Experimental Departures from Self-Interest When Competing Partnerships Share Output

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DISCUSSION PAPER

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Experimental Departures from Self-Interest When Competing Partnerships Share Output[*]

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March 11, 2013

Abstract

When every individual's effort imposes negative externalities, self-interested behavior leads to socially excessive effort. To curb these excesses when effort cannot be monitored, competing output-sharing partnerships can form. With the right-sized groups, aggregate effort falls to the socially optimal level. We investigate this theory experimentally and find it makes correct qualitative predictions but there are systematic quantitative deviations, always in the direction of the socially optimal investment. By using data on subjects' conjectures of each other's behavior we show that deviations are consistent with both altruism and conformity (but not extremeness aversion).

Keywords: Output-Sharing, Partnership Solution, Laboratory Experiment, Altruism, Conformity

JEL Classification: L23, Q20, Q22, O13

1 Introduction

When every individual's effort imposes negative externalities on his competitors, self-interested behavior results in more aggregate effort than is socially optimal. If competitors are partitioned into output-sharing groups, their resulting free riding should reduce aggregate effort. If groups of the right size form, all the deadweight loss can, at least in theory, be eliminated.[1] This paper investigates in a controlled laboratory setting whether agents, given an opportunity to choose the size of their output-sharing groups, will eliminate or at least substantially reduce the inefficiencies that would otherwise occur.

In competitions to exploit common properties, aggregate effort by competing fishermen exceeds the level that maximizes aggregate profits (Dasgupta and Heal 1979)—the so-called "tragedy of the commons." Similarly, in innovation tournaments, aggregate investment by firms competing to develop the best innovation exceeds the level that would maximize their joint profits (Baye and Hoppe 2003)—the so-called "problem of R&D duplication." Moreover, in sports contests, aggregate investment by competing teams to identify and cultivate the athletic talent of their players goes beyond the level that would maximize total earnings (Canes 1974, Dietl et al. 2008)—the so-called "problem of ruinous competition between clubs." The classic example of competing players imposing negative externalities on each other to their collective detriment is oligopoly where, as Cournot (1838) observed long ago, joint output exceeds the level that maximizes industry profits. Henceforth, we will refer to all such situations as the "negative aggregate spillover problem."

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[1]In the Nash equilibrium, a marginal increase in the effort of any player has no net effect on his own payoff. If partnerships are of the "right size," the sum of the positive spillovers this increase in his effort provides members of his own partnership exactly offsets the sum of the negative spillovers imposed on nonpartners. Hence, social surplus is also at a stationary point, a maximum given concavity. The allocation coincides with what would be achieved with Pigouvian taxation and equal lump-sum redistribution. But there is no governmental authority imposing taxes or redistributing revenues.

Since the negative aggregate spillover problem results in lost aggregate profits, arrangements have evolved to dampen effort incentives.[2] When effort cannot be monitored, a common arrangement is for competitors to form groups that *share* revenue or output. Thus, as the collective work of Nobel Laureate Elinor Ostrom has documented (among others, Ostrom 1990; Ostrom and Walker 1991, and Ostrom et al. 1994), extractors of a common property often form groups that share whatever is extracted by any member of the group.[3] Similarly, to avoid wasteful duplication, researchers often form joint ventures and share the benefits of their discoveries within their group (Kamien et al. 1992). In the same way, college football teams share revenues within their conferences (Brown 1994) to attenuate over-investment aimed at attracting fans (upgrading the home stadium, searching for the best coach, and coddling players).[4] Finally, oligopolists sometimes form revenue-sharing groups that, although competing against each other, raise prices and industry profits. This occurs at a local level within competing law and medical partnerships (Newhouse 1973) and at an international level within ocean liner conferences, which share gross revenues to facilitate cartelization (see Bennathan and Walters 1969).

Heintzelman et al. (2009) analyze theoretically the consequences of output sharing in an environment with negative externalities and unobservable effort. They consider a game where

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[2]According to anthropologists, those tribes of hunter-gatherers that have survived may have done so because their traditional practice of sharing the fish and game they caught deterred them from exhausting their resource base (Kagi 2001; Sahlins 1972).

[3]In Japan, 147 Japanese fisheries currently engage in output sharing. Platteau and Seki (2000) interviewed skippers in one such fishery and were surprised to find that insurance was never mentioned by any of the skippers interviewed as a motive for output sharing. Platteau and Seki concluded that "the desire to avoid the various costs of crowding while operating in attractive fishing spots appears as the main reason stated by Japanese fishermen for adopting pooling arrangements."

[4]Brown concludes that "the empirical results confirm the theoretical prediction that revenue sharing provides a disincentive to build a stronger team, other factors constant— conferences which share more tend to have weaker teams..."

N self-interested players partition themselves into groups, each of which shares output but not costs. They show that forming N solo groups (the degenerate partnership case equivalent to the standard commons model) generates too much effort due to negative externalities, and forming one group with N members generates too little effort due to too much free riding. Socially optimal effort can be achieved (or approximated due to an integer constraint) with output sharing groups of intermediate size.

In this paper, we investigate whether players behave as predicted when assigned exogenously to symmetrically sized groups of different sizes. We also check that when subjects are allowed to choose the size of their groups, they choose the socially optimal size and, whatever they choose, invest as they did when exogenously grouped.[5]

To do this, we conduct a laboratory experiment where, for a given cost level, subjects play an investment game in a group structure that is either assigned exogenously or chosen endogenously. Throughout, we vary the cost of investment and compare theoretical predictions based on self-interest to behavior observed in the lab.

Schott et al. (2007) were the first to examine output-sharing experimentally but confined their attention to the investment behavior with an unchanged cost of investment and when subjects were assigned to groups exogenously.[6] Schott et al. did not note departures from self-interested behavior.

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[5]Although ours is the first paper to investigate endogenous output-sharing groups in a setting with negative externalities, the formation of groups has been investigated in public goods environments (Page et al. 2005; Ahn et al. 2008, 2009; Brekke et al. 2009; Charness and Yang 2010).

[6]Establishing how subjects partition themselves endogenously is important, since, in the field, participants *choose* how many groups to form. If players turned out always to choose a suboptimal number of groups or, having chosen the optimal number of groups, turned out to invest differently than when assigned to them exogenously, then our laboratory society would never achieve efficiency even if, as in Schott et al. (2007), subjects make socially optimal choices when the optimal group structure is exogenously mandated.

In our experiments, individuals in solo groups invested more than is socially optimal, just as theory predicts. Moreover, they reduced their investments when in larger groups regardless of the cost of investment. In addition, individuals increased their investments as the opportunity cost of investing decreased for a given group size. These results hold for both exogenously and endogenously chosen group sizes. Hence, we observed no departures from the comparative-static predictions of the theory.

