Efficient inter-group competition and the provision of public goods*

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Abstract: We propose an intergroup competition scheme (ICS) to solve the free-riding problem in the public goods game. Our solution only requires knowledge of the group contributions, is budget balanced and with the right parameters a dominant strategy. The main innovations of our design are that the prize to the winning group is paid by the losing group and that the size of the transfer depends on the difference in contribution by the two groups. With the right parameters, this scheme changes the dominant strategy from none to full contribution. We tested different parameterizations for the ICS. The experiments show dramatic gains in efficiency in all the ICS treatments. Moreover, versions of the ICS in which intergroup competition should not change the zero contribution Nash equilibrium also produce remarkable gains in efficiency and no decline in contributions over time.

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1. Introduction

Free riding on the contribution to public goods is a well known economic issue. Samuelson (1954) was the first to describe this problem in mathematical terms. In order to overcome it, theorists have been proposing a variety of taxation schemes since the early 1970s, e.g. Clark (1971), Groves and Ledyard (1977) or Green and Laffont (1979). Experimental evidence hints that free riding is a somehow less acute problem than the theory suggests (Sweeny 1973; Marwell and Ames 1979; Andreoni 1988). Experiments show subjects' tendencies to behave in a conditionally cooperative manner (Keser and van Winden 2000). Typically, initial contributions in finitely repeated public goods games start substantially higher than zero (around 50 percent of the individual endowment on average) but decline over time and approach zero in the last period. Gains on efficiency are significant with respect to the theoretical prediction but far from the social optimum. A few schemes manage to achieve degrees of efficiency closer to the social optimum. They rely, however, on participants having knowledge of their peers' individual contributions Fehr and Gaechter (2000); or on an informed third party (Holmstrom 1982; Falkinger et al. 2000). This is a serious shortcoming for the real-life implementation of such schemes in many salient applications.

We propose a simple intergroup competition scheme (ICS) to solve free riding in a linear version of the public goods game, namely the well known voluntary contributions mechanism (VCM). The proposed intergroup competition (ICS) scheme has desirable properties. First of all the ICS requires little information as it is enough to only know the aggregate contributions of each of two groups. Second, it is budget balanced. And third, as it is proportional to the difference in contributions, contributing fully becomes a dominant strategy with the right parameters. Moreover the ICS has the same good properties with some non-linear versions of the public goods game, more general than the VCM.

The ICS works as follows. The difference between the aggregate contributions of two groups is multiplied by a parameter (δ). This product is subtracted from the payoff of each member of the low aggregate contribution group and added to the payoff of each member of the high aggregate contribution group. Thus, by increasing contribution to the public good by one unit, a player receives the marginal per capita return (MPCR) plus δ. If the sum of the MPCR and δ is bigger than one, the efficient (full) contribution to the public good becomes a dominant strategy.

The ICS design is most applicable to organisational settings involving team production in groups. Sales teams, technology firms, and maybe even automotive factories[1] can be examples of firms that could use such a design to increase productivity.[2] Similar applications could be used in energy saving initiatives where groups compete to save the most energy and a proportion of the savings is distributed to the participants of the group with the greatest savings from the group with the least.

Our ICS design addresses the shortfalls of some incentivized tournaments proposeed to raise team performance (for examples see Lazear and Rosen 1981; Ehrenberg and Bognanno 1990). Tournament designs have the advantage of reducing the cost of providing the incentives by eliminating common shocks that affect agents' performance. A drawback of these designs however is that the agents are only incentivised to reach effort levels marginally better than their opponent. For the winners, any effort beyond the winning threshold yields no additional return. Arce and Jerez (2009) show after analysing a sales contest organized by a commodity company that winning participants decrease their effort as their lead increases. Similarly, losing participants decreased their efforts when the gap became very large.

Most of the literature on intergroup competition to date has examined competition under schemes where members of the winning team receive a bonus or reward. In contrast to our design, no transfer between the groups occurs under these schemes. Rapoport and Bornstein (1987) were the first to introduce an intergroup competition paradigm into social dilemmas by proposing a binary public goods game where two groups compete in aggregate contributions for a reward. The primary motivation for such games was to examine the effect of differing endowment sizes, group sizes and game structure on contributions in an environment of intergroup conflict (Rapoport,

[1] Two factories producing the same car with the same techonology.
[2] Note that in theses contexts a principal may base an ICS on variables like output of sales rather than aggregate group contribution or aggregate group effort.

