

Voluntary Contributions to Multiple Linear Public Goods

Rob Moir

University of New Brunswick in Saint John

rmoir@unbsj.ca

Abstract

There is a lengthy economic tradition studying “public goods.” Despite the pluralistic title, much of the modeling and experimental work to date has made use of a composite public good. Theorists have recently begun to model economic choice when agents are faced with multiple public goods. Meanwhile there is a lack of behavioural analysis in this area. In this paper, I examine the behavioural effects of the voluntary contributions mechanism when a second, less socially-valued public good exists in a linear payoff environment. There seems to be a small increase in overall public good contributions.

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1. INTRODUCTION

In 1965, Mancur Olson Jr. published *The Logic of Collective Action: Public Goods and the Theory of Groups*. This spawned a rich literature on the provision of public goods. A simple search on EconLit reveals 1,342 refereed journal articles between 1969 and May of 2008 containing either “public goods” or “public good” in the title. Since 2007, 88 such articles have been published. Much of the economic modeling in this literature has made the convenient simplification of including a composite public good. While demonstrably false, this simplification has permitted significant insight into theory, policy, and behaviour in relation to the provision of public goods. Only recently have theorists begun to probe into the subtleties of the provision of multiple public goods.

This recent theoretical shift has not been complemented with behavioural research. Are the general behavioural results of voluntary contributions to a composite public good robust to the inclusion of additional public goods? More specifically, in a linear public good environment, does the addition of a second, less socially desirable public good, alter people’s voluntary contribution behaviour? This paper presents the results of an experiment designed to answer this second question.

The remainder of this paper is constructed as follows. Section 2 provides a brief overview of the theoretical literature modeling economic decision-making in the face of multiple public goods. Also included is a brief summary of some tangentially related experiments. The linear public good model, game theoretic predictions, and experimental design are outlined in Section 3. Linearity necessarily imposes perfect substitutability between private and public goods; while overly simplistic compared to reality, this simplification permits us to see if there are unexpected behavioural phenomena when a second public good is present. Section 4 presents results from three sessions – a baseline with only one public good and two treatment sessions with two public goods. Section 4 concludes with suggestions for future behavioural research.

2. LITERATURE REVIEW

Uncovering the history of theoretical modeling of multiple public goods is quite difficult because of a certain degree of grammatical laxity in the terms “public good” and “public goods.”¹ As far as I can tell, the history of multiple public goods research was founded in Warr’s (1983) famous neutrality result which showed that the level of voluntary public good provision is independent of the distribution of income. While his model was based

¹ For instance, McGuire (1974), Warr (1983), Cornes and Sandler (1985) all have titles with the singular term “public good,” while Young (1982) and Cornes and Sandler (1984) use the plural, “public goods,” yet in all instances the models include a composite public good. Experimental economists have likewise contributed to the confusion with early papers like Smith (1980) using the singular and Isaac, McCue and Plott (1985) using the plural, yet both papers are based on a payoff function with a composite public good. Indeed two key survey papers of composite public good experiments, Ledyard (1995) and Zelmer (2003), both contain “public goods” in their titles.

upon a composite public good, Kemp (1984), and independently Bernheim (1986), extended the neutrality result to a model with two public goods, in 4-page and 5-page notes respectively.² In their effort to expand upon Warr's result and Kemp's extension, Bergstrom, Blume, and Varian (1986) provided a more complete discussion of neutrality with multiple public goods (pp. 44-47). For a long while, these 13 pages were the extent of modeling public goods as opposed to a composite public good.³

Recently, theorists have examined multiple public goods in greater detail. Cornes and Schweinberger (1996) posit a household production model with multiple private and public goods and derive both efficiency and free-riding results. They also show that, relative to a Nash equilibrium, significant welfare improvements can be attained with a reallocation of factors just among the public goods. This second result is examined in greater detail in a recent working paper (Cornes and Itaya, 2004). Fang and Norman (2008) explore bundling as an optimal solution to the provision of multiple excludable public goods while Ghosh et al. (2007) propose bundling specifically as a solution to the issues identified in Cornes and Itaya. In the tradition of Hotelling (1929), Ehlers (2001, 2002, and 2003) considers location- or attribute-specific models of an otherwise identical public good as an example of the provision of multiple public goods. Mechanism design (Sprumont, 1998; Koster, et al., 2003; Mutuswami and Winter, 2004) and strategyproofness of rules governing the cost sharing and allocation of multiple goods (Mutuswami, 2007; Svensson and Torstensson, 2008) have received recent attention. Clark and Kanbur (2006) consider the varying degrees of "publicness" of private goods, positing a "Samuelson machine" that converts otherwise private goods into public goods.

The recent explosion in the theoretical literature concerning the provision of multiple public goods has not been accompanied by a noticeable increase in experimental research. Early experiments focusing on voluntary contributions to a composite public good clearly indicate a divergence between the theoretical prediction of complete free-riding and a behavioural regularity of modest contributions that decline through repetition (e.g., Marwell and Ames (1979) and Isaac et al. (1984)). It is an untested hypothesis that these behavioural regularities extend to environments in which subjects are faced with voluntary contributions to more than one public good.

Andreoni and Petrie (2004) examine the role of confidentiality in voluntary contributions to public goods. Treatments include the revelation of subject identity through the posting a digital photograph and the revelation of individual contribution activities. In an attempt to replicate a field situation, the authors conduct a session in which subjects can choose to donate to two public goods. For the first public good, a subject's voluntary contribution is revealed at the end of the period. A subject's voluntary contribution to the second public good remains anonymous. In either case, the subject's photo and contribution to the first public good is revealed at the end of the period. Because payoffs are linear in

² Kemp's work can be seen as a direct extension of Warr's neutrality result in the case of two public goods, while Bernheim provides a similar extension of neutrality but maintains the position that the neutrality result is problematic when compared to empirical and anecdotal observation.

³ Fries et al. (1991) critique the concept of neutrality, and while they mention an extension to multiple public goods, they provide little more than intuition as support.

contributions and returns to individual contributions to both public goods are fixed and equal, this is equivalent to a composite public good with two similar voluntary contribution mechanisms.⁴ They find that subjects typically opt for recognition and that total voluntary contributions to all public goods (which are effectively a composite public good) increase relative to the treatment with a single public good and mandated photo and contribution revelation.

Moir (2006) is the first to specifically examine voluntary contributions in a multiple public goods setting. Again, payoffs are linear in contributions and while returns to individual contributions to both public goods are fixed, they are unequal. Contribution to either public good increases aggregate payoffs, but one public good is always more socially desirable. Contributions in this baseline session are compared to a treatment in which a fixed-prize lottery, as suggested by Morgan (2000), is introduced in support of the less socially desirable public good. The results indicate that a lottery is effective in shifting contributions to the “wrong” public good and consequently reducing efficiency.

These are the only multiple public good experiments of which I am aware, and neither is designed to specifically compare contributions to multiple distinct public goods and contributions to a composite public good. The experimental design presented in the next section is an initial attempt to fill this gap in the literature.

3. MODEL, PREDICTIONS, AND DESIGN

A linear payoff function has become a standard for public good research ever since Isaac et al. (1984) formed a systematic reply to the early experiments in voluntary contributions to public goods conducted by sociologists Marwell and Ames (1979). While such payoff functions represent a gross simplification of the utility people likely gain from the consumption of private and public goods, the stark equilibrium predictions provide a simple test of game theoretic models.

