Managing the Tragedy of the Commons: A Partial Output-Sharing Approach

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Abstract

Common-pool resources (CPRs) suffer from a social dilemma known as the *'Tragedy of the Commons'*, in which a selfish individual's rational decision leads to over-extraction of the resources and, consequently, leads to depletion of the resources. We can overcome the commons problem by changing the incentive mechanism. Introducing sharing arrangements among resource users induces free-riding behavior which can offset the over-extraction and potentially achieve a socially optimal level of outcome. One potential method of achieving this is partial output-sharing. Under this process, resource users are pooled into a single group, then required to share a proportion of their output evenly with group members. I conduct a laboratory experiment to assess the effectiveness of the partial output-sharing model in CPR environments.

Keywords: Common Pool Resource, Group Behavior, Experiments

JEL Codes: C71, C92, Q28

Contents

1 Introduction

Common-pool resources (CPRs) are defined to be natural or man-made resources that are non-excludable and rivalrous. Anyone can extract resources and enjoy its benefits since the resources are open to everyone. One's extraction[1] of resources can exclude others from obtaining benefits from it since the resources are finite. Thus, individuals have the incentive to exploit the resources as much as possible before someone else takes them. Such behavior leads to the over-extraction of resources which causes a higher marginal cost since resources become harder to find, lower marginal benefit since the price of resources decreases, and consequently depletion of the resources. Since Hardin's (1968) seminal paper, the phenomenon is called '*Tragedy of the Commons*,' where individuals' rational decisions result in sub-optimal outcomes for the community. The most common examples are fishery, forestry, and groundwater irrigation. However, the '*Tragedy of the Commons*' problems are not limited to replenishable resources, but could also apply to non-replenishable resources such as crude oil, natural gas, and other underground resources. Rapid extraction of such resources could leads to losses while more advanced future technologies could increase extraction efficiency. Thus, avoiding rapid-extraction can increase aggregate outcomes which resemble that of fishery, forestry, and groundwater irrigation. Further, the commons dilemma could also be found in environmental resources such as clean air, since excessive pollution leads to environmental damage, biodiversity loss, and global warming (Barrett, 1994).

In many countries, individual quotas and individual transferable quotas (ITQs) have become popular management regimes in which a government agency announces a total allowable catch and determines how it is distributed among resource users. However, individual quotas and ITQs have several problems. First, they rely on accurate stock estimation which is often difficult in many CPRs. Second, they are susceptible to policymakers' interests. The total allowable catch may be based on election cycles and not on the long-term interest of

[1] In this paper, terms such as "extraction," "harvesting," "exploitation," and "appropriation" are used as equivalent terms for devoting effort to obtaining the product of a CPR.

resource users. Third, they provide incentives to harvest as much as legally possible which could lead to a high-grading problem, where fishermen discard low quality fish (Copes, 1986). However, there are some cases of successful government intervention to sustain CPRs. In the case of Maine lobster fishery and Chile shellfish fishery, territorial user rights for fisheries (TURFs) were established and the distribution of property rights was based on the territory and managed resources sustainably (Steneck et al., 2017). However, TURFs are only effective when the resources are stationary.

Looking at the problems of top-down management regimes, it seems advantageous to have bottom-up management regimes which provide resource users with control and long-term ownership over the resource. Community-based management regimes have the benefit of community members sharing and monitoring information about harvesting activities (Pinkerton, 1994). Ostrom, Gardner, and Walker (1994) summarize various community-based solutions to overcome the CPR problems. In particular, the research using laboratory experiments regarding CPRs provides useful insights on institutional change that could increase cooperation in CPR environments and potentially ameliorate the '*Tragedy of the Commons*' problem. Face-to-face communication (Ostrom and Walker, 1991), communication with sanctions (Ostrom et al., 1992), proposed rules and voting (Walker et al., 2000), and two-stage management where resource users voluntarily participate in preservation after appropriation (Botelho et al., 2015) prove to be effective at reducing the extraction of resources in the laboratory experiments.

We have looked at how changes in rules could encourage cooperation among resource users and reduce over-extraction. We can also manage the CPRs by changing the incentive mechanism of resource users. One such method is output-sharing (Schott, 2001; Heintzelman et al., 2009). The sharing arrangement induces free-riding behavior that reduces extraction of CPRs. The reduced appropriation could be beneficial in the context of CPRs where resource users are prone to over-harvest. Taking advantage of this feature, Schott (2001) proposed the 'Partnership Solution' that a socially optimum level of harvesting could be induced by dividing the set of resource users into a number of partnerships in such a way that each resource user's tendency to over-extract is exactly offset by the user's tendency to free-ride on the effort of others. Although Cherry et al. (2015) demonstrated that the 'Partnership Solution' is effective in laboratory experiments, its effectiveness in reducing over-extraction in real-world scenarios remains questionable. This uncertainty arises because motivations in field settings may differ from those in laboratory environments. Platteau and Seki (2001) documented the Japanese fishery communities that adopt pooling arrangement. In the interview, the fishermen never mentioned insuring against low catches as one of the motivations for forming output-sharing partnerships. Instead, the desire to avoid the crowding in attractive fishing spots is the motivation for adopting pooling arrangements. From the interview, we notice that the motivation for forming partnerships is to effectively extract more resources rather than to free-ride on the effort of others.

