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SOCIAL DILEMMAS: EXTERNALITIES, SPARSE INSTITUTIONS, AND BEHAVIOR

by

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I. Introduction

In the context of individual and group decision making, the existence of social dilemmas imply a divergence between expected outcomes and outcomes that would be optimal from the perspective of the group. The existence of social dilemmas and the degree of predicted suboptimality depends on three components of the decision situation: (1) the existence of a physical domain in which there are externalities in production or consumption, (2) modes of behavior in which individuals make decisions based on calculations that do not fully incorporate the utilities of others, and (3) an environment or institutional setting that does not create incentives for internalizing such externalities into each individual's decision calculus.

Externalities occur when the actions of one individual create a positive (negative) impact on other individuals. Such externalities create a divergence in the private costs or benefits from an action and the full social costs or benefits from that action. When individuals make choices that do not fully account for all social costs or benefits, then-choices lead to outcomes that are suboptimal from the perspective of the group. The empirical significance of social dilemmas thus depends on the physical characteristics of the externalities created in a given situation, the paradigmatic mode of behavior of individuals in that situation, and the incentives created by the institutions governing the situation-

Drawing on results from several laboratory studies, this paper explores the links between these components of a social dilemma in the context of two stylized decision situations; public goods and common pool resources. These two situations offer several contrasting characteristics that shed light on the process of group and individual decision making and on the empirical significance of social dilemma problems. Public goods are man-made facilities (or services) where the production of the public good by one individual (or contribution to provision) creates an external benefit that is shared by other individuals.[1] Common-pool resources are natural or man-made resources in which appropriation by one individual creates an external cost on other users. Exclusion from obtaining external benefits in the case of public goods or exclusion from the resource in the case of common-pool resources is considered to be infeasible or nontrivial from either a technological, constitutional, or economical perspective. Both situations are generally assumed to create a social dilemma due to the externalities created by individuals in their production or appropriation decisions. This prediction is based on a paradigm of self interested behavior and an institutional structure that does not yield individual incentives in accordance with group optimality. Under production is predicted in the case of public goods and over appropriation is predicted in the case of common pool resources.

This paper is organized around four principal sections. In the next two sections, the laboratory decision situation, theoretical benchmarks, and summary observations are presented for the public goods and common-pool resource environments. Following this summary discussion, a closer look is taken at individual decisions in these two environments. Following the discussion of experimental results, issues related to differences in behavior across these two social dilemmas situations are addressed.

II. Public Goods

The Decision Environment - VCM

Consider the operationalization of a public goods situation utilizing the following decision framework, commonly referred to as the voluntary contributions mechanism (VCM).[2] N subjects participate in a series of decision rounds. Each participant is endowed with z tokens that are to be divided between a 'private account' and a 'group account.' Tokens cannot be carried across rounds. The subject is informed that for each token he/she places in the private account he/she earns p cents with certainty. The subject is also informed that earnings from the group account are dependent upon the decisions of all group members. For a given round, let X represent the sum of tokens placed in the group account by all individuals in the group. Earnings from the group account are dependent upon the preassigned earnings function G(X). Each individual receives earnings from the group account regardless of whether he/she allocates tokens to that account–thus the publicness (nonexcludability) of the group account. For simplicity, each individual is symmetric with respect to his/her earnings from the group account. That is, each earns an equal amount from the group account equal to [G(X)]/N cents. Figure 1 illustrates the type of information subjects receive for a given parameterization of the game. Prior to the start of each decision round, each individual knows the number of remaining rounds, the groups' aggregate token endowment, and the groups' aggregate token allocation to the group account in previous rounds. It is explained that the decisions for each round are binding and rewards are based on the sum of earnings from all rounds. During each round, subjects can view their personal token allocations, earnings, and total tokens from the group placed in the group account for all previous rounds.[3]

Each participant's decision to allocate a marginal token to the group account costs that individual p cents. For appropriate initializations, however, allocations to the group account yield a positive gain in group surplus of $[G'(\bullet) - p]$. In the experiments that we focus upon here, p = \$.01, so the strategic nature of the game depends on the parameterizations utilized for G(X). In particular, for the individual, the strategic nature of the game depends on critically on the marginal per capita return from the group account (MPCR), defined as the ratio of '\$' benefits to costs for moving a single token from the individual to the group account, or $[G'(\bullet)/N]/p$. The behavioral results summarized below, focus on two alternative parameterizations that have been investigated by the author and coauthors in previous work.