In one respect, however, subject behavior consistently departed from predictions. Without exception, when investment behavior was predicted to result in inefficiency given the number of groups and the cost of investment, subjects invested in aggregate on the socially optimal side of the Nash equilibrium. Given our experimental design, this sometimes required subjects to invest more than the Nash prediction and sometimes required them to invest less than the Nash prediction. We find evidence of altruism and conformity by conducting a maximum likelihood estimation of a conditional logit model. Our findings contrast with the Nash findings of Schott et al. (2007) but are consistent with the findings in other games of Charness and Rabin (2002); Ostrom et al. (1992); Ostrom et al. (1994); Ledyard (1995); Camerer (2003); Falk et al. (2005); Velez et al. 2009; and others. We highlight that the existence of social preferences may change the outcomes in surprising and unexpected ways. In particular, we have observed individuals voting differently than predicted in an environment (with high opportunity cost) where all individuals are symmetric and hence there is no conflict among the voters.

When given the opportunity to *choose* the size of their groups, most of the subjects vote for the theoretically predicted group size, and subjects on average cut the waste associated with the negative aggregate spillover problem by at least two-thirds when the cost of investment is *not* high. When the cost of investment is high, subjects do not vote in accordance with theoretical predictions based on self-interest but vote in the way that maximizes the aggregate payoff given their previous experience in the experiment.

The paper proceeds as follows: Section 2 describes our experimental design and proce-

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dures. Section 3 presents our theoretical hypotheses. Section 4 reports our experimental findings and the results of our hypothesis tests. Section 5 discusses possible explanations for the departures from Nash equilibrium predictions apparent in our data. Section 6 discusses directions for future research and concludes the paper.

2   The Experiment

2.1   Design and Procedures

We conducted 25 sessions, each with a different set of six participants. Most participants were undergraduates at University of Michigan.[7] Subjects earned experimental currency (tokens), which was converted at the conclusion of the session into US dollars (1 token = 0.01 US dollars). The experiment was programmed and conducted with the software z-Tree (Fischbacher 2007). Sessions lasted approximately one hour and a half.

Each session was divided into six separate parts. Each of the first five parts (Parts I–V) consisted of a sequence of 5 rounds of decision-making. Therefore, each subject went through 25 rounds in total. One aim of the first four parts was to give subjects experience investing as members of groups of different sizes. In Part V of the experiment, subjects *chose* the size of the groups endogenously. In Part VI, subjects completed a short questionnaire. At the end of the experiment, we randomly selected one round from each of the first five parts, added up the tokens each subject had earned in the selected rounds, converted that sum to dollars, added in the $5 show-up fee, and paid everyone. The average payment in the experiment was approximately $25 per subject.

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[7]Recruited subjects included graduate students at University of Michigan and individuals from outside the university. These subjects were randomly distributed across different treatments.

In the first four parts, subjects were exogenously divided into groups of identical size: one-member groups, two-member groups, three-member groups, or a six-member group. Subjects were randomly rematched across groups in every round but played 5 consecutive rounds in each group size. In total, there were 20 rounds in the first four parts. To control for order effects, we changed the order of the first four parts across sessions.

At the beginning of each decision round in the first four parts, participants were given six experimental tokens and had to decide how many of them $(0, 1, \ldots, 6)$ to invest in Project B. Whatever a subject did not invest in Project B was automatically invested in Project A. Denote x_{ik} as the investment in Project B by agent k in group i. Let Y_i^{-k} denote the aggregate investment in Project B by the other members of group i, X_{-i} denote the aggregate investment in Project B by other groups, and X denote the total investment in Project B by all six participants $(X = X_{-i} + Y_i^{-k} + x_{ik})$.

Project A had a fixed return of c tokens per token invested; i.e., the subject's earnings from Project A equaled c times his investment in Project A. Therefore, for each subject, the "opportunity cost" of investing one additional token in Project B equaled c, the lost earnings from Project A. In different sessions of the experiment, we varied this opportunity cost of investing. Note that this was a between-subjects design; each subject within a given session faced only one cost parameter.

The return per token invested in Project B, $P(X)$, was a decreasing linear function of the aggregate investment in Project B. Therefore, each token invested in Project B imposed a negative externality on everyone else—the essence of the *negative aggregate spillover* problem. For each token invested in Project B, the return from Project B was given by

$$P(X) = 200 - 5X.$$

Every member of a given group received an equal share of his or her group's return from Project B regardless of his or her own investment in that project. An individual's earnings

from Project B (E_{ik}) depended on the aggregate investment in Project B of subjects in other groups (X_{-i}), the aggregate investment of members of the individual's own group ($x_{ik}+Y_i^{-k}$), and the size of his group (m):

$$E_{ik} = \frac{1}{m}(200 - 5[X_{-i} + Y_i^{-k} + x_{ik}])(x_{ik} + Y_i^{-k}).$$

When there was no output sharing ($m = 1$ and $Y_i^{-k} = 0$), an individual k's earning from Project B was given by $E_{ik} = (200 - 5[X_{-i} + x_{ik}])x_{ik}$, which is simply the return multiplied by the individual investment in Project B. This functional form is consistent with the formulation that is found in the common-property literature (Dasgupta and Heal 1979, p. 59), the innovation-tournament literature (Baye and Hoppe, Theorem 1), and the sports-contest literature (Dietl et al. 2008, equation 2 with $\alpha = \gamma = 1$), among others.[8] In all these seemingly unrelated strategic interactions, the same game has been analyzed repeatedly in disparate literatures.[9]

Final earnings in each round (in tokens) were simply the sum of earnings from Project

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[8]The same model also appears in the "rent-seeking" literature (Chung 1996, equation 2). For other literatures where this model appears, see the excellent book-length survey by Konrad (2009).

[9]In each case, player k chooses effort/investment x_k and achieves payoff $\frac{x_k}{x_k+X_{-k}}v(x_k + X_{-k}) - cx_k$ where $v(\cdot)$, the reward function, gives the value of the output or prize. When the payoff function of each player is rewritten as $x_k(P(x_k+X_{-k})-c)$, where the strictly decreasing function $P(x_k + X_{-k}) = \frac{v(x_k+X_{-k})}{x_k+X_{-k}}$, the paternity of this ubiquitous model becomes apparent: it is the Cournot model (1838) in disguise (with x_k reinterpreted as effort instead of output). In the Cournot model, of course, the negative aggregate spillover problem results in larger industry output than a monopolist would choose. These literatures all assume that $v(\cdot)$ is strictly concave but differ in whether this function reaches a maximum (as in the Cournot model) or is strictly increasing (as in Baye and Hoppe 2003); the qualitative results in these literatures are unaffected by this minor difference in assumption. We chose the simpler of the two formulations as easier to explain to subjects. We assumed that $P(X)$ decreases linearly, which implies that $v(X)$ is a parabola that passes through the origin, rises to a maximum at $\hat{X}$, and then returns to the X axis again at $2\hat{X}$; for $X > 2\hat{X}, v(X) = 0$.

