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Law and Behaviours in Social Dilemmas: Testing the Effect of Obligations on Cooperation

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Abstract - Laws consist of two components: the 'obligations' they express and the 'incentives' designed to enforce them. In this paper we run a public good experiment to test whether or not obligations have any independent effect on cooperation in social dilemmas. The results show that, for given marginal incentives, different levels of minimum contribution required by obligation determine significantly different levels of average contributions. Moreover, unexpected changes in the minimum contribution set up by obligation have asymmetric dynamic effects on the levels of cooperation: a reduction does not alter the descending trend of cooperation, whereas an increase induces a temporary re-start in the average level of cooperation. Nonetheless, obligations *per se* cannot sustain cooperation over time.

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JEL Classification: K40, H26, C92, C91.

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1. Introduction

In human society individual behaviour and social interactions are often regulated by means of the law. In particular laws set constraints and determine how people should behave in social dilemma situations, where individual interests and the common good conflict. This is apparent by observing the role of legal rules in the provision of public goods, in local environmental control, in road safety and in numerous other situations. In such contexts, laws may serve the purpose to induce efficient behaviours, thus aligning individual and collective interests. Following the definition suggested by Raz (1980), laws are made by two components: the 'obligations' they express and the 'incentives'[1] designed to enforce them. While the impact of incentives on individual behaviour has been widely studied, the economic literature has generally neglected to reflect on the role of obligations. The aim of this paper is to shed light on the effects of obligations on individual behaviour in social dilemmas.

According to the traditional economic analysis of law, legal rules can influence individual behaviours only through the effect of incentives on individual material payoffs (see Polinsky and Shavell, 2000; Cooter and Ulen, 2003). Despite its success in other contexts, this view can hardly explain why most people cooperate and obey legal rules even when the expected sanctions are very low (see Tyler, 1990; Robinson and Darley, 1997; Kahan, 2004). In order to provide a rationale for these phenomena, legal theorists and economists have recently advanced several explanations which focus on the interactions between laws and social norms[2]. Two theories are particularly noteworthy. The first suggests that, in social interactions with coordination problems or conflicting interests and where multiple equilibria are possible, laws may act as coordination devices which channel individual beliefs about others' behaviours to a common focal point tipping the system into a certain equilibrium (see Cooter, 1998; Bohnet and Cooter, 2003; McAdams and Nadler, 2005). According to the second line of reasoning, laws may influence individual behaviours even through direct psychological effects on individual preferences. In particular, as long as individuals have personal norms suggesting what are the 'fair rules' to follow, the message conveyed by the law may urge people to update their values and subsequently their behaviours (see Kahan, 1997 and Cooter, 1998).

These theories have gained a widespread and growing success among theoretical scholars. However, there is a marked paucity of consistent empirical evidence[3]. In this paper we try to fill this gap by analysing experimentally the separate effect of obligations on individual behaviours in a social dilemma situation. In particular we run a finitely repeated public good game in which individuals are required to contribute a minimum fraction of their endowment for a public project facing a given structure of incentives. According to the traditional theory, only the economic incentives drive individual behaviours. This means that, for given marginal incentives, the level of minimum contribution set up by obligation is not expected to affect individual behaviours. We want to test this conclusion versus the alternative hypothesis that, for

[1] With the term 'incentives' we refer both to rewards and sanctions.

[2] See for example Ellickson (1991) and the literature quoted by McAdams and Rasmusen (forthcoming).