Another approach to utilize the free-riding feature in the context of CPRs is partial output-sharing. Instead of separating resource users into smaller groups and sharing all of the output, pooling all resource users into one large group and sharing only a portion of the output. In this setting, resource users who voluntarily joined the output-sharing group must share a certain proportion of their output to the group, then the shared outputs are distributed equally among group members. The sharing arrangement reduces the marginal benefit of extraction by converting part of the private benefit to the public benefit. The incentive structure is similar to that of a Pigouvian tax on harvest, where the tax revenue is evenly distributed among members.

The sharing arrangement solution offers multiple advantages for managing CPRs, compared to other methods. It directly addresses the commons problem's core issue—economic incentives—by adjusting key parameters to encourage sustainable management, even in non-cooperative scenarios. Additionally, its political acceptability is enhanced since resource rents stay with the users and participation is voluntary, making it preferable to taxes or Individual Transferable Quotas (ITQs).The partial output-sharing model, a variant of the full-output sharing model[2] further benefits from its centralized management structure with one large group in the community. This setup enables organized decision-making that represents all group members, improving information sharing and monitoring of harvesting activities. Unlike the full-output sharing model, where partnerships may frequently change, leading to instability, the partial output-sharing model promises more consistent and stable management over time.

There are many studies on the full output-sharing model including theoretical analysis (Schott, 2001; Heintzelman et al., 2009), and laboratory experiments (Schott et al., 2007; Cherry et al., 2015; Buckley et al., 2018). The key findings are: 1) Increase in group size significantly reduces harvest effort which closely traced Nash predictions, but group assignment makes no significant difference whether it is random or fixed for the period (Schott et al., 2007), 2) Confirmed that right-sized groups reduce harvest effort to the socially optimal level and found systematic deviation toward the socially optimal level due to both altruism and conformity (Cherry et al., 2015), and 3) Local communication within partnerships decreases efficiency because of less free-riding and allowing global communication worsens the efficiency (Buckley et al., 2018).

On the contrary, we know little about the effectiveness of the partial output-sharing model. In particular, there is no research on the behavioral aspect of the partial output-sharing model. To the best of my knowledge, there is one paper by Tilman et al. (2018). They studied the partial output-sharing model[3] using game theoretic analyses and agent-based modeling simulations. They found that output-sharing arrangements can emerge and lead to improvements in resource management under certain conditions[4].

The goal of this study is to examine the effectiveness of the partial output-sharing model in the context of the CPR problem using a laboratory experiment. This will provide behav-

[2]Also known as the partnership solution (Schott, 2001; Schott et al., 2007; Heintzelman et al., 2009; Cherry et al., 2015; Buckley et al., 2018).

[3]Authors called it the revenue-sharing club.

[4]When there is large variability in production and when this variability is uncorrelated across members of the partial output-sharing group.

ioral evidence on the partial output-sharing model. The previous study on the partnership solution has found that the output-sharing reduced appropriation effort and the effect increased with group size (Cherry et al., 2015). We may expect that the partial output-sharing model will reduce appropriation effort, but it is not so clear what percentage of sharing will be most efficient for the community. Although several studies (Schott et al., 2007; Cherry et al., 2015; Buckley et al., 2018) have shown that the appropriation effort coincided with the Nash predictions which assume selfish and rational preferences, we may expect more cooperative behavior in the partial output-sharing model as it unites the community by tying them to a common group, creating a stronger sense of unity. Fischbacher et al. (2001) found that about a third of subjects showed behavior consistent with *homo economicus* and about half displayed conditional cooperation which further complicates our predictions. Thus, it is essential to study the partial output-sharing model in the laboratory to obtain behavioral evidence.

In the rest of the paper, I describe the experimental design to study the effectiveness of the partial output-sharing model using CPR games in the laboratory and discuss the potential analyses, policy implications, and future works. The paper proceeds as follows: section 2 outlines CPR model in detail. section 3 describes the experimental design, including the treatments, parameter choices, Social Value Orientation task, survey, and experimental procedures. In section 4, I will discuss future analyses. Section 5 discusses the implication of the research and future works. Subject instructions are included in the appendix.