A and earnings from Project B:

$$\pi_{ik} = (6 - x_{ik})c + \frac{1}{m}(200 - 5[X_{-i} + Y_i^{-k} + x_{ik}])(x_{ik} + Y_i^{-k}).$$

It can be seen that each individual paid the cost of his or her investment but shared the revenue equally with the members of his group.

In each of the five rounds of Part V, subjects first *voted* for one of the four group sizes. Then, subjects were divided up in groups of the size that won the most votes and played the investment game.[10] In cases of a tied vote, the winner was chosen at random.

Subjects in a given experimental session faced only one cost parameter and had to make investment decisions in all five parts of the experiment (25 rounds). A summary of the experimental design is provided in Table 1.[11] As Table 1 reflects, the surplus maximizing group size is determined by the cost used in that treatment. In other words, according to a theory based solely on self-interest, the group size that would lead subjects to achieve the highest possible payoff differs across treatments. For example, for opportunity cost $c = 20$, the optimal size of each group is 3 members (or, equivalently, the optimal number of equal-sized groups is 2). Other group sizes would generate lower *total* payoff for subjects (assuming individuals are self-interested and best respond to their guesses of others' behavior).[12] In our

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[10]Note that in our experiment, voting is used to select group sizes and not some policy regarding the level of effort/investment. Voting is found to be useful as a tool for policy selection in common pool resources or public goods literature (Walker et al. 2000; Tyran and Feld 2006; Putterman et al. 2010).

[11]The order of the group sizes was changed across sessions. The sequence of group sizes for each cost treatment was as follows: 1236, 6312, 2163, 3621, and 1623 for $c = 1$; 1236, 3261, 6312, 2163, and 6231 for $c = 20$; 1236, 3621, 2163, 6312, and 1623 for $c = 55$; 1236, 6312, 2163, 3261, and 6132 for $c = 100$. Note that in each case the optimal group size (see column 2 of Table 1) was presented at each location at least once.

[12]As will be explained in more detail in Section 3, when divided into optimal group sizes, subjects' total payoff will be close to the socially optimal payoff.

experimental design, as the opportunity cost of investing in Project B increases, the optimal group size decreases.

Table 1: Experimental Design

Cost parameter c	Optimal group size	Parts I – IV	Part V	Number of sessions	Number of subjects
1	6	Exogenous	Voting	5	30
20	3	Exogenous	Voting	5	30
55	2	Exogenous	Voting	5	30
100	1	Exogenous	Voting	5	30

Prior to the experiment, a test was administered to the subjects to make sure they understood the consequences of their choices for their own payoffs The computer prevented anyone from beginning the session until *everyone* had a perfect score on the test.

During the experiment, subjects either could calculate their payoffs by hand or could utilize a "Situation Analyzer" provided to facilitate their calculations. A subject could enter his or her conjecture about (1) the total investment in Project B by others *inside* his or her group and (2) the total investment in Project B by subjects *outside* his or her group. The Situation Analyzer would then provide a table listing in one row the seven choices for investing in Project B $(0, 1, \ldots, 6$ tokens) and in the other row the total payoff from the two projects that the subject would earn if he or she made the particular investment choice and those two conjectures were accurate. Subjects were free to make such calculations by hand or to use the Situation Analyzer as often as they wanted before making a decision. The information provided by the Situation Analyzer in response to the conjecture pair $(4, 12)$ of a subject in a treatment with $cost = 100$ and $m = 2$ is shown in Figure 1.

To facilitate decision-making in each of the 25 rounds, we also provided each subject with a table containing the history of his own investments, the investments of others in his group,

Figure 1: Situation Analyzer for Groups of Two

If the total investment by others outside your group in Project B is 12

If the total investment by others inside your group in Project B is 4

Analyze this situation

Your investment in B	0	1	2	3	4	5	6
Your earnings (A + B)	840.0	787.5	730.0	667.5	600.0	527.5	450.0

and the total investment of the six subjects, as well as his earnings from previous rounds.

After the session, we administered a short questionnaire. We asked subjects the basis of their investment decisions and the basis of their vote on group size. Responses clearly showed that subjects understood the experiment. Most of the subjects reported that they tried to maximize their monetary earnings.

We summarize the predictions of the theory and our experimental hypotheses in the next section.

3   Theoretical Predictions and Hypotheses

Theoretical predictions are based on Heintzelman et al. (2009). Given the size of each group and the opportunity cost of investing in Project B, every individual simultaneously invests to maximize the sum of his or her own payoff from the two projects. Proposition 1 summarizes the mean investment in Project B in the Nash equilibrium.[13]

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[13]Total investment within each group is uniquely determined in the equilibrium, but not the investment of individual members of a group. Therefore, we focus on the mean investment level. See Heintzelman et al. (2009) for more details.

Proposition 1. *For a given opportunity cost (c) and group size (m), mean investment in Project B is* $\bar{x} = \frac{200-cm}{30+5m}$.

We use this formula to calculate the mean equilibrium investment in Table 2 for each of the 16 group size–cost combinations in the various experimental treatments. For any opportunity cost (c), note that Nash equilibrium investment in Project B decreases with the size of each group and that, for any group size (m), investment also decreases with the opportunity cost.

Proposition 2 summarizes the mean investment in Project B that would maximize the aggregate revenue from the two projects. We refer to this as the "socially optimal investment level" and denote it x^*. It is simply 1/6 of the aggregate investment that maximizes $XP(X)+ (36-X)c$.

Proposition 2. *To maximize social surplus, mean investment in Project B must be* $x^* = \frac{200-c}{60}$.[14]

This formula is used to calculate the socially optimal levels in the last row of Table 2. Note that as the opportunity cost rises, the socially optimal investment level falls.

Equilibrium investment in Project B exceeds the socially optimal level when no one shares (one-person groups) and falls short of the socially optimal level when everyone shares (six-person group). Moreover, as the group size increases from one to six, aggregate investment in Project B declines monotonically. There is, therefore, a unique real number m (not necessarily an integer) that induces mean investment in the Nash equilibrium $(\bar{x})$ to equal

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[14]In the absence of any effort cost $(c = 0)$, it is socially optimal to put everyone in a single group since that would internalize the negative externality; hence, in this extreme case $(c = 0)$, equilibrium investment in Proposition 1 (for $m = 1$) equals socially optimal investment in Proposition 2. When $c > 0$, however, such internalization is not optimal; it would generate massive free riding since effort cannot be monitored.

socially optimal investment (x^*). When the integer constraint is respected, one of the six group sizes will generate a larger social surplus in the Nash equilibrium than any other group size and is predicted to increase efficiency close to the socially optimal level. We refer to this group size as the "partnership solution" (Heintzelman et al. 2009). Note that the partnership solution is a self-enforcing mechanism that requires neither monitoring of individual behavior nor intervention of the government.