Suppose n individuals are endowed with equal units of a resource, w , which can be contributed to the production of three goods – \mathbf{X} , \mathbf{G} , and \mathbf{H} .⁵ Each individual, indexed by i , receives a return,

$$(1) \quad \pi_i = x_i + \alpha G + \beta H,$$

where lower case variables indicate individual contributions and upper case variables refer to aggregate amounts contributed by all n individuals (i.e., $G = \sum g_i$ and $H = \sum h_i$). I normalize the return from good \mathbf{X} at \$1. Contributions to \mathbf{X} can be thought of as a private good purchase while contributions to \mathbf{G} or \mathbf{H} are public in that individual i 's contribution affects the return of individuals j and k and vice versa. If we restrict $\alpha, \beta > 0$, then we

⁴ You can pledge your support for a new public sidewalk by buying a brick to be laid in the walkway. The brick can be inscribed with either your name or *Anonymous* (or equivalently go in with no inscription).

⁵ Agents are identical in terms of resource endowments and payoff construction. However, because subjects are idiosyncratic in behaviour we should not refer to them as identical agents.

ensure that both **G** and **H** have positive marginal per capita returns (MPCR as defined by Isaac and Walker, 1988) and are simultaneously “public” and “goods.”

Further, let $0 < \alpha, \beta < 1$ and $n\alpha, n\beta > 1$ and suppose that each individual maximizes her own payoff (Eq. (1)) subject to the resource constraint,

$$(2) \quad w = x_i + g_i + h_i.$$

Because the MPCR from either public good is less than one, each individual generates a higher return from contributing all of her resources to **X** and none to **G** or **H** (i.e., $x_i = w$, $g_i = h_i = 0$ for all i) independent of the actions of others. This is the dominant Nash equilibrium prediction for the one-shot game and the sub-game perfect Nash equilibrium for any finite game.

The social dilemma occurs because each unit of resource contributed to **G** generates $n\alpha > 1$ for society and each unit of resource contributed to **H** generates $n\beta > 1$ for society. Further imposing the restriction $\alpha > \beta$ means there is a unique social preference ordering with each individual contributing all of her resources to **G** (i.e., $g_i = w$, $x_i = h_i = 0$ for all i).

An across-subject design for examining voluntary contributions is outlined in Table 1. In the baseline case with one public good, $\beta = 0$ and the option to contribute to **H** is not even presented to subjects.⁶

The first prediction follows directly from the theory.

Prediction 1: *Free-riding is complete in all sessions such that $x_i = 20$, $g_i = h_i = 0$ for all individuals.*

Experimental results suggest that free-riding is incomplete. As such, we might expect deviation away from the sub-game perfect Nash equilibrium such that $g_i, h_i > 0$. These form an alternate hypothesis for prediction 1.

Traditional game theoretic analysis makes no further prediction in this matter. However, accepting that incomplete free-riding is a behavioural regularity (e.g., Ledyard, 1995 and Zelmer, 2003), and without postulating a particular reason for such behaviour, it is possible to make conjectures regarding behaviour when multiple public goods exist.

In this environment, the private and public goods are perfect substitutes as individual contributions to any market do not alter individualized returns. Thus, any motive to contribute to public good provision in the baseline ($g_i^B \geq 0$) still exists in the treatment condition ($c_i^T = g_i^T + h_i^T \geq 0$), where c_i^T reflects an individual’s aggregate contribution to the provision of all public goods.⁷ This leads to our first conjecture.

⁶ This design choice could be relaxed so that contribution to market **H** is an option even when it has a fixed return of \$0. This would test for what social psychologists call a “demand effect.”

⁷ In the baseline session with no good **H**, $c_i^B = g_i^B$ is necessarily the case.

Conjecture 1: *Contribution to public good provision remains constant in the baseline and treatment conditions so that $g^B=c^T$.*⁸

Experimental evidence reveals a behavioural regularity that voluntary contributions in a linear public good environment are positively related to the MPCR (Zelmer, 2003). Recognizing that public goods **G** and **H** are perfect substitutes and that the MPCR from **H** is lower than from **G**, then contributions to **G** should crowd-out contributions to **H**. Any existing individual contribution shifted from good **H** to good **G** is necessarily Pareto-improving. Without proposing a behavioural explanation, I conjecture that subjects will shift contributions from the public good with a lower MPCR to the public good with a higher MPCR (i.e., from **H** to **G**).

Conjecture 2: *In the treatment sessions, contributions to good **H** provision are completely crowded-out by contributions to good **G** provision (i.e., $h^T=0$). More generally, $g^T>h^T$.*

Conjecture 3 is a logical extension of the first two conjectures.

Conjecture 3: *Contribution to good **G** remains constant in the baseline and treatment conditions so that $g^B=g^T$.*

Given the anonymous-but-partnered design of this experiment, individual observations cannot reasonably be assumed to be independent in anything but the first period of observation. As such, the predictions and conjectures should strictly be tested using data aggregated at the group level. Table 2 thus summarizes the hypothesis tests for both individual and group-aggregate statistics.

4. RESULTS

In total, 3 sessions of 15 subjects each were conducted – one in Trento, Italy (2004 – *TR_2*) and two in Saint John, Canada (2006 – *SJ_1* and *SJ_2*). Subjects were recruited from the general student population at the local university and invited to participate in an experiment. In all cases, subjects were seated at computer terminals and read instructions. Subjects were clearly informed that each person had an identical payoff function, that there were 3 people in each group, and that group membership would remain constant for the 15 periods of the experiment. It was also made clear that while group membership was constant, subjects would not know the specific identity of other members in their group.⁹ Subjects knew that their payoffs would be totaled across 15 periods and paid to them in private according to a pre-specified exchange rate at the end of the session.¹⁰

⁸ Because this is an across-subject design, I drop the subscript i and instead compare distributions of individual contributions for Conjectures 1-3.

⁹ Subjects knew that of the 14 people in the room just 2 were permanently made part of their group.

¹⁰ In *TR_2*, \$1 Lab = 0.035 € while in *SJ_1* and *SJ_2*, \$1 Lab = \$ 0.05.

In the *TR_2* session, the computer mediated all interaction while in the *SJ* sessions, students submitted contribution decisions on paper which were recorded in a central spreadsheet, aggregated by the session monitor, returned, and entered by the subject into a local spreadsheet at his/her terminal. In each case the software calculated the payoff for the particular set of own (e.g., g_i and h_i) and the aggregate of other's public good contributions (e.g, G_i and H_i). Because payoffs are multi-dimensional a scenario calculator was provided to indicate potential payoffs based on hypothetical own and other contribution decisions. While payoffs could more easily be represented as a payoff table in the case of a single public good, subjects received only a scenario calculator to facilitate treatment comparisons.

Average subject pay by treatment is presented in Table 3. The experiment was designed with an expectation of a modest level of cooperation and a projected payoff of about two times the existing local minimum hourly wage. On average, subjects earned slightly more than two times the existing local minimum hourly wage for approximately 1.5 hours work.

