, even when per period earnings are fairly predictable. Furthermore, to preserve the incentives, researchers in some cases have to pay the same stream of cumulative payoffs to more than one experimental participant. For example, in the growth experiment by Lei and Noussair (2002), a horizon that did not terminate within a scheduled session time continued during the next session; if a substitute took place of the original subject in the continuation session, then both the substitute and the original subject were paid the amount of money that the substitute made. In the inter-generational infinite-horizon dynamic game experiment by Sherstyuk et al. (2009), each period game was played by a new generation of subjects, who were paid their own payoffs plus the sum of the payoffs of all their successors. Such payment scheme, while necessary to induce proper dynamic incentives, produced a snowball effect on the experimenter expenditures.

The objective of this paper is to explore payment schemes that may provide a reasonable alternative to cumulative payments in random-termination games. Ideally, we seek a payment method that would allow for various attitudes towards risk, and at the same time reduce variability of the experimenter budget.

We explore two alternatives to the cumulative payment scheme, and their consequences for subject motivation in random-termination games. One alternative is the random selection payment method (Davis and Holt 1993) that is often used in individual choice or strategic game experiments containing multiple tasks. Each subject is paid based on one task, or a subset of tasks, chosen randomly at the end of the experiment (e.g., Charness and Rabin 2002; Chen and Li 2009). Aside from avoiding wealth and portfolio effects that may emerge if subjects are paid for each task (Holt 1986; Cox 2010),[1] there are also added advantages in economizing on the data collection efforts (Davis and Holt, 1993).

Another alternative to the cumulative payment is the last period payment, under which the subjects are paid for the last realized period of the game. We show that, theoretically, paying the subjects their earnings for just the last period of the horizon induces preferences that are equivalent, under expected utility representation, to maximizing the infinite sum of discounted utilities across periods. Moreover, unlike the cumulative payment, it does not require risk neutrality.

In Section 2, we present a theoretical comparison of the three payment methods discussed above. In Sections 3 and 4, we compare the payment alternatives experimentally. Section 5 concludes.

2 Theory

Consider an infinite-horizon dynamic game, where $t = 1, ..$ refers to the period of the game. Let δ be a player's discount factor ($0 < \delta < 1$) and π_t the player's period-wise payoff in period t. The player's life-time payoff is given by

$$U \equiv \sum_{t=1}^{\infty} \delta^{t-1} \pi_t. \tag{1}$$

To implement such dynamic game in economic laboratory, experimenters have their subjects play the game where one period is followed by the next in a matter of a few minutes, and hence the subjects' time preference would not matter. Instead, the discount factor is induced by the possibility that the game may terminate at the end of each period.[2] The following

[1] Holt (1986) shows that the random selection method may be used if subjects behave in accordance with the independence axiom of expected utility theory. Several carefully designed experiments give reassuring evidence for using the random selection method in individual choice experiments (Starmer and Sugden 1991; Cubitt et. al. 1998; Hey and Lee 2005). We are unaware of studies that test the validity of the random selection method in game theory experiments.

[2] Fudenberg and Tirole (1991, p. 148) note that the discount factor in an infinitely repeated game can represent pure time preference, or the possibility that the game may terminate at the end of each period.

random termination rule is used: given that period t is reached, the game continues to the next period $t+1$ with probability p (such that $0 < p < 1$). Then the game ends in the first period with probability $1-p$, the second period with probability $p(1-p)$, the third with probability $p^2(1-p)$, and so on. The following describes the induced discount factor for each subject under alternative payment schemes.

Assume risk neutrality first. Implications of risk aversion will be discussed at the end of this section.

Cumulative payment scheme Suppose the subjects are informed that if the game ends in period T, then each subject receives the sum of the period-wise payoffs from all realized periods $1,\dots,T$. Given the random variable T, the expected payoff to a player is given by:

$$\begin{aligned}
&(1-p)\pi_1 + p(1-p)[\pi_1+\pi_2] + p^2(1-p)[\pi_1+\pi_2+\pi_3] + \dots \\
&= \pi_1\left\{(1-p)+(1-p)p+(1-p)p^2+\dots\right\} + \pi_2\left\{(1-p)p+(1-p)p^2+(1-p)p^3+\dots\right\} \\
&\quad +\pi_3\left\{(1-p)p^2+(1-p)p^3+(1-p)p^4+\dots\right\}+\dots \\
&= \pi_1(1-p)\cdot\frac{1}{1-p} + \pi_2(1-p)\cdot\frac{p}{1-p} + \pi_3(1-p)\cdot\frac{p^2}{1-p} + \dots = \sum_{t=1}^{\infty} p^{t-1}\pi_t. \qquad (2)
\end{aligned}$$

Thus p (equal to one minus the termination probability) represents the period-wise discount factor. With p set equal to δ, the expected payoff under the cumulative payment scheme is equivalent to U, the payoff under the original dynamic game given in equation (1).

Random payment scheme Under this scheme, the payoff to each subject, if the game ends in period T, is randomly chosen from all the realized period-wise returns over T periods, $\pi_1,\pi_2,\dots,\pi_T$. Then the expected payoff is:

$$\begin{aligned}
&(1-p)\pi_1 + p(1-p)\frac{1}{2}[\pi_1+\pi_2] + p^2(1-p)\frac{1}{3}[\pi_1+\pi_2+\pi_3] + \dots \\
&= \pi_1\underbrace{\left\{(1-p)+(1-p)p\frac{1}{2}+(1-p)p^2\frac{1}{3}+\dots\right\}}_{\delta_1^r} \\
&\quad +\pi_2\underbrace{\left\{(1-p)p\frac{1}{2}+(1-p)p^2\frac{1}{3}+(1-p)p^3\frac{1}{4}+\dots\right\}}_{\delta_2^r} \\
&\quad +\pi_3\underbrace{\left\{(1-p)p^2\frac{1}{3}+(1-p)p^3\frac{1}{4}+(1-p)p^4\frac{1}{5}+\dots\right\}}_{\delta_3^r}+\dots \qquad (3)
\end{aligned}$$

This implies a discount factor that is different from the one given under the objective function displayed in equation (1). In particular, the random payment induces players to discount future returns more heavily than the cumulative payment. Therefore, the subjects are expected to be more myopic under the random payment. To see this, normalize the discount factors under the cumulative payment, by multiplying them by $(1-p)$, so that they sum up to 1:

$$\delta_1^c = 1-p, \delta_2^c = (1-p)p, \delta_3^c, (1-p)p^2, \ldots.$$

(The superscript c represents the cumulative payment rule.) Note that $\sum_{t=1}^{\infty} \delta_t^c = 1$. The discount factors under the random payment rules, $\delta_1^r, \delta_2^r, \ldots$ are already normalized: they also satisfy

$$\sum_{t=1}^{\infty} \delta_t^r = \frac{1-p}{p} \cdot \left(\begin{array}{cccccc} p & +\frac{p^2}{2} & +\frac{p^3}{3} & +\frac{p^4}{4} & +\cdots \\ & +\frac{p^2}{2} & +\frac{p^3}{3} & +\frac{p^4}{4} & +\cdots \\ & & +\frac{p^3}{3} & +\frac{p^4}{4} & +\cdots \\ & & & +\frac{p^4}{4} & +\ldots \\ & & & & +\ddots \end{array} \right)$$

$$= \frac{1-p}{p}(p + p^2 + p^3 + \ldots) = \frac{1-p}{p}\frac{p}{1-p} = 1.$$

Then we observe that

$$\delta_1^c = 1-p < \delta_1^r \quad \text{for any } p \text{ between 0 and 1,}$$

i.e. the random payment rule places a higher weight on the current payment irrespective of the termination probability.

Figure 1 illustrates the normalized discount factor schedules with $p = 3/4$ (the value used in our experiments). The figure verifies that the random payment rule puts a larger weight on the initial period than the cumulative payment does.