In Table 2, in every cost column there is a shaded entry. The associated row is the partnership solution for that particular opportunity cost. The shaded entry is the Nash equilibrium mean investment in Project B for that opportunity cost and group size.[15]

Table 2: Nash Equilibrium Mean Investment in Project B

Group size	Cost = 1	Cost = 20	Cost = 55	Cost = 100
1	5.69	5.14	4.14	2.86
2	4.95	4	2.25	0
3	4.38	3.11	0.78	0
6	3.23	1.33	0	0
Socially optimal level	3.32	3	2.42	1.67

Proposition 3 follows from the definition of the partnership solution:

Proposition 3. *For a given opportunity cost (c), every individual strictly prefers the partnership solution to any other group size.*

The partnership solution is the Condorcet winner, because it would be chosen unanimously if every subject voted for the group size he most preferred. Of course, as in many voting

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[15]In this experiment, subjects faced a discrete action space. Though the theoretical predictions were generated from a game with continuous actions, the assumption of discrete actions does not change the predictions. More specifically, suppose agents choose a noninteger investment level x for Project B in the symmetric equilibrium of the continuous investment game. Then, in the discrete version, there is an equilibrium in which every player chooses the integer above x or below x, or mixes between the two. As a result, both the actions and the payoffs in the discrete and continuous versions are very similar.

games, inferior alternatives can also be supported as Nash equilibria since if everyone expects that everyone else is voting for the same alternative, then no one can change the outcome by deviating unilaterally. However, these spurious Nash equilibria can be eliminated by iterative elimination of weakly dominated strategies. The partnership solution would then be predicted to receive the most votes.[16]

In this paper we investigate the investment behavior of subjects when group size is both exogenously imposed and endogenously selected. We study whether subjects will "elect efficiency"—whether they will vote for the partnership solution and whether endogenous group selection will increase social surplus compared to the case of solo groups.

The experimental data and findings are presented in the next section.

4   Data Analysis

4.1   Exogenous Groups and Investment Decisions

Figure 2 shows the average investment corresponding to each opportunity cost parameter in the first 20 rounds (Parts I–IV). Horizontal lines represent the theoretical predictions. For simplicity, group sizes are presented in the following order: one-member, two-member, three-member, and six-member groups, although orders were randomized during the sessions. Consistent with the theoretical predictions, contributions decrease with the group size for any cost level.

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[16]We piloted a second voting mechanism that needs no such refinement since its Nash equilibrium is unique: after each subject had voted in the pilot, one of the six subjects was randomly chosen to be "dictator," and his or her vote determined the partnership structure. Since every subject anticipated being chosen as the dictator with positive probability, each subject should have been motivated to vote for his or her most preferred alternative. However, we were unable to distinguish behavior under the two voting schemes. Hence, we used the more familiar nondictatorial scheme for this paper.

Figure 2: Mean Investment
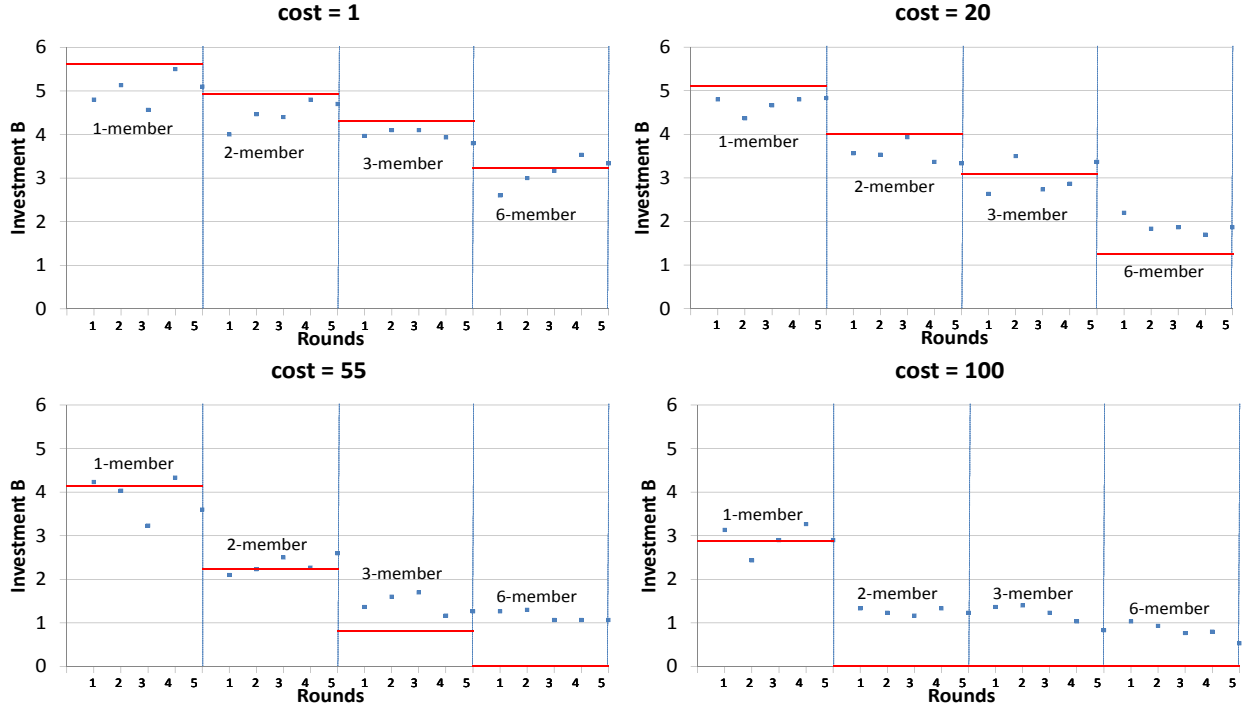
Theoretical predictions and the observed mean levels of investment in Project B are provided in Table 3. Theory predicts that the partnership solution decreases with cost. Observed mean investment and predicted investment in Project B are shaded for the partnership solution. Observed mean investment at the partnership solution for each cost is remarkably close to the theoretical predictions.

We performed some nonparametric tests by using independent observations (one data point per session). Two-sided sign tests confirm that there are no significant differences between the observed levels of investment and the theoretical predictions at the partnership solution (p-values> 0.2).

For *nonoptimal* group sizes, one-sided sign tests show that point predictions do not hold in general (p-values are generally less than 0.05).[17] Notice that deviations are toward the

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[17]The two exceptions are when cost is 20 and group size is six and when cost is 55 and

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Table 3: Predicted versus Observed Mean Investment

Group size	c = 1		c = 20		c = 55		c = 100	
	Predicted	Observed	Predicted	Observed	Predicted	Observed	Predicted	Observed
1	5.69	5.02 (1.36)	5.14	4.69 (1.55)	4.14	3.89 (1.50)	2.86	2.93 (1.70)
2	4.95	4.47 (1.41)	4	3.55 (1.54)	2.25	2.34 (1.68)	0	1.26 (1.38)
3	4.38	3.98 (1.55)	3.11	3.02 (1.56)	0.78	1.42 (1.35)	0	1.17 (1.46)
6	3.23	3.13 (1.85)	1.33	1.89 (1.59)	0	1.15 (1.47)	0	0.81 (1.12)
	Socially optimal investment = 3.32		Socially optimal investment = 3		Socially optimal investment = 2.42		Socially optimal investment = 1.67	
Standard deviations are in parentheses Number of observations = 150 per cell								

socially optimal level.

