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Behaviour in a Two-Stage Public Goods Experiment

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Abstract

In a two-stage public goods experiment, we study the effect that subjects' possibility of contributing to a public good in the first stage of the game has on the voluntary contributions to the second public good. Our results show that subjects do not follow either the Nash strategy or the Pareto efficient strategy and that they perceive the two public goods as substitutes.

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1. Introduction

This paper deals with individuals' choices regarding the voluntary provision of two public goods in an experimental context. We present a two-stage public goods game where the individuals can contribute to one public good in each of two stages. Each public good is available in one stage only. The two public goods only differ in the marginal per capita return (MPR) accruing to each participant. In particular, the MPR of the public good available in stage 1 is greater than the one of the public good in stage 2. There is also a strong relationship between the contributions to the two public goods because the individual income from stage 2 depends on the decisions taken in the two stages of the game and not those in stage 2 only.

Our work refers to the growing literature on two-game experiments. These experiments investigate the effects on subsequent social behaviour of both reinforcement and pre-existing tendencies toward cooperation or defection. For example, Cain (1998) has players participating in a dictator game in a first stage of the experiment, and then has them playing a prisoner's dilemma. The first game allows players to be classified into "nice" and "stingy" subjects according to the percentage of endowment sent to the recipient and the second shows that "nice" players choose to cooperate most of the times when they are paired with other "nice" players. In Silverstein et al. (1998), subjects play two different versions of the prisoner's dilemma, and find that cooperation in the second game declines regardless of the results coming from the earlier game. Albert et al. (2002) have participants play, first, an asymmetric prisoner's dilemma and, second, a trust game. Their results indicate the possibility of spillover effects between decision tasks. Also, Chaudhuri at al. (2002) have an experimental design with a prisoner's dilemma and a modified trust game where subjects play both roles. They find that cooperative individuals in the prisoner's dilemma are more trusting in the second game; regardless of the different reward they receive for being cooperators in the prisoner's dilemma. Hence, the main result, common to almost all of these works, is that what

subjects do in an apparently unrelated social environment may affect their choices and provide a reliable signal for others with whom they are strategically interacting.

Our work relates to above mentioned papers in the sense that we are testing whether there are any differences in the eventual cooperation in a two-stage, two public goods, experiment compared to the cooperation coming from a standard VCM treatment. From a game-theoretical point of view, there should be no difference, and all the subjects should invest all their endowment in the private good in both stages. However, in our experiment, we expect that the share of subjects willing to contribute to the public good should do so in the first stage only, given that the MPR is higher than the one in the second stage of the game. Subjects may sustain the level of cooperation in the first stage because of the higher obtainable earnings. They should then decide to decrease the contributions in the second stage, or to free ride completely because of the lower MPR.

In one of their treatments, Andreoni and Petrie (2004) show that the behaviour of subjects when allocating their initial endowments between two public goods differs only in terms of information. In particular, there is a broadcast public good and an anonymous public good available to subjects in each period. The authors show that participants contribute more when they are given the option of having their contribution announced. Moreover, if subjects do not contribute to the publicly announced public good, it is very unlikely that they will contribute anonymously. Then, while we tend to confirm the first result of Andreoni and Petrie (2004), quite surprisingly, our data are in contrast with their second result. In fact, we show that subjects tend to contribute to both public goods, although at a low level, regardless of the difference between the MPRs of the two public goods.

The present study may also contribute to the experimental literature investigating the effects of confusion in public good games. This research postulates that high initial contributions decrease because players start understanding the game's incentives better after some rounds. In a pioneering paper, Andreoni (1995) makes the following findings. Firstly, in the treatment implemented to eliminate the incentive for kindness, subjects are more likely to choose the dominant strategy of

free-riding; secondly, about half of the cooperators are confused about incentives, while the other half understand the dominant strategy but choose to cooperate out of kindness; finally, the decrease in cooperation may be not due to learning but to a frustrated attempt at kindness. Houser and Kurzban (2002) conduct a modified version of Andreoni's (1995) experiment. They show that, consistent with Andreoni (1995), about half of all cooperation in the standard public good game is due to confusion, that confusion is responsible for more cooperation in early rounds than in later rounds and that reductions in confusion can explain the cooperation decay in the standard public good game.