FIGURE 1 AROUND HERE

We further note that the random payment rule induces time inconsistency. This is because, as equation (3) indicates, the periodwise discount factor $\delta_{t+1}^r/\delta_t^r$ changes across periods. The optimal plan this period becomes suboptimal in the next period. This would be another undesirable feature of this payment rule.

Is there any payment scheme, other than the cumulative one, that induces the same discounting as the objective function (1)? We now demonstrate that such discounting can be achieved by paying each subject based on their last period.

Last-period payment scheme Each subject receives the payoff for the last period T. With probability $(1-p)$ the game lasts for only one period and the subject receives π_1.

With probability $(1-p)p$ the game lasts for exactly 2 periods and the subject receives π_2, etc. Hence, the subject's expected payoff is

$$(1-p)\pi_1 + p(1-p)\pi_2 + p^2(1-p)\pi_3 + \cdots = (1-p)\sum_{t=1}^{\infty} p^{t-1}\pi_t. \tag{4}$$

This is exactly $(1-p)$ times the expected payoff for the cumulative payment case.

Hence, the theory predicts that, up to the normalization factor $(1-p)$, the incentives induced under the last period payment are the same as those induced under the cumulative payment, with both being consistent with the objective function (1).

If the payoffs are replaced by utilities, and if the subject's utility is concave in the payoffs, then the above equivalence result does not hold. Specifically, the subject's expected utility under the cumulative payment scheme is not equivalent to U, the subject's utility in the infinite-horizon setup defined in equation (1). This discrepancy implies that the subjects would behave more myopically under the cumulative payment scheme than what the payoff specification U would predict. This has been pointed out in the literature (e.g. Lei and Noussair 2002);[3] Appendix B presents the proof of this statement for the dynamic game considered in Section 3. However, as it is obvious from equation (4), the subject's expected utility under the last-period payment scheme is still equivalent to U defined in equation (1). Therefore, provided that the subjects may be risk averse, the last-period payment scheme induces the players' objective function under the original dynamic game more accurately than the cumulative payment scheme.

3 Game setting and experimental design

We now present experimental evidence on the effect of payment schemes on subject behavior from the following infinite-horizon games with dynamic externalities. This game has been studied in Dutta and Radner (2009) and in Sherstyuk et al. (2009) to address the problem of climate change mitigation among countries.

Model settings There are $N \geq 2$ players. In each period $t = 1, 2, \ldots$, each player i chooses an action (emission level) x_{it}, where $0 \leq x_{it} \leq \bar{x}$, and $\bar{x} > 0$ represents each player's maximum feasible action. Emission x_{it} generates current benefits to player i in period t, but increases the global pollution stock S that imposes a negative dynamic externality on all players. The period-wise return of player i, π_i, in period t consists of two components: the

[3] In the context of a growth model, Lei and Noussair (2002) note that risk averse agents would behave more myopically as they would underweight the future uncertain payoffs relative to the risk neutral agents.

benefit from its own action, $B_i(x_{it})$, and the damages due to the existing pollution stock, $D_i(S_t)$:

$$\pi_i(x_{it}, S_t) = B_i(x_{it}) - D_i(S_t). \tag{5}$$

We assume that all players have the same return functions and omit the player subscript from the return functions in what follows. The benefit function is quadratic, $B(x) = ax - \frac{1}{2}cx^2$, and the damage function is linear, $D(S_t) = dS_t$, where the parameter $d > 0$ represents the marginal damages due to the stock of pollution.

The pollution stock S evolves across periods according to the following equation:

$$S_{t+1} = \lambda S_t + X_t, \quad t = 0, 1, \ldots, \tag{6}$$

where $\lambda \in [0, 1]$ represents the retention rate of the pollution stock, and $X_t \equiv \sum_i x_{it}$ is the total emission. The initial stock S_0 is given.

Given a discount factor $\delta \in (0, 1)$, player i's payoff is given by the present value of the period-wise returns $\sum_{t=0}^{\infty} \delta^t \pi_i(x_{it}, S_t)$. There is no uncertainty in the model. In each period, each player observes the history of pollution stock levels and all players' previous actions.

We consider the following benchmark solutions to the model.

First Best solution (FB): This cooperative emission allocation maximizes the sum of N players' payoffs and hence solves the following problem:

$$\max \sum_{t=0}^{\infty} \sum_{i=1}^{N} \delta^t \pi_i(x_{it}, S_t) \quad \text{subject to the constraints (6).} \tag{7}$$

The solution to this problem generates a sequence of actions $\{x_t^*\}_{t=0}^{\infty}$ where $x_t^* = \{x_{it}^*\}_{i=1}^{N}$. With the linear damage function, the solution is constant over periods and hence independent of stock level. The solution satisfies $B'(x_{it}^*) = \frac{\delta N d}{1-\delta\lambda}$ for all i, t. Given infinite horizon, the folk theorem for dynamic games (Dutta 1995) implies that, under some parameter values, the first best outcome is supportable as a subgame perfect equilibrium outcome (e.g. with Nash reversion trigger strategies).

Markov Perfect equilibrium (MP): There are many subgame perfect equilibria in this dynamic game. In a Markov perfect equilibrium, each player conditions its action in each period only on the current pollution stock. For the above model specification, there exists a unique Markov perfect equilibrium of a simple form where each player's action is independent of the pollution stock (and hence constant). The solution is given by $\{\tilde{x}_i\}_{i=1}^{N}$ such that $B'(\tilde{x}_i) = \frac{\delta d}{1-\lambda\delta}$ for all i. We focus on this Markov perfect equilibrium (MP) as a natural benchmark for the noncooperative outcome where the players take the dynamic externalities into account.

Myopic Nash solution (MN): If the dynamic externality is ignored by players, as in the case with $\delta = 0$, then the Nash equilibrium action of player i, $\hat{x}_i$, solves $B'(\hat{x}_i) = 0$. We call $\{\hat{x}_i\}_{i=1}^N$ the Myopic Nash (MN) solution.

Experimental parameters Groups consisting of $N = 3$ subjects each participated in sequences of decision periods. The following parameter values were used in the experiment: $a = 208$, $c = 13$, $d = 26.867$, $\lambda = 0.3$, $\delta = 0.75$, implying the following stationary per person emissions, as discussed above: First Best (FB): $x^* = 10$; Markov Perfect (MP): $\tilde{x} = 14$, and Myopic Nash (MN): $\hat{x} = 16$. (The player's subscript is dropped here.) The starting stock S_0 was set at the First Best steady state level.

Given these parameter values, a Nash-reversion trigger strategy where a deviation results in MP strategies supports the First Best solution as a subgame perfect equilibrium outcome (see Appendix A).

In each decision period, each subject in a group chose between 1 and 11 tokens, which were translated into the emission levels using the following linear transformation function: $x_{it} = 2y_{it} + 2$, where y_{it} is subject i's token choice in period t. This allowed to reduce the subject decision space to 11 choices. The parameter values are chosen so that all theoretical benchmarks (First Best: $y_i = 4$; Markov Perfect: $y_i = 6$; and Myopic Nash: $y_i = 7$) for individual token investments are distinct from each other and integer-valued. The cooperative FB outcome path gives the subjects substantially higher expected stream of payoffs than the MN or the MP outcome.

Treatments To study the effects of payment schemes on subject behavior, we considered the following three treatments which differed in the way the subject total payoffs were determined. (As before, T denotes the last realized period in the game):

1. Cumulative payment: Each subject receives the sum of the period-wise returns from all periods $1, \ldots, T$.

2. Random-period payment: The payoff to each subject is randomly chosen from all the realized period-wise returns over T periods.

3. Last-period payment: Each subject receives the period-wise return in period T, i.e. the last realized period, as the payoff.

Based on the analysis from Section 2, we hypothesize that the Random-period payment treatment should result in more myopic (higher) token choices than either the Cumulative or the Last-period payment treatments. The Cumulative and the Last-period treatments should result in the same token choices, provided the subjects are risk neutral. If the subjects are risk averse, then the theory (see Appendix B) suggests the actions will be more myopic (imply higher token choices and higher steady state pollution stock) under the Cumulative payment than under the Last-period payment.