Figures 1-4 and Table 4 present graphical and summary data on contribution decisions by treatment session for the variables **G** (aggregate contribution to good **G** calculated by group within session) and **C** (aggregate contribution to goods **G** plus **H** calculated by group within session). Because individual contributions are both group and history dependent, each group can be thought of as a unit of observation. Consequently contributions are averaged over all periods, periods 3-13, and periods 6-10 and presented in Table 4. These data are used in non-parametric tests of distribution. Given the small number of observations, I use the Fisher exact randomization test for difference in means (see Moir (1998) for details).¹¹ Treatment effects are tested for both as a whole (*Treatment*) and session-specific (*SJ_2* or *TR_2*).

First consider Figures 1 and 2. Clearly contributions are positive in all sessions and for all groups, both for **G** and consequently **C**. Similar to the composite public good case, complete free-riding does not explain these data. Note however that there is a declining trend in contributions through time, again mimicking a behavioural regularity seen in the single public good case. Also evident in Figure 1 and Figure 3, and columns headed by **G** in Table 4, is the similarity in contributions to **G** in *SJ_1* and *SJ_2* and the relative increase in contributions to **G** in *TR_2*. When we compare contributions to **C** (all public goods – see Figures 2 and 4, and columns headed by **C** in Table 4), *SJ_2* more closely resembles *TR_2*. The interocular-trauma test suggests that when contributions to all public goods are considered (i.e., to both public goods **G** and **H**) there is on average an increase in overall contributions when multiple public goods exist. It is simple to conclude that while subjects in the *TR_2* session quickly learned to contribute only to public good **G**, at least some subjects in the *SJ_2* session did not learn the same lesson or did not learn it as quickly. Figure 5 graphs contributions to **H** by session through periods and provides visual evidence of this general result as do columns headed by **H** in Table 4.

¹¹ Kaiser (2006) provides a Stata routine for this test – *permtest1* and *permtest2*.

Parametric regression analysis also uses contribution data aggregated by group within session. Time and learning is controlled for through the quadratic inclusion of period. The basic regression model is of the form,

$$(3) \quad K_{j,t} = \alpha + \gamma_1 period + \gamma_2 period^2 + \theta Treatment + \varepsilon_{j,t}$$

where K reflects either group contributions to **G**, **C**, or **H**, j is a unique group identifier, and t reflects period number. *Treatment* is a dummy variable equal to 1 when the session involved two public goods. When possible, regressions were run that replaced *Treatment* with dummy variables for *SJ_2* and *TR_2* to consider session-specific effects. Both OLS and Tobit regressions are reported.¹²

Prediction 1 (Result): *Free-riding does not characterize subject behaviour in a linear environment with either a composite public good or two public goods.*

Clearly from Figures 1-4 and Table 4, there are substantial contributions to public goods (**G** and **H**) in both the baseline and treatment sessions. At the individual level, complete contributions to private good consumption (i.e., $x = 20$) occurred just 131 times in 675 observations (19.4%). At the aggregate level, the dominant strategy of complete free-riding by all members of a group (e.g., $X = 60$) occurred twice in 225 observations (0.9%) and these took place in different sessions – hardly an equilibrium outcome. Table 5 presents a further summary of these results. Likewise the positive and significant coefficients on **G** and **C** in the regression analysis, see Table 6, indicate that subjects are not strong free-riders. Both the linear and Tobit regressions have intercept coefficients slightly greater than 23 when **G** is the dependent variable and slightly greater than 27 when **C** is the dependent variable. In all cases, the associated p-value is 0.000. Positive coefficients on the treatment variables suggest that free-riding is even less of an issue when a second public good is available. This naturally leads to my second result.

Conjecture 1 (Result): *There is some evidence that the addition of a second public good leads subjects to contribute more to public goods as a whole.*

Whatever behavioural motivation exists to contribute in a linear environment with just one public good likewise exists in a linear environment with a second public good. In other words, the treatment should have no effect on overall contributions. This is not necessarily the case.

For now, focus on the total group contributions to all public goods (i.e., columns headed by **C** in Tables 6 and 7). If we focus on the Tobit analysis (Table 6), the *Treatment* coefficient is 8.967 and significant (p-value=0.000) suggesting that the inclusion of a second public good increases total contributions by almost 9 units. Separating the treatment into the two sessions indicates that the effect is smaller for *SJ_2* (6.2 unit increase, p-value=0.013) than for *TR_2* (11.8 unit increase, p-value=0.000). Exact randomization tests for pairwise difference in means are presented in Table 7. Focusing

¹² Tobit regressions account for censored data. In this case, the data is censored at 0 at the lower boundary and 60 at the upper boundary.

on columns headed by **C** and pairwise comparisons with *SJ_1*, we see that in no case is the p-value less than 0.1500. While non-parametric analysis does not suggest statistical significance, in all cases the difference in means with respect to **C** suggests that the addition of a second public good increases total contributions.

Conjecture 2 (Result): *While contributions to **H** are not completely shifted to contributions to **G**, contributions to **G** almost always exceed contributions to **H**. Moreover, contributions to **H** quickly decline toward zero through time.*

It is clear from Figure 5 that contributions to **H** differ from contributions to **G** in Figure 1. With the exception of groups 3 and 5 in *SJ_2*, it seems that once a group reaches the point that $H=0$, they no longer contribute to **H** for the remainder of the session. Group 5 in *SJ_2* was the only group for which $H>G$ at any point in a session.¹³ Tobit regression results presented in Table 8 suggest that while contributions to **H** are positive and statistically significant, the effect of time is both negative and significant. Subjects quickly learn to stop contributing to **H**. Likewise, exact randomization tests for $G=H$ within a session always reject the null of equivalence (p-value=0.0625). This result is interesting as it suggests that subjects clearly understand the concept behind free-riding, but at least in some cases they consciously choose to express less free-riding than theorists predict.

Conjecture 3 (Result): *It is not clear that contributions to **G** remain constant as the environment is expanded to include a second public good.*

If subjects contribute more to all public goods (**C**) when two public goods exist, and if contributions to **G** completely crowd-out contributions to **H**, then contributions to **G** must increase when two public goods exist. While this is basically true for *TR_2*, the results are less clear for *SJ_2* because of the number of contributions to **H** in this session.

Consider the Tobit regression results in Table 6 under the columns headed by **G**. When the *SJ_2* and *TR_2* sessions are combined into a larger *Treatment* session, the *Treatment* coefficient is both positive (6.254) and statistically significant (p-value=0.004) suggesting that, on the whole, adding a second public good increases contributions to **G**. However, when the two sessions are treated separately, the *SJ_2* coefficient is positive (1.693) but no longer statistically significant (p-value=0.484) whereas the *TR_2* coefficient is positive (10.874) and statistically significant (p-value=0.000). The pairwise comparison of *SJ_2* to *TR_2* in Table 7 leads to a comparable conclusion. All p-values from the exact randomization for difference in means for **G** are lower (suggesting greater dissimilarity) than for **C** (suggesting greater similarity). While contributions to **G** are dissimilar in the two sessions with two public goods, they are more similar when one compares contributions to all public goods (**C**).

¹³ In period 9, this group contributed 4 to **G** and 28 to **H**. In period 10 they contributed 4 to **G** and 31 to **H**.

5. CONCLUSIONS

For a long while, economists have made the assumption that voluntary contributions to public goods and the resulting public policy prescriptions may be modeled using a composite public good. One cannot deny that important insights, both theoretical and behavioural, have been gained from this simplification. Recently theorists have started to address this simplification and have revealed some interesting results. Experimental analysis has lagged far behind these theoretical advances.