We believe our design may contribute to the discussion on the role of confusion. In fact, one result of the present work shows the level of cooperation in the standard public good game to be higher than that in the two-stage two public goods treatment. According to confusion theories, while in the former case the cooperation should be due to both confusion and social motives, in the latter, where the contribution choice in each period is doubled, subjects should be more aware of the free-riding opportunity. Then, this result may be due to the decrease in confusion caused by our design.

The present paper is structured as follows. Section 2 describes the experimental design and the theoretical predictions. Section 3 presents and discusses the results of the experiment and Section 4 concludes.

2. Experimental Design and Predictions

2.1 The Design

Our experimental setting involves two treatments, each of them played for 10 periods. The first treatment is a standard public-good game with participants divided into five groups of four players. All subjects are endowed with six tokens. They have to decide on the allocation of their endowment between a private good, A (x_i), and a public good B (g_i). Each token placed in A (x_i) earns one Experimental Unit (EU) for the subject. In contrast, each token allocated to B (g_i) gives

exactly the same payoff to each member of the group as shown in equation (1). Then, each subject gets the following payoff,

$$\pi_i = x_i + 0.3\sum_{i=1}^{4} g_i, \quad s.t. \;\; x_i + g_i = 6 \tag{1}$$

The second treatment is organised as a two-stage two public goods game, where the second stage of the game is identical to the first treatment, differing only in the initial endowment. During stage I, subjects are asked to decide whether to allocate their initial endowment of six tokens between a private good, C (y_i), and a public good D (z_i). They are informed that the payoff from C (y_i), together with a fixed amount of 6 tokens, will constitute the initial endowment for each participant available at the beginning of each period of stage II. Each token allocated to D (z_i) gives exactly the same payoff to each member of the group, as shown in equation (2). Then, each subject gets the following payoff,

$$\pi_i = x_i + \left(0.4\sum_{j=1}^{4} z_j + 0.3\sum_{j=1}^{4} g_j \right) \quad s.t. \;\; y_i + z_i = 6 \text{ and } x_i - y_i + g_i = 6 \tag{2}$$

Considering equation (2), it is important to remember that the term in parentheses represents the earnings accruing equally to each member of the group from both D (z_i) and B (g_i). In this case, the marginal return accruing to every subject from D (z_i) is 0.4.

To summarize, we have 2 treatments, each with five groups of four subjects, each lasting for ten periods. We implement a fixed matching protocol[1]. That is, each subject plays with the same group members during each treatment. The first treatment (T1) is a standard public good game; while the second treatment (T2) is organised as a two-stage two public goods game, where the second stage of the game has the same structure of T1 but subjects may have different endowments.

The experiment was conducted at the University of Catania. A total of 80 subjects were recruited among a population of students from a wide range of fields, such as economics, law and

[1] Subjects were aware that the software was assigning a new subject number to each of them after each period of the experiment. This is usually done in order to avoid any reputation effect within each group.

political science[2]. Each student participated in only one treatment of the experiment. The staff of the *Centro Informazione Giuridica*, at the University of Catania, developed the experimental software. Before beginning the experiment, the instructions were read aloud and explained in detail[3]. Any kind of communication was forbidden. Subjects typed written responses directly into the computer in their own time. At the end of each treatment, subjects were paid anonymously in cash at an exchange rate of 0.10 euro per EU earned. On average, the subjects earned 16.50 euro including a 5 euro show-up fee. Each treatment lasted between 40 and 60 minutes.