Procedures The experiments were computerized using z-Tree software (Fischbacher, 2007). Several (up to three) independent groups of subjects, with three subjects in each group, participated in each experimental session. The actual game was preceded by experimental instructions (included in the Supplementary materials) and five-period training for which the subjects were paid a flat training fee. Groups of subjects made token decisions in all decision periods until the game stopped.[4] To help with decision-making, the subjects were provided with payoff calculators, as well as tabular and graphical information about the current payoffs from own token choices and the effect of group token choices on future periods' payoffs; see Figure 3 in Appendix C. In addition, to help the subjects coordinate on outcomes, at the conclusion of each period the subjects were asked to suggest token levels and type verbal advice to other group members. These procedures were the same in all three treatments of the experiment.

A randomization device (an eight-sided die or a bingo cage) was used after each period to determine whether the game continued to the next period. Given $\delta = 0.75$, the continuation probability was set at 3/4, implying the expected length of 4 period in each game. Only one dynamic game per group was conducted in each session. We chose not to restart short games if they ended early, for the reason that it could have an effect on subject motivation in each game. At the end of the session, each subject responded to a short post-experiment survey (included in the Supplementary materials) which contained questions about one's major, the number of economics courses taken, and the reasoning behind token choices in the experiment.

We allowed enough time for each session to guarantee that each game terminated within the allocated time interval. Experimental sessions lasted up to three hours each, including

[4] In the instructions, each period was called a "series." Each period consisted of three decision trials. At the end of the period, one of the trials was chosen randomly as a paid trial, and was used to determine next period's stock level. Having more than one trial in a period allowed the subjects to better learn the behavior of other subjects in their group, while reducing the dynamic externalities (effect on next period's stock) from such learning. As the number of trials is fixed and known to subjects, it does not change the subject motivation in the way a random or an unknown number of trials would. Our data indicate that the subject decisions were rather consistent across trials within periods. In what follows, we will therefore focus on the data analysis for the chosen (paid) trials of each period; see Section 4 below.

instructions and training. The exchange rates were set at \$100 experimental = \$1 US in the Cumulative treatment, and \$30 experimental = \$1 US in the Last-period and the Random-period treatments.[5] The average payment was \$32.24 per subject, including \$10 flat training fee.

4 Results

The experiments were conducted at the University of Hawaii at Manoa between June 2008 and June 2010. The total of 81 subjects participated; they were undergraduate students, with about a half majoring in social sciences or business. The mean number of economics courses taken by the participants was 1.5 in the Cumulative treatment, 1.67 in the Last-period treatment, and 1.27 in the Random-period treatment; in all treatments, the median number of economics courses taken was one.

Six to fifteen independent dynamic games, with three participants each, were conducted per treatment. Some games ended after the first period. The data analysis revealed no differences in first-period token choices among any two treatments; for this reason, we exclude one-period-long games from the analysis, and focus on the games that lasted for at least two periods. This leaves us with six independent observations (games) per treatment.

Table 1 displays descriptive statistics by treatment, focusing on per period group token contributions. Figure 2 shows the group token dynamics across periods by treatment. Lower token levels imply more long-sighted, i.e., less myopic, behavior. Three theoretical benchmarks, given $p = 3/4$, are also exhibited on the graphs: First Best, or Socially Optimal group tokens, FB=12; Markov Perfect Equilibrium group tokens, MP=18; and Myopic Nash Equilibrium group tokens, MN=21.

TABLE 1 AND FIGURE 2 AROUND HERE

The table and the figure suggest a few observations. First, in contrast to the theoretical prediction under risk neutrality, the subject behavior under the Last-period payment was quite different from the behavior under the Cumulative payment. Although the overall average group tokens were not significantly different between the Cumulative and the Last-period payment (13.56 group tokens under Cumulative as compared to 14.17 under Last-period), the variance of group tokens across games was much lower under the Cumulative than under the Last-period payment: 1.49 tokens as compared to 5.61 tokens, respectively.

[5] We set the exchange rates in the Cumulative, the Random-period and the Last-period treatments based on pilot runs, so that the average payments to subjects would be about the same in all treatments.

Furthermore, group tokens under the Cumulative payment exhibited a decreasing trend over time; groups invested on average 16.17 tokens in the first period, as compared to 12.5 tokens in the last period (p=0.0938, Wilcoxon sign rank test). This suggests that the subjects in this treatment were learning to play more long-sightedly as the game progressed. In contrast, the group tokens did not significantly change from the first to the last period under the Last-period payment; the groups invested, on average, 14.33 tokens in the first period, as compared to 15.5 tokens in the last period. Consequently, while the tokens in the first period were not significantly different between these two treatments, they became different at 10% significance level in the last period of the game (p=0.066, Wilcoxon Mann-Whitney rank sum test).

The post-experimental questionnaire confirms the observed difference in behavior between the Cumulative and the Last-period treatments: The mean response to the question "How many tokens would you order if you are to participate again in this experiment?" was 4.11 tokens in the Cumulative treatment, and 5.17 tokens in the Last-period treatment; the median responses were 4 and 5.5 tokens for the Cumulative and for the Last-period treatments, respectively. We summarize:

Observation 1 *Subject behavior under the Cumulative payment was less variable than under the Last-period payment. Further, group tokens decreased from the first to the last period under the Cumulative payment, indicating a tendency towards a less myopic behavior. No such tendency was observed under the Last-period payment.*

Next, our experimental data suggest that, consistent with the theoretical predictions, the subjects behaved more myopically under the Random-period pay treatment than under the Cumulative payment treatment. While the first period group tokens were no different under these two treatments, all other descriptive statistics, including average group tokens, the tokens in the last periods, and the average group tokens in early and late periods were all statistically different (higher) at 5% (and often at 1%) significance level under the Random-period treatment than under the Cumulative treatment. Unlike under the Cumulative payment, the group tokens did not significantly change from the first (16.17 tokens average) to the last period (18.17 tokens average) under the Random-period payment; clearly, there was no decreasing trend in the token levels. The overall average group tokens under the Random-period payment were at 17.83, the highest among all three treatments, which was significantly different from the Cumulative group token average (p=0.0076, WMW test). We also note that the variance of average tokens across games in the Random-period payment treatment was 2.42, which was higher than in the Cumulative treatment, but lower than in the Last-period treatment. Finally, the mean response to the post-experiment question

"How many tokens would you order if you are to participate again in this experiment?" in the Random treatment was 5.22 tokens, and the median was 6 tokens; both were the highest among all three treatments.[6] In sum,

Observation 2 *Consistent with the theoretical prediction, the subjects behaved more myopically under the Random-period payment treatment than under the Cumulative payment.*

Finally, the subjects behavior under the Last-period and the Random-period payment treatments also appears quite different, although the differences are statistically insignificant. The latter is likely due to a large variation in the Last-period treatment observations across individual games. On average, however, the differences are in the direction predicted by the theory discussed in Section 2, with Last-period average group tokens at a lower (less myopic) level of 14.17, as compared to Random-period average group tokens of 17.83.

5 Summary

To summarize, comparison of the three payment schemes studied in the context of dynamic games with random termination indicate the following. In line with the theoretical prediction, the Random-period pay treatment results in more myopic behavior than the Cumulative payment. This is likely due to a higher discounting induced by the Random-period payment in combination with random termination.

Further, the Cumulative payment and the Last-period payment schemes imply, under risk neutrality, the same discount factor theoretically, but appear to be quite different behaviorally. Specifically, the Cumulative payment appears to induce less noisy and more long-sighted behavior than the Last-period payment.