[3] As far as we know recent papers testing some of these possible effects of laws are: Cardenas et al. (2000), Gneezy and Rustichini (2000), Tyran and Feld (forthcoming), Bohnet and Cooter (2003), McAdams and Nadler (2005).

given marginal incentives, different levels of the minimum contribution set up by obligation may imply different levels of cooperation. In order to test these hypotheses, we let vary across the different treatments the minimum fraction of the endowment the individuals are required to contribute while we keep the marginal incentives unaltered. Our results show that obligations *per se* significantly affect the average level of individual contributions. Nevertheless, in all treatments, average contributions tend to decline over time, suggesting that, with low incentives, obligations *per se* cannot sustain cooperation in repeated interactions. Moreover, we provide evidence that unexpected changes in the level of the minimum contribution set up by obligation have asymmetric dynamic effects on the levels of cooperation: a reduction does not alter the pattern of deterioration of cooperation over time, whereas an increase triggers a re-start in the cooperation.

The paper is organized as follows. In section 2 we describe in detail the experimental design. Section 3 analyses and discusses the experimental results. The last section draws some concluding remarks.

2. The Experimental Design

2.1. Individual Payoffs and Theoretical Predictions

Consider $n \geq 2$ individuals ($j = 1,...,n$) who are asked to contribute to a public good for 10 periods. In each of the 10 periods each individual receives an endowment y and has to decide how much to keep for herself and how much to invest into the public project. Moreover suppose that an obligation of minimum contribution $\hat{a} < y$ is imposed by an external authority. This obligation fixes a minimum level of contribution that one *should* provide to finance the public good. This obligation is enforced by a structure of incentives. In particular each individual is audited by the authority with a probability p (with $0 < p < 1$). In case of audit, if the individual's actual contribution a_i is lower than the required contribution $\hat{a}$, she has to pay a penalty equal to $g(\hat{a} - a_i)$, where $g > 1$; on the contrary, if her actual contribution a_i is higher than the minimum one required, the audited individual receives a positive reward equal to $g(a_i - \hat{a})$[4]. No penalty or reward is assigned to an audited individual whose actual contribution is exactly equal to the minimum contribution set up by obligation.

In each period, the expected monetary payoff of an individual i is:

$$X_i = y - a_i + m\sum_{j=1}^{n} a_j - pg(\hat{a} - a_i) \qquad (1)$$

where m indicates the marginal per capita return to the public good $A \equiv \sum_{j=1}^{n} a_j$. We set the parameters such that the following inequalities hold: $m > 1/n$ and $m + pg < 1$. The first inequality implies that the aggregate monetary payoff is maximized when each

[4] The parameters y, p and g are held constant for all 10 periods.

individual fully cooperates. The second inequality assures that the expected individual monetary return from one unit of contribution is negative.

A well supported result in the experimental literature on public good[5] is that in a given population (or sample), some individuals are fully self-interested, that is they care only about their own monetary payoff, whereas some others have social preferences, that is they are also other-regarding and/or process-regarding. Consider in our setting the optimal choice of a risk neutral and fully self-interested individual. Her optimal contribution, a_i^*, is the value of a_i which maximizes (1). The first order condition of the maximization problem yields:

$$\frac{\partial X_i}{\partial a_i} = -1 + m + pg < 0 \qquad (2)$$

Hence the dominant strategy for a (risk-neutral) self-interested individual is always the full free-riding: $a_i^* = 0$. This result depends crucially on the assumption that $m + pg < 1$, meaning that the monetary incentives are not sufficiently high to make the expected return from one unit of contribution higher than one unit kept for herself. Condition (2) predicts that that the level of minimum contribution $\hat{a}$ required by obligation does not affect the optimal choice of a self-interested individual. This result is straightforward under the hypotheses that a self-interested individual cares only about her monetary payoff and that obligations do not affect the individual monetary outcomes.

Notice that in condition (2), given the values of the parameters p and g, the marginal effects of the monetary incentives designed to enforce the obligation are fixed and do not depend on the minimum contribution required $\hat{a}$. This is a crucial condition which is necessary in order to separate the effect of obligations from that of incentives and it is achieved by introducing a reward (symmetric to the penalty) for the individuals contributing less than the minimum contribution. Instead, considering only a probabilistic penalty for the individuals who contribute less than $\hat{a}$, we would obtain two distinct first-order conditions for the maximization problem, one for the interval $a_i \leq \hat{a}$ and the another one for the interval $a_i > \hat{a}$. But in this case different levels of $\hat{a}$ would imply different monetary incentives, which is instead a component we want to keep fixed in order to isolate the effect of different obligations.