The experiment described here is an attempt to fill this gap in the literature. The results indicate that contributions in environments with either a composite public good or two public goods share some common features. Simple game theory predicts complete free-riding (zero contributions to the public good(s)) but there is abundant evidence of positive contributions. Moreover, contributions typically decrease over time in both environments but do not seem to fall to zero.

The data presented here reveal an important difference however. Total contributions to all public goods increase with an increase in the number of public goods available for contributions. While there may exist a Pareto-improving reallocation of the mix of realized contributions (see Cornes and Itaya (2004) and Ghosh et al. (2007) for a discussion) it is indeed the case that there is a small increase in total contributions in the two public good environment. This suggests that additional experiments are warranted to generate more data. Likewise, the difference between the two sessions with two public goods indicates the need for replication and perhaps cultural/country-specific analysis.

So far these data have been subjected to very simple econometric analysis – simple game theory predicts no contribution, yet we find positive contributions that increase with the number of public goods available. Future experiments should increase the number of observations with within-subject design, longer time periods, and a larger number of groups. This would permit researchers to test richer behavioural models.

Obviously the existence of positive contributions to the less socially desirable public good provides an argument for *ex post* bundling of funds, as welfare could be improved. However this raises an interesting policy dilemma. If people contribute a larger amount when more public goods are available, then perhaps the government should create fictitious charities and re-designate funds to projects after contributions have been made. Charities themselves could consider advertising multiple activities, raising funds for each activity, and then re-designating funds according to internal preferences. Obviously the answer to this policy conundrum relies not just on theoretical advances, but also upon further behavioural analysis which should include behavioural models that are expanded to include multiple public goods.