2 The Common-Pool Resource Model

The early model in CPR games is based on the public good game. Andreoni (1995) introduced negatively framed public good games that are different from positively framed typical public good games. In a typical public good game, each person in a group is endowed with some money first, then each person decides how much to contribute to public goods for the group. The amount of contribution will be multiplied by M and then divided evenly to people. Here, $M > 1$ captures the positive externality from the contribution. On the other hand, in a negatively framed public good game, the endowment is a group resource first, and then each person in the group decides how much to appropriate from the group resource.

$$u_i(x) = x_i + \frac{M}{N}(E - \sum_{j=1}^{N} x_j) \tag{1}$$

In this game, the pooled endowment $E = \sum_{j=1}^{N} e_j$ is given, and each person decides how much to appropriate, x_i. The payoff of each person, $u_i(x)$, is decided by how much they appropriate from the group resource, x_i, and how much is left after the group's total, which is multiplied by M and then divided equally among group members. This is called an appropriation game. Later, Ostrom et al. (1994) introduced CPR game that added more features of common resources to Andreoni's appropriation game.

In the CPR games, there are n appropriators with access to the CPR. Each appropriator i has an endowment of e which can be invested either in the CPR or a safe, outside activity. The marginal payoff of the outside activity is equal to w. The payoff to an individual appropriator from investing in the CPR depends on the aggregate group investment in the CPR and on the appropriator investment as a percentage of the aggregate. Let x_i denote appropriator i's investment in the CPR, where $0 \leq x_i \leq e$. The group return to investment in CPR is given by the production function $F(\sum x_i)$, where F is a concave function, with $F(0) = 0$, $F'(0) > w$, and $F'(ne) < 0$. Initially, investment in the CPR pays better than the opportunity cost of the forgone safe investment $[F'(0) > w]$; but if the appropriators invest all resources in the CPR, the outcome is counterproductive $[F'(ne) < 0]$. Thus, the yield from the CPR reaches a maximum net level when individuals invest some, but not all, of their endowments in the CPR (See figure 1).

$$
\begin{aligned}
u_i(x) &= we \text{ if } x_i = 0 \\
&= w(e - x_i) + (x_i / \sum x_i) F(\sum x_i) \text{ if } x_i > 0
\end{aligned} \tag{2}
$$

Let the payoff in the equation 2 be the payoff functions in a symmetric, non-cooperative game. There is a symmetric Nash equilibrium, with each player investing x_i^* in the CPR, where

$$
-w + (1/n)F'(nx_i^*) + F(nx_i^*)[(n-1)/x_i^* n^2] = 0 \tag{3}
$$

For the optimal solution to the group, summing across individual payoffs $u_i(x)$ for all appropriators i, we have group payoff function

$$
u(x) = nwe - w \sum x_i + F(\sum x_i),
$$

which is to be maximized subject to the constraints $0 \leq \sum x_i \leq ne$. Given, the production function F, the group maximization problem has a unique solution characterized by the condition:

$$
-w + F'(\sum x_i) = 0 \tag{4}
$$

According to equation 4, the marginal return from a CPR should equal the opportunity cost of the outside alternative for the last unit invested in the CPR. Note that neither Nash equilibrium investment nor the optimum group investment depend on the endowment e, as long as e is sufficiently large. However, out of equilibrium, larger e means players are capable of making larger negative yields when appropriating too much from CPR.

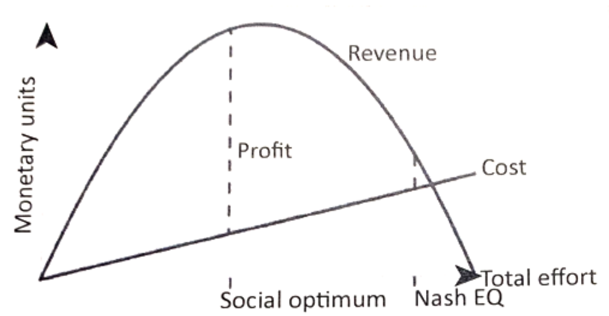

Figure 1: Production function for CPRs

3 Experimental Design

In experiments that use CPR games, the CPR scenario is modeled using quadratic production functions denoted as $F(\sum x_i)$, where $F(\sum x_i) = a\sum x_i - b(\sum x_i)^2$ with conditions that $F'(0) = a > w$ and $F'(ne) = a - 2bne < 0$. This quadratic specification leads to a payoff function where the investment level at symmetric Nash equilibrium $x_i = (a-w)/(n+1)b$ falls between the maximal net yield (the group optimum) condition $x_i = (a-w)/2nb$ and the zero net yield condition $x_i = (a-w)/nb$.

$$\begin{aligned} u_i(x) &= we \text{ if } x_i = 0 \\ &= w(e - x_i) + \big(\frac{x_i}{\sum x_i}\big)\big(a\sum x_i - b(\sum x_i)^2\big) \text{ if } x_i > 0 \end{aligned} \tag{5}$$

3.1 CPR Games and Partial Output-Sharing Treatments

I use the CPR game as the baseline game, following the seminal work of Ostrom et al. (1992). In CPR games, subjects are randomly assigned into the group size of N. After the group assignment, subjects are given an endowment e by the experimenter, and they must allocate this endowment between two possible investments. One option is to invest in a safe, outside activity which gives a fixed return, w on each invested endowment. The other option is to invest in the CPR which gives variable returns depending on the aggregate group investment in the CPR, X. As the aggregated group investment in the CPR increases, the returns from investment in the CPR decreases. The individual payoff for CPR games in each round is expressed in equation 6.