In the first parameterization, G(X) is linear, with G' a constant greater than \$.01 and $[G'(\bullet)/N] <$ \$.01. Given these specifications, the Pareto Optimum (defined simply as the outcome that maximizes **group** earnings) is for each individual to place all tokens in the group account. Further, from the perspective of the group, for any level of group good provision, group earnings increase with increases in MPCR and, holding MPCR constant, group earnings increase with increases in N. On the other hand, the single-period dominant strategy is for each individual to place zero tokens in the group account. The 'social dilemma' follows strategically because p and $G(\bullet)$ are chosen so that the MPCR < 1. For finitely repeated play, the outcome of **zero** allocations to the group account is also the unique, backward induction, complete information Nash equilibrium. In summary, for all parameterizations in which MPCR < 1, complete information noncooperative game theory yields the same prediction – zero allocations to the group account.

For the second parameterization, consider the case where G(X) is quadratic. In particular, consider parameterizations of the form $G(X) = BX-CX^2$ and $[G'(\bullet)/N] > .01$ for initial allocations to the group account, but declining so that $[G'(\bullet)/N]$ becomes equal to .01 at some allocation level X_{NASH}. With this parameterization, the Nash equilibrium for a single play of the game is for group allocations to the group account to equal X_{NASH}. However, the Pareto Optimal allocation of tokens to the group account is an allocation level where $G'(\bullet) = .01$, an allocation level greater than that predicted by the Nash equilibrium.

For clarification, a diagrammatic exposition of the two types of parameterizations are shown in Figure 2. Both panels display characterizations of: marginal private benefits (MPB) from provision of the public good, marginal social benefits (MSB) from provision of the public good, and marginal cost (MC) of provision of the public good. The upper panel displays a characterization of a setting where the Nash equilibrium implies a zero allocation to the group account. The lower panel displays a characterization in which the Nash equilibrium is an "interior" prediction of X_{NASH} tokens allocated to the group account.

Summary Results - VCM

Consider first the set of experiments where zero tokens allocated to the group account is the Nash equilibrium prediction. Behavior from experiments involving groups of size 4, 10, 40, and 100 yield the following summary conclusions.

1. Depending upon specific parameterizations, replicable behavior is observed where allocations are very near the predicted outcome of zero allocations to the group account or are significantly above zero allocations to the group account.

2. Allocations to the group account are either unaffected by MPCR or are inversely related to MPCR.

3. Holding MPCR constant, allocations to the group account are either unaffected by group size or are **positively** related to group size.

4. Increasing group size in conjunction with a **sufficient** decrease in MPCR leads to lower allocations to the group account.

5. There tends to be some decay (but generally incomplete) to the predicted outcome of zero allocations to the group account.

6. Even with a richer information set regarding the implications of alternative allocation decisions, highly experienced subject groups continue to follow a pattern of behavior generally inconsistent with the predictions of the complete

information Nash model.

7. Inconsistent with models of learning, the rate of decay of allocations to the group account is inversely related to the number of decision rounds.

Now turn to experiments in which the Nash prediction is interior — a positive allocation to the group account

8. In experiments in which the Nash prediction of tokens allocated to the group account is a relatively small percentage of total token endowments (less than 50%), allocations to the group account tend to follow a pattern of being greater than the Nash prediction, but with some decay in the direction of the Nash prediction over decision rounds.

9. In parameterizations in which the Nash prediction of tokens allocated to the group account is a relatively large proportion of total endowments, allocations to the group account tend to fall below that predicted by the Nash equilibrium.

In summary, results from this VCM setting (with minimal institutional structure in regard to coordinating decision making by group members) reveals a pattern of behavior in which provision of the public good is above that predicted by complete information noncooperative game theory. This result is contingent, however, on the particular parameterizations investigated. In experiments with a sufficiently low MPCR or with an interior Nash equilibrium that requires a high percentage of tokens being allocated to the public good, the patterns of behavior are more supportive of game theoretical predictions (at least at the level of aggregate group behavior).

II. Common Pool Resources

The Decision Environment - CPR

Contrast the CPR appropriation game with the VCM game.[4] In the appropriation game, subjects are endowed each decision round with a specified number of tokens that are to be divided between two markets. Market 1 is described as an investment opportunity in which each token yields a fixed (constant) rate of output and each unit of output yields a fixed (constant) return. Market 2 (the CPR) is described as a market that yields a rate of output per token dependent upon the total number of tokens invested by the entire group. Investments in Market 2 can be though of as appropriating units from the CPR. Subjects are informed that they receive a level of output from Market 2 that is equivalent to the percentage of total group tokens they invest. Further, subjects know that each unit of output from Market 2 yields a fixed (constant) rate of return. Prior to each decision round, subjects know the total number of decision makers in the group, that individual endowments are equal, and total investments in Market 2 for all prior decision rounds.