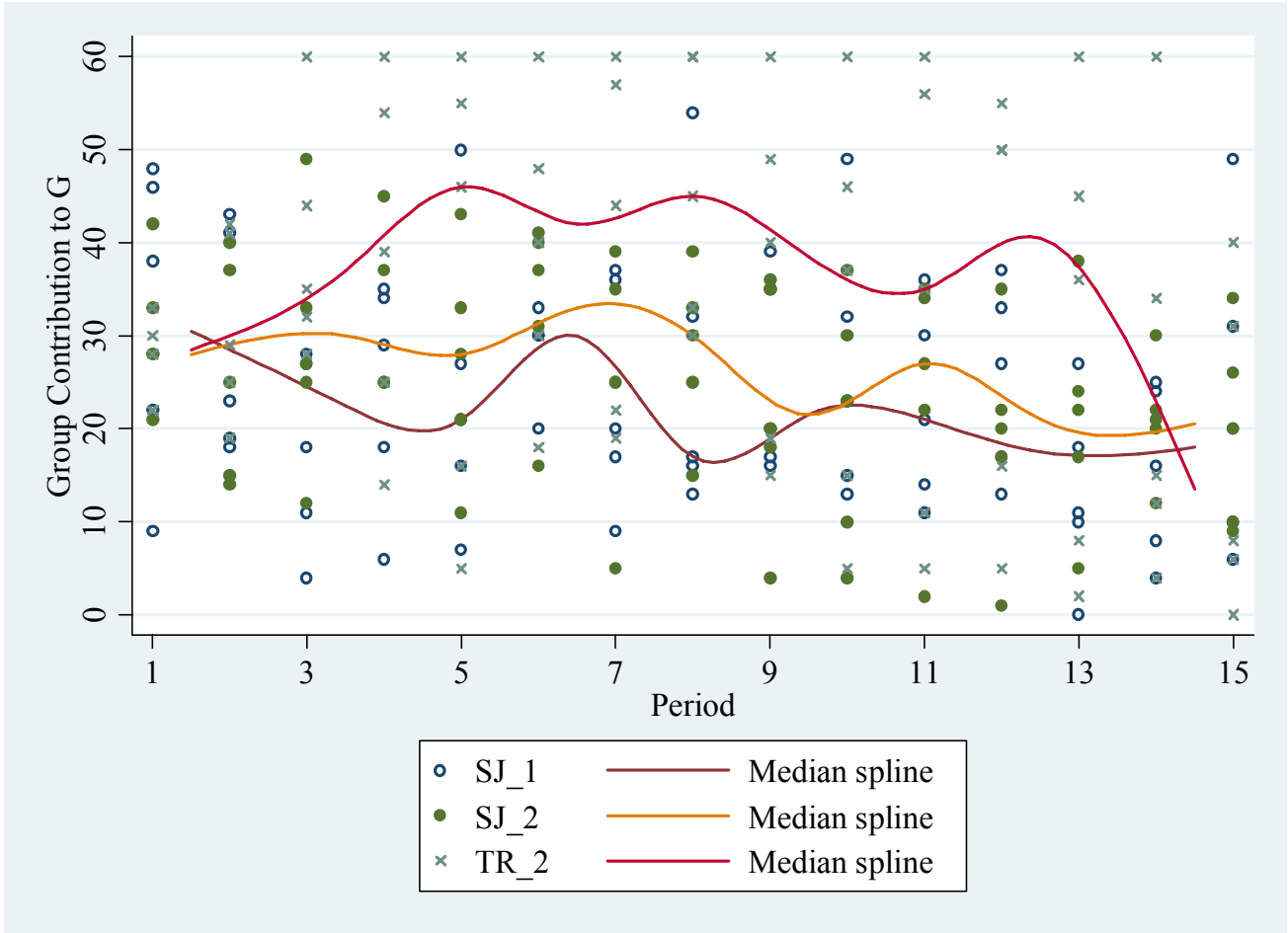


Figure 1: Group Contribution to Public Good G by Treatment

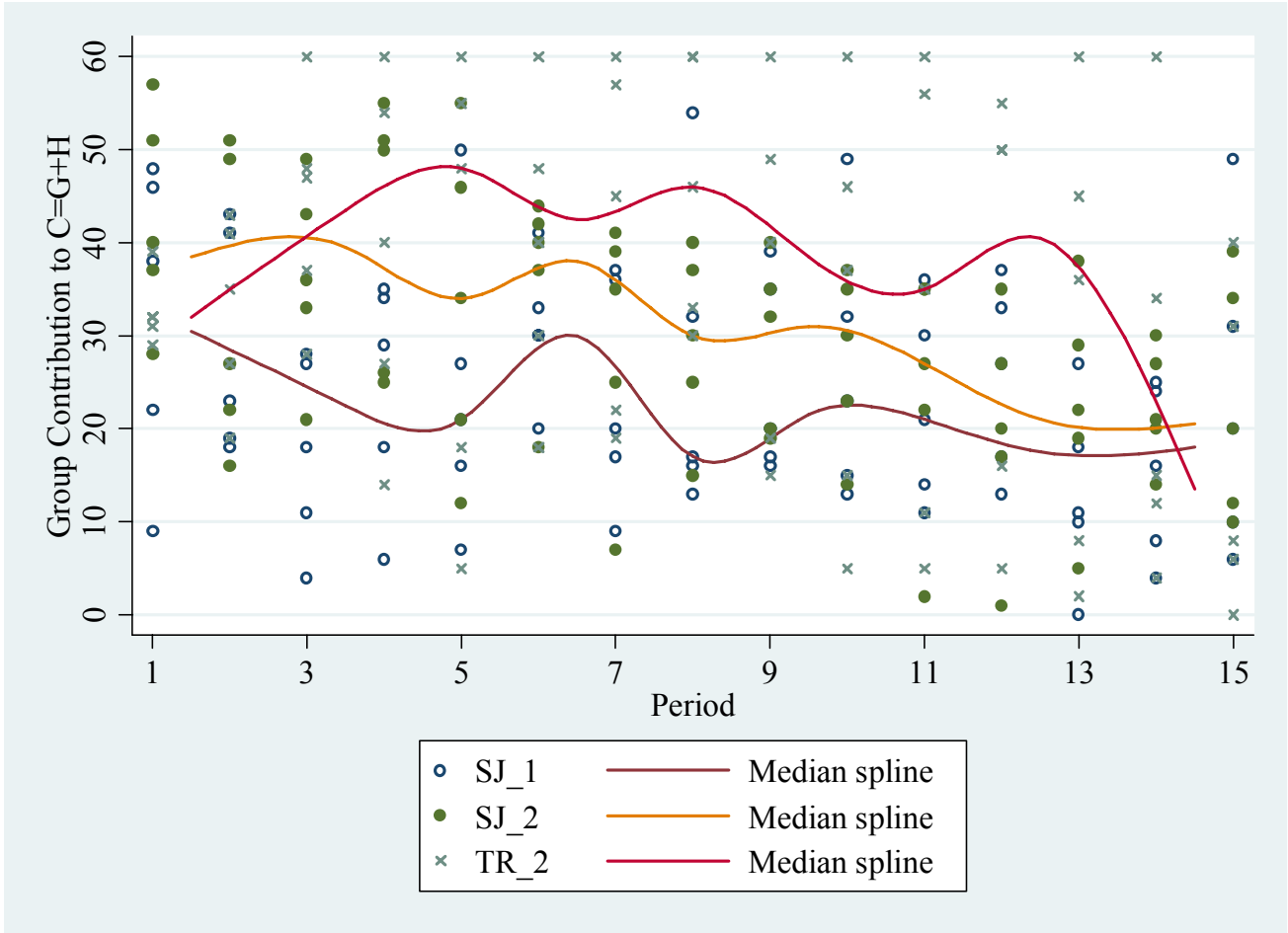


Figure 2: Group Contribution to all Public Goods (G+H) by Treatment

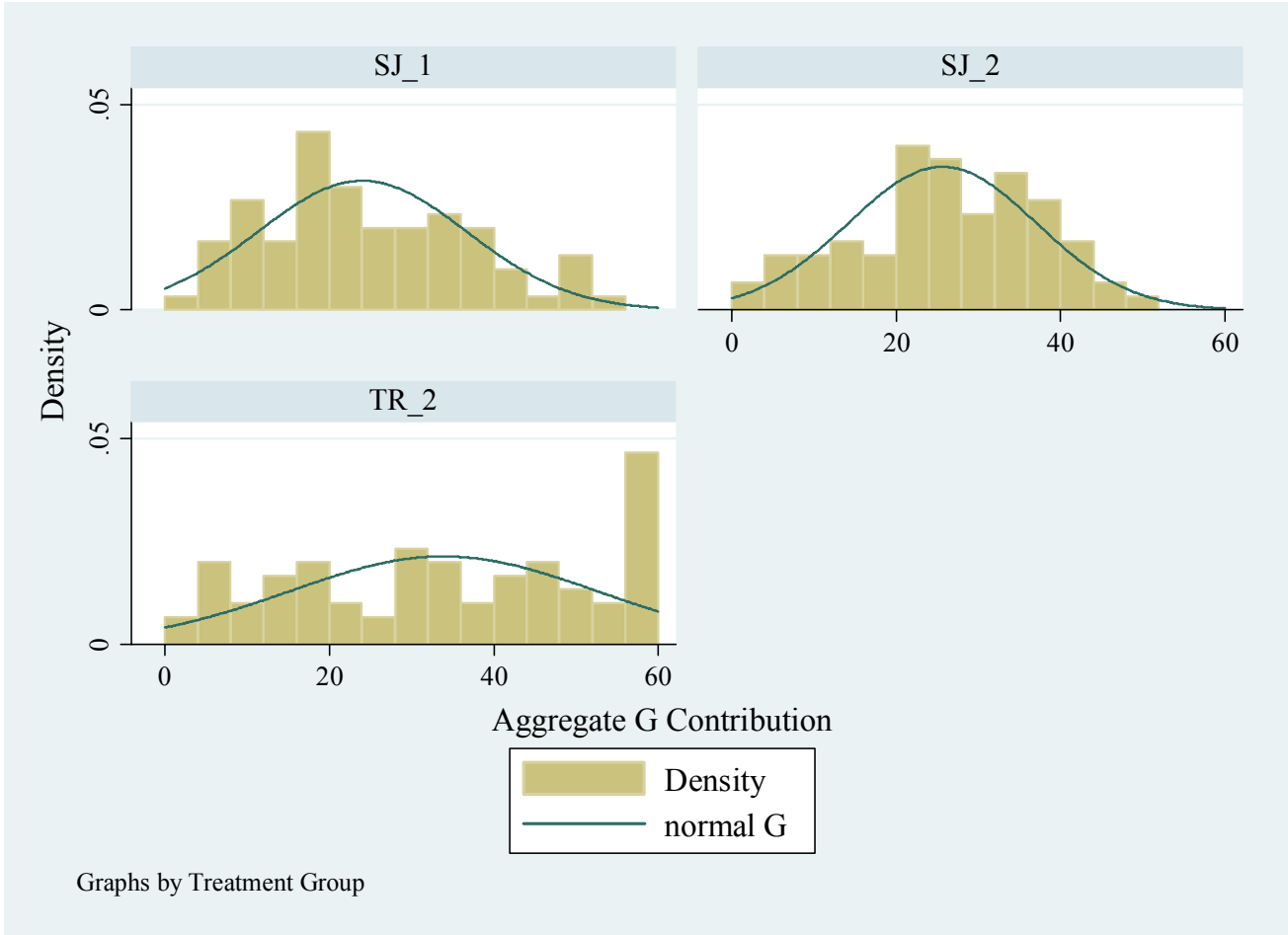


Figure 3: Histogram of Group Contribution to Public Good G by Treatment