Bornstein and Erev 1989; Bornstein, Erev and Goren 1994; Bornstein 2003). Intergroup conflict exacerbated inefficiencies in the Chicken game (Bornstein, Budescu and Zamir 1997) and intergroup competition was initially framed as an economic and societal problem to be examined. The possibility of exploiting intergroup competition to achieve socially efficient outcomes started to emerge experimentally with Borstein, Erev and Rosen (1990); Bornstein Gneezy and Nagel (2002); and Gunnthorsdottir and Rapoport (2006). Intergroup competition was shown to reduce free riding in social dilemma experiments and raise effort levels in a field study involving team production (Erev, Bornstein and Galil 1993). Still, all of these studies (and the theoretical literature of taxation and tournament schemes) use designs that rely on rewards that are funded by the experimenter. The additional cost of these rewards imposes a non-balanced budget and a loss of efficiency.

The closet study to ours is one by Tan and Bolle (2007) who found that a awarding a higher MPCR of the public good to the winning group increased contributions under intergroup competition in the public goods game compared to no differentiation of MPCR. Their study consisted of fewer subjects with no treatments in which the parameters changed the Nash equilibrium to full contribution. Our study aims to directly test a transfer design in which the parameters change the Nash equilibrium to full contribution. We also test the performance of the ICS compared with a reward scheme with no transfer. Our no transfer reward scheme is similar to that of prior intergroup competition schemes mentioned above in that the reward is funded by the experimenter. Although it is also different in that the amount rewarded depends on the difference between the two groups, providing an incentive not to only win but to win by a larger amount. To assess the sensitivity of the ICS to changes in the parameters and separate the different motivations that might be driving the mechanism, we additionally test a weaker version of the ICS.

The ICS can be also superior to a scheme in which group members are rewarded if the group output reaches a threshold. Note that with the right parameters this scheme would also generate an efficient solution through a dominant strategy. The ICS does not require setting a threshold and therefore it is not necessary to know how far a group can increase its productivity.

This paper is structured as follows. Section 2 discusses the ICS. Section 3 contains the experimental design. Section 4 summarises the results and section 5 concludes. An Appendix contains a sample of the experimental instructions.

2. The intergroup competition scheme (ICS)

We model a public goods situation using a standard Voluntary Contributions Mechanism (VCM) (see Davis and Holt 1993; Ledyard 1995). Participants are given the same endowment *w* so that each participant has the same budget. Participants interact in groups of *N*. Each individual has to decide how much of his endowment to allocate to a public account t_i and how much to keep for himself $w- t_i$. For each group, the sum of the individual allocations to the public good $\sum_{j=1}^{N} t_j$ is then multiplied by a factor a (where $N > a > 1$), to model the additional value generated from the public nature of the good. The final value of the public account is then shared equally among the group members. The payoff therefore of player *i* under a VCM is given by:

$$\pi_i = (w - t_i) + \frac{a}{N}\sum_{j=1}^{N} t_j \ .$$

Since $\frac{a}{N} < 1$, under the assumptions of selfishness and common knowledge of perfect rationality, it is a dominant strategy for each individual to free ride, that is to allocate nothing to the public account. This is because the returns from the public account are shared equally and no individual receives the full return from their own investment. However, maximum efficiency is achieved when all members allocate their entire endowment $t_i = w, \forall i$. The VCM mechanism models the conflict between individual and group incentives.

We propose the following Intergroup Competition Scheme (ICS) to solve the free rider problem. The mechanism involves competition between two groups where the prize to the winning group is funded by the losing group. Thus the mechanism works through a *transfer* from one group to another. Let us suppose two groups, denoted A and B, compete in aggregate allocations to the public account. The difference in aggregate allocations between the two groups is multiplied by a parameter δ. This product is then subtracted from the payoff of each member of the group with the lower aggregate contribution and added to each participant's payoff in the group with the higher aggregate contribution. Participants still receive the MPCR from the public good but now also receive an additional return on the public account from the transfer parameter δ. formally, the payoff of member *i* belonging to group A can be described as:

$$\pi_i^A = (w - t_i^A) + \frac{a}{N}\sum_{j=1}^{N} t_j^A + \delta(\sum_{j=1}^{N} t_j^A - \sum_{j=1}^{N} t_j^B)$$

Conversely, for member *l* of group B:

$$\pi_l^B = (w - t_l^B) + \frac{a}{N}\sum_{j=1}^{N} t_j^B + \delta(\sum_{j=1}^{N} t_j^B - \sum_{j=1}^{N} t_j^A)$$

Note that if $\frac{a}{N} + \delta > 1$, then $t_i^k = w$ (with *k = A or B*) is a dominant strategy under the assumptions of selfishness and common knowledge of perfect rationality[3]. Regardless of the contributions of the other team members, it will always be in an individual's best interest to contribute fully to the public account. At the very least, an individual can always minimise their loses by contributing maximally. Under the ICS, even though the equilibrium yields max π_i, it is still possible for participants to make losses out of equilibrium.