Consider now the possibility that some individuals have social preferences, i.e. they care not only about their monetary payoffs, but they have also other-regarding and/or process regarding preferences. We conjecture that, in a public good environment, the level of minimum contribution set up by obligation could affect their behaviours for two possible reasons:

1) An individual may be a reciprocator, i.e. she is willing to cooperate (despite monetary incentives to free-ride) if the other members of their group cooperate at a sufficient extent. We capture this motive by assuming a reciprocity payoff, r_i, depending on individual i's contribution relative to the average contribution

[5] For a survey of the literature on public good experiments, see Ledyard (1995).

$\overline{a} = \frac{1}{n}\sum_{J=1}^{n} a_j$ in the group: $r_i = -\lambda_i (\overline{a} - a_i)^2$, where the parameter $\lambda_i \geq 0$ represents individual i's reciprocity motive. For a purely self-interested individual, $\lambda_i = 0$. Since in each period all contributions are made simultaneously, individual i does not know $\overline{a}$ but she has some *beliefs* about it. We call $\overline{a}_i^e$ the individual i's expectations about $\overline{a}$ [6]. Given this reason of behaviour, an obligation, highlighting a certain level of contribution, could be a focal point for individual beliefs. In formal terms, $\hat{a}$ could affect $\overline{a}_i^e$ and, as a consequence, also individual i's optimal choice.

2) An individual may have internalized a norm of contribution and may suffer emotional consequences when her actual contribution departs from her personal norm. We can capture this reason of behaviour by assuming, as in Bowles and Gintis (2003), that individual i may suffer a psychic cost c_i when her actual contribution is different than the contribution a_i^p required by her personal norm of behaviour[7]: $c_i = -\beta_i (a_i^p - a_i)^2$, where the parameter $\beta_i \geq 0$ indicates how much individual i is susceptible of deviations from her personal norm of contribution. For a purely self-interested individual, $\beta_i = 0$. An obligation, expressing a certain level of 'fair contribution' for the community, could affect an individual i's personal norm of contribution: in this case, individual i will adapt her behaviour to the values expressed by the obligation in order to minimize a negative emotional cost. In formal terms, $\hat{a}$ could influence a_i^p and, as a result, also individual i's optimal choice.

Taking into account these possible reasons of behaviours, in each period individual i will decide her optimal contribution a_i^* maximising the following expected utility:

$$EU_i = \left\{ y - a_i + m\left(\sum_{j=1}^{n} a_j\right) - pg(\hat{a} - a_i) - \lambda_i \left(\overline{a}_i^e(\hat{a}) - a_i\right)^2 - \beta_i \left(a_i^p(\hat{a}) - a_i\right)^2 \right\} \quad (3)$$

The first order condition for an interior optimum is:

$$\frac{\partial EU_i}{\partial a_i} = -1 + m + pg + 2\lambda_i \left(\overline{a}_i^e(\hat{a}) - a_i^*\right) + 2\beta_i \left(a_i^p(\hat{a}) - a_i^*\right) = 0 \quad (4)$$

Condition (4) allows for interior optimal contributions of individuals whose preferences are not fully self-interested. Moreover, it captures two possible ways in which obligations may affect individual optimal contributions. These two possible effects are strictly related. Indeed if obligations affect individuals' preferences, it is plausible that they influence also their beliefs about others' preferences and behaviours. At the same time, if the obligations affect individuals' beliefs about others' behaviours, it is plausible that they influence also their personal beliefs about the 'fair' norms of

[6] Notice that, for reciprocators, the public good game becomes a coordination game (Camerer and Fehr, 2002).