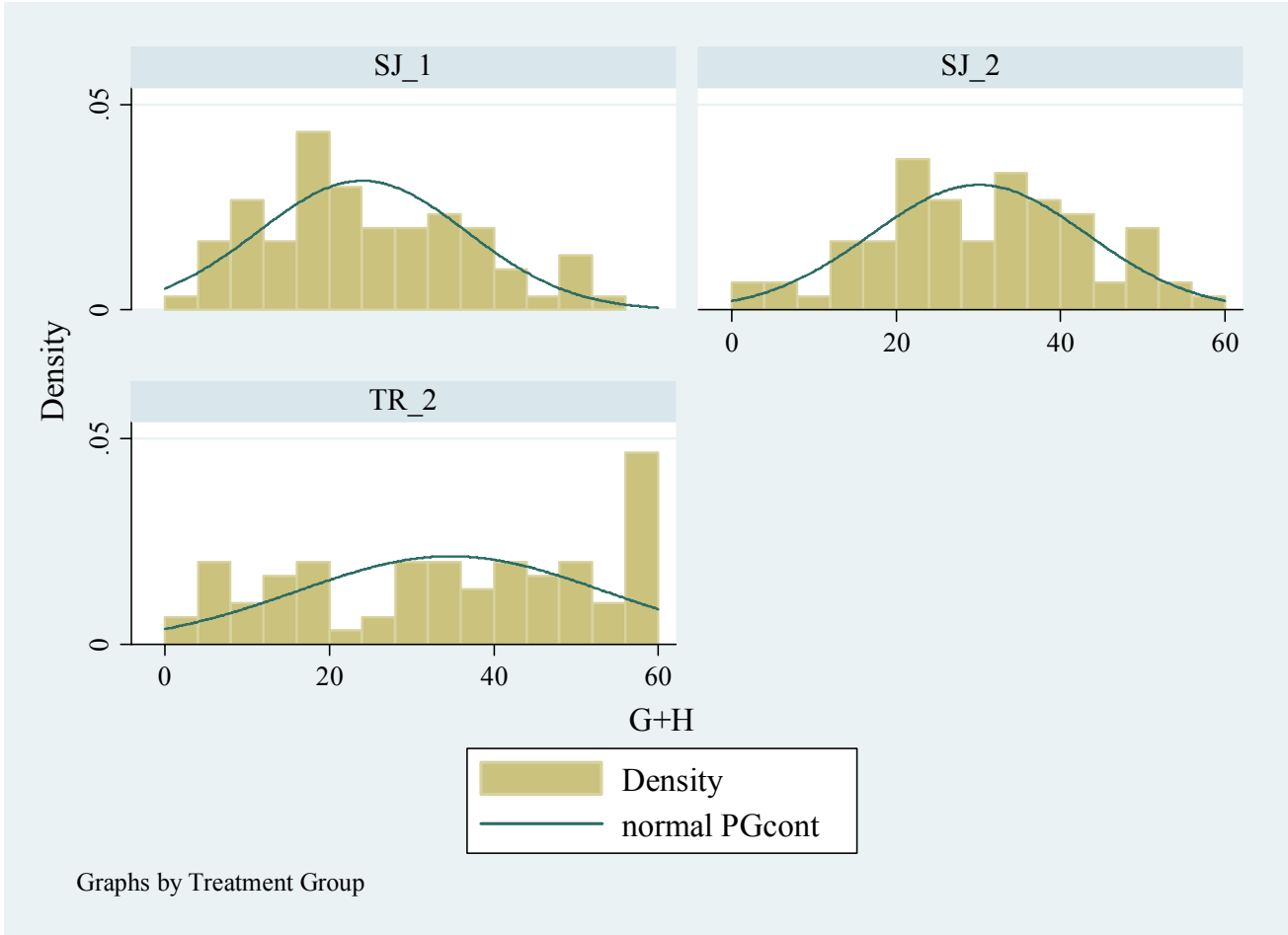


Figure 4: Histogram of Group Contribution to all Public Goods (G+H) by Treatment

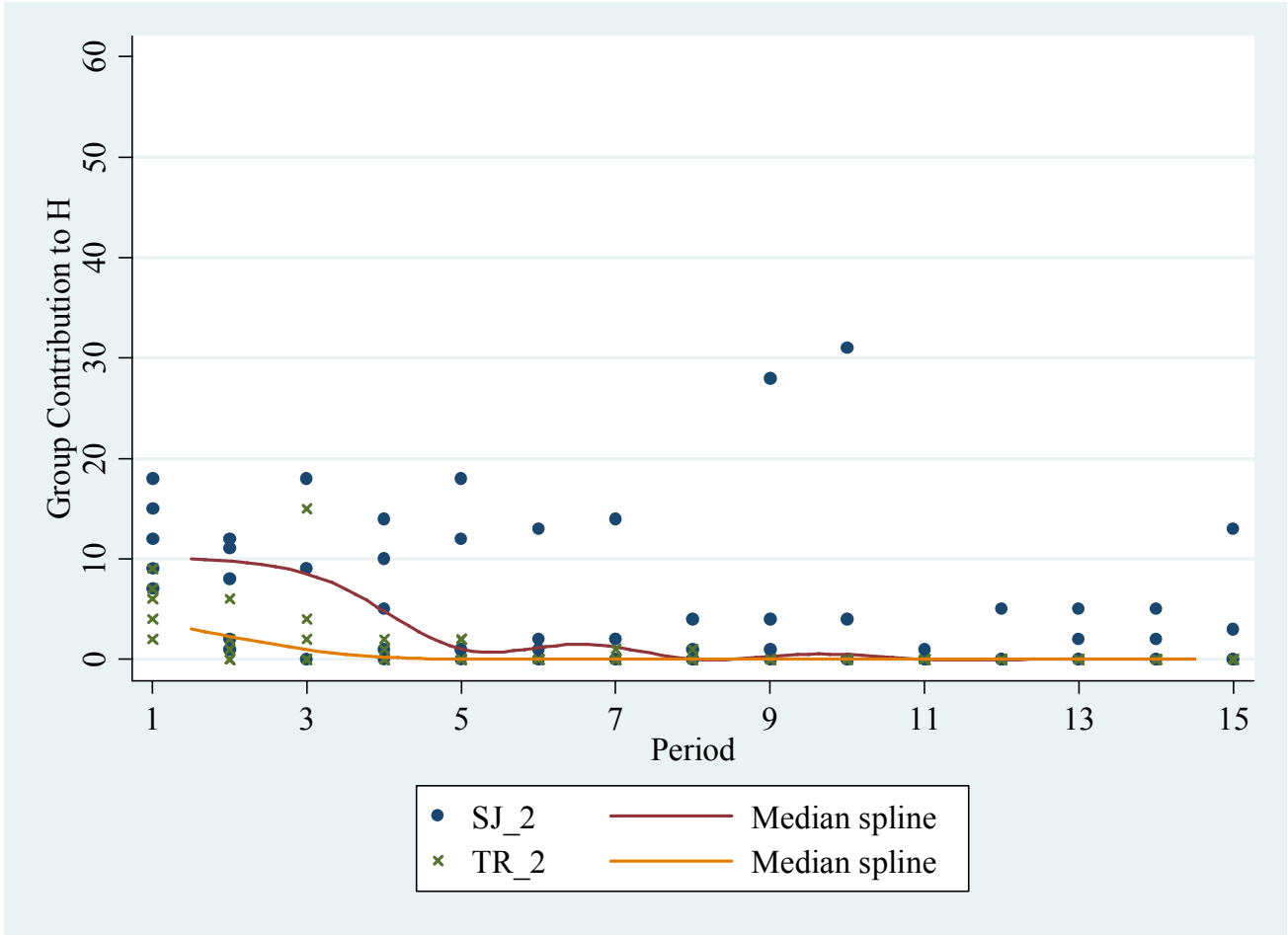


Figure 5: Group Contribution to Public Good H by Treatment

Table 1: Design Parameters

Variable	Baseline	Treatment
n	3	3
w	20	20
α	0.75	0.75
β	n/a	0.50
Groups	5	5
Sessions ¹⁴	1	2