Prior experimental research has focused primarily on a parameterization of the CPR situation with the following conditions. The CPR is operationalized with eight appropriators (N = 8) and quadratic production functions $F(\Sigma x_i)$ for Market 2, where:

$$F(\Sigma x_i) = a\Sigma x_i - b(\Sigma x_i)^2 \qquad (1)$$

with $F'(0) = a > w$ and $F'(ne) = a - 2bNe < 0$, where w is the per token return from Market 1, and e is individual token endowments. Specific to the experiments reported here, subjects are endowed each round with either 10 tokens or 25 tokens, a return from Market 1 of \$.05 per token, and a production function for Market 2 of the form:

$$F(\Sigma x_i) = 23\Sigma x_i - .25(\Sigma x_i)^2 \qquad (2)$$

and a return from Market 2 of \$.01 per unit of output. With these payoff parameters, a group investment of 36 tokens yields the optimal level of investment. The complete information symmetric noncooperative Nash equilibrium is for each subject to invest 8 tokens in Market 2 (regardless of the endowment condition) -- for a total group investment in Market 2 of 64 tokens.[5]

Figure 3 illustrates the type of information subjects see in a given parameterization of the game. The negative externality imbedded in this game is a result of the production function used for Market 2. More specifically, as an individual invests tokens in Market 2 the marginal and average return to that individual and all other individuals is reduced for Market 2. A self interested decision maker is assumed to take into account the impact on his/her own investments, but disregard the negative return imposed on others.

Summary Results - CPR

1. Subjects make investments in Market 2 (appropriate from the CPR) well above optimum, leading to significant inefficiencies.

2. Investments in Market 2 are characterized by a 'pulsing' pattern in which investments are increased leading to a reduction in yield, at which time investors tend to reduce their investments in Market 2 and yields increase. This pattern reoccurs across decision rounds within an experiment, with a tendency for the variation across rounds to diminish as the experiment continues.

3. Investment behavior is affected by token endowments. Yields as a percentage of optimum are less in 25-token experiments than in 10-token experiments.

4. The Nash equilibrium is the best predictor of **aggregate** outcomes for low-endowment experiments. In the high-endowment setting, aggregate behavior is far from Nash in early rounds but approaches Nash in later rounds. However, at the individual decision level, there is virtually no evidence that

behavior converges to the Nash equilibrium.

III. Taking a Closer Look

The summary conclusions reported above are derived from the aggregation of data from numerous laboratory sessions, across numerous designs. In this section, we take a closer look at decisions in these two dilemma situations by focusing on the data from two illustrative experimental sessions. This analysis has two purposes. It gives the reader a better understanding of the types of dynamics observed in both individual and group behavior. It also allows one to address questions related to behavior (and resulting outcomes) across the two decision situations. Because the experiments come from two different research programs, the experimental designs do not lend themselves to comparisons that are strictly "parallel" in an experimental sense. Nevertheless, the data suggests behavioral, physical, and institutional differences between the two settings that are relevant to our understanding of differences between the two dilemma situations.

To draw comparisons, focus on two components of each decision situation: (1) aggregate behavior and its relation to efficiency in provision of the public good (appropriation from the CPR); and (2) individual behavior and its relation to behavior that would yield the collective optimum.[6] To increase the "parallelism" between the two situations, we examine parameterizations in which both the Nash and group optimal allocations are interior. That is, in both situations the Nash and the group optimal allocation (investment) of tokens calls for a division of tokens between decision alternatives.

The Public Goods Experiment

The public goods experiment illustrated in this section is parameterized with 5 subjects, participating in 20 decision rounds. Each subject is endowed with 125 tokens per round. Figure 4 shows the summary information subjects see regarding potential payoffs from individual and group allocations to the private and group accounts. In this particular parameterization, the non-cooperative Nash equilibrium yields a predicted group allocation to the group account of 100 tokens, with a resulting yield from the group account equal to 42% of group optimum. The group optimum is achieved with an allocation of 420 tokens to the group account.