Result 1. *Theoretical predictions are supported at the partnership solution. However, there are deviations from quantitative predictions for other group sizes, always in the direction of socially optimal level.*

Table 4 shows the observed mean payoff for each cost and group size. For cost levels $c = \{1, 20, 55\}$ partnership solution generates the highest level of payoff. Note that for $c = 100$ partnership solution is 1 (no output sharing). However, for $c = 100$, higher levels of payoff are achieved with group sizes larger than 1. One possible explanation is that, for this particular cost level, the theoretically predicted level of investment (2.86 tokens in Table 3) is not very close to the socially efficient level (1.67 tokens) due to the integer constraint. Even though the mean investment with solo groups is not significantly different than predicted, there is significantly less free riding than predicted in larger groups. We will return to this when discussing the presence of altruistic behavior in our data.[18]

For cost levels $c = \{1, 20, 55\}$, we test whether the partnership solution improves the

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group size is one. In these cases, investments are not significantly different than the predicted

Table 4: Predicted versus Observed Mean Payoff

	c = 1		c = 20		c = 55		c = 100	
Group size	Predicted payoff	Obs. ave. payoff	Predicted payoff	Obs. ave. payoff	Predicted payoff	Obs. ave. payoff	Predicted payoff	Obs. ave. payoff
1	168	241 (88.03)	252	295 (90.61)	416	427 (75.65)	640	625 (61.61)
2	256	286 (75.70)	360	370 (67.48)	504	497 (101.21)	600	670 (109.19)
3	302	314 (58.25)	390	377 (64.86)	425	465 (85.11)	600	671 (132.10)
6	336	323 (22.34)	307	341 (48.99)	330	443 (88.00)	600	656 (105.90)
	Socially optimal payoff = 336		Socially optimal payoff = 390		Socially optimal payoff = 505		Socially optimal payoff = 683	
Standard deviations are in parentheses Number of observations = 150 per cell								

payoff of participants relative to the case where there is no output sharing (being solo). By using matched-pair sign-rank tests, we confirm that the partnership solution increases the payoffs. In particular, we compare the mean payoff levels at the partnership solution with the mean payoff levels at the group size of one. Individuals' payoffs increase with the partnership solution, and the difference is significant at the 5% level.

For $c = 100$, the group size of 1 brings the lowest payoff, even though it is the partnership solution (p-values for all pairwise comparisons are 0.04). Output sharing, which should be unstable if individuals were purely self-interested, helps individuals.

Result 2. *Output sharing improves payoffs (compared to being solo) when groups are exogenously formed.*

We complement nonparametric tests with a regression analysis. We investigate the impact of different group sizes, costs, the order of presenting group sizes, and rounds on individual levels.

[18]For group sizes greater than 1, complete free riding is not observed as predicted. This is consistent with behavior observed in public goods experiments. It has been documented that subjects do not free ride completely (see Ledyard 1995).

investment decisions by an ordered logistic regression with robust standard errors (see Table 5).[19]

Regression results (specification 1) show that both the opportunity cost parameter, c, and the group size affect the level of investment negatively.[20] Specifications 2–4 show that these results continue to hold even when we add control variables or when we include the different treatments as dummy variables. In addition, we see that the order of treatments and experience do not affect investment decisions.[21]

Result 3. *The data are consistent with the (qualitative) theoretical predictions. For each cost level, investment decreases with group size. Moreover, investment decreases with cost for a given group size.*

4.2 Voting for Group Size: The Plurality Rule

Table 6 presents the percentage of votes that each group size received for each cost level. There are 150 observations for a given level of cost. Except for $c = 100$, groups frequently vote for the partnership solution. Approximately 60% of the votes cast are for the partnership solution when $c = \{1, 55\}$, and approximately 40% of the votes cast are for the partnership

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[19]Data are clustered by 20 sessions.

[20]For robustness checks, we have also conducted OLS regressions. None of the qualitative results change with this method. Results are available upon request.

[21]In our experiment, socially optimal level is sometimes higher than the Nash contribution level and sometimes lower. When we control for the location of the socially optimal investment level compared to the Nash level, we then ask whether the order of the treatments and experience of 5 rounds within that treatment matter. We repeated the same regression for these two cases. Our qualitative results on the effect on *cost* and *groupsize* are exactly the same as before. In addition, we still do not find any effect of *round*. However, now we see some effect of the *block* when socially optimal level is below the Nash equilibrium level. The log odds of investing closer to the Nash level is slightly higher for later blocks. We see a much smaller effect of *block* when the Nash level is higher than the socially optimal level.

Table 5: Ordered Logistic Regression Results

Dependent Variable: Investment B	1	2	3	4
cost	-0.03***	-0.03***		
	(0.00)	(0.00)		
groupsize	-0.49***	-0.49***		
	(0.04)	(0.04)		
block		-0.03		
		(0.07)		
round		-0.01		
		(0.03)		
cost20			-0.98***	-0.98***
			(0.14)	(0.14)
cost55			-2.25***	-2.25***
			(0.16)	(0.16)
cost100			-3.05***	-3.05***
			(0.16)	(0.16)
grsize2			-1.47***	-1.47***
			(0.14)	(0.14)
grsize3			-2.05***	-2.06***
			(0.17)	(0.17)
grsize6			-2.84***	-2.84***
			(0.21)	(0.20)
block2				-0.04
				(0.10)
block3				0.04
				(0.13)
block4				0.01
				(0.15)
round2				0.03
				(0.12)
round3				-0.03
				(0.11)
round4				0.04
				(0.12)
round5				-0.06
				(0.13)
N	2400	2400	2400	2400
Wald Chi2	239.15	252.90	415.25	908.08
Robust standard errors, clustered at the session level, are in parentheses. ***: p-value < 0.01				

solution when $c = 20$.