$$\pi_i = w(e - x_i) + x_i(a - bX) \tag{6}$$

For the partial output-sharing treatments, two components are added from the baseline CPR games to operationalize the partial sharing among group members. One component is the percentage of sharing arrangement, $\lambda \in [0, 1]$, and the other component is the additional income source from the equal distribution of the shared output from the group. In the partial output-sharing treatments, similar to the CPR games, subjects are randomly assigned into the group size of N. Then, they are given an endowment e to allocate between two possible investments. However, they must share λ percentage of their output from the investment into the CPR. The shared output will be distributed equally to the group members. The λ is the key parameter of the partial output-sharing model since it controls the individual's final payoff, and thus it governs the individual's behavior. As the sharing arrangement λ increases, the benefit of appropriation from CPR decreases, while the benefit from the shared income increases, which results in reduced appropriation of CPR. For example, if an individual decides not to appropriate CPR and stays home, the individual earns $w * e$ plus the amount shared from the group. An individual who decides to appropriate x_i, earns $w * (e - x_i)$ plus their own portion of the output from the appropriation of CPR plus the amount shared from the group (See equation 7).

$$\pi_i = w(e - x_i) + x_i(1 - \lambda)(a - bX) + \frac{\lambda}{N}(aX - bX^2) \tag{7}$$

We can set the percentage of sharing arrangement, λ to satisfy the investment level at symmetric Nash equilibrium in equation 8 to meet the group optimum condition $x_i =$

$(a-w)/2nb$.

$$x_i = \frac{(1-\lambda+\lambda/n)a - w}{\big((n+1)-\lambda(n-1)\big)b} \tag{8}$$

3.2 Parameter Choices

Table 1: Parameters for a Given Decision Round

		Type of Experiment	
	Parameters	Main	Supplementary
Number of subjects	N	8	8
Individual token endowment	e	25	25
Production function	$aX - bX^2$	$20X - 0.1171X^2$	$13X - 0.0375X^2$
Market 1 return/ unit of output	w	5 ECU	7 ECU
Nash equilibrium investment in Market 2		14	18
Group maximum investment in Market 2		8	10
Earnings/ subject at group maximum		185 ECU	205 ECU
Earnings/ subject at Nash equilibrium		148.7 ECU	186 ECU
Earnings difference: Group max vs Nash (%)		20%	9%
Optimum sharing arrangement	λ^*	0.60	0.30

I focus on experiments utilizing the parameters shown in table 1. Parameters for the number of subjects and the individual token endowment are chosen based on the experiments from Ostrom et al. (1992), Walker and Gardner (1992), and Ostrom et al. (1994). Other parameters, such as the production function for investing in CPR, and a fixed return from other activities, are selected to ensure that both the Nash equilibrium and the group maximum investment in CPR are close to integer values. The main parameters are chosen to guarantee that the difference in individual earnings between the group maximum and the Nash equilibrium is 20%. The optimum sharing arrangement in the main parameters, denoted by λ, is 0.6. This implies that self-interested subjects under a partial output-sharing treatment with $\lambda = 0.6$ will choose to appropriate in CPR at the socially optimal level. I selected the supplementary parameters to make the optimal sharing arrangement half of that in the main parameters, where λ is 0.3. Figures 2 and 3 depict the theoretical predictions of an individual appropriation in CPR when varying the sharing arrangement level, λ, for the main and the supplementary parameters, respectively.

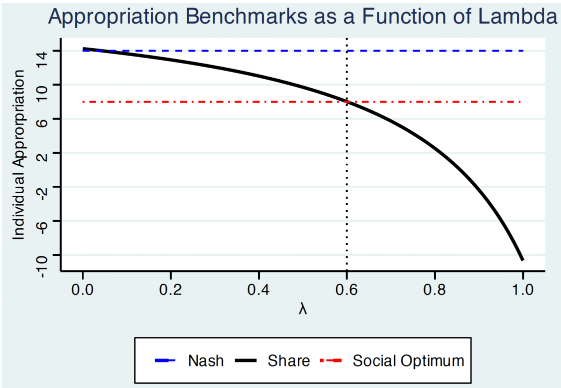

Figure 2: Appropriation benchmark as a function of percentage of sharing (λ) on the main parameters

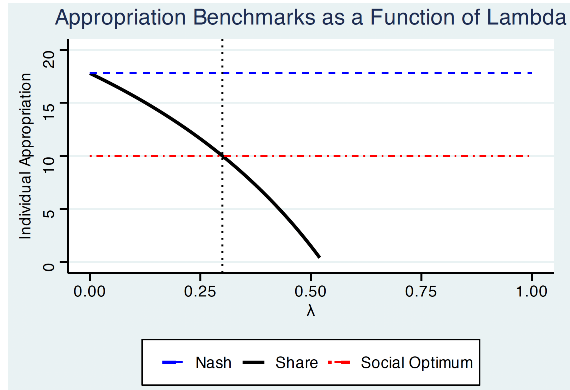

Figure 3: Appropriation benchmark as a function of percentage of sharing (λ) on the supplementary parameters