The ICS is designed to work with the VCM, that is, a simple linear version of the public goods game. When generalising the ICS beyond a simple linear version some problems need to be taken into account. In the VCM, maximum efficiency is achieved when the whole endowment is allocated to the public good. A non linear version of the public goods game has, in general, an interior solution. That is, optimality is achieved by allocating a positive amount lower than the endowment. In this case, under the ICS, there is a risk of overshooting and therefore providing too much of the public good. Overshooting can be avoided and efficiency can still be

[3] Under fairly general assumptions the scheme would also work for conditional cooperators.

achieved in a more general public goods environment. Consider for instance the simplest of the Holmstrom (1982) team production models. In that model n individuals who take a costly non-observable action (that can be understood as a contribution to a public good) $a_i \in A_i = [0, \infty)$ with a private (nonmonetary) cost $v_i : A_i \to \Re; v_i$ is strictly convex, differentiable and increasing with $v_i(0) = 0$. Let $a = (a_1 ... a_n) \in A \equiv \overset{n}{\underset{i=1}{X}}$. The actions taken by the n individuals determine a monetary outcome $x : A \to \Re$, that must be allocated among them. The function x should be strictly increasing, differentiable and concave with $x(0) = 0$. Finally $s_i(x)$ is the share of agent i in the output. The preference function of agent i is supposed to be additively separable in money and action and linear in money. Holmstrom demonstrates the inexistence of Pareto efficient, budget balanced sharing rules.

In the Holmstrom model, efficiency can be achieved through intergroup competition. As earlier we assume there are two groups, A and B, with the same number of members. Let us suppose the sharing rule is simply $\frac{x^K}{n}$, $K = A$ or B, group members share the output equally. The maximization problem for a member of group A is

$$\max_{a_i^A} \frac{x^A}{n} - v_i^A(a_i^A) + \delta(x^A - x^B).$$

The first order condition characterizes the optimal effort: $(\frac{1}{n} + \delta)\frac{\partial x^A}{\partial a_i^A} - \frac{\partial v_i^A}{\partial a_i^A} = 0$. Following Holmstrom Pareto optimality implies $\frac{\partial x^A}{\partial a_i^A} - \frac{\partial v_i^A}{\partial a_i^A} = 0$. Hence an efficient solution can be achieved through intergroup competition if $\frac{1}{n} + \delta = 1 \Leftrightarrow \delta = \frac{n-1}{n}$.

Note that intergroup competition breaks budget balancing within each group but there is budget balancing when considering the two groups. There might be intergroup transfers in equilibrium but money does not exogenously enter or exit from outside of the two groups.

Even if overshooting could be sometimes avoided in a general public goods context, if heterogeneity exits amongst agents, some agents could be worse off by participating in public good production or in a team effort task. In a team effort task, the participation constraint may have a positive effect as the agents who can obtain a benefit would self-select into the task. Note that the ICS entails the right incentives for the teams to improve in the long run by learning to perform better or by hiring better team members. In a similar vein, it may become unnecessary to know what the efficient provision to the public good (or to the team is). Hiring better team members would push the envelope of what can be achieved in the Pareto optimal situation, everyone always has the incentive to go the extra mile.

3. Experimental design

A total of 328 subjects (mainly undergraduates) participated in one of 14 experimental sessions of a zTree (Fischbacher, 2007) computerized experiment conducted at the Behavioural Experimental Lab at the University of Sydney. The experimental lab seats 36 privately partitioned computer stations inhibiting communication and line of sight. Average individual earnings were $31.50 AUS for a 1.5 hour long experiment.

There were five conditions in our study, two controls and three treatments (see table 1 for a summary of conditions). The main condition to test the performance of the ICS in raising contributions was IG1. This condition had parameters designed such that the Nash equilibrium was full contribution. The IG2 condition tests whether the same results of IG1 can be induced without a transfer. The IG3 condition tests the extent to which economic rationality is a motivator of the mechanism through a weakened transfer parameter. For simplicity in describing the conditions we denote α as the MPCR of the public good and δ equal the return from the inter-group transfer for every dollar contributed.