This experimental session is illustrative of many other public goods experiments in two essential ways. First, as shown in the top panel of Figure 5, aggregate group allocations yield returns from the public good that are in excess of the Nash equilibrium prediction, but less than optimal.[7] Across, the 20 decision rounds, allocations to the group account yield an average return from the group account equal to 92.5% of optimum. Second, as shown in the lower panel of Figure 5, individual decisions vary considerably across subjects and across decision rounds. As one can see, however, subjects 2,3, and 4 tend to follow a more consistent pattern of "cooperative" play - especially subject 4. In early rounds, subjects 1 and 5 make decisions that are somewhat cooperative. By round 6, however, these two subjects begin to follow a pattern of play that is essentially noncooperative. In early rounds, it is the group allocations by all subjects that yield near optimal returns in provision of the group good. Even in later rounds, subjects 2, 3, and 4, faced with noncooperative play of 1 and 5, continue to make allocations to the group account that maintain a level of provision generally over 90% of optimum.

The CPR Experiment

The CPR experiment, illustrated in this section, is operationalized with 8 subjects, participating in 20 decision rounds. Each subject is endowed with 25 tokens per decision round. Refer to Figure 3 for the type of summary payoff information subjects see in this experiment. In this particular parameterization, the symmetric non-cooperative Nash equilibrium yields a predicted investment of 8 tokens per subject in Market 2, with a resulting yield from the CPR equal to 39% of optimum. Optimal investment in Market 2 occurs with an overall group investment of 36 tokens.

This experimental session is illustrative of other CPR experiments in several ways. First, as shown in the top panel of Figure 6, aggregate group investment in Market 2 yields returns from the CPR that fall well below optimum, in some rounds well below that predicted at the Nash equilibrium. Across, the 20 decision rounds, investments in the CPR yield an average return equal to -28.2% of optimum. Yields are especially low in early rounds. Even in later rounds, however, yields remain well below optimum and somewhat lower than predicted by the Nash equilibrium. Second, yields tend to follow the pulsing pattern described in the summary results discussed above. Third, as shown in the lower panel of Figure 6, individual decisions vary considerably across subjects and across decision rounds. As one can see, however, following round 1, subjects 3 and 5 tend to follow a more consistent pattern of "cooperative" play, while subjects 1, 2, 7, and 8 follow investment patterns that are clearly noncooperative. Subjects 4 and 6 follow investment patterns that oscillate between cooperative and noncooperative. Finally, in later rounds of the experiment, when *aggregate* investments tend to fall to a level closer to the Nash prediction, there remains considerable variation at the individual level.

IV. **Reflections on Public Good and CPR Situations**

The summary data presented in section II and data from the individual experiments presented in section IQ offer somewhat of a puzzle in regard to behavior. In experiments utilizing subjects drawn from virtually the same population, with very similar payoff potentials, VCM public goods experiments yield outcomes with efficiency of resource use considerably higher than that observed in the CPR experiments. This occurs in two situations where the Nash equilibrium prediction yields virtually the same efficiency of resource use.

One explanation for this discrepancy may lie in the fact that the VCM and CPR applications of the theory - complete information noncooperative game theory - may account for the behavior of many individuals, but not **all.** Rationales for the discrepancy between the theoretical prediction and behavior of some individuals include: (1) some players have utility over aspects of the game beyond that characterized by the modelled payoff function; (2) the game may played as one of incomplete information on the part of some players regarding the expected play of others, (3) although the game is finite, some players may view the game as if it were to be infinitely repeated. Each of these possible explanations complicates the expected play of the game and leads to games with multiple equilibria. The play of these 'nontheoretical' players prevents convergence to a single theoretical equilibrium, and the impact of such players can be decision setting/institution specific. That is, out of equilibrium play can have very different consequences across situations and across different parameterizations within a situation.

Contrast, for example, the 25 token CPR experiment illustrated in Section m, with a different parameterization in which subjects are endowed with only 10 tokens each. Results from such an experiment are presented in Figure 7. Notice in this experiment that yields are significantly higher than that observed in the 25 token endowment experiment Assume that in the CPR game, some players are trying tacitly to reach a cooperative solution to the game. Noncooperative players reap (at least short-term) benefits from taking advantage of such players by investing more heavily in the CPR. In the low-endowment CPR game, however, there are clear constraints on an individual's ability to unilaterally defeat (take advantage of) such an attempt In the high-endowment parameterization, an individual's strategic "leverage" is increased. One or two players can invest sufficiently in the CPR to take full advantage of attempts at cooperation, yielding an aggregate result that is near the inefficient game equilibrium. Thus, as individual decision makers are endowed with (or invest in) a greater capacity to utilize the commonly held resource, or as the number of appropriators increases, the ability of a subset of individuals attempting to foster cooperative use of the resource may be severely restricted.