3.3 Social Value Orientation

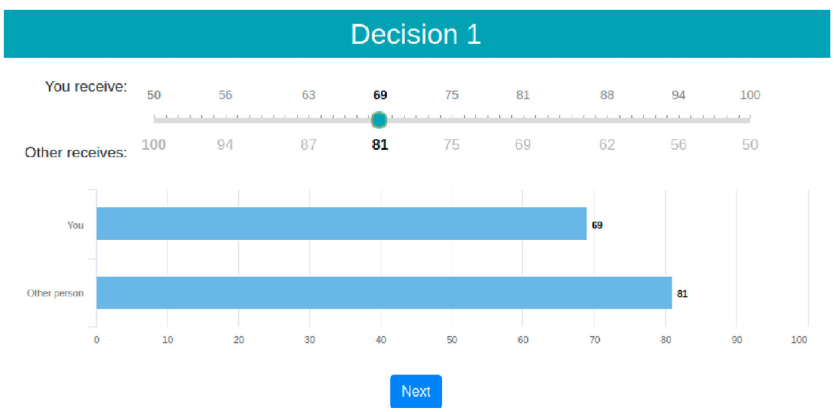

Figure 4: *Source:* Crosetto et al. (2019). Screenshot of Social Value Orientation Task.

To assess subjects' other-regarding preferences, their Social Value Orientation (SVO) is measured using a Social Value Orientation Slider Measure (Crosetto et al. 2019; Murphy et al. 2011). In this measure, subject make 15 independent allocation decisions in dictator games. Figure 4 shows the screenshot of the decision task. The decisions include how to split a fixed endowment between oneself and the receiver to measure altruism, equality, or selfishness. Furthermore, some decisions yield additional payoff when giving, which increase the sum of joint payoffs to measure efficiency concerns. Responses can be scored to yield a single angle-index of a participant's SVO, where low values indicate a pro-self orientation and high values indicate a prosocial orientation. The SVO score can help in interpreting the behavior in CPR games. Payoffs are determined from one randomly selected round where the subject is a proposer and one where the subject is a receiver.

3.4 Survey

On top of the payoffs from the games, subjects will receive a \$3 bonus for filling out the questionnaire at the end of the experiment to avoid the income effect of the participation fee. The questionnaire includes questions on demographics, strategies, preferences over two games, and beliefs about others in the group.

3.5 Experimental Procedures

There will be randomly assigned subjects with a group size of 8. The session will consist of two CPR games of 10 rounds. I will use three different CPR games by varying the intensity of the sharing arrangement, λ. The baseline game is the typical CPR game without any sharing arrangement, which represents the natural state. The second game is a 60% output-sharing game. In this game, everyone in the group is forced to enroll in the partial output-sharing group, thus they must share 60% of their output from CPR to the group account, then it will be distributed equally among group members. The $\lambda^* = 0.6$ is chosen from the symmetric Nash equilibrium prediction in which individuals' selfish decision is equal to the social optimal appropriation. The third game is a 30% output-sharing game. Similar to the second game, everyone in the group is forced to enroll in the partial output-sharing group, thus they must share their output with the group members. But, the sharing arrangement is reduced by half from the second game. For simplicity, I will refer to the baseline game, the 60% output-sharing game, and the 30% output-sharing game as Game A, Game B, and Game C, respectively.

There are three different treatment sessions in the experiment. All subjects will play game A first, then subjects play one of the three games for the second game. Thus, the experimental design is AA, AB, and AC. The design has both within-session variation and between-session variation. There are several advantages to this design. First, the institutional changes take place after the natural state, which resembles the real-world implementation. We can observe how subjects react to policy changes that potentially provide insights into how we should implement a partial output-sharing model. Second, playing the baseline game first alleviates the concern for learning during the session. Subjects will gain a sufficient understanding of the game by playing the baseline game for 10 rounds. This will allow me to estimate the treatment effect by comparing the result from the second game A, B, and C.

The detail of the gameplay is as follows. First, after the subject instructions, the subjects will be randomly assigned to groups of 8. Then the subject will play 10 rounds of game A followed by either game A, B, or C. After the group assignment, the subject will decide how much to appropriate from the CPR, x_i for each round. After all subjects in the group submit decisions privately, payoffs for the round are determined. Subjects will receive information on their own payoff, and payoff decomposition including earnings from appropriation, earnings from other work, and earnings from the group account. They will also receive information on the total appropriation of the group, and the history of their earnings in each round. Earnings will be accumulated for all 20 rounds of CPR games.

Once they complete CPR games, subjects will complete the Social Value Orientation task, which consists of 15 sets of dictator games. For the payoff, one randomly selected round as the proposer, and the one randomly selected round as the receiver will be realized and added to the final payoff.