Table 6: Percentage of Votes in Part V

Group size	c = 1	c = 20	c = 55	c = 100
1	8	12.7	7.3	22
2	16	39.3	57.3	24.7
3	16.7	39.3	11.3	33.3
6	59.3	8.7	24	20

For each cost parameter, we test whether one can reject the null hypothesis that the proportion of votes is 25% for each group size. For $c = \{1, 20, 55\}$, one can strongly reject this null hypothesis (chi-square goodness of fit test, p-values < 0.01). For $c = 100$, one cannot reject that the proportion of votes is 25% for each group size (for p-value $= 0.10$). More important, when the cost of investing is not very high, the highest percentage of votes is for the partnership solution. In particular, for $c = 1$, group size 6 received the highest number of votes; for $c = 20$, group sizes 2 and 3 received the highest number of votes; and for $c = 55$, group size 2 received the highest number of votes (proportion tests, p-values < 0.01). For $c = 100$, group size 3 received significantly more votes than the partnership solution of solo groups (proportion test, p-value $= 0.049$).

Result 4. *For $c = \{1, 20, 55\}$, the highest proportion of votes is received by the corresponding partnership solution. (This holds weakly for $c = 20$.) At all cost levels, output sharing receives a significantly positive share of votes.*

Result 4 shows that participants choose to form output-sharing groups for all cost levels. This includes treatments in which $c = 100$, where theory predicts subjects would vote for solo groups. The majority of votes corresponds to the group size that has generated the highest average payoff in the first four parts of the experiment. Out of 600 possible cases, subjects voted for the group size that generated the highest average payoff 348 times (172 out of these 348 are for the partnership solution), and 252 votes are for the group sizes that have not generated highest payoff (95 out of these 252 are for the partnership solution).

To evaluate the findings reported in Result 4 systematically, we complement it with a conditional logistic regression with both alternative and case-specific regressors.[22] Our objective is to determine the factors influencing voting behavior. The dependent variable, *vote*, is categorical, indicating the group size voted for by a subject in each round. We construct for each group size a dummy variable *isbesttreat* that takes the value of 1 if that group size delivered the subject a higher average payoff than other group sizes in Parts I–IV. Similarly, we construct for each group size a dummy variable *isoptimal* that takes the value of 1 if that group size is the partnership solution for the cost parameter in that session. Both *isbesttreat* and *isoptimal* are alternative-specific regressors. The cost parameter of a session (as well as a constant) is case-specific.

Table 7 reports maximum likelihood estimates of the conditional logit regression. Subjects strongly prefer voting for group sizes that delivered the highest payoff and for group sizes that are partnership solutions.[23] For perspective, the probability a subject votes for a particular group size is about 25 percentage points higher if that group size delivered the highest payoff and about 15 percentage points higher if that group size is the partnership solution. Our results show that subjects care for efficiency even when we control for previous experience (or the group size that generated the highest payoff for each subject).

Result 5. *When we control for the partnership solution, subjects vote most often for the group size that provided the highest previous payoffs. When we control for previous payoffs, subjects vote most often for the partnership solution.*

Table 8 presents the voting outcomes, mean investment decisions and payoffs conditional

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[22]We use conditional logit model (instead of multinomial logit model) since we have alternative-specific regressors. Alternative-specific regressors are those that vary across both cases and alternatives. Case-specific regressors do not vary across alternatives.

[23]We have also run a specification to see whether there is any change in choices over the rounds, but we did not observe any effect.

Table 7: Conditional Logistic Regression: Voting Behavior

	vote	vote
isbesttreat	1.26***	1.31***
	(0.13)	(0.13)
isoptimal	0.71***	0.85***
	(0.15)	(0.16)
Group Size 1		
	—	—
Group Size 2		
Constant	0.55**	0.61
	(0.25)	(0.36)
Cost	—	-0.00
	—	(0.00)
Group Size 3		
Constant	0.11	0.01
	(0.30)	(0.47)
Cost	—	0.01*
	—	(0.00)
Group Size 6		
Constant	0.46**	0.00
	(0.23)	(0.41)
Cost	—	0.00
	—	(0.00)
Cases	600	600
Wald χ^2	136.88	240.81
Standard errors, clustered at the session level, are in parentheses		
***: p-value < 0.01, **: p-value < 0.05, *: p-value< 0.10		

Table 8: Mean Investment and Payoff Conditional on Chosen Group Size

c	Group size	Frequency of Wins (out of 25)	Investment		Payoff	
			Predicted	Observed	Predicted	Observed
c = 1	1	2	5.69	5.75 (0.62)	168	158 (21.45)
	2	2	4.95	4.67 (1.23)	256	278 (53.76)
	3	1	4.38	4.50 (1.22)	302	294 (58.43)
	6	20	3.23	3.26 (1.71)	336	323 (20.82)
			Predicted	Observed	Predicted	Observed
c = 20	1	3	5.14	4.89 (1.49)	252	266 (102.95)
	2	12	4.00	3.74 (1.65)	360	369 (86.64)
	3	10	3.11	3.00 (1.28)	390	383 (48.70)
	6	0	1.33	−	307	−
			Predicted	Observed	Predicted	Observed
c = 55	1	0	4.14	−	416	−
	2	18	2.25	2.20 (1.37)	504	498 (88.20)
	3	1	0.78	0.83 (0.98)	425	430 (57.47)
	6	6	0	1.11 (1.69)	330	442 (95.41)
			Predicted	Observed	Predicted	Observed
c = 100	1	7	2.86	2.67 (1.51)	640	648 (39.62)
	2	6	0	1.00 (1.39)	600	659 (111.82)
	3	11	0	0.85 (1.18)	600	661 (105.97)
	6	1	0	0.50 (0.83)	600	643 (83.67)

on the chosen group size.[24] As in the exogenous groups, we see that participants choose investment levels that are consistent with the theoretical predictions at the partnership solution (all p-values are greater than 0.54).[25] Moreover, qualitative results are similar to the case when groups are exogenously imposed: investment decreases with the group size (p-value < 0.01) and cost (p-value < 0.01). Regression results are available from the authors.

Result 6. *Mean investment levels in Part V are not significantly different than theoretically predicted levels at the partnership solution. In addition, investments are consistent with the (qualitative) theoretical predictions. Investment decreases with group size and cost.*

Finally, we compare the efficiency of endogenous group formation with the case of exogenous groups. Efficiency of each part is defined by the observed average payoff divided by the socially optimal payoff. In Table 9, we provide the efficiency levels in all parts for each cost treatment.[26] As expected, efficiency levels are quite large. Endogenous group formation increases efficiency compared with the case of no output sharing for all cost levels. In particular, efficiency loss decreased by 50% for $cost = 100$ and by 68% to 71% for the other cost levels.[27] Tables 6 and 9 together show that subjects do vote for efficient outcomes. For

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[24]Since ties are broken randomly, even though there are equal numbers of votes for group sizes 2 and 3 when cost is 20, group size 2 won the voting more frequently than group size 3.

[25]We focus on the partnership solution, since votes are more often for the optimal group size. Therefore, there are not too much data available on the other group sizes. In fact, there are too few data points for many of the nonoptimal group sizes, which makes statistical testing not very meaningful.

[26]We have also used a normalized measure of efficiency. We took the difference between the observed average payoff and the minimum possible payoff and divided this with the difference between the socially optimal payoff and the minimum possible payoff. This alternative measure gives very similar efficiency levels, and all our qualitative results are the same.