Now consider the public goods VCM situation. Especially for large groups or groups in which the optimal level of public goods provision is "small" relative to group endowment, an individual has very limited strategic leverage to take advantage of cooperative attempts. For example, consider the two parameterizations of the VCM game illustrated in Figure 8. In both parameterizations, each individual has the same valuation for the public good (MPB) and the same endowment, 125 tokens. In the top panel, the decision situation is parameterized for a game with N=5, in the lower panel N=10. Notice with N=5 the optimal provision of the public good requires an allocation of tokens to the public good of 67% of total group "wealth." In contrast, with N= 10 optimal provision of the public good requires an allocation of tokens to the public good of only 37% of total group "wealth." With N=100, optimal provision of the public good requires an allocation of tokens to the public good of only 4% of total group "wealth." Further, in such public good situations, cooperative play by a subset of individuals cannot be offset by noncooperative play by other group members.

It is the strategic decision space and characteristics of these classes of VCM games that differ fundamentally from the types of CPR games examined here. Clearly, it is the lack of subtractability of the pubic good and the subtractability of the CPR that attributes to such an outcome. Thus, if in the VCM game, players could either contribute toward provision, or appropriate tokens that have been contributed by others, the strategy space of the game would be altered in such a way that a noncooperative player could offset attempts at cooperation by others.

V. Summary Comments

Externalities in consumption and/or production create a divergence in the private costs or benefits from an action and the full social costs or benefits from that action. Rational choice theory generally assumes that individuals will make choices that do not fully account for all social costs or benefits. Individual choices will therefore lead to outcomes that are suboptimal from the perspective of the group. It follows that the empirical significance of social dilemmas depends on the actual paradigmatic mode of behavior chosen by individuals in conjunction with the physical characteristics of the externalities created and the institutional structure governing the situation.

Drawing on results from several laboratory studies, this paper explores the links between these components of a social dilemma in the context of two stylized decision situations; public goods and common pool resources. These two situations offer contrasting characteristics, yielding insights into the process of decision making and the empirical significance of social dilemma problems. The experimental evidence suggest that behavior by individuals in social dilemma situations with institutional settings that do not facilitate coordination and cooperative behavior **can** lead to outcomes consistent with pessimistic predictions of significant suboptimality in allocation of resources.[8] However, holding "institutional sparseness" constant, behavior in such settings can show considerable variation across individuals, parameterizations within a given institutional setting, and across institutional settings. Understanding the foundations/explanations for such variations in behavior is critical to building a positive theory of collective action. Understanding such variations will require a research approach designed toward separating the independent (and potentially confounding) affects of: (1) true differences in the modes of behavior of individuals - modes dependent upon true differences in the calculus of decision making used by the subjects, (2) differences in how subjects perceive the decision problem - independent of their paradigmatic mode of behavior, and (3) a continued focus on how differences in the institutional component of the decision setting affects incentives and strategic opportunities of subjects.

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ENDNOTES

1. Public good situations can be defined over situations where the shared outcome is either positive, zero, or negative to recipients. Here we focus on the case where values are positive.

2. The discussion and results presented in this section draws heavily on Isaac, Walker, and Williams (1994) and Isaac and Walker (1994).

3. There have numerous other studies of public goods provision games using institutional settings similar to the VCM game described here. For a summary of these papers see Ledyard (1994).

4. The discussion in this section relies heavily on Ostrom, Gardner, and Walker (1994).

5. See E. Ostrom, Gardner, and Walker (1994) for details of the derivation of this game equilibrium.

6. For comparison purposes we calculate efficiency as the ratio of actual earnings from the public good/ (the CPR) relative to that earned at the group optimum. More specifically, efficiency in the case of public goods provision is [actual earnings from the group account - the value of those tokens if they had been allocated to the private account]/[earnings from the group account at the group optimum - the value of those tokens if they had been allocated to the private account]. Efficiency in the case of the CPR is [actual earnings from Market 2 - the value of those tokens if they had been in Market l]/[earnings from Market 2 at the group optimum - the value of those tokens if they had been allocated to Market 1].

7. See Isaac and Walker for a discussion of interior Nash experiments in which provision of the public good is suboptimal relative to Nash.

8. Numerous experimental studies have explored alternative institutional settings for the VCM and CPR decision settings. See for example Bagnoli and McKee (1991), Dorsey (1992), Isaac, Schmidtz, and Walker (1989), Ostrom, Gardner, and Walker (1992).