We briefly discuss several hypotheses that could potentially explain the differences between the Cumulative and the Last-period payment treatments:

1. Risk aversion. The differences in behavior between the Cumulative and the Last-period payment treatments are unlikely to be explained by subject risk aversion alone. The theoretical analysis (Appendix B) indicates that if the subjects are risk averse, then the steady

[6] Advices that the subjects sent to their group members at the conclusion of periods give additional support that the random selection of the paid period made the subjects reason more myopically. For example, one of the subjects (ID 5, Game 1, Random treatment) sent the following advice to his group members: "7 again. Hope it ends by now and the series 1 is selected !!!" In comparison, many subjects in the Cumulative and in the Last-period treatments advised their group members to restrain token levels for the benefit of the future payoffs. E.g.: "I think the best number to order is 4 because that way you get the most consistent payoff from trial to trial no matter how long it goes." (ID 4, Game 2, Cumulative treatment).

state stock level for the dynamic game considered would be higher under the Cumulative payment than under the Last-period payment. This would imply that if our participants are risk averse, they would invest more tokens under Cumulative than under the Last-period payment treatment. Yet, we observe the opposite.

2. Risk aversion combined with wealth effects. Following Mas-Colell et al. (1995, p. 192), “it is a common contention that wealthier people are willing to bear more risk than poor people.” If experimental subjects exhibit decreasing absolute risk aversion over the payoff ranges used in the experiment, then accumulated payoffs in the Cumulative payment may make people less risk averse, leading to lower token investments in later periods. In contrast, as no payoffs are accumulated under the Last-period payment, no decreasing trend in tokens should be expected. This is consistent with what we observe in our experiments.

3. Risk aversion combined with higher stakes for each decision under the Last-period payment as compared to the Cumulative payment. Holt and Laury (2002) demonstrate that higher stakes lead to greater risk aversion. Theoretically, this may be explained by preferences that exhibit decreasing absolute risk aversion and increasing relative risk aversion. If our experimental subjects are influenced by the stakes per decision, then they may choose higher (less risky) token levels under the Last-period payment as compared to the Cumulative payment because of higher per-period stakes under the Last-period payment. This is consistent with our experimental observations.

4. Differences between treatments in subjective probabilities of the game ending after each given period. This cannot be ruled out, although we do not have a reasonable explanation for why the payment rule would affect subject perception about the game ending.[7]

5. Unobserved differences (such as in the degree of sophistication) between participants in the Cumulative and the Last-period pay treatments. As discussed at the beginning of Section 4, the mean and median numbers of economics courses taken by the subjects are indistinguishable between any two treatment. This gives us grounds to believe that the subjects' levels of economic reasoning should be comparable across treatments.

6. Specificity of the dynamic game employed in our experimental design. The dynamic

[7] Responses to post-experiment questionnaire indicate that some subjects may have believed that the probability of the game ending increased over periods. However, this was not specific to any one of the treatments. Here are some examples of subject responses: Question: “What do you think is the best number of tokens to order and why?” Answer: “Lower first, then higher” (ID 1, Game 1, Random-period payment treatment). Question: “How did you make your decision to order [tokens]?” Answer: “Begin conservatively and gradually order in more aggressive numbers because there is a higher possibility that the experiment might end as you go along..” (ID 3, Game 3, Cumulative treatment). We do not have sufficient evidence to reject the hypothesis that the subjective probabilities of the game ending were the same across treatments.

externality game that we use is rather complex along several dimensions. First, unlike a repeated game, it evolves from period to period. Second, the action space in each period consists of eleven choices, which adds complexity as compared to, for example, a binary choice game. It is possible that the Last-period payment scheme could work better in inducing dynamic incentives in a simple two-by-two repeated game, such as the Prisoners' dilemma. It is also possible that the differences in subject behavior observed under the two payment schemes would disappear with more experienced subjects. What our experimental evidence suggests, however, is that in contrast to the theoretical predictions, there are dynamic settings for which the Last-period payment cannot be relied upon to induce dynamic incentives as well as, or better, than the Cumulative payment.

There is insufficient evidence to distinguish which of the above factors are responsible for the differences between the Cumulative and the Last-period payment schemes within the framework of this study. We conjecture that risk aversion, wealth effects, stakes and game complexity all may play a role. However, we may draw two conclusions from our research. First, neither the Last-period payment nor the Random-period payment are reliable alternatives to the Cumulative payment scheme in inducing long-sighted incentives in dynamic games. Second, the Random-period payment appears to be a good alternative to the Cumulative payment for repeated (or more generally dynamic) settings where experimenters seek to minimize the repeated game effects and focus experimental subjects' attention solely on the decisions in the current decision period. Examples of the latter may include auctions, markets, and other settings, where repetition is needed for subjects to gain experience with the game, but the supergame effects which come from repetition are to be minimized.

Appendix A

Supporting the first best solution with a trigger strategy

Can cooperation be supported as a subgame perfect equilibrium outcome given the parameter values in the experiment? Let $S_0 = S^*$ where S^* is the steady state under the cooperative outcome:

$$S^* = \lambda S^* + X^*, \text{ i.e. } S^* = \frac{X^*}{1-\lambda},$$

where $X^* = Nx^*$ and $x^* = 10$, the optimal action. The payoff under cooperation is

$$\Pi^* \equiv \sum_t \delta^t \left[ax^* - \frac{c}{2}x^{*2} - dS^*\right] = \frac{ax^* - \frac{c}{2}x^{*2} - dS^*}{1-\delta}.$$

Consider a trigger strategy where deviation from x^* by a player induces the Markov perfect equilibrium profile (where every player chooses $\widetilde{x}$ forever). Suppose a player deviates from cooperation in period 1 (or any period preceded by a history of cooperative play). With the choice of one-shot deviation x^d, the deviating player's immediate periodwise payoff is

$$\pi^d = ax^d - \frac{c}{2}x^{d2} - dS^*.$$

The stock level immediately after deviation is

$$S^d \equiv \lambda S^* + 2x^* + x^d.$$

Then, under the MP actions, the stock level evolves according to $S_{t+1} = S_t + \widetilde{X}$:

$$S_0 = S^d, \quad S_1 = \lambda S^d + \widetilde{X}, \quad S_2 = \lambda S_1 + \widetilde{X} = \lambda^2 S^d + (1+\lambda)\widetilde{X}, \ldots$$

$$S_t = \lambda^t S^d + (1 + \lambda + \cdots + \lambda^{t-1}\widetilde{X}) = \lambda^t S^d + \frac{\widetilde{X}}{1-\lambda} - \lambda^t \cdot \frac{\widetilde{X}}{1-\lambda}.$$

So the continuation payoff for the player who deviated, after deviation, is given by

$$\Pi^d_{cont} \equiv \sum_{t=0}^{\infty} \delta^t \left[a\widetilde{x} - \frac{c}{2}\widetilde{x}^2 - dS_t \right],$$

where

$$\sum_{t=0}^{\infty} \delta^t dS_t = d\sum_{t=0}^{\infty} \delta^t \left\{ \lambda^t S^d + (1-\lambda^t)\frac{\widetilde{X}}{1-\lambda} \right\} = \frac{dS^d}{1-\delta\lambda} + \frac{d\widetilde{X}}{(1-\delta\lambda)(1-\lambda)}.$$

So the present value of the payoff upon deviation is

$$\Pi^d = \pi^d + \delta\Pi^d_{cont}.$$

Given the parameter values specified for the experiment, we have $\Pi^* \approx 1,114$ as the payoff upon cooperation and $V^d \equiv \max_{x^d \geq 0} \Pi^d(x^d) \approx 906$. Hence, the above trigger strategy supports the first best outcome.

Appendix B

Implications of risk aversion for the first best solution

Let $u(\pi_t)$ be each player's utility from monetary return π_t in period t where $u' > 0$ and $u'' \leq 0$. If the players are risk averse, then $u'' < 0$. Suppose $u(\pi_t)$ replaces π_t in each player's objective function given in equation (1):

$$\sum_{t=1}^{\infty} \delta^{t-1} u(\pi_t). \tag{1'}$$

Let S^{*rn} (S^{*ra}) be the first-best steady state stock for the original infinite-horizon model when the players are risk neutral (risk averse). Let S^{*rn}_{cum} (S^{*ra}_{cum}) be the corresponding steady state under the cumulative payment scheme, and S^{*rn}_{lp} (S^{*ra}_{lp}) be the steady state under the last-period payment scheme.