[27]The efficiency levels are quite high considering the fact that voting was performed at the

example, when $cost = 100$, Table 6 shows that subjects are not choosing the theoretically predicted group size but instead vote for group sizes 2 and 3.[28] Table 9 shows that by doing so, they are actually achieving higher payoffs/efficiency.

Table 9: A Comparison of Efficiency Levels

	Group size	c = 1	c = 20	c = 55	c = 100
Exogenous	1	0.72	0.76	0.84	0.92
	2	0.85	0.95	0.98	0.98
	3	0.93	0.97	0.92	0.98
	6	0.96	0.87	0.88	0.96
Endogenous	voting	0.91	0.93	0.95	0.96

Result 7. *Subjects cut the inefficiency by one-half when* $cost = 100$ *and by at least two-thirds in the remaining cost treatments.*

We discuss the source of these unexpected results in the next section.

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very last stage of the experiment since, as public goods literature has consistently shown, free riding increases over periods.

[28]Note that since group size can only be an integer, partnership solution size does not imply that the highest possible level of efficiency will be reached at that group size. It only implies, given selfish individuals, that this predicted group size will bring higher efficiency compared to other group sizes. While for $cost = 1, 20, 55$, data are consistent with this prediction, for $cost = 100$, higher efficiency is reached for group size of 3. As Table 2 shows, the gap between the Nash equilibrium investment level at the partnership solution and the socially optimal investment level is highest for $cost = 100$. This explains why higher levels of payoffs are reached at $cost = 100$ compared to the predicted payoff of 640 (see Table 8), but not at the other cost levels.

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5 Discussion

5.1 Convergence Analysis

As previously noted, whenever aggregate investment in the Nash equilibrium differs substantially from socially optimal aggregate investment, subjects deviate from our Nash prediction, always in the direction of socially optimal investment.

We first consider whether such departures from self-interested behavior are transient. Do the data suggest that these departures would disappear if we had run the experiment longer?

To project whether these departures from self-interested behavior would ultimately disappear, we perform a convergence analysis. For each cost and group size, we run a simple linear regression analysis to estimate asymptotic investment behavior.[29] Both initial and long-term (asymptotic) estimates for investments are provided in Table 10. Except for the group sizes that are socially optimal for a given cost, in most of the cases asymptotic estimates are significantly different than the predicted levels and closer to the socially optimal investment levels.[30]

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[29]We run the following specification:

$investment_i = \alpha(\frac{1}{t}) + \beta(\frac{t-1}{t}) + \epsilon_i$

where i indicates observations and t represents the period number. Notice that as t gets larger, $(\frac{1}{t})$ approaches zero, and $(\frac{t-1}{t})$ approaches 1. Hence, the constant β gives the asymptotic estimate of investment, and the constant α gives an estimate for the initial investment.

[30]In contrast to these findings, Schott et al. (2007) report no systematic departures from self-interested behavior. Perhaps the difference in our results arises because we had fewer subjects per session (6 subjects instead of 12 subjects) or because we explored a range of cost parameters while they confined themselves to a single cost parameter (outside of our range).

Table 10: Initial versus Asymptotic Estimates

	Group size	Average	Initial Point	Asymptote	Predicted
c = 1	1	5.02	4.98 (0.11)	5.10*** (0.12)	5.69
	2	4.47	4.04 (0.17)	4.57* (0.16)	4.95
	3	3.98	3.43 (0.11)	4.10 (0.13)	4.38
	6	3.13	2.41 (0.13)	3.28 (0.04)	3.23
c = 20	Group size	Average	Initial Point	Asymptote	Predicted
	1	4.69	4.48 (0.15)	4.75* (0.15)	5.14
	2	3.55	2.44 (0.10)	3.79** (0.07)	4.00
	3	3.02	2.01 (0.08)	3.16 (0.14)	3.11
	6	1.89	2.59 (0.45)	1.69 (0.20)	1.33
c = 55	Group size	Average	Initial Point	Asymptote	Predicted
	1	3.89	4.09 (0.64)	3.83* (0.13)	4.14
	2	2.34	2.97 (0.06)	2.20 (0.08)	2.25
	3	1.42	0.75 (0.18)	1.51*** (0.11)	0.78
	6	1.15	1.32 (0.20)	1.11** (0.28)	0
c = 100	Group size	Average	Initial Point	Asymptote	Predicted
	1	2.93	2.23 (0.09)	2.98 (0.07)	2.86
	2	1.26	1.11 (0.10)	1.23*** (0.17)	0
	3	1.17	1.35 (0.17)	1.03*** (0.05)	0
	6	0.81	1.57 (0.24)	0.59*** (0.89)	0

Robust standard errors clustered at the session level are provided in parenthesis.
***Significantly different than the predicted investment at 1% level, **at 5% level, *at 10% level.

5.2 Identifying Social Preferences and Psychological Biases

Having concluded that these departures from self-interested behavior are not transient, we attempt to interpret them. Do they reflect genuine altruism or merely a tendency to avoid extremes or conform to the behavior of others?

Altruism has been used to explain departures from Nash predictions in prisoner's dilemma experiments, dictator experiments, common property experiments, and public goods experiments, among others (for an overview of altruism in experiments, see Andreoni et al. 2008; see also Ostrom et al. 1994; Ledyard 1995; Charness and Rabin 2002).[31]

Tendencies to avoid extremes have been used to explain the attraction and compromise effects (Simonson 1989; Simonson and Tversky 1992). In addition, extremeness aversion may explain why dictators choose more selfish actions when the action set in a dictator game includes taking from receiver (Bardsley 2008; List 2007).

Systematic deviations from the standard theory can also be explained by a preference for conformity (Bernheim 1994; Luzzati 1999). The experimental literature has documented a conformity effect (Velez et al. 2009). All else equal, subjects exhibit a preference for actions more similar to the actions of others.

In order to capture altruism, extremeness aversion, and conformity, we assume the fol-

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[31]In the dictator game, a selfish dictator would contribute nothing to the other player. In the linear public goods game, selfish players would make no contributions to the public account. Positive contributions in either game are interpreted as altruism but, as Ledyard (1995) pointed out, all errors in such games must lie on the side of the Nash prediction interpreted as altruism. In contrast, aggregate investment motivated by altruism in our experiment is predicted to be larger than aggregate investment motivated by self-interest for some sets of parameters (the number of groups and the cost of investing) but smaller than self-interested investment for other sets of parameters. This makes it all the more remarkable that *every* departure from Nash equilibrium that we observe is in the direction of socially efficient aggregate investment.

lowing utility function:

$$U_i = \alpha_1 \pi_i + \alpha_2 \sum_{j \neq i} \pi_j - \alpha_3 (x_i - 3)^2 - \alpha_4 (x_i - \frac{\sum_{j \neq i} x_j}{5})$$

This functional form allows preferences to depend on own payoff and others' payoffs, as well as being sensitive to extreme decisions with respect to both outcome space and the decisions of others.