2.2 Predictions

According to the standard game-theoretic approach, the Nash dominant strategy, obtained applying the backward induction procedure, predicts zero contribution to the provision of public goods. In each period, a self-interested fully rational subject should be playing the free-riding strategy[4]. From equation (1) and (2), it is clear that the Nash equilibrium does not coincide with the Pareto optimal solution. The full cooperation strategy suggests that each member of a group should invest all of her endowment in the provision of public goods, reaching the level of full cooperation at both stages.

An alternative possible outcome of our experimental setting is the case where a subject decides to invest more into the public good in stage I than in stage II[5]. The subjects decision not to contribute in stage II may be due to the decrease in confusion. In fact, our design may help to eliminate the effects of confusion when subjects play almost the same game twice. In the absence of confusion, subjects should notice the differences in the MPR of the public goods and opt for the one with the highest MPR, free-riding on the provision of other public good. Our data confirm this

[2] Our treatments have been run under both a neutral (40 subjects) and a cultural context (40 subjects). We checked for eventual framing effects without finding any significant differences between the average contributions in the neutral and cultural contexts. Hence, we have chosen to aggregate the data coming from the two treatments. For a detailed description of the cultural framing see Finocchiaro Castro (2004).

[3] In our experiment, we adopted the standard VCM instructions that, however, are available upon request.

[4] This strategy leads to the payoff of 6 tokens and 12 tokens in each period in the first and second treatment respectively.

[5] This strategy may lead to an individual payoff of 15.6 tokens, in the case of full contribution to the public good in stage I and of zero contributions to the public good in stage II.

tendency although it shows low contribution levels to the public good in stage II of the second treatment.

3. The Results

3.1 The data

We first discuss some general aspects of our data. In Table 1 we show the average level of contribution of each treatment as a percentage of the endowment[6]. We begin by looking at the differences in the rates of contribution to the public good between the first (T1) and the second (T2) treatment. The contributions to the public good from T1 are always higher than the ones from the second stage of T2. On average, the level of contribution is 47.1% in T1 and 37.5% in T2. The same can be said if we consider only the results from period 1. While T1 starts at a very high level of contributions (62.1%), the second treatment shows a lower level of contributions (47%)[7].

- Table 1 about here -

Turning our attention to the patterns of public goods contributions, we analyse the relationship between the values of T1 and T2. They show two decreasing patterns and their relationships are negative and significant[8]. It is important to notice that both trends end up a long way away from the Nash prediction of complete free-riding (36.3% in T1 and 29.5% in T2). In T1, the level of contribution in the last period (36.3%) is higher than the previous one (35.4%) and does not show the usual steep end-effect. At this point, checking the trends of the contributions to the public goods in each stage of T2, we find that the decreasing patterns present in Fig.1 seem to be

[6] The levels of contributions coming from the second stages of both contexts have been weighted according to the different endowments available to each subject.
[7] Note that those levels of cooperation are perfectly in line with other experimental results on public goods (see Ledyard, 1995; Davis and Holt, 1993).
[8] At the 5% level, the p-values, referring to the 2-tailed Pearson correlation test, are p=0.01 and p=0.03 in T1 and T2 respectively.

the same across treatments. In fact, in both stages of T2, we find negative and highly significant time trends of the contributions to the public good[9].

- Figure 1 about here -

3.2 Public goods contributions across treatments

The first aspect we are going to deal with will be the effect of the differences in the contribution levels to the public good in T1 and in the second stage of T2. As shown by Fig.1 and Table 1, the average contributions to the public good from the first treatment are almost always higher than the ones from stage II T2. In order to test for the significance of this difference, we implement the non-parametric Mann-Whitney U test (MWU). The value we obtain from this test shows that the differences are significant ($p=0.019$)[10]. Thus, our hypothesis has been confirmed by the experimental data. In fact, as expected, we see a change in the level of contributions to the public good when the subjects face a two-stage two public goods treatment.