Table 2: Predictions/Conjectures Summary

Prediction/Conjecture	Individual		Group-Aggregate	
	H_0	H_A	H_0	H_A
P1	$x_i=20$	$x_i<20$	$X_j=60$	$X_j<60$
C1	$g^B=c^T$	$g^B \neq c^T$	$G^B=C^T$	$G^B \neq C^T$
C2	$h_i^T=0$	$h_i^T>0$	$H_j^T=0$	$H_j^T>0$
	$g_i^T=h_i^T$	$g_i^T>h_i^T$	$G_j^T=H_j^T$	$G_j^T>H_j^T$
C3	$g^B=g^T$	$g^B \neq g^T$	$G^B=G^T$	$G^B \neq G^T$

Table 3: Average Payoff Statistics

Session	Average Payoff	Standard Deviation
<i>TR_2</i> (2004)	17.99 €	3.43 €
<i>SJ_1</i> (2006)	\$22.50	\$3.64
<i>SJ_2</i> (2006)	\$23.56	\$3.92

¹⁴ A two public good session with the same design features was conducted in 2004 at the University of Trento, Italy as a baseline condition for the effect of a lottery in a multiple public good environment (Moir, 2006). The baseline session for this experiment and a second treatment session were conducted in 2006 at the University of New Brunswick in Saint John (UNBSJ), Canada.

Table 4: Mean Group Contributions by Group and Treatment

Group	All Periods			Periods 3-13			Periods 6-10			
	G	H	C	G	H	C	G	H	C	
SJ_1	1	13.267	.	13.267	12.364	.	12.364	15.400	.	15.400
	2	32.667	.	32.667	31.455	.	31.455	35.400	.	35.400
	3	17.400	.	17.400	18.727	.	18.727	18.600	.	18.600
	4	29.067	.	29.067	28.364	.	28.364	26.400	.	26.400
	5	27.600	.	27.600	27.273	.	27.273	37.000	.	37.000
	AVG	24.000	.	24.000	23.636	.	23.636	26.560	.	26.560
SJ_2	11	15.200	2.600	17.800	12.000	2.000	14.000	12.800	1.800	14.600
	12	25.133	0.600	25.733	27.273	0.000	27.273	32.000	0.000	32.000
	13	29.000	3.133	32.133	29.000	0.545	29.545	28.000	0.000	28.000
	14	34.667	4.267	38.933	37.545	4.364	41.909	38.400	1.600	40.000
	15	24.000	11.800	35.800	24.455	12.909	37.364	19.400	18.000	37.400
	AVG	25.600	5.200	30.800	26.055	3.963	30.018	26.120	4.280	30.400
TR_2	21	14.267	0.133	14.400	14.636	0.000	14.636	20.400	0.000	20.400
	22	48.467	0.467	48.933	51.273	0.000	51.273	46.800	0.000	46.800
	23	40.467	2.333	42.800	44.636	1.818	46.455	46.400	0.400	46.800
	24	46.867	0.733	47.600	55.273	0.364	55.636	60.000	0.000	60.000
	25	19.267	0.800	20.067	19.545	0.545	20.091	20.800	0.000	20.800
	AVG	33.867	0.893	34.760	37.073	0.545	37.618	38.880	0.080	38.960

Table 5: Complete Contributions to Private Consumption by Individual and Group (Evidence for Free-Riding)

	<i>SJ_1</i>	<i>SJ_2</i>	<i>TR_2</i>	<i>Treatment</i>	<i>All</i>
Individual	50/225=22.2%	50/225=22.2%	31/225=13.8%	81/450=18.0%	131/675=19.4%
Group	1/75=1.3%	0/75=0.0%	1/75=1.3%	1/150=0.7%	2/225=0.9%

Table 6: Regression Coefficients (p-values)¹⁵

	Linear				Tobit			
	G	C	G	C	G	C	G	C
Constant	23.785 (0.000)	23.785 (0.000)	27.586 (0.000)	27.586 (0.000)	23.231 (0.000)	23.219 (0.000)	27.025 (0.000)	27.009 (0.000)
<i>period</i>	1.420 (0.140)	1.420 (0.130)	0.574 (0.549)	0.574 (0.546)	1.619 (0.110)	1.622 (0.100)	0.776 (0.441)	0.781 (0.434)
<i>period</i> ²	-0.135 (0.022)	-0.135 (0.019)	-0.099 (0.090)	-0.099 (0.088)	-0.149 (0.016)	-0.149 (0.013)	-0.113 (0.066)	-0.113 (0.063)
Treatment	5.733 (0.006)	-	8.42 (0.000)	-	6.254 (0.004)	-	8.967 (0.000)	-
<i>SJ_2</i>	-	1.600 (0.489)	-	6.080 (0.010)	-	1.693 (0.484)	-	6.178 (0.013)
<i>TR_2</i>	-	9.867 (0.000)	-	10.760 (0.000)	-	10.874 (0.000)	-	11.810 (0.000)
N	225	225	225	225	225	225	225	225
R²	0.0857	0.1322	0.1427	0.1541	0.0129	0.0207	0.0203	0.0232

Table 7: Randomization Test Results – p-values

Period Range	<i>SJ_1</i> vs <i>Treatment</i>		<i>SJ_1</i> vs <i>SJ_2</i>		<i>SJ_1</i> vs <i>TR_2</i>		<i>SJ_2</i> vs <i>TR_2</i>	
	G	C	G	C	G	C	G	C
All	0.3736	0.1931	0.7857	0.2698	0.2381	0.1905	0.3095	0.5714
3-13	0.2977	0.1785	0.6587	0.3175	0.1587	0.1508	0.2698	0.4365
6-10	0.4469	0.2717	0.9444	0.5397	0.1984	0.1905	0.1825	0.3810

Table 8: Tobit Regression Coefficients for Contributions to H (p-values)

	<i>Treatment</i>	<i>SJ_2</i>	<i>TR_2</i>
Constant	5.227 (0.048)	12.734 (0.002)	6.549 (0.009)
<i>period</i>	-2.797 (0.001)	-2.323 (0.049)	-1.933 (0.082)
<i>period</i> ²	0.101 (0.049)	0.082 (0.256)	-0.029 (0.779)
<i>SJ_2</i>	10.128 (0.000)	-	-
N	150	75	75
Censored (lower, upper)	91,0	33,0	58,0
R²	0.1205	0.0410	0.2484

Table 9: Randomization Test for G=H in *SJ_2* and *TR_2* – p-values

Period Range	<i>Treatment</i>	<i>SJ_2</i>	<i>TR_2</i>
All	0.0020	0.0625	0.0625
3-13	0.0020	0.0625	0.0625
6-10	0.0020	0.0625	0.0625

¹⁵ *Italicized* entries are statistically significant at the 10% level of significance or lower. This procedure is followed for all subsequent tables.

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APPENDIX – Instructions for SJ Sessions

Experiment Instructions (SJ_I)

Overview

Thank you for agreeing to be part of this experiment. Today you will be asked to make a number of choices. All of your choices are to be private. The choices you and others make will lead to payoffs expressed in lab dollars. Over the course of this session, your payoffs will be cumulated and used to determine the amount of money you earn. For each lab dollar you earn you will get 5¢ Canadian. A claim form will be converted to a cheque at the Business Office in Oland Hall.