Table 1: Summary of experimental conditions

		Marginal return	Payoff parameters		Nash Equilibria:
C1	Standard public Goods	$\alpha < 1$	$\alpha = 0.5$		$[t_i=0]$ (contribute zero)
C2	inter-group information only	$\alpha < 1$	$\alpha = 0.5$	$\delta = 0$	$[t_i=0]$ (contribute zero)
IG1	**Inter-group mechanism**	$\alpha + \delta > 1$	$\alpha = 0.5$	$\delta = 0.75$	**$[t_i=w_i]$ (full contribution)**
IG2	No transfer design[e] (bonus scheme)	$\alpha + \delta > 1$	$\alpha = 0.5$	$\delta = 0.75$	$[t_i^A=w_i,\ t_i^B=0]$; $[t_i^A=0,\ t_i^B=w_i]$ (one group full contribution)
IG3	Weakened inter-group mechanism	$\alpha + \delta < 1$	$\alpha = 0.5$	$\delta = 0.25$	$[t_i=0]$ (contribute zero)

e=transfer funded by the experimentalist

There were two stages to the experiment. Two sets of instructions were given to subjects, one for stage one, given before the commencement of stage one and one for stage two given after the completion of stage one. The instructions carefully explained the experiment within a neutral frame and how subjects' payoffs would be calculated using a formula and examples. After five minutes reading time the instructions were read allow and subjects were given an opportunity to ask questions. We took great care to make sure subjects understood the rules and payoff functions by making subjects answer three numerically rigorous control questions (see supplementary material for instructions and questions). Those requiring assistance were counselled privately. The experiment did not proceed until all subjects answered the questions correctly and we presume all subjects fully understood the experiment.

In the first stage of our experiment, subjects played 10 rounds of a standard Public Goods Game (Marwell and Ames 1979; Isaac and Walker 1988; Ledyard 1995). In this standard game, subjects were anonymously matched into groups of four at the beginning of stage one and remained in the same group for the entire 10 rounds. Every round each subject was given an endowment of 100 cents in which they had to decide how much to keep and how much to contribute to a public project. At the end of each round, total contributions to the public project were multiplied by two and then shared equally between the members of the group. Subjects were given feedback on the total contributions made to the public project by their group and their calculated payoffs (for that round and in total) at the end of each round. All treatments began with this first stage standard Public Goods Game.

In the second stage, subjects played 10 rounds of a modified treatment Public Goods Game in all treatments except C1 where stage two was identical to stage one. Subjects were re-matched into new groups at the beginning of stage two. The re-matching was designed so that none of a subject's group members from stage one would be in their new group. In all the conditions except C1, the subject's group was also paired with another group at the beginning of stage two. The groups and group pairs remained the same for the entire 10 rounds. In stage two, all conditions except C1 were given additional information at the end of each round on the total contributions of their paired group. In the C2 condition, the comparative information was given but the individual payoffs were calculated the same way as in stage one. For the IG1-3 conditions however, the calculated payoffs depended on the difference in contributions between their own group and the other group they were paired with. In the IG1 condition, parameters were chosen so the marginal payoffs for contributing to the public project were greater than one, thus theoretically overcoming an individual's disincentive to contribute. Subjects received an equal share of the return of the public project (as in stage one) however their payoff would also be increased or decreased by 75 percent (δ =0.75) of the difference in total contributions between their group and the group they are paired with. If their group contributed more (less) than the other, then their payoff would increase (decrease) by 75 percent of the difference in contributions. Only in the IG1 condition, was it possible to earn a negative income in a round. For this condition, any losses in a round was covered by a subject's previous earnings in stage one.

4. Results

Cooperation

The average subject contribution using independent group and group-pair contributions for C1 and C2 are 49.86 (s.d. 14.20) and 34.73 (s.d.11.74) respectively. In the absence of incentives, providing comparative contribution information to subjects lowered the proportion contributed by an average of 15 percent. The average contribution in the inter-group conditions IG1, IG2, IG3 were 80.90 (s.d.10.78), 64.03 (s.d. 9.02) and 67.61 (s.d.13.69) respectively. Consistent with theoretical predictions, IG1 yielded the highest average contribution of all the conditions with an average more than double that of C2. However, average IG1 contributions did not quite reach the Nash prediction of 100 percent contribution. Interestingly, in conditions IG2 and IG3, where the Nash equilibrium is still zero, we observe a significant increase in average contributions. Median values for each condition were similar to the means and are reported in Table 2.

The average contributions in each treatment condition are all significantly different from the control conditions C1 and C2 using the Mann Whitney test (Table 2). Significant differences between the conditions also exist, particularly IG1, indicating strong empirical support for the theoretical inter-group solution.

Table 2. Mean, median contributions and Mann-Whitney tests using independent observations

	Condition				
	C1	**C2**	**IG1**	**IG2**	**IG3**
Mean contribution	49.86	34.73	80.92	64.03	67.61
Median contribution	50.31	36.54	81.11	64.93	69.38
Mann Whitney (p-val)					
C1	-	0.055*	0.0002***	0.0253**	0.0157**
C2		-	0.0003***	0.0008***	0.0005***
IG1			-	0.0094***	0.0469**
IG2				-	0.4414
IG3					-

When we analyse cooperative behaviour in the stage two game by grouping individuals into four main types[4] (Table 3), we make an interesting observation: that proportion of Weak co-operators is most affected (positively) by the introduction of intergroup competition. This leads to the question, are there some contributor types that are more (less) sensitive to incentives than others?