Here we prove that the first-best actions are more myopic under the cumulative payment scheme than under the infinite-horizon game when the players are risk averse.

Proposition 1 *For the model specified with equations (5) and (6), the following holds for the steady states under alternative payment schemes.*

(i) The steady states under the infinite-horizon model with objective function given by (1') and under the last-period payment scheme are the same regardless of the players' risk attitudes, i.e. $S^{*rn} = S^{*rn}_{lp}$ *and* $S^{*ra} = S^{*ra}_{lp}$*.*

(ii) The steady states under the infinite-horizon model and under the cumulative payment scheme are equivalent if the players are risk neutral: $S^{*rn} = S^{*rn}_{cum}$*.*

(iii) If players are risk averse, then the first-best steady state under the cumulative payment scheme is larger than the first-best steady state under the last-period payment scheme: $S^{*ra}_{cum} > S^{*ra}_{lp}$*.*

Proof. Part (i) follows because the expressions in equations (1) and (4) represent the same payoffs regardless of whether π_t's are replaced with $u(\pi_t)$'s. Part (ii) holds given (1) and (2) and because we have $u(\pi_i) = \pi_i$ (without loss of generality) under risk neutrality. To show part (iii), first we show that $S^{*ra} = S^{*rn}$: the first-best steady state is the same regardless of whether the players' objective function is given by (1') or (1) (i.e. whether the players are risk averse or not). Given the utility function u, the first best solution solves the following functional equation:

$$V(S) = \max_{\{x_i\}_{i=1}^N} \sum_{i=1}^N u\left(B(x_i) - dS\right) + \delta V(S')$$

subject to $S' = \lambda S + X$ and $x_i \geq 0$ for all i, where V is the optimal value function (the maximum total payoffs of all players). The first order condition is given by

$$u'(\cdot) \cdot B'(x_i) + \delta V'(S') = 0 \quad \text{for all } i,$$

and the envelope equation implies

$$V'(S) = \sum_i u'(\cdot) \cdot (-d) + \delta V'(S')\lambda.$$

At the steady state S^*, the above equality implies

$$V'(S^*) = -u'(\cdot)D + \delta\lambda V'(S^*),$$

where $D \equiv \sum_i d$. Together with the first order condition, we have

$$u'B'(x_i^*) = \frac{u'\delta D}{1-\delta\lambda}, \quad \text{i.e.} \quad B'(x_i^*) = \frac{\delta D}{1-\delta\lambda}. \tag{8}$$

This condition for the first-best steady-state token is the same under any risk attitude. Hence, $S^{*ra} = S^{*rn} = S^*$.

We now show that $S^{*ra}_{cum} > S^*$. Under the cumulative payment scheme, the expected payoff to each player is given by

$$(1-p)u(\pi_1)+p(1-p)u(\pi_1+\pi_2)+(1-p)p^2u(\pi_1+\pi_2+\pi_3)+\cdots = (1-p)\sum_{t=1}^{\infty} p^{t-1}u\left(\textstyle\sum_{s=1}^{t}\pi_s\right).$$

As specified in the Section 3, let $\pi_t = B(x_{it}) - dS_t$ and $S_{t+1} = \lambda S_t + X_t$ where $X_t = \sum_{i=1}^{N} x_{it}$ and μ_t is the Lagrangian multiplier associated with the constraint $S_{t+1} = \lambda S_t + X_t$. Let $\Pi_t \equiv \sum_{s=1}^{t}\pi_s$. An interior first best solution satisfies the following first-order conditions:

$$p^{t-1}u'(\Pi_t)B'(x_{it}) + p^t u'(\Pi_{t+1})B'(x_{it}) + \cdots - \mu_t = 0,$$

$$-\mu_t\lambda + \mu_{t-1} - p^{t-1}u'(\Pi_t)D - p^t u'(\Pi_{t+1})D - \cdots = 0,$$

for $t = 1, 2, \ldots$ where $D \equiv \sum_{i=1}^{N} d$. Under the steady state ($x_{it} = x$ for all i, t), it follows that

$$-p^{t-1}B'(x)\{u'(\Pi_t) + pu'(\Pi_{t+1}) + \ldots\}\lambda + p^{t-2}B'(x)\{u'(\Pi_{t-1}) + pu'(\Pi_t) + \ldots\}$$
$$-p^{t-1}D\{u'(\Pi_t) + pu'(\Pi_{t+1}) + \ldots\} = 0.$$

Divide all terms by p^{t-1} and arrange the terms to obtain

$$-B'(x)\{u'(\Pi_t) + pu'(\Pi_{t+1}) + \ldots\}\lambda + B'(x)\left\{\frac{u'(\Pi_{t-1})}{p} + u'(\Pi_t) + pu'(\Pi_{t+1}) + \ldots\right\}$$
$$-D\{u'(\Pi_t) + pu'(\Pi_{t+1}) + \ldots\}$$
$$= B'(x)\frac{u'(\Pi_{t-1})}{p} + \{(1-\lambda)B'(x) - D\}\{u'(\Pi_t) + pu'(\Pi_{t+1}) + \ldots\} = 0.$$

If the players are risk neutral (i.e. $u'' = 0$), then u' is constant and the above equality simplifies to

$$\frac{B'(x)}{p} + \frac{(1-\lambda)B'(x) - D}{1-p} = 0, \quad \text{i.e. } B'(x) = \frac{pD}{1-p\lambda}.$$

This is the steady-state condition for the first best solution under risk neutrality (equation 8). In contrast, if $u'' < 0$, we have $u'(\Pi_t) > u'(\Pi_{t+1}) > \ldots$. It follows from $(1-\lambda)b'(x) - D < 0$ that

$$\begin{aligned} 0 &= B'(x)\frac{u'(\Pi_{t-1})}{p} + \{(1-\lambda)B'(x) - D\}\{u'(\Pi_t) + pu'(\Pi_{t+1}) + \ldots\} \\ &> B'(x)\frac{u'(\Pi_{t-1})}{p} + \{(1-\lambda)B'(x) - D\}u'(\Pi_{t-1})\frac{1}{1-p}. \end{aligned}$$

The last inequality implies $B'(x) < \frac{pD}{1-p\lambda}$. Because $B'' < 0$, this inequality implies that the steady-state solution x under the cumulative payment scheme is larger than the steady-state solution specified by (8). Hence, $S^{*ra}_{cum} > S^* = S^*_{lp}$. ∎

Remark. It is straightforward to show that the same properties hold for the Markov-perfect equilibrium steady-state stocks under alternative payment schemes (i.e. equivalence of the infinite-horizon model and the last-period payment scheme, and a larger steady state under the cumulative payment scheme). The same properties regarding the last-period and cumulative payment schemes hold in other general contexts such as neoclassical growth models (Lei and Noussair 2002) and infinitely repeated games (as opposed to a special class of dynamic games considered here).