To investigate the observed departures from self-interested behavior in our experiment and distinguish among possibly competing theories, we utilize data obtained from our Situation Analyzer. We examine the last pair of conjectures entered by each subject before making an investment decision in a given period.[32] Note that given the conjectures of a subject, altruism, extremeness aversion, and conformity theories may all make different predictions. While extremeness aversion theory will always bias the contributions toward the midpoint of 3 tokens, altruism and conformity may imply extreme decisions and not necessarily in the same direction. Therefore, we will be able to differentiate among these theories.

We again employ a conditional logistic regression to explain subjects' investment choices. The dependent variable *Investment* is categorical, indicating the investment in Project B chosen by a subject in a given period. Conditioning on a subject's conjecture of others' choices, we compute the variable *ownpay*, which equals the monetary payoff earned by a subject for each possible investment level. Similarly, we compute the variable *otherspay*, which equals the monetary payoff earned by the other subjects for each possible investment level. To investigate extremeness aversion, we consider the variable *extreme*, which equals the negative squared deviation between an investment level and 3, the midpoint of the action space. To investigate conformity, we also consider the variable *conformity*, which equals the

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[32]Another possibility is to consider the average of the conjectures as the real conjecture of the subjects. Our results do not change with this different specification.

negative squared deviation between an investment level and the average investment of others conjectured by the subject. We assume a standard logit probabilistic choice rule, where the choice probability depends on the relative expected utility of that choice compared to the other choices, i.e., $Prob(x) = \frac{exp(U(x))}{\sum exp(U(x))}$ where x can be any integer between 0 and 6.

Table 11: Conditional Logistic Regression: Situation Analyzer

	Investment	Investment
ownpay	0.036***	0.013***
	(0.005)	(0.001)
otherspay	0.028***	0.003**
	(0.006)	(0.001)
extreme	-0.781***	-0.133***
	(0.161)	(0.035)
conformity	0.758***	0.135***
	(0.142)	(0.029)
Case Variables	Group Size Cost	Conjectured Inside Conjectured Outside
Cases	1892	1892
Wald χ^2	1187.45	1007.59
Standard Errors, clustered at the session level, are in parentheses ***: p-value < 0.01, **: p-value < 0.05, *: p-value < 0.10		

Our estimations provide evidence of altruism and a preference for conformity, but not extremeness aversion (Table 11). The predicted probability of choosing a particular investment level is increasing in a subject's own payoff from that choice and other subjects' payoffs from that choice. More specifically, subjects exhibit a preference for actions that increase other players' payoffs (when we control for their own monetary payoff). We interpret this as evidence for altruism. When the monetary earnings for both oneself and others are controlled for, the positive coefficient on conformity indicates that subjects exhibit a preference for

choices that are more similar to those of other subjects. Furthermore, our estimates allow us to reject the extremeness aversion theory since, when we control for payoff and conformity, *more* extreme choices increase the probability of any particular choice.

We should, of course, qualify this discussion by noting that (1) in our Situation Analyzer data, subjects made conjectures for 1,892 out of the 3,000 investment decisions we observe,[33] and (2) subjects have no direct financial incentive to input their actual conjectures. Nonetheless, these data seem to provide some insight into the observed behavior.

6   Conclusions

When every individual's effort imposes negative externalities on his competitors, competition results in excessive aggregate effort. This explains overfishing when competing on common properties, duplication in innovation tournaments, and excessive talent searches among competing sports teams. In theory, one way to curb these excesses when costs cannot be monitored is for subsets of competitors to form groups that share output or revenue. If the right number of groups forms, Nash equilibrium aggregate effort should fall to the socially optimal level.

In this paper, we investigate whether players behave as predicted when assigned exogenously to equal-sized groups of different sizes and whether they form groups of the socially

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[33]Subjects decline to use the Situation Analyzer 798 of the times before entering their investment decision, and the rest of the time subjects enter conjectures that are out of range. Our Situation Analyzer only restricts subjects to enter conjectures between 0 and 30, but for group sizes 2 and 3, this restriction is not enough. For example, for a group size of 3, the conjecture for others inside the group cannot exceed 12 and the conjecture for others outside the group cannot exceed 18. We have eliminated the conjectures that are out of range from our analysis because they reflect either a misunderstanding or possibly a subject experimenting with the Situation Analyzer. In any case, our results are not affected by including these conjectures.

optimal size when permitted to do so. In addition, we investigate whether the group size selected motivates subjects to invest efficiently.[34] We find that output sharing attenuates the negative aggregate spillover problem *regardless* of the opportunity cost of investing. Consistent with theoretical predictions, we find a negative relationship between the aggregate investment levels and group size. Moreover, for a given group size, aggregate investment decreases as the opportunity cost of investing in it increases.

When investment based on self-interest and socially optimal investment differ significantly, however, theory does not predict aggregate investment well. Remarkably, deviations from Nash equilibrium predictions in such cases are without exception in the direction of socially efficient aggregate investment.[35] One explanation for this is that individuals have social preferences. Our data are consistent with theories of altruism and preferences for conformity. If individuals care not only about themselves but also about others, and if they prefer to conform with others' behavior, then one would expect to see higher levels of efficiency than predicted by a theory predicated on the assumption of self-interested behavior. This is highly consistent with our experimental data for the investment stage. In addition, social preferences would explain why subjects vote to have partners even when the cost of investment is so high that we predicted they would choose to go solo. Based on their experience

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[34]Future research should address the stability of the partnership mechanism. By stability, we mean migrations of subjects from one existing group to another or from an existing group to a newly formed group. Heintzelman et al. (2009) predict that no such migrations should occur. However, they also predict that migrations to newly formed solo partnerships would occur *unless* there was a direct cost to such migrations or there was a benefit to team production that would be lost by going solo. Their predictions, however, are based on self-interested behavior. As we have found in our voting treatment, altruism reduces the incentive of subjects to go solo. In addition, preplay communication may affect cooperation levels (Charness 2000; Charness and Dufwenberg 2006; Brandts and Cooper 2007; Chaudhuri et al. 2009; Brandts et al. 2012). For a preliminary study of the effects of such communication on the partnership solution, see Buckley et al. (2009, 2010).

[35]This is based on the investment data from the exogenous groups since there are very few data points for statistical testing for endogenous groups at the nonoptimal group sizes.

in exogenously formed groups, subjects anticipated that there would be less free riding in the investment stage than would occur if every subject were self-interested. As a result, solo groups were no longer their best option.

In sum, what started out as a "mere" test of the theory has ended up showing that there are systematic departures from self-interested behavior. By documenting these and the experiment in which they arise, we provide data that a future theory of behavior must admit as possible predicted outcomes if it is not to be rejected.

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