At the end of the experiment, subjects will fill out the post-survey which mainly asks for information about the demographics of the subject. Subjects will be paid a fixed amount of \$3 in return for completing the survey.

Final payoff for the subjects will be the sum of accumulated earnings from the CPR games, earnings from SVO task, and $3 from the completing the post-survey, which will be converted to United States dollars and paid in cash at the end of the session. Table 2 shows the experimental procedures.

Table 2: Experimental Procedures

Part 1	Common-Pool Resource Games (AA, AB, AC)
	Instructions for CPR Game A (Baseline)
	Game A: 10 Rounds
	Instructions for CPR Game A or B or C
	Game A or B or C: 10 Rounds
	Payoff: Pay all sequentially.
Part 2	Social Value Orientation Tasks
	Instructions for SVO tasks
	Dictator Game: 15 Games
	Payoff: One randomly selected round (Proposer) One randomly selected round (Receiver)
Part 3	Post-Survey
	Questionnaire through Qualtrics
	Payoff: $3

4 Analysis

Using the data obtained from the experiments, I can test the following hypotheses.

Hypothesis 1 (H1): *Subjects will appropriate less in the partial output-sharing model than in the baseline model.*

Hypothesis 2 (H2): *Total appropriation decreases as the proportion of sharing increases.*

Hypothesis 3 (H3): *Subjects will appropriate at the socially optimum level in the partial output-sharing model.*

For the first and second hypotheses, I can compare the average appropriation from each game played in the second half of the CPR games. If the average appropriation is less in game B and C than game A, we can conclude that the first hypothesis is true. If the average appropriation is less in game C than game B, we can argue that the second hypothesis is also true. For the third hypothesis, I will compare the average appropriation and net payoff for each round. If the average appropriation converges to the social optimum, and the net payoff converges to the social maximum amount, we can conclude that the third hypothesis is true.

I can also estimate the average treatment effect of the partial output-sharing model using within-subject comparison. Concerning the learning effect, I will exclude the first few rounds for each game when executing the within-subject comparison. Moreover, if I can observe some stylized behavior for each individual, then I can potentially classify subjects into some categories such as free-rider, over-appropriator, or rational player.

5 Discussion

5.1 Policy Implications

If the result proves the effectiveness of the partial output-sharing model in reducing the over-extraction in the CPR environment, the partial output-sharing model could be considered as one of the potential policy tools to control the sustainability of the commons. Although it is difficult to conclude that the new model works in the field from the evidence from one laboratory experiment, the study could provide insights into a potential solution in the real world.

5.2 Future Works

The partial output-sharing model can be further tested in the laboratory with settings that resemble the real world. After sufficient knowledge of the model is gained from the laboratory experiments, the model can be tested outside the laboratory in the field, possibly a fishery, to provide insights on the implementation of the model.

5.2.1 Free to Join the Group

The first extension of the partial output-sharing model is to let people freely join the sharing group. In the previous experiment, we forced every subject to be enrolled in the sharing group. However, in this experiment, all subjects are in a natural state, and they can decide whether to join the partial output-sharing group at the beginning of each round. To encourage the subject to join, a subsidy such as a sign-up bonus will be provided. Once they decided to join, they must stay with the group. This experiment would shed light on voluntary participation in resource preservation. It can also provide insights into how to implement the model in the real world.

5.2.2 Vote to Choose the Sharing Intensity

The second extension of the partial output-sharing model is to let people vote to choose their own group's sharing intensity for each round. There will be two stages for the voting. The first stage is the anonymous proposal of the sharing intensity. Then at the second stage, subjects vote for the proposed intensities. If there is a tie, there will be a runoff voting for tied proposals. It would be interesting to see if subjects can find the optimum sharing arrangement found in the previous experiment and if subjects can achieve social optimum. Given that many studies conclude voting encouraged subjects to play cooperatively, we may expect that the social optimum would be achieved with a lower sharing arrangement than we found in the original study.

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Subject Instruction

General Information

Welcome to Experimental Economics Center. Thank you for participating in this experiment. Please note that all personal electronics must be turned off and put away during the experiment session.

No Talking Allowed
Now that the experiment has begun, we ask that you do not communicate with other participants. If you have any questions after we finish reading the instructions, please raise your hand and the experimenter will answer your question in private.

Complete Privacy
This experiment is structured so that no one, including the experimenters or the other participants, will ever know your personal decision or money earnings in the experiment. This is accomplished by giving you the only key to a numbered mailbox that contains a sealed envelope with your earnings inside. Your privacy is guaranteed because neither your name nor student ID number will be entered into the computer that records your decisions in the experiment. The only identifying information that will be used is the number on the mailbox key that has been given to you. You will collect your money payoffs with privacy by using the key, which opens a mailbox located in the reception room. The key and mailbox are labeled with the same number. You are the only person who knows your key and mailbox number.

Two Parts
In this experiment, there will be two parts. The first part consists of two games, and each game consists of ten rounds. The second part consists of fifteen decision tasks. Your final earnings will be the sum of the earnings from each part.