In T2, on average, participants surprisingly allocated their endowments almost evenly between the two public goods, regardless of the difference in the MPR, and they contributed smaller amounts to the public good in the second stage when compared with the contributions in T1[11]. Regarding the first observation, subjects clearly perceived the two public goods available in the second stage of T2 as substitutes and did not take the opportunity to gain higher total payoffs by focusing on the public good with the higher MPR or by fully contributing to both public goods. Regarding the second observation, two factors may explain the differences in the cooperation shown in T1 and in the second stage of T2. The first effect is given by the difference in endowments

[9] At the 1% level, the p-values, referring to the 2-tailed Pearson correlation test, are $p=0.002$ and $p=0.003$ in stage 1 and stage 2 respectively.

[10] We have always used 10 independent observations to compute the Mann-Whitney U test, except when we tested the first period data where we could use 40 independent observations. All the p-values represent the results of 2-tailed Mann-Whitney U tests.

[11] The MWU test, run on the first and last period observations, finds significant differences in the first case ($p = 0.004$), but not in the second case ($p = 0.172$).

between the T1 and the second stage of T2. While in the former the initial endowment is 6 tokens in each period, in the latter the initial endowment is never smaller than 6 tokens and may be different between subjects[12]. We investigate the effect of this endowment effect looking at the coefficient of the independent variable OwnStage1C in table 2. On the one hand, this coefficient tells us the impact of the contribution in stage I of T2 on the contribution in stage II of T2. On the other hand, it tells us the effect of the decrease in the endowment available in the second stage of T2. In fact, the positive sign of this coefficient means that an increase in the contribution to the public good in the first stage in other words a decrease in the endowment in the second stage leads to a higher contribution to the public good in the second stage. Hence, when subjects faced an increase in the endowments in each period of the second stage, they constantly contributed less compared to the contributions in T1[13]. The second effect, working in combination with this endowment effect, seems to be due to the decrease in confusion (Andreoni 1995). The contributions in T1 may arise from both confusion and social motives while, in the second stage of T2, subjects' cooperative choices should be driven less by confusion than by social motives[14] because of our two-stage design.

The second aspect we want to check is the presence of a relationship between individual and group contributions in T2. Hence we run a regression that has as the dependent variable the individual contribution in the second stage of T2 and as independent variables the own contribution in the first stage of T2, the own contribution in the last period of the second stage of T2, the total contribution of the other members of the group in the first stage of T2 and the total contribution of the other members of the group in the last period of the second stage of T2. All the data used in the regression are expressed as a percentage of endowment. From Table 2, we notice that the only significant variable is the own contribution in the first stage of T2 (OwnStage1C)[15]. Then, the

[12] The mean endowment in the second stage of T2 is 10.2 tokens, which is significantly different from the T1's endowment of 6 tokens. The t-test for equality of means rejects the null hypothesis at 1% level of significance.
[13] This result is in line with other experimental works on the same issue (see, Chan et al., 1996 and 1999; Cherry et al., 2003).
[14] Although we do not test formally for the effects of confusion versus those due to social motives, it seems rational to us to expect confusion in subjects after playing almost the same game twice for ten rounds.
[15] Removing the least significant independent variables from the regression, we end up always with the same result.

positive sign of the coefficient shows that the more (less) each individual contributes to the public good in the first stage, the more (less) he should allocate to the public good in the second stage.

Using the public good contributions in T2, we can investigate the presence of correlation between the allocations chosen by subjects with both high and low contribution rates[16]. In this case, we do not find any systematic and significant tendency of "cooperators" to contribute high amounts of endowment in both stages[17]. This result may be due to the presence of two counteracting effects. First, the presence of cooperators who contribute relevant portions of their endowment in each stage and, second, subjects contributing a lot in the first stage and almost nothing in the second stage driven by the difference in the public goods' MPR. Applying the 2-tailed Pearson correlation test on the individual investment decisions in the case of low cooperators, all low subjects but one show a positive and, in half the cases, significant level of correlation. In doing so, they make the correlation between first and second stage contribution in treatment 2 significant at an aggregate level, even if there is no systematic and significant tendency of "cooperators" to contribute high amounts of endowment in both stages.