[7] As in Bowles and Gintis (2003), we assume that an individual suffers negative emotional consequences not only when she contributes *less* than her personal norm of contribution, but also, symmetrically, when she contributed *more* than her ideal. Indeed, in this last case, she is subtracting resources from other 'worthy' purposes about which she also has personal norms.

contribution and then their preferences. For this reason we do not try to isolate the two components, but we simply aim at testing whether or not obligations affect individual behaviours in the public good game, i.e. whether or not a_i^* is a function of $\hat{a}$.

As long as obligations significantly affect the optimal choices of individuals having social preferences and these individuals represent a consistent fraction of the population, obligations can affect the average pattern of cooperation to the public good emerging in a certain population.

2.2. Experimental Treatments, Parameters and Information Conditions

The experiment consists of a repeated public good game lasting for 10 periods. Differently from a standard voluntary public good game, an *obligation* of minimum contribution is fixed exogenously. This obligation indicates a minimum level of contribution that each subject *should* provide for the public good[8]. We implement three different conditions for the minimum contribution: a 'zero obligation condition' ('O condition')[9] where the minimum contribution is zero, a 'low obligation condition' ('L condition') where in each period subjects are required to contribute a fraction of 2/5 of their total endowment and a 'high obligation condition' ('H condition'), where the minimum contribution required in each period corresponds to 4/5 of an individual's total endowment. The obligation expressed by the minimum contribution required is enforced by a structure of incentives: in particular there is a probability of audit and a probabilistic penalty (reward) when contributions are lower (higher) than the level of minimum contribution required[10]. As we are interested in the effects of obligations *per se*, we keep as fixed across all treatments the level of marginal incentives, i.e. the probability to be audited and the penalty/reward rate. On the contrary, the level of the minimum contribution required by obligation changes across the treatments. In the instructions we stress that the obligation fixes a minimum contribution required to each individual, but that in each period the feasible contribution for each participant varies between 0 and her endowment. Moreover we explain in detail the consequences of each choice on individual payoffs.

The incentives are fixed at a very low level. This choice is due to two reasons: firstly, we aim at testing whether or not an obligation of minimum contribution affects cooperation when incentives are such that the optimal strategy for self-interested individuals is the full free-riding even if they are risk averse within reasonable degrees. Secondly, we want to minimize the possible bias in our results caused by differences in risk preferences across samples (even if we control for this bias using the test described in section 2.3).

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[8] Notice that the minimum level of contribution required is an individual obligation. Differently from a step level public good game (see among the others: Offerman et al. (2001) and the literature quoted there), we do not impose any collective threshold to be reached in order to provide the public good. As in a step level public good game, we maintain that the presence of the obligation may affect beliefs about others' cooperation. Notice that our setting does not imply multiple equilibria for self interested players.

[9] In the "0 condition" treatment there is no explicit mention to any minimum contribution required. Moreover notice that in this treatment there is a probabilistic reward (proportional to the actual contribution of an audited individual) but not a probabilistic penalty (since negative contribution are obviously not allowed).

[10] The penalty (reward) is proportional to the negative (positive) difference with respect to the minimum contribution required.

As we are interested in the possible effects of a change in the obligation on the overall level of cooperation, in some sessions we extend the public good game for other 10 periods. Hence, in these sessions we implement a repeated public good game for twenty periods divided into two segments of 10 periods. In the second 10 periods segment we change the minimum contribution required with respect to the first 10 periods segment. In all treatment conditions subjects are informed that the experiment lasts exactly 10 periods. When a second segment is added, subjects play the first treatment condition without knowing that the experiment would be continued for other 10 periods. After the period 10, the subjects are informed that a new experiment is beginning, lasting again 10 periods.