Appendix C

An example of subject payoff table

FIGURE 3 AROUND HERE

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3. An example of subject payoff table

Table 1: Desciptive statistics, by treatment (excluding one-period-long games)

Variable	Cumulative Pay Mean (Std. Dev.)	Last Period Pay Mean (Std. Dev.)	Random Period Pay Mean (Std. Dev.)	WMW test p-value, Cum==Last	WMW test p-value, Cum==Random	WMW test p-value, Last==Random
game length, periods	7	5.67	6	--	--	--
	(1.67)	(3.39)	(4.10)			
first period group tokens	16.17	14.33	16.17	n/s	n/s	n/s
	(4.92)	(6.44)	(4.22)			
last period group tokens	12.50	15.50	18.17	0.066	0.0022	n/s
	(2.07)	(5.75)	(1.72)			
average group tokens	13.56	14.17	17.83	n/s	0.0076	n/s
	(1.49)	(5.61)	(2.42)			
avg tokens, early (periods 1-4)	14.33	14.19	17.29	n/s	0.0325	n/s
	(2.16)	(6.59)	(3.03)			
avg tokens, late (periods 5-end)	12.69	14.00	17.43	n/s	0.0095	0.1649
	(1.93)	(2.59)	(2.35)			
Number of obs (games), all	6	6	6			
Number of obs (games) of length above 4	6	2	4			
Signrank test p-value, First==Last period	0.0938	n/s	n/s			
Signrank test p-value, Avg early==Avg late	0.1094	n/s	0.1250			

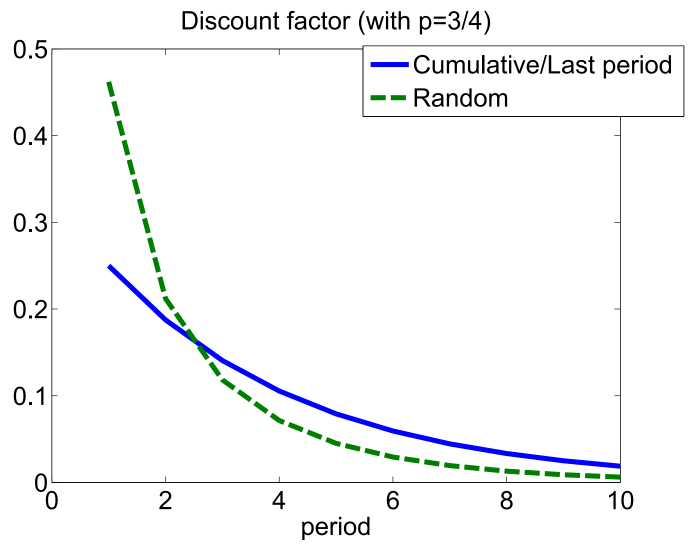


Figure 1: Discount factor schedule under alternative payment rules. ($p = 3/4$)

Figure 2: Group token dynamics under different payment schemes

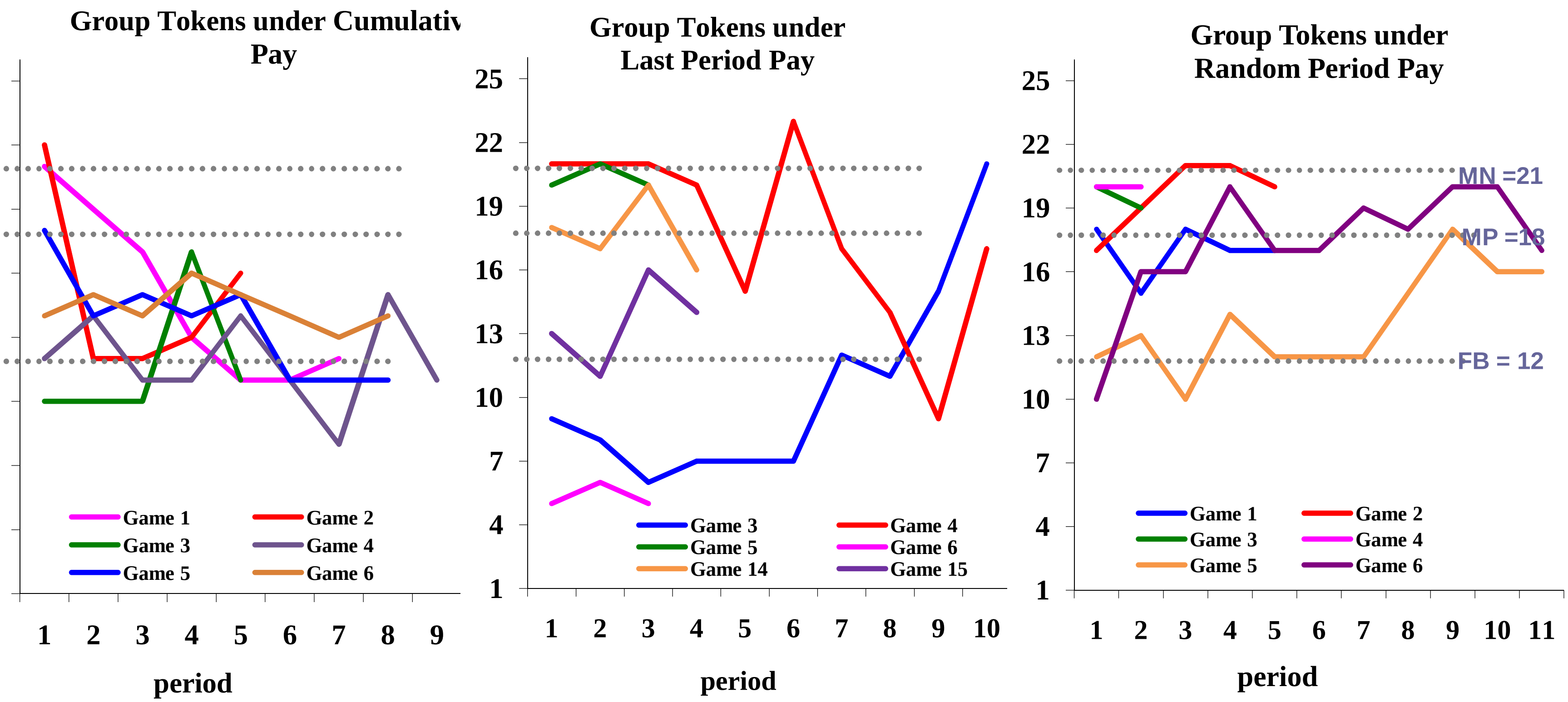
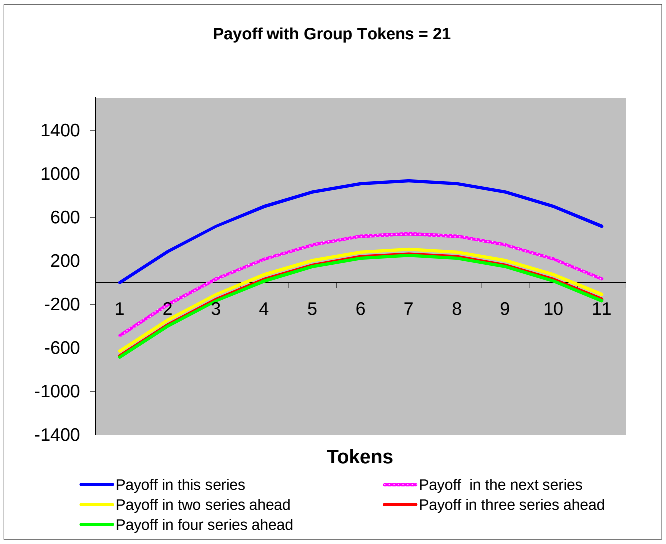


Figure 3: An example of subject payoff table

Payoffs with Group Tokens = 21 in each series

Your Tokens	Payoff Level	1	2	3	4	5	6	7	8	9	10	11
Payoff in this series	1394	1	287	521	703	833	911	937	911	833	703	521
Payoff in the next series	910	-483	-197	37	219	349	427	453	427	349	219	37
Payoff in two series ahead	765	-628	-342	-108	74	204	282	308	282	204	74	-108
Payoff in three series ahead	722	-671	-385	-151	31	161	239	265	239	161	31	-151
Payoff in four series ahead	709	-684	-398	-164	18	148	226	252	226	148	18	-164



Experimental Instructions (BL)

Introduction

You are about to participate in an experiment in the economics of decision making in which you will earn money based on the decisions you make. All earnings you make are yours to keep and will be paid to you IN CASH at the end of the experiment. During the experiment all units of account will be in experimental dollars. Upon concluding the experiment the amount of experimental dollars you receive as payoff will be converted into dollars at the conversion rate of US $1 per ______ experimental dollars, and will be paid to you in private.

Do not communicate with the other participants except according to the specific rules of the experiment. If you have a question, feel free to raise your hand. An experimenter will come over to you and answer your question in private.

In this experiment you are going to participate in a decision process along with several other participants. From now on, you will be referred to by your ID number. Your ID number will be assigned to you by the computer.