- Table 2 about here -

[16] We consider a high contribution rate in stage I to be when it is greater than the 50% of the endowment; while a low contribution rate in stage I is when it is less than the 30% of the endowment. According to the above classification, only 6 of 40 (15%) subjects can be labelled as "high cooperators", while 16 of 40 (40%) subjects can be labelled as "low cooperators".

[17] Applying the 2-tailed Pearson correlation test on the individual investment decisions in the case of high cooperators, one subject only shows a positive and significant correlation ($p=0.011$), while all the other subjects show correlation levels with mixed signs but never significant levels.

4. Concluding Remarks

This paper provides an answer to the question of whether the adoption of a two-stage two public goods game design would cause a change in the contributions to public goods compared to the case of a standard public good game.

In our design, individuals can contribute to one public good in each of two stages. Each public good is available in one stage only. The two public goods only differ in the marginal per capita return (MPR) accruing to each participant. In particular, the MPR of the public good available in stage 1 is greater than the one of the public good in stage 2. Also, there is a strong relationship between the contributions to both the public goods because the individual income from stage 2 depends on the decisions taken in the two stages of the game and not on those in stage 2 only.

We showed that the public good contributions in the second stage of the T2 are lower than the ones that take place in the standard VCM. Our result contributes to the literature on two-game experimental designs whose main aim is to investigate both the effects on subsequent social behaviour of reinforcement and pre-existing tendencies toward cooperation or defection. For example, Cain (1998) shows that subjects playing a prisoner's dilemma strongly take the information gathered from a dictator game previously played into consideration. Albert et al. (2002) indicates the possibility of spillover effects between decisions taken in an asymmetric prisoner's dilemma and those taken in a following a trust game. A similar result is also shown in Chaudhuri et al. (2002). A work very close to ours is the one from Andreoni and Petrie (2004). They show that, when subjects are deciding on the contributions to two public goods, one publicly announced and one anonymous, they give more to the latter. Moreover, if subjects do not contribute to the publicly announced public good, they are unlikely to contribute anonymously. Thus, subjects may rank the two public goods in terms of prestige.

In our design, subjects may also rank the two public goods, however, in terms of monetary rewards. Hence, we expected that the share of subjects willing to contribute to the public good

would do so in the first stage only, given the higher MPR there than the one in the second stage of the game. Subjects may sustain the level of cooperation in the first stage, because of the higher obtainable earnings, and then decide to decrease the contributions in the second stage or to free ride completely because of the lower MPR. Quite surprisingly, our data showed that subjects tend to contribute at a low level to both public goods. Moreover, it is interesting to notice that the contributions made in the standard VCM did not show the common end-effect.

Our design also contributes to the discussion on the role of confusion in public good games. This stream of research postulates that high initial contributions decrease because (as shown by Andreoni (1995), Palfrey and Prisbrey (1997) and Houser and Kurzban, 2002)) players start understanding the game's incentives after some rounds. The results from the present paper showed that, on average, the level of cooperation in the standard public good game is higher than that in the two-stage two public goods treatment. While in the former the cooperation should be due to both confusion and social motives, in the latter, subjects should be more aware of the free-riding opportunity, given that they face a similar choice twice. Therefore, our findings tend to confirm the effects of the reduction in confusion discussed by Andreoni (1995).

Our experimental findings indicate that more attention has to be devoted to the design of experiments' ability to discern between the effects of confusion and social motives through the exploitation of all the positive externalities for the group.

Table 1: Average Contributions to Public Goods as Percentage of Endowment*

Period	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*Average*
Treatment 1	62.1	58.8	54.2	45.8	47.1	50.0	43.8	37.5	35.4	36.3	47.1
	(12.2)	(16.5)	(14.0)	(24.7)	(17.2)	(19.6)	(22.6)	(17.7)	(14.7)	(10.2)	(9.30)
Treatment 2 - Stage 1	43.8	40.4	46.3	46.7	38.3	29.6	24.6	24.6	32.1	22.9	34.9
	(8.8)	(11.1)	(20.0)	(8.1)	(22.4)	(16.3)	(15.6)	(8.4)	(12.4)	(17.4)	(9.31)
Treatment 2 - Stage 2	47.0	39.9	44.1	43.0	43.5	30.5	32.2	29.2	35.5	29.5	37.5
	(11.8)	(11.6)	(13.8)	(13.1)	(13.2)	(9.6)	(15.1)	(12.7)	(14.1)	(17.5)	(6.82)

*The values in parentheses are the standard errors.