Table 1 provides some information about the different experimental sessions and treatments. In each session players are divided into 6 groups of size 6 (except for session 6 where we had 5 groups of size 6) and play the repeated public good game. In Session 1 subjects play the first 10-periods segment with the 'O condition' and the second 10-periods segment with the 'L condition'. In Session 2 subjects play the first segment under the 'L condition' and the second segment under the 'O condition'. In Session 3 the 'L condition' is implemented for the first segment and the 'H condition' for the second segment. Session 4 begins with the 'H condition' in the first segment and then implements the 'L condition' in the second segment. In Session 5 and Section 6 only a 10-periods segment is played, respectively with the 'L condition' and the 'H condition'.

TABLE 1
CHARACTERISTICS OF THE EXPERIMENTAL TREATMENTS AND SESSIONS

Session	Number of Subjects	Minimum Contribution Required 1st 10-periods Segment	Minimum Contribution Required 2nd 10-periods Segment
1	36	O	L
2	36	L	O
3	36	L	H
4	36	H	L
5	36	L	-
6	30	H	-

The experiment was conducted in a computerized laboratory where subjects anonymously interacted with each others[11]. No subject is ever informed about the identity of other group members. The composition of group is held constant during the all length of the experiment (partner condition) and subjects know it. In all treatments, the individual endowment in each period is equal to $y = 25$ tokens. The marginal per capita return of the public good is fixed at $m = 0.3$. In each period contributions take place simultaneously. Each group is audited with a probability of $\frac{1}{2}$. In case a group is selected, only one of the six components of the group is randomly chosen to be audited.

[11] For conducting the experiment we used the experimental software "z-Tree" developed by Fischbacher (1999).

Hence the probability of being audited for a subject is equal to $p = \frac{1}{2} \times \frac{1}{6} = \frac{1}{12}$. The sanction/reward rate is equal to $g = 1.2$. Both the probability of being audited and the sanction/reward rate are held constant for all treatments. In all treatments the payoff functions and the parameters y, n, p and g are common knowledge. Furthermore in the instructions we stress that in each period the probability of being audited is independent on the probability of having been audited in a former period and does not affect the probability of being audited in a following period. The contributions' audit takes place by a computerized random extraction and all subjects are informed about it. The minimum level of contribution required by obligation is $\hat{a} = 0$ in the 'O condition', $\hat{a} = 10$ in the 'L condition' and $\hat{a} = 20$ in the 'H condition'.

At the end of each period, participants are informed about the total contribution to the public good in their group, and receive information about the results of the auditing process. In particular they know whether or not there has been an audit in their group, whether or not their own contribution has been audited and, in this case, the effect of the audit on their own payoff. Nonetheless, in case their group is audited but they have not been selected for the audit, they do not know the identity of the audited group mate. This condition guarantees that participants do not take their choices in order to avoid being ashamed by group mates in the case they are audited and rules out any reputation effect.

2.3. The Role of Risk Preferences: a Control Test

In presence of a probabilistic punishment/reward enforcing a certain obligation, risk preferences may contribute to explain differences in individual contributions. In particular, *ceteris paribus*, risk averse people will contribute closer to the minimum level of contribution required by obligation because they prefer to insure themselves.

In order to control for the possible effect of risk preferences, at the end of each public good session we run a lottery to single out subjects' risk preferences. In the lottery we implement an experimental design similar to that implemented by Holt and Laury (2001). The experimental test is based on five choices between the paired lotteries reported in Table 2. In each paired lottery, subjects choose between an alternative A and an alternative B. Once all subjects have taken their choice, a pair of lotteries is randomly chosen and the computer assigns to each subject the option she has chosen before.