Decisions and Earnings

Decisions in this experiment will occur in a number of decision series. At the beginning of the first decision series, you will be assigned to a decision group with 2 other participant(s). You will not be told which of the other participants are in your decision group. *What happens in your group has no effect on the participants in other groups and vice versa.* The group composition will stay the same for the whole experiment.

In each series, you will be asked to order between 1 and 11 tokens. All participants in your group will make their orders at the same time. You payoff from each series will depend on two things: (1) the current payoff level for your group, and (2) the number of tokens you order. The higher is the group payoff level for the series, the higher are your payoffs in this series. All members of your group have the same group payoff level in this series.

Given a group payoff level, the relationship between the number of tokens you order and your payoff may look something like this:

PAYOFF SCHEDULE IN THIS SERIES; GROUP PAYOFF LEVEL: 1394

Your token order	1	2	3	4	5	6	7	8	9	10	11
Payoff in this series	1	287	521	703	833	911	937	911	833	703	521

For example, the table above indicates that the group payoff level in this series is 1394. At this level, if you choose to order 5 tokens, then your payoff will be 833 experimental dollars.

The group payoff level for the first series will be given to you by the computer. The payoff level for your group in the next series will depend on your group's total token order in this series. Your group payoff level in the next series may increase if the number of tokens ordered by the group in this series is low; Your group payoff level in the next series may decrease if the number of tokens ordered by the group in this series is high; For some group token order, your group payoff level in the next series may be the same as in this series.

Example 1 To illustrate how your payoff schedule may change from series to series, depending on your group orders, consider the attachment called "Example 1 Scenarios". Suppose, as in this attachment, that your group has a payoff level of 1394 in the current series. The table and figure A1 illustrate how the payoffs change from series to series if your group orders the sum of 3 tokens in each series. The table shows the group payoff level will increase from 1394 in this series to 1878 in the next series, resulting in increased payoffs from token orders. For example, if you order 1 token, your payoff will be 1 experimental dollar in this series, but in the next series your payoff from the same order will increase to 485 experimental dollars. The table also shows that if the group order is again 3 tokens in the next series, the group payoff level will further increase in the series after next. Similarly, the table demonstrates the payoff changes in the future series up to three series ahead. The graph illustrates.

When making token orders, you will be given a calculator which will help you estimate the effect of your and the other participants' token choices on the payoff levels in the future series. In fact, you will have to use this calculator before you can order your tokens.

TRY THE CALCULATOR ON YOUR DECISION SCREEN NOW. *In the calculator box, enter "1" for your token order, and "2" for the sum of the other participants' orders. (The group tokens will be then equal to 3.) The "Calculator Outcome" box will show the changes in the payoff levels and the actual payoffs from the current series to the next and up to four series ahead, if these token orders are chosen in every series. Notice how the payoff levels and the actual payoffs increase from series to series.*

Consider now the table and figure A4. They illustrate how group payoff levels change from series to series if your group orders the total of 30 tokens in each series. Suppose, for example, that you order 11 tokens in this series. The table shows that, given the current payoff level, your payoff will be 521 experimental dollar in this series, but in the next series your payoff from the same order will be -446 experimental dollars. (This is because the group payoff level will decrease from 1394 in this series to 427 in the next series.) Again, the table and the graph illustrate how the payoffs change in the future series up to three series ahead, assuming that the total group order stays at 30 tokens in each series.

TRY THE CALCULATOR WITH THE NEW NUMBERS NOW. *In the calculator box, enter "11" for your token order, and "19" for the sum of the other participants' orders. (The group tokens will be then equal to 30.) The "Calculator Outcome" box will again show the changes in the payoff levels and the actual payoffs from the current series to the next and up to four series ahead, given the new token orders. Notice how the payoff levels and the actual payoffs decrease from series to series.*

Now try the calculator with some other numbers.

After you practice with the calculator, **ENTER A TOKEN ORDER IN THE DECISION BOX.** *The decision box is located on your decision screen below the calculator box.*

Predictions Along with making your token order, you will be also asked to predict the sum of token orders by other participants in your group. You will get an extra 50 experimental dollars for an accurate prediction. Your payoff from prediction will decrease with the difference between your prediction and the actual tokens ordered by others in your group. The table below explains how you payoff from prediction depends on how accurate your prediction is.

PAYOFF FROM PREDICTIONS

Difference between predicted and actual sum of others' tokens	0	2	4	6	8	10	12	14	16	18	20
Your Payoff from Prediction	50	50	48	46	42	38	32	26	18	10	0

PLEASE ENTER A PREDICTION INTO THE DECISION BOX NOW.

Results After all participants make their token orders and predictions, the computer will display the "Results" screen, which will inform you about your token order, the sum of the other participants' tokens, and your total payoff in this series. Your total payoff equals the sum of your payoff from token order and your payoff from prediction. The results screen will also inform you about the change in the payoff levels from this series to the next series, and display the corresponding payoff schedules.

Trials In each series, you will be given <u>three independent decision trials</u> to make your token orders and predictions. The payoff levels for your group will stay the same across the trials of a given series. At the end of the series, the computer will randomly choose one of these three trials as a paid trial. This paid trial will determine your earnings for this series, and the payoff level for your group in the next series. All other trials will be unpaid. At the end of the series, the series results screen will inform you which trial is chosen as the paid trial for this series.

Advice for the next series At the end of each decision series, after the participants are informed about the results in this series, each participant in your group will be asked to send an advice message to other participants in the group, suggesting number of tokens to be chosen by each participant if their decisions were to continue. This will conclude a given series.

PLEASE ENTER AN ADVICE (A SUGGESTED NUMBER OF TOKENS AND A VERBAL ADVICE) NOW.

Continuation to the next decision series Upon conclusion of each series, we will roll an eight-sided die to determine whether the experiment ends or continues to the next series. If the die comes up with a number between 1 and 6, then the experiment continues to the next series. If the die shows number 7 or 8, then the experiment stops. Thus, there are THREE CHANCES OUT OF FOUR that the experiment continues to the next series, and ONE CHANCE OUT OF FOUR that the experiments stops.

If the experiment continues, each new series that follows will be identical to the previous one except for the possible group payoff level change that was explained above. You will be given the new payoff table at the beginning of the new series.

Practice Before making decisions in the paid series, all participants will go through 5-series practice, with each practice series consisting of one trial only. You will receive a flat payment of 10 dollars for the practice.

Total payoff Your total payoff in this experiment will consist of two parts: (1) The flat payment for the practice; plus (2) the payoff for the LAST series, i.e., the series after which your experiment ends.

If you have a question, please raise your hand and I will come by to answer your question.

ARE THERE ANY QUESTIONS?

Frequently asked questions

- What is the difference between a trial and a series?

  Each series consists of three decision trials. One of the decision trials is then randomly chosen by the computer to determine your payoffs in this series.

- What does my payoff in this series depend upon?

  It depends upon your GROUP PAYOFF LEVEL in this series, and YOUR TOKEN ORDER.

- What is the group payoff level?

  It is a positive number that is related to the payoffs you can get from token orders in the series. The higher is the group payoff level, the higher is the payoff you get from any token order.

- Does my payoff in a series depend upon other participants' token orders in this series?

  No. Given your group payoff level in a series, your payoff in this series is determined only by your own tokens order.

- Why do the total group tokens matter?

  Because THEY AFFECT THE PAYOFF LEVEL IN THE NEXT SERIES for your group. The higher is the group tokens in this series, the lower will be the payoffs in the next series.