Figure 1

VCM - Summary Payoff Table - N=10, MPCR=.3

ROUND 1 CURRENTLY IN PROGRESS

YOUR ENDOWMENT of tokens in each round: 50 ; Group size: 10
TOTAL GROUP ENDOWMENT of tokens in each round: 500
Each token retained in your PRIVATE ACCOUNT earns: $ 0.01

Examples of possible earnings from the GROUP ACCOUNT

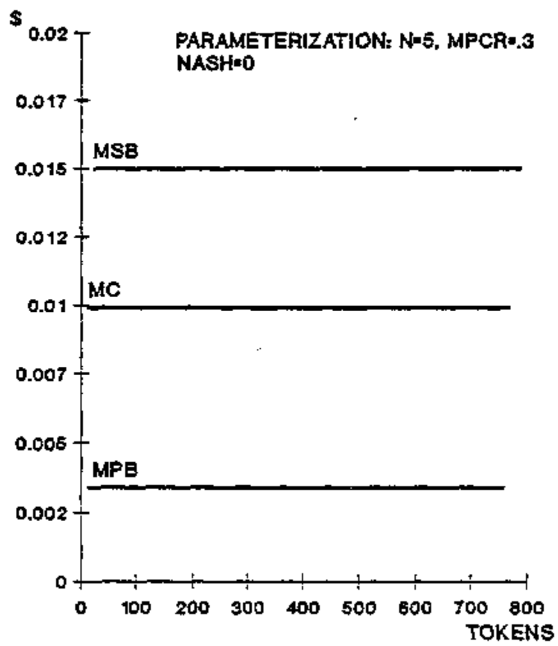
Tokens in GROUP ACCOUNT (from the entire group)	Total Group Earnings	Your 10% share of Group Earnings
0	$ 0.000	$ 0.000
31	$ 0.930	$ 0.093
63	$ 1.890	$ 0.189
94	$ 2.820	$ 0.282
125	$ 3.750	$ 0.375
156	$ 4.680	$ 0.468
188	$ 5.640	$ 0.564
219	$ 6.570	$ 0.657
250	$ 7.500	$ 0.750
281	$ 8.430	$ 0.843
313	$ 9.390	$ 0.939
344	$ 10.320	$ 1.032
375	$ 11.250	$ 1.125
406	$ 12.180	$ 1.218
438	$ 13.140	$ 1.314
469	$ 14.070	$ 1.407
500	$ 15.000	$ 1.500

-HELP→ review instructions.
-LAB→ view the earnings from the group account for any possible value of "Tokens in Group Account".

How many tokens do you wish to place in the GROUP ACCOUNT? ≫

Figure 2

VCM - Boundary and Interior Designs
Marginal Social Benefits and Marginal Private Benefits



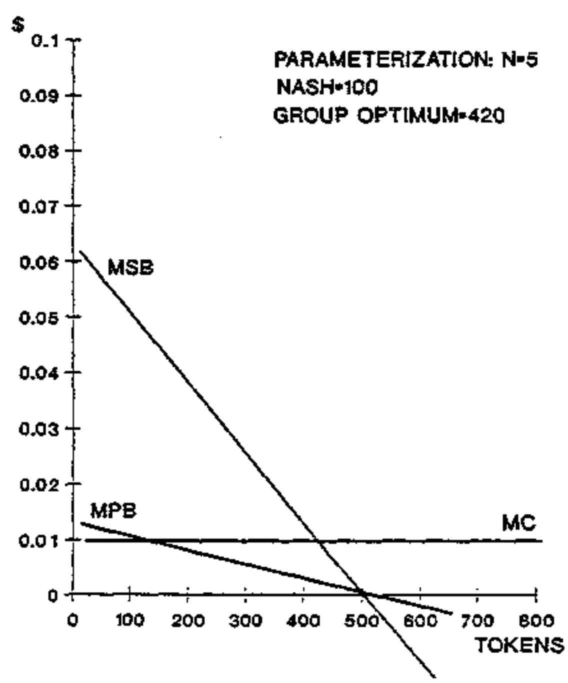


Figure 3

CPR - Summary Payoff Table - N=8, Endowment=25

UNITS PRODUCED AND CASH RETURN FROM INVESTMENTS IN MARKET 2
commodity 2 value per unit = $ 0.01