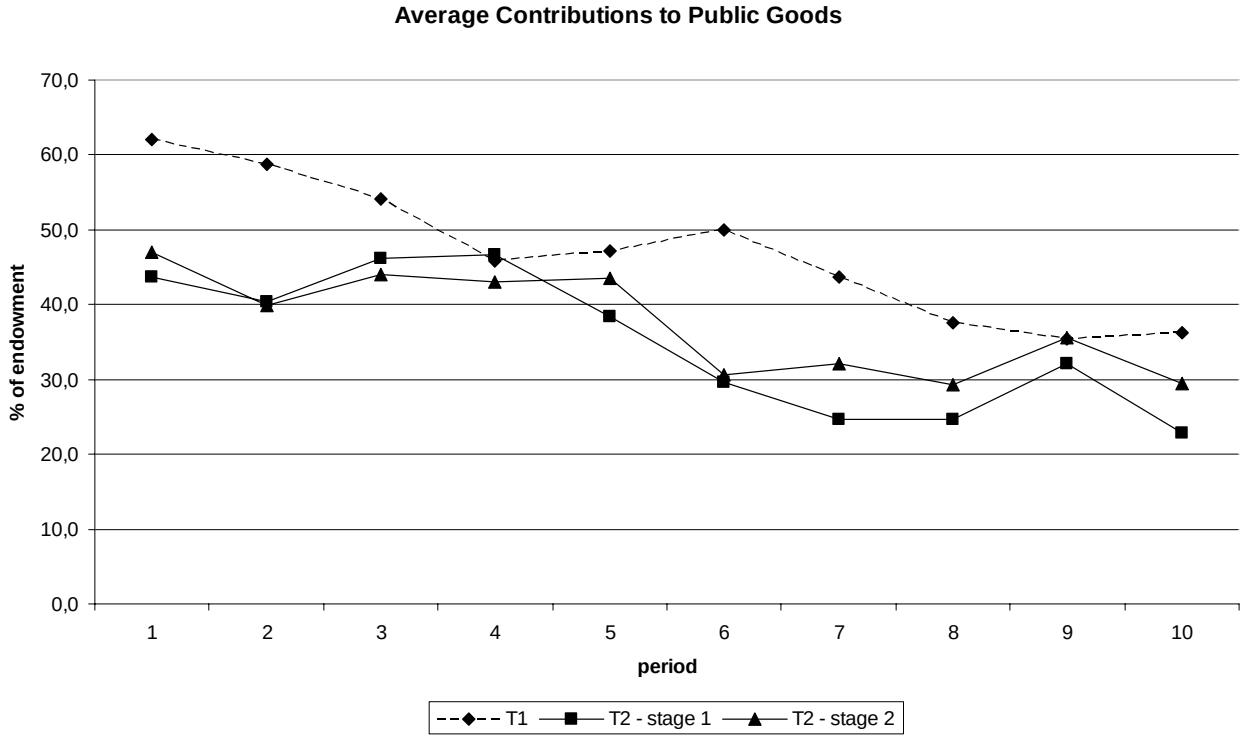

Figure 1

Table 2: Regression (Dependent Variable: Stage 2C)

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.
	B	Std. Error	Beta		
Constant	15.113	10.502		1.439	.159
OwnStage1C	.628	.196	.653	3.208	.003
OwnlastpS2C	-.045	.107	-.085	-.415	.680
OthersS1C	.078	.348	.040	.224	.824
OtherslastpS2C	-.017	.154	-.020	-.109	.914

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