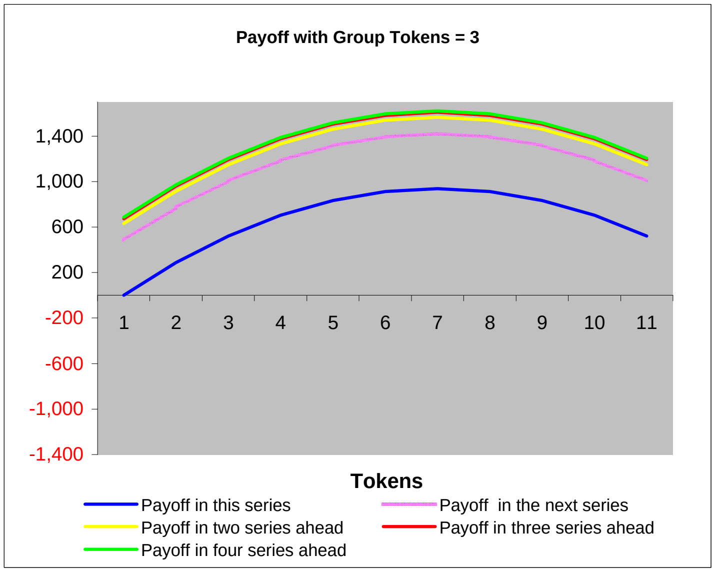
- How many series are there in this experiment?

  The number of series will be determined by a random draw. There will be 3 OUT OF 4 CHANCES that each series will continue to the next series, and 1 OUT OF 4 CHANCE that the experiment will stop after this series. We will roll a die to determine the outcome.

Example 1 Scenarios

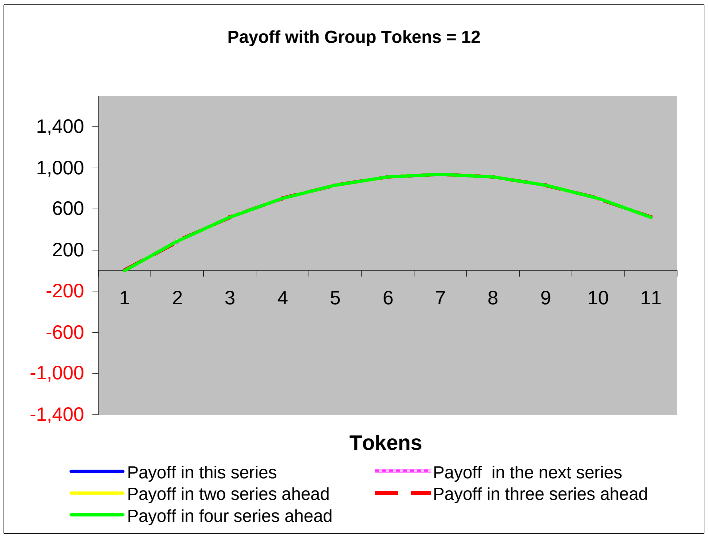
A1. Payoff with Group Tokens = 3 in each series

Your Tokens	Payoff Level	1	2	3	4	5	6	7	8	9	10	11
Payoff in this series	1394	1	287	521	703	833	911	937	911	833	703	521
Payoff in the next series	1878	485	771	1,005	1,187	1,317	1,395	1,421	1,395	1,317	1,187	1,005
Payoff in two series ahead	2023	630	916	1,150	1,332	1,462	1,540	1,566	1,540	1,462	1,332	1,150
Payoff in three series ahead	2066	673	959	1,193	1,375	1,505	1,583	1,609	1,583	1,505	1,375	1,193
Payoff in four series ahead	2079	686	972	1,206	1,388	1,518	1,596	1,622	1,596	1,518	1,388	1,206



A2. Payoff with Group Tokens = 12 in each series

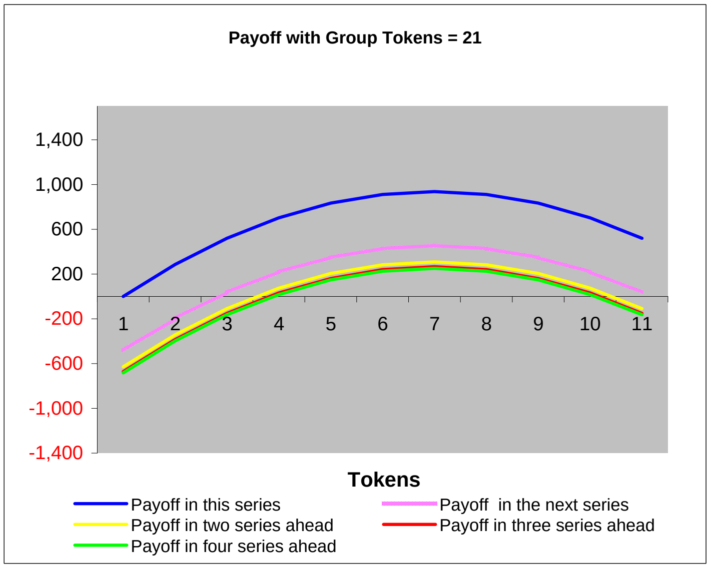
Your Tokens	Payoff Level	1	2	3	4	5	6	7	8	9	10	11
Payoff in this series	1394	1	287	521	703	833	911	937	911	833	703	521
Payoff in the next series	1394	1	287	521	703	833	911	937	911	833	703	521
Payoff in two series ahead	1394	1	287	521	703	833	911	937	911	833	703	521
Payoff in three series ahead	1394	1	287	521	703	833	911	937	911	833	703	521
Payoff in four series ahead	1394	1	287	521	703	833	911	937	911	833	703	521



Example 1 Scenarios

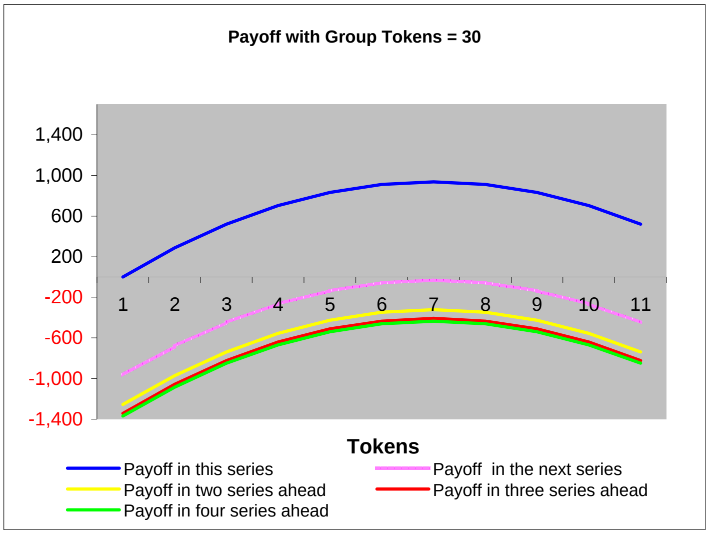
A3. Payoff with Group Tokens = 21 in each series

Your Tokens	Payoff Level	1	2	3	4	5	6	7	8	9	10	11
Payoff in this series	1394	1	287	521	703	833	911	937	911	833	703	521
Payoff in the next series	910	-483	-197	37	219	349	427	453	427	349	219	37
Payoff in two series ahead	765	-628	-342	-108	74	204	282	308	282	204	74	-108
Payoff in three series ahead	722	-671	-385	-151	31	161	239	265	239	161	31	-151
Payoff in four series ahead	709	-684	-398	-164	18	148	226	252	226	148	18	-164



A4. Payoff with Group Tokens = 30 in each series

Your Tokens	Payoff Level	1	2	3	4	5	6	7	8	9	10	11
Payoff in this series	1394	1	287	521	703	833	911	937	911	833	703	521
Payoff in the next series	427	-966	-680	-446	-264	-134	-56	-30	-56	-134	-264	-446
Payoff in two series ahead	137	-1,256	-970	-736	-554	-424	-346	-320	-346	-424	-554	-736
Payoff in three series ahead	50	-1,343	-1,057	-823	-641	-511	-433	-407	-433	-511	-641	-823
Payoff in four series ahead	23	-1,370	-1,084	-850	-668	-538	-460	-434	-460	-538	-668	-850



Post-Experiment Questionnaire

What do you think is the best number of tokens to order and why?
How did you make your decision to order?
How many tokens would you order if you are to participate again in this experiment?
How easy to understand were the instructions?
Was the main screen well organized?
Did you find yourself getting bored by the end?
Are you still glad you came (knowing that you are about to get paid)?
How many economics courses have you taken so far?
What is your major?
Please add any additional comments below