[4] We define strong free riders as individuals who contribute on average between zero and 25 percent, weak free riders as having average contributions between 25.1 and 50 percent, weak cooperators as having average contributions between 50.1 and 75 percent; strong cooperators as individuals who contribute on average between 75.1 to 100 percent. We do not use Kaser and van Winden's (2000) definitions because they cannot be used to catagorize the entire set of contributors.

Table 3. Percentage of free riding and co-operating individuals in each condition

Condition	Strong free riders	Weak free riders	Weak co-operators	Strong co-operators
C1	12.50	37.50	16.70	33.30
C2	39.00	36.10	5.50	19.40
IG1	1.4	9.7	73.6	15.3
IG2	15.65	21.90	48.40	14.05
IG3	11.15	18.05	47.20	23.60

To answer this we needed to find out how persistent individual contribution preferences were under the different condition mechanisms (regression a) Table 4). We therefore regressed each subjects' average stage two contribution (*S2Cont*) on their average stage one contribution (*S1*) along with condition dummies, the base being C1, and interaction terms (see Table 4).

Table 4. Effect of an individual's stage one contribution on stage two contributions and probability of contribution type change

	a) S2Cont (n=328)		b) Ctype (p=1)
Constant	9.381 (7.857)	Constant	-0.364 (0.393)
S1	0.758*** (0.131)	s1wf	-0.105 (0.316)
C2	2.611 (9.619)	s1wc	0.267 (0.357)
IG1	64.430*** (9.152)	s1sc	-1.170** (0.457)
IG2	28.361*** (9.473)	C2	0.452 (0.392)
IG3	43.341*** (9.012)	IG1	2.313*** (0.470)
S1.C2	-0.204 (.177)	IG2	0.947** (0.407)
S1.T1	-0.556*** (0.172)	IG3	1.691*** (0.424)
S1.T2	-0.099 (0.173)		

S1.T3	-0.357**
	(0.162)
R-square	0.475

Dependent variables: a)S2Cont= stage two average contribution of individual *i.* b) (logit) Ctype = 1 if an individual's contribution type changed from game 1 to game 2, zero otherwise.

The significantly negative coefficients of S1IG1 and S1IG2 imply that the transfer mechanism removes a lot of the dependence of stage one contributions on the second stage. No significant interaction effect is evident for the IG2 condition implying that bonuses are not enough to remove individuals' prior contribution inclination. Regression b) in table 4 suggests that no particular contributor type was more sensitive to incentives than others. The significance of *s1sc* shows that strong co-operators were less likely to change after incentives were introduced. This suggests that these incentives were not at the very least crowding out their motivation to contribute.

Temporal analysis

The control conditions replicate the temporal results of earlier VCM experiments (Ledyard 1995) where mean contributions start between 40 to 60 percent of the endowment and decline to close to zero. This is evident from Figure 1. In contrast to our controls, inter-group competition in all three conditions halted the typical decay of contributions over time. Contribution decay was even halted in the weakened inter-group condition IG3 where the dominant strategy of zero contribution was the same as the control conditions. A similar halting and reduction of decay in intergroup competition VCM treatments are observed in Gunnthordottir and Rapoport (2006) and Tan and Bolle (2007). A graph of the difference in group contributions over time for condition IG3 is also given to show the mild convergence towards the equilibrium prediction of a 100 percent difference in contributions between the two groups.