Throughout this session, you will be linked, to 2 other individuals. While the 3 of you will be linked for the entire session, you will not know the identity of the other individuals.

The session will be divided into a total of 15 periods. At the beginning of each period, you will be given 20 tokens. You must choose how to allocate your tokens between two different options. Allocations may be any non-negative integer (e.g., 0, 1, 2, ..., 20). A valid allocation decision will use **ALL** of your available tokens. However, you are free to contribute any non-negative amount (including zero) to each of the two options. Below we describe how payoffs are determined from allocation decisions for each option.

Market X

Your payoff from market X is determined solely by your own allocation decision. For each token you allocate to X, you earn 1 lab dollar. Mathematically, if you allocate x tokens to good X, you earn $1*x$.

Market G

Your payoff from market G is determined by what you and the other 2 individuals allocate to market G. For each token you allocate to market G, you earn 0.75 lab dollars, *as do the other 2 individuals*. Mathematically, if we let G represent the total allocation to good G by the 3 of you, you earn $0.75*G$ as do the other 2 individuals.

Total Payoff

In total, you earn $1*x + 0.75*G$ in lab dollars for a particular allocation decision.

Example

Please note that all values in this example are hypothetical. They have been created only for the purpose of example. Suppose you were endowed with 30 tokens. Suppose you made the following allocation decision (lower case letters refer to your (hypothetical) allocation decisions): $x=17$ and $g=13$. This is a valid decision for you as $x+g=17+13=30$ which is your token endowment. Suppose the other two individuals made total allocations (the sum of their individual decisions) to G of 16.

Your payoff would then be:

$$x+0.75G = 17+0.75(13+16) = 17+0.75(29) = 38.75.$$

Please remember that these are hypothetical values (recall that the endowment is 20 tokens in the experiment) and are only used for the purpose of demonstration. You are free to make any valid decision you choose.

A Period

You are identified throughout this experiment by the letter on your folder. In addition to these instructions, you will find 15 slips of paper with your Subject ID letter and period number listed. You will also find a piece of paper upon which we ask that you keep a history of your decisions made in each period.

After you make a decision, record *Your* allocation decisions for **Market X, and Market G** on the slip of paper. Put up your hand and an assistant will collect your slip. Once all slips are collected, an assistant will enter each subject's decisions into a central computer. They will also fill in the row for *Others* allocation decision for **Market G** (this is the sum of the other two individual's allocation decisions to Market G).

If you enter these values on your computer screen in the Decision History, it will calculate your payoff in both lab dollars and Canadian dollars. If the word "Error" appears, please raised your hand and let an assistant know.

Periods will last a maximum of 5 minutes.

The Payoff Wizard

The environment in which you are being asked to operate is quite complex. In order to assist you, a Payoff Wizard is available on your computer screen. You can enter hypothetical values for *Your* allocation decision to **Market G** for the allocation decision of *Others*. The computer automatically ensures that the decision is valid and warns you if it is not.

If all hypothetical allocations are valid, the computer will tabulate your earnings in this hypothetical scenario. Please note that while you control your own decisions, you do not make the decisions of others. The Payoff Wizard only allows you to examine different potential outcomes.

Questions

If you have a question, now or at any time during the session, please raise your hand and the experiment assistant will answer it.

Experiment Instructions (SJ_2)

Overview

Thank you for agreeing to be part of this experiment. Today you will be asked to make a number of choices. All of your choices are to be private. The choices you and others make will lead to payoffs expressed in lab dollars. Over the course of this session, your payoffs will be cumulated and used to determine the amount of money you earn. For each lab dollar you earn you will get 5¢ Canadian. A claim form will be converted to a cheque at the Business Office in Oland Hall.

Throughout this session, you will be linked, to 2 other individuals. While the 3 of you will be linked for the entire session, you will not know the identity of the other individuals.

The session will be divided into a total of 15 periods. At the beginning of each period, you will be given 20 tokens. You must choose how to allocate your tokens between three different options. Allocations may be any non-negative integer (e.g., 0, 1, 2, ..., 20). A valid allocation decision will use **ALL** of your available tokens. However, you are free to contribute any non-negative amount (including zero) to each of the three options. Below we describe how payoffs are determined from allocation decisions for each option.

Market X

Your payoff from market X is determined solely by your own allocation decision. For each token you allocate to X, you earn 1 lab dollar. Mathematically, if you allocate x tokens to good X, you earn $1*x$.

Market G

Your payoff from market G is determined by what you and the other 2 individuals allocate to market G. For each token you allocate to market G, you earn 0.75 lab dollars, *as do the other 2 individuals*. Mathematically, if we let G represent the total allocation to good G by the 3 of you, you earn $0.75*G$ as do the other 2 individuals.

Market H

Your payoff from market H is determined by what you and the other 2 individuals allocate to market H. For each token you allocate to market H, you earn 0.50 lab dollars, *as do the other 2 individuals*. Mathematically, if we let H represent the total allocation to good H by the 3 of you, you earn $0.50*H$ as do the other 2 individuals.

Total Payoff

In total, you earn $1*x + 0.75*G + 0.50*H$ in lab dollars for a particular allocation decision.

Example

Please note that all values in this example are hypothetical. They have been created only for the purpose of example. Suppose you were endowed with 30 tokens. Suppose you made the following allocation decision (lower case letters refer to your (hypothetical) allocation decisions): $x=14$, $g=3$, and $h=13$. This is a valid decision for you as $x+g+h=14+3+13=30$ which is your token endowment. Suppose the other two individuals made total allocations (the sum of their individual decisions) to G of 9 and to H of 7.

Your payoff would then be:

$$x+0.75G+0.5H = 14+0.75(3+9)+0.5(13+7) = 14+0.75(12)+0.5(20) = 33.$$

Please remember that these are hypothetical values (recall that the endowment is 20 tokens in the experiment) and are only used for the purpose of demonstration. You are free to make any valid decision

you choose.

A Period

You are identified throughout this experiment by the letter on your folder. In addition to these instructions, you will find 15 slips of paper with your Subject ID letter and period number listed. You will also find a piece of paper upon which we ask that you keep a history of your decisions made in each period.

After you make a decision, record *Your* allocation decisions for **Market X, Market G, and Market H** on the slip of paper. Put up your hand and an assistant will collect your slip. Once all slips are collected, an assistant will enter each subject's decisions into a central computer. They will also fill in the row for *Others* allocation decisions for **Market G and Market H** (this is the sum of the other two individual's allocation decisions to each of Markets G and H).

If you enter these values on your computer screen in the Decision History, it will calculate your payoff in both lab dollars and Canadian dollars. If the word "Error" appears, please raised your hand and let an assistant know.

Periods will last a maximum of 5 minutes.

The Payoff Wizard

The environment in which you are being asked to operate is quite complex. In order to assist you, a Payoff Wizard is available on your computer screen. You can enter hypothetical values for *Your* allocation decisions to **Market G** and **Market H** and for the allocation decisions of *Others*. The computer automatically ensures that the decision is valid, and warns you if it is not.

If all hypothetical allocations are valid, the computer will tabulate your earnings in this hypothetical scenario. Please note that while you control your own decisions, you do not make the decisions of others. The Payoff Wizard only allows you to examine different potential outcomes.

Questions

If you have a question, now or at any time during the session, please raise your hand and the experiment assistant will answer it.