Tokens Invested by Group	Units of Commodity 2 Produced	Total Group Return	Average Return per Token	Additional Return per Token
20	360	$ 3.60	$ 0.18	$ 0.18
40	520	$ 5.20	$ 0.13	$ 0.08
60	480	$ 4.80	$ 0.08	$-0.02
80	240	$ 2.40	$ 0.03	$-0.12
100	-200	$ -2.00	$-0.02	$-0.22
120	-840	$ -8.40	$-0.07	$-0.32
140	-1680	$-16.80	$-0.12	$-0.42
160	-2720	$-27.20	$-0.17	$-0.52
180	-3960	$-39.60	$-0.22	$-0.62
200	-5400	$-54.00	$-0.27	$-0.72

The table shown above displays information on investments in Market 2 at various levels of group investment. Your return from Market 2 depends on what percentage of the total group investment is made by you.

Market 1 returns you one unit of commodity 1 for each token you invest in Market 1. Each unit of commodity 1 pays you $ 0.05.

Press -BACK-

Figure 4

VCM - Summary Payoff Table - N=5, Nash=100

ROUND 1 CURRENTLY IN PROGRESS

YOUR ENDOWMENT of tokens in each round: 125 ; Group size: 5
TOTAL GROUP ENDOWMENT of tokens in each round: 625
Each token retained in your PRIVATE ACCOUNT earns: $ 0.01

Examples of possible earnings from the GROUP ACCOUNT

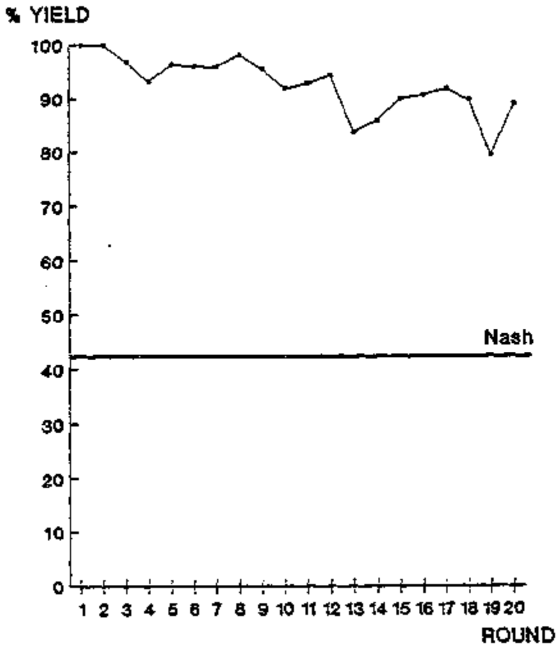
Tokens in GROUP ACCOUNT (from the entire group)	Total Group Earnings	Your 20% share of Group Earnings
0	$ 0.000	$ 0.000
39	$ 2.342	$ 0.468
78	$ 4.495	$ 0.899
117	$ 6.457	$ 1.291
156	$ 8.229	$ 1.646
195	$ 9.811	$ 1.962
234	$ 11.203	$ 2.241
273	$ 12.404	$ 2.481
313	$ 13.439	$ 2.688
352	$ 14.256	$ 2.851
391	$ 14.882	$ 2.976
430	$ 15.319	$ 3.064
469	$ 15.565	$ 3.113
508	$ 15.621	$ 3.124
547	$ 15.487	$ 3.097
586	$ 15.163	$ 3.033
625	$ 14.648	$ 2.930

-HELP→ review instructions.
-LAB→ view the earnings from the group account for any possible value of "Tokens in Group Account".