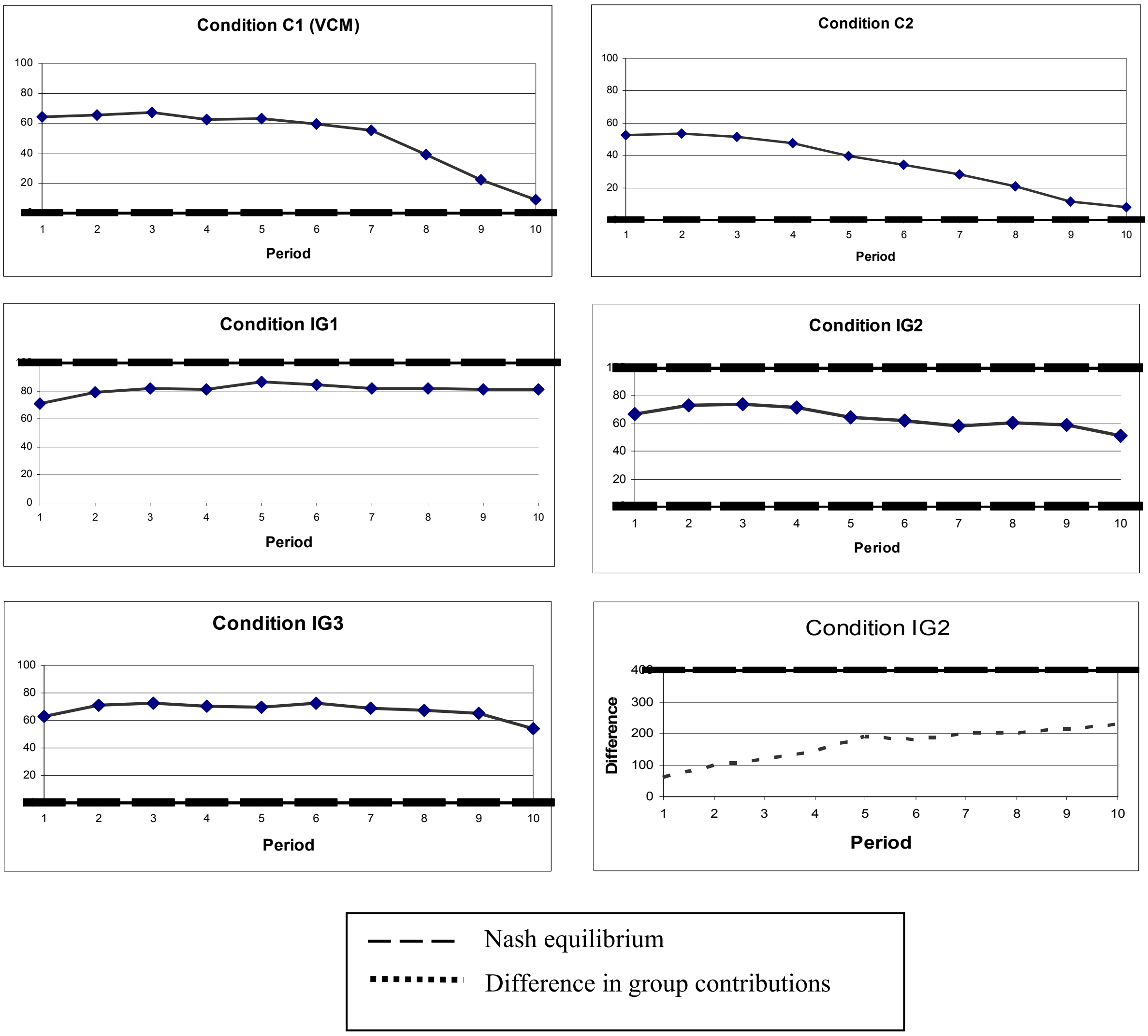


Figure 1. Mean contributions per period

The second aspect of our temporal analysis concerns the percentage of non-contributors over time. Non-contributors grew early in the control conditions and by the end of the game, nearly 80 percent of subjects in condition C1 contributed nothing (Figure 2). In contrast to the control conditions, non-contributors remained low in the inter-group competition conditions until the last round, with the exception of the IG1 condition where there was no increase in non-contributors in the final round. The IG1 condition outperformed all the conditions with the lowest percentage of non-contributors throughout all 10 periods.

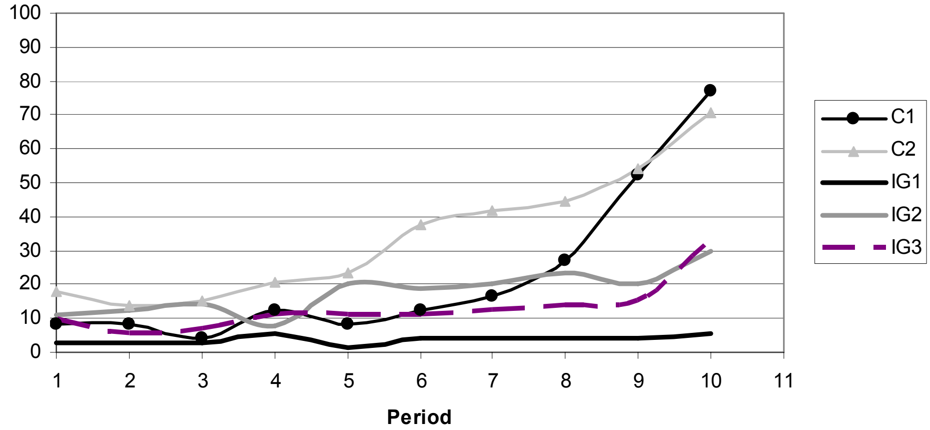
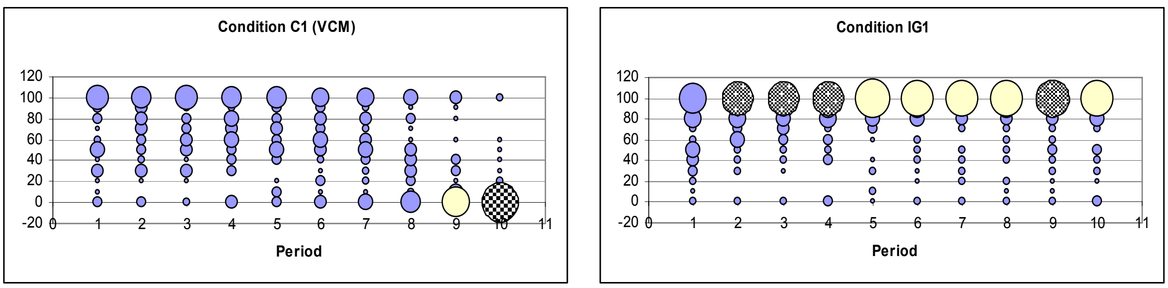