Cash Payoffs
Your earnings in this experiment are expressed in EXPERIMENTAL CURRENCY UNIT, which we will refer to as ECUs. At the conclusion of the experiment you will be paid in U.S. dollars using a conversion rate of $1 for every 200 ECUs of earnings from the experiment.

200 ECU = $1

If you read the instructions carefully and act wisely, you can earn a considerable amount of money. Your earnings in this experiment depend both on your decisions and the decisions of others.

If you have any questions, please raise your hand and wait for the experimenter to come and help you.

Part 1

Random Matching and Anonymity
You will be randomly matched with 7 other people to form a group of 8 individuals that will stay the same for Part 1.

Multiple Rounds
This experiment consists of a TWO games, and each game consists of TEN decision rounds. In each round, you will face the same decision task. The decision task in each round is described below.

Settings
You will be playing an investment game. You will be making 10 investment decisions in each game. In each round, you will be endowed with 25 tokens and decide how much to invest in two different markets.

- Market 1 will yield a fixed amount of return on each tokens invested.
- Market 2 will yield a a variable return that depend on the total investment including yours.

Your earnings depend on your own decision and others' decision in your group.

Game A: Baseline

In this game, there are 10 rounds. In each round, you will receive **25 tokens**. You will decide **how many tokens to invest in Market 2**. The tokens not invested in Market 2 will be automatically invested in Market 1.You will receive earning in ECUs from your investment of Market 1 and Market 2.

- Market 1: You will receive 5 ECUs for each token invested in Market 1.
- Market 2: Your return on investment in Market 2 is decided by the group's total investment in Market 2.

  The return for each token invested in Market 2 is:

  $$\mathbf{20 - 0.1171 * (\text{group's total investment in Market 2}) \text{ ECUs per token}}$$

Notice that return on investment in Market 2 decreases as the group's total investment in Market 2 increases.

For example, if the **group's total investment in Market 2 is 60, and you decided to invest 10** tokens in Market 2. The return on Market 2 will be $\mathbf{20 - 0.1171 * 60 = 12.97}$ **ECUs** for each token invested. Your earnings from the the Market 2 is **129.7 ECUs**. For your remaining tokens of **15**, you will earn **5 ECUs** for each invested tokens in Market 1, which is **75 ECUs**. Thus, your final earned tokens this round will be **204.7 ECUs**.

After everyone has submitted, the earnings of the round will be calculated and shown to you.

Rules

- The game consists of **10 rounds**.
- You will be **given 25 tokens** in every round and submit how much to invest in Market 2.
- The return on Market 2 is decided by the group's total investment in Market 2.

  $\mathbf{20 - 0.1171 * (Group's\ Total\ Investment\ in\ Market\ 2)\ ECUs\ per\ token}$
- The return on Market 1 is **5 ECUs** per token.
- Your earnings for the round is

  $\mathbf{Investment\ in\ Market\ 2 * (20 - 0.1171(Group's\ Total\ Investment\ in\ Market\ 2)) + Investment\ in\ Market\ 1 * 5}$

- After everyone submitted, you will see your earnings.

Examples

- **Situation 1**
  This is round 1 of the game.
  Let's assume that in this round, the group's total investment in Market 2 was **60**.
  Thus, the return from Market 2 is $\mathbf{20 - 0.1171 * 60 = 12.97}$ **ECUs**.

  If you decided to invest **10 tokens** in Market 2.
  You will be earning $\mathbf{10 * 12.97 = 129.7}$ **ECUs** from Market 2 , $\mathbf{5 * 15 = 75}$ **ECUs** from Market 1.
  Thus, Your earnings in this round is **204.7 ECUs**.

- **Situation 2**
  This is round 5 of the game.
  Let's assume that in this round, the group's total investment in Market 2 was **120**.
  Thus, the return from Market 2 is $\mathbf{20 - 0.1171 * 120 = 5.95}$ **ECUs**.

  If you decided to invest **10 tokens** in Market 2.
  You will be earning $\mathbf{10 * 5.95 = 59.5}$ **ECUs** from Market 2, $\mathbf{5 * 15 = 75}$ **ECUs** from Market 1.
  Thus, Your earnings in this round is **134.5 ECUs**.

Game B: 60% Partial-Output Sharing

In this game, there are 10 rounds. In each round, you will receive **25 tokens**. You will decide **how many tokens to invest in Market 2**. The tokens not invested in Market 2 will be automatically invested in Market 1.You will receive earning in ECUs from your investment of Market 1 and Market 2.

But the following is new in this game:

Now you are **sharing 60% of returns from Market 2** with the group members. You will only keep 40% of returns from Market 2. This means that you will also **receive an equal amount from the group's share**. You will **not be sharing the returns from Market 1**.

- Market 1: You will receive 5 ECUs for each token invested in Market 1.
- Market 2: Your return on investment in Market 2 is decided by the group's total investment in Market 2.