TABLE 2
PAIRED LOTTERY CHOICES

Option A	Option B	Payoff Differences (A-B)
1/10 100 tokens; 9/10 80 tokens	1/10 170 tokens; 9/10 10 tokens	56
3/10 100 tokens; 7/10 80 tokens	3/10 170 tokens; 7/10 10 tokens	28
5/10 100 tokens; 5/10 80 tokens	5/10 170 tokens; 5/10 10 tokens	0
7/10 100 tokens; 3/10 80 tokens	7/10 170 tokens; 3/10 10 tokens	-28
9/10 100 tokens; 1/10 80 tokens	9/10 170 tokens; 1/10 10 tokens	-56

Finally the lottery is run in order to determine each subject's payoff. Following the method proposed by Holt and Laury (2001), we classify individual risk preferences according to the sequence of choices taken in the lottery (see table 3).

TABLE 3
RISK PREFERENCES ASSOCIATED TO LOTTERY CHOICES

Sequence of Choices	Risk type
A-A-A-A-A	highly risk averse
A-A-A-A-B	risk averse
A-A-A-B-B or A-A-B-B-B	risk neutral
A-B-B-B-B	risk lover
B-B-B-B-B	highly risk lover
Other Sequences	inconsistent choices

3. Experimental Results

All sessions were held in October 2004 at the University of Siena (Italy). In total, 210 subjects took part in the experiment. All subjects were students recruited from undergraduate courses in different fields. Nobody had previously participated to a public good game. Each subject took part only in one of the six sessions. An experimental session lasted about 60 minutes and the average earning was 12 euros (about 16 dollars), including a show-up fee of 3 euros.

3.1. Obligations and Cooperation Levels

In figure 1 we report the time series of average contributions from period 1 through 10 for the three different levels of minimum contribution required.