Figure 2. Percentage of non-contributors by period

Next we examine the distribution of contributions over time for each of the five conditions. As expected, Figure 3 shows that the control conditions converge to a positively skewed, unimodal distribution. There is more spread in the contributions in periods one to 8 in the control conditions compared with the competition conditions. However, in the final two rounds the concentration of contributions quickly surpasses the competition treatments by falling to zero. Condition IG1 consistently displays a unimodal distribution in the opposite direction (full contribution). In the IG2 condition, where the Nash equilibrium is for one team contribute fully and the other nothing, we observed a convergence to relevant bimodal distribution. In condition IG3, where the Nash equilibrium is to contribute nothing, the distribution is unimodally positively skewed towards full contribution until the last round where some players defect to lower contributions creating a bimodal distribution.



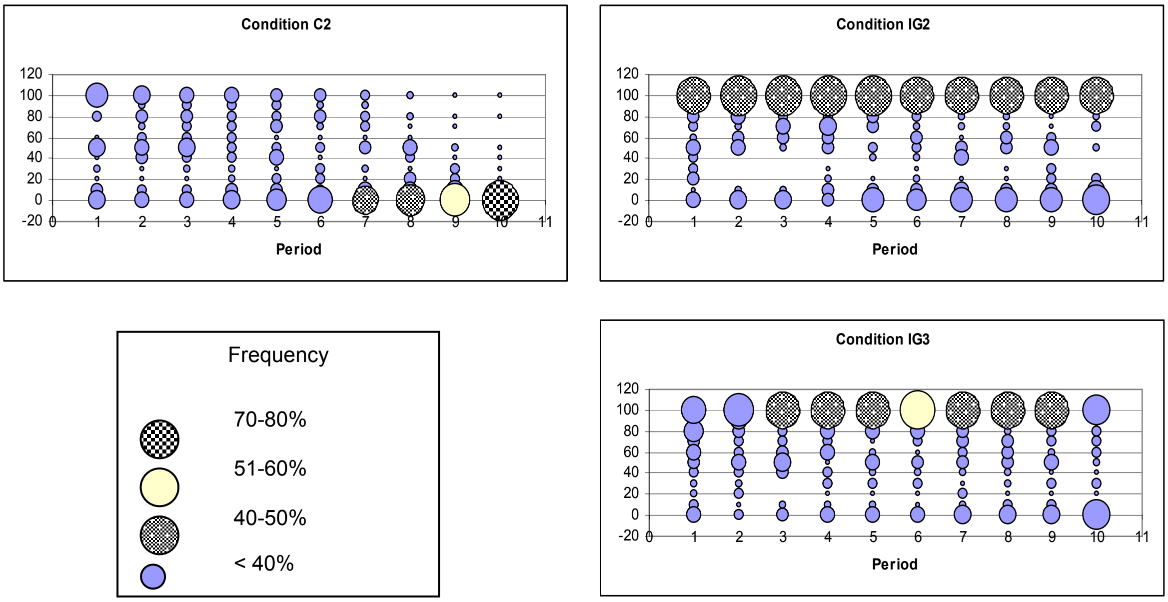


Figure 3. Distribution of contributions over time

Conditional and competitive behaviour

To what extent do the effects of conditional cooperation and competitive inter-group behaviour explain the different results in each of the conditions? To investigate exactly what motivated an individual to change their contribution from one round to the next we performed a panel data analysis. A Hausman test (Prob>chi2 = 0.000) suggested that the individual effects were correlated with our regressors therefore fixed effects estimation was the appropriate estimator for our data (Table 5). In these regressions the dependent variable is the change in a subject's contribution from the previous period (DCont). The significance of difference between own's contribution an the average contributions of others (LDiff) in all regressions in table 5 provides strong evidence of conditional cooperation in all conditions. Contributions are adjusted downwards (upwards) if in the previous round, one contributed more (less) than the average contribution of her co-members in the previous period. The interaction term LDiff.IG2 suggests that conditional cooperation is slightly stronger in the IG2 condition compared with C2.