How many tokens do you wish to place in the GROUP ACCOUNT? ≫_

Figure 5
VCM Illustrative Experiment

Yield as a Percent of Optimum



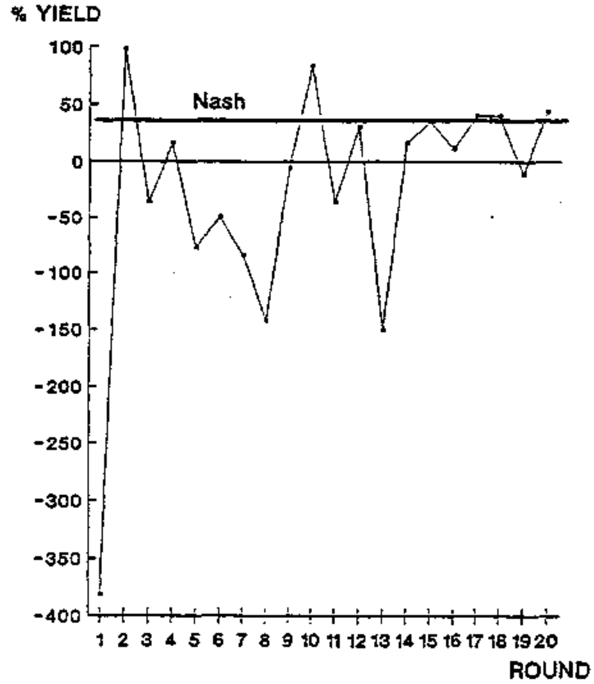
Individual Allocations to the CPR

Subject/ Round

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	95	90	90	50	75	35	50	70	38	30	45	25	25	25	37	26	27	27	0	25
2	100	75	70	75	125	76	75	80	83	95	97	75	72	79	75	76	78	75	79	80
3	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75	75
4	94	94	100	100	125	125	125	125	125	75	75	70	69	73	100	115	120	108	75	80
5	75	95	10	10	100	25	10	10	10	25	15	75	10	10	0	0	0	0	0	20

Figure 6
CPR Illustrative Experiment

Yield as a Percent of Optimum



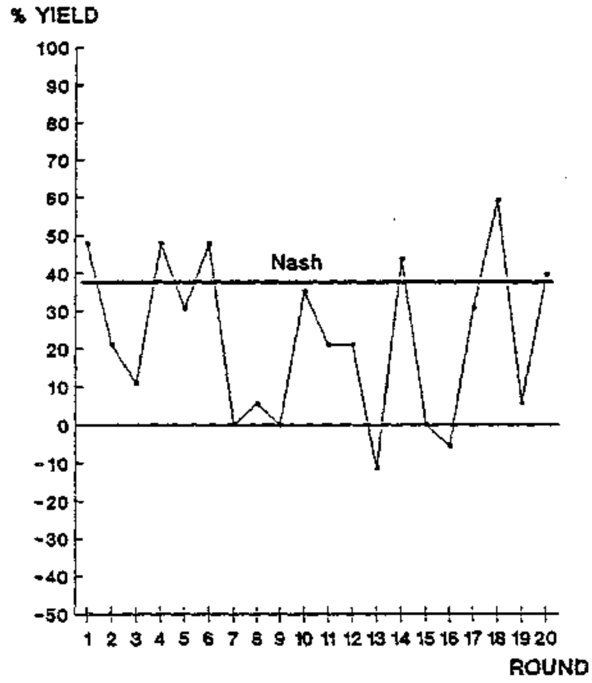
Individual Allocations to the CPR

Subject/ Round

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	15	15	15	10	15	15	14	13	16	16	16	16	17	17	17	16	15	16	16	16
2	23	1	19	20	13	25	22	19	23	0	23	2	23	13	12	14	12	13	13	13
3	25	0	0	0	4	4	2	0	0	3	5	3	3	0	1	2	3	2	3	2
4	15	10	10	7	11	9	12	10	8	6	5	11	16	10	8	9	1	3	8	2
5	5	1	2	2	4	1	3	3	2	2	3	3	3	4	1	3	3	2	4	4
6	17	5	7	8	10	3	6	21	3	5	7	10	11	6	7	6	7	5	6	7
7	5	5	5	10	10	13	13	15	9	7	7	9	8	7	7	8	8	8	8	7
8	10	5	20	12	17	10	13	11	12	12	12	12	12	12	12	12	15	15	16	12

Figure 7
CPR Illustrative Experiment - 10 Token Endowment

Yield as a Percent of Optimum



Individual Allocations to the CPR

Subject/ Round

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	5	5	7	3	8	7	7	7	4	3	5	7	7	4	8	4	5	5	6	5
2	6	8	7	6	5	8	10	10	10	10	9	9	10	10	10	9	8	9	10	6
3	6	9	10	3	5	4	5	6	10	7	10	10	10	6	10	10	10	3	6	6
4	5	7	8	10	9	10	10	8	8	10	10	9	10	10	10	10	9	10	10	10
5	10	10	10	10	10	10	10	10	10	6	6	6	10	6	6	10	6	5	10	10
6	10	10	10	10	10	5	10	10	10	10	10	10	10	10	10	10	10	10	10	10
7	10	9	8	10	9	8	10	10	10	9	8	7	7	7	8	10	8	7	9	7
8	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10

Figure 8

VCM - Interior Designs - N=5 & N=10
Marginal Social Benefits and Marginal Private Benefits