  The return for each token invested in Market 2 is:

  $$\mathbf{20 - 0.1171 * (group's\ total\ investment\ in\ Market\ 2)\ ECUs\ per\ token}$$

Notice that return on investment in Market 2 decreases as the group's total investment in Market 2 increases.

Also, you must share 60% of your earnings from Market 2 with your group members, and receive equal distribution from the group account.

For example, if the **group's total investment in Market 2 is 60, and you decided to invest 10** tokens in Market 2. The return on Market 2 will be $\mathbf{20 - 0.1171 * 60 = 12.97}$ **ECUs** for each token invested. Your earnings from the the Market 2 is **129.7 ECUs**. However, you only keep 40% of it, which is **51.9 ECUs**, and contribute remaining of your earnings from Market 2 to group account. For your remaining tokens of **15**, you will earn **5 ECUs** for each invested tokens in Market 1, which is **75 ECUs**. If group account is 460 ECUs, then you will receive an equal share of it, which is **57.5 ECUs**. Thus, your final earned tokens this round will be $\mathbf{75 + 51.9 + 57.5 = 184.4}$ **ECUs**.

After everyone has submitted, the earnings of the round will be calculated and shown to you.

Rules

- The game consists of **10 rounds**.
- You will be **given 25 tokens** in every round and submit how much to invest in Market 2.
- The return on Market 2 is decided by the group's total investment in Market 2.

  $$\mathbf{20 - 0.1171 * (Group's\ Total\ Investment\ in\ Market\ 2)\ ECUs\ per\ token}$$

- The return on Market 1 is **5 ECUs** per token.

- You must **put 60% of your returns from Market 2 into a group account**.
- The tokens in the **group account will be distributed equally to group members**.
- Your final earnings for the round is the sum of the followings:
  - Return from Market 1
  - 40% of the Return from Market 2
  - An equal distribution from the group account.
- After everyone submitted, you will see your earnings.

Game C: 30% Partial-Output Sharing

In this game, there are 10 rounds. In each round, you will receive **25 tokens**. You will decide **how many tokens to invest in Market 2**. The tokens not invested in Market 2 will be automatically invested in Market 1.You will receive earning in ECUs from your investment of Market 1 and Market 2.

But the following is new in this game:

Now you are **sharing 30% of returns from Market 2** with the group members. You will only keep 70% of returns from Market 2. This means that you will also **receive an equal amount from the group's share**. You will **not be sharing the returns from Market 1**.

- Market 1: You will receive 5 ECUs for each token invested in Market 1.
- Market 2: Your return on investment in Market 2 is decided by the group's total investment in Market 2.

  The return for each token invested in Market 2 is:

$$\mathbf{20 - 0.1171 * (\text{group's total investment in Market 2}) \text{ ECUs per token}}$$

Notice that return on investment in Market 2 decreases as the group's total investment in Market 2 increases.

Also, you must share 30% of your earnings from Market 2 with your group members, and receive equal distribution from the group account.

For example, if the **group's total investment in Market 2 is 60, and you decided to invest 10** tokens in Market 2. The return on Market 2 will be $\mathbf{20-0.1171*60 = 12.97}$ **ECUs** for each token invested. Your earnings from the the Market 2 is **129.7 ECUs**. However, you only keep 70% of it, which is **90.8 ECUs**, and contribute remaining of your earnings from Market 2 to group account. For your remaining tokens of **15**, you will earn **5 ECUs** for each invested tokens in Market 1, which is **75 ECUs**. If group account is 460 ECUs, then you will receive an equal share of it, which is **57.5 ECUs**. Thus, your final earned tokens this round will be $\mathbf{75 + 90.8 + 57.5 = 223.3}$ **ECUs**.

After everyone has submitted, the earnings of the round will be calculated and shown to you.

Rules

- The game consists of **10 rounds**.
- You will be **given 25 tokens** in every round and submit how much to invest in Market 2.
- The return on Market 2 is decided by the group's total investment in Market 2.

  $\mathbf{20 - 0.1171 *}$ **(Group's Total Investment in Market 2) ECUs per token**
- The return on Market 1 is **5 ECUs** per token.
- You must **put 30% of your returns from Market 2 into a group account**.
- The tokens in the **group account will be distributed equally to group members**.
- Your final earnings for the round is the sum of the followings:
  - Return from Market 1
  - 70% of the Return from Market 2
  - An equal distribution from the group account.
- After everyone submitted, you will see your earnings.

Part 2

Random Matching and Anonymity
For each decisions, you will be randomly matched with one other person from this room. Matching will change every round.

Multiple Rounds
This part consists of a one games that consists of FIFTEEN decision rounds. In each round, you will face the similar decision tasks. The decision tasks in each round is described below. Your earnings in this part will be the sum of earnings from one randomly chosen round as a proposer and one randomly chosen round as a receiver.

Decision Tasks
You will be presented with two sliders. One on the top slider value indicates your earnings from the round, and the other one on the bottom slider value indicates earning for other person that you are matched with for the round. Move sliders to make decision between your earning and the other person's earning for the round.