The variable LGDiff estimates the marginal effect of winning (win sample) and losing (loss sample) in the previous round on an individual's change in contribution.

The coefficient can be interpreted as the average change in contribution for a one cent increase in the size of the difference between the aggregate group contributions. Our estimates show that a loss to the other group raised contributions in the next round. However, a win also had the effect of *decreasing* contributions in the next round. Losing though, did have a slightly bigger impact than winning. This was true for all inter-group conditions (C1 not being an inter-group condition) except for IG1. In the IG1 condition, where the parameters make full contribution the Nash equilibrium, the negative effect of winning was significantly reversed. The parameterization was successful at stopping the downward adjustment of contributions from the winners. It is in the loss sample that the IG1 condition is primarily distinguished from the other treatments by significantly increasing the marginal effect of losing on raising contributions. These estimates suggest that success of the IG1 condition in raising contributions over the other conditions rests on its greater ability to motivate the members of losing teams to raise their level of contribution.

Table 5: Fixed effects regressions of DCont

	DCont of subject		
	C1	*Win sample*	*Loss sample*
Constant	-16.646	5.925	-2.336
	(3.352)***	(1.862)***	(2.589)
LDiff	-0.562	-0.486	-0.731
	(0.045)***	(0.043)***	(0.052)***
LGDiff		-0.056	0.093
		(0.023)**	(0.032)***
LDiff.IG1		0.028	-0.040
		(0.100)	(0.085)
LDiff.IG2		-0.132	-0.024
		(0.079)*	(0.068)
LDiff.IG3		0.000	0.086
		(0.075)	(0.071)
LGDiff.IG1		0.054	0.136
		(0.032)*	(0.045)***
LGDiff.IG2		0.040	-0.029
		(0.029)	(0.040)
LGDiff.IG3		0.048	0.038
		(0.032)	(0.045)
+ Round dummies (output not reported)			
R-square (within)	0.34	0.26	0.46

DCont=current period contribution – previous period contribution; LDiff = previous round contribution – previous round average contribution of co-members; LGdiff = previous round difference between paired groups' aggregate contributions (LDdiff for loss sample was multiplied by -1 so as to interpret the variable as the magnitude of the loss). Dummies for rounds two to 10 were added (output excluded).Win sample if own group's contributions were greater than the other group in the previous round and Loss sample if otherwise. Base condition for win and loss sample regressions is C2. Standard errors are reported in parentheses.

5. Conclusion

This paper demonstrates that an ICS with the right parameters can successfully increase cooperation close to Pareto optimal levels in a linear public goods game. The mechanism under IG1 parameters successfully removed prior contribution inclination and outperformed the bonus scheme in raising cooperation. We further reveal that intergroup competition broadly has the effect of halting contribution decay over time. Conditional cooperation seems to be robust to the presence of intergroup competition and was confirmed in all treatments. Under an ICS, losing against another team motivated subjects to contribute more the next period. With the right parameters this effect can yield significantly higher aggregate contributions to public goods.

Higher average contributions in IG1 when compared with IG3, demonstrate that subjects follow some economic rationality (cost-benefit considerations). The marginal return to contribution in IG1 is higher than in IG3. However in IG3 we observe average contributions levels of 70 percent of the endowment which is significantly higher than both the equilibrium prediction of zero and the average contributions in the C2 control treatment (35 percent). It is clear that competitive behaviour is driving at most of the results. One could argue that out of the 80 percent average contribution in IG1, 35 percent can be attributed to competitive motivations and only 10 percent can be attributed to rational considerations.

Why the mean contribution in C2 was significantly lower than the mean contribution of the C1 condition is not clear. This result was slightly unexpected as we believed that if providing comparative information on aggregate group contributions had any effect on contributions at all, it would be positive. Figure 1 shows that average contributions in C2 were lower than C1 even in the first round. Contributions therefore may be depressed due to the imposed comparison institution rather than the comparative information per se. This anomaly requires further research to understand the mechanism depressing contributions in C2.

The ICS was successful in raising aggregate contributions close to efficient levels. This mechanism primarily works by motivating losing teams to contribute more. For best results though, parameters should be set so that the marginal return from contribution is greater than one.

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