FIGURE 1
AVERAGE CONTRIBUTIONS IN PERIODS 1-10

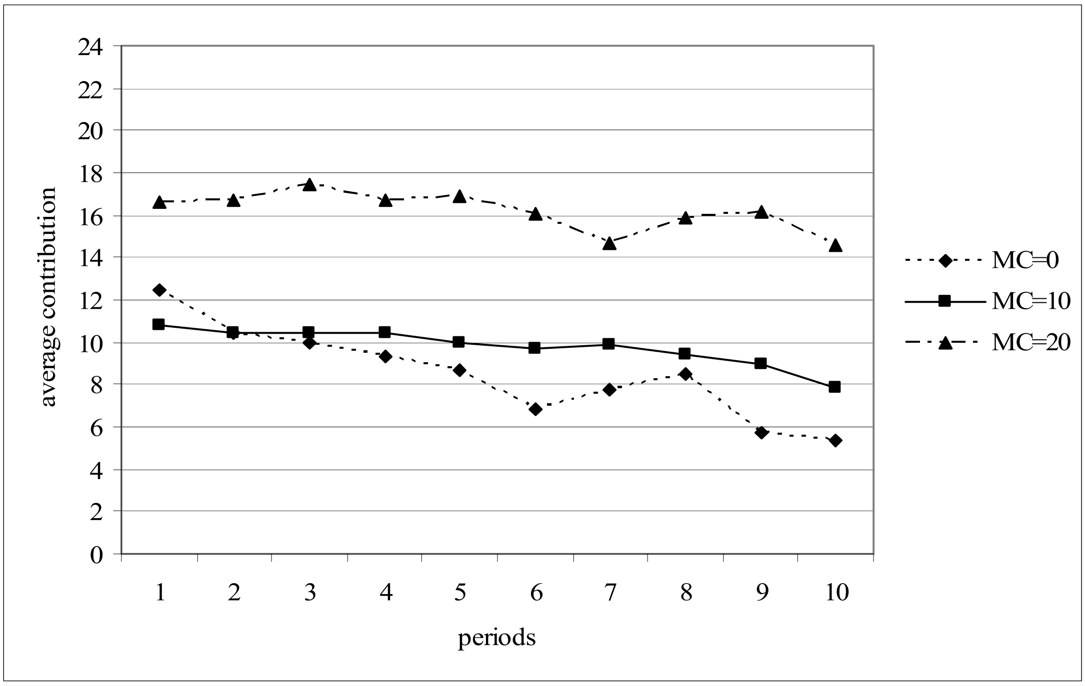


Figure 1 shows that similar average contributions characterise the treatment in which there is not a minimum contribution required ('0 condition') and the treatment in which the minimum contribution required is 10 tokens (the 'L condition'). Instead, average contributions in the treatment where the minimum contribution required is 20 tokens ('H condition') are clearly higher than in the other two treatments characterised respectively by the '0 condition' or and 'L condition'. Moreover we notice that, in all treatments, average contributions tend to decline over time at similar rates. In Table A1 in Appendix 1 we present data on average contributions disaggregated by group. It is worth noting that average contributions are very similar in the sessions characterised by the same level of minimum contribution set up by obligation. Moreover the group level data confirm the results shown in figure 1 for data aggregated by treatment conditions.

In Table 4 we present the results of a Mann-Whitney rank-sum test[12] of the difference in contribution levels between treatments in periods 1-10[13]. We find that mean contributions under the 'H condition' are higher at significant statistical levels than mean contributions both in the treatment with the '0 condition' and in the treatment implementing the 'L condition'. Instead, average contributions under the '0 condition' are not significantly different at conventional statistical levels than average contributions under the 'L condition'.

TABLE 4

MANN-WHITNEY TEST RESULTS FOR DIFFERENCES IN CONTRIBUTIONS BETWEEN TREATMENTS

Treatment Conditions	MC=10	MC=20
MC=0	z=-0.667; p=0.505	z=-2.717; p=0.0067
MC=10		z=-2.714; p=0.0067

MC=Minimum Contribution Required

These results suggest that, for given marginal incentives, the minimum contribution set up by obligation can affect average cooperation. In particular, when the minimum contribution required is high ('H condition'), the level of cooperation is significantly higher than in presence of low or null obligation.

In order to better interpret the previous findings based on comparisons of average contributions, it is worth analysing how the patterns of individual data vary across treatments. In figures A1-A6 in Appendix 1 we report the distributions of individual contributions in the first round of sessions 1-6. As one can notice, the distribution of individual contributions in the first period is quite similar in sessions 1, 2, 3 and 5 (where the minimum contribution is 0 or 10 tokens), whereas it differs in a relevant way in sessions 4 and 6, where the minimum contribution is fixed at 20 tokens. In particular, while the distribution of contributions tends to be concentrated around the level of 10-12 tokens when the '0 condition' or the 'L condition' is implemented, under the 'H condition' the distribution is significantly more shifted towards right, being individual contributions concentrated around the level of 20-25 tokens. Instead the number of individuals contributing 0 or close to 0 (self-interested individuals) is quite similar across sessions (with the partial exception of session 5, characterised by a larger proportion of self-interested subjects).

[12] The unit of observation in the statistical test is the group average contribution.

[13] We report both the values of the test (z) and the p-values (p).

We can give this evidence the following interpretation. In the first round of a public good game, selfish individuals do not contribute, whereas conditional co-operators make a positive contribution expecting to be reciprocated. In our sample, when the minimum contribution required is null, in the first round reciprocators tend to contribute about 10-12 tokens. When the minimum contribution required is 10 tokens, a very similar pattern emerges in both our samples. A possible explanation of these findings is that, fixing exogenously the minimum contribution required at a level very close to 40-50% of the endowment (as in our 'L condition'), reciprocators tend to find confirmation (on average) of their preferences and beliefs when no obligation exists, so they will contribute at similar levels than in the no obligation case. This may explain why there is not a significant difference in average contributions between the treatment with the '0 condition' and the one with the 'L condition'.

Instead, when the minimum contribution required is significantly higher than 40-50% of the endowment (as in our 'H condition'), reciprocators are induced to contribute more, making average contributions under the 'H condition' significantly higher than under the two other conditions. Since marginal incentives are the same, this result can be explained only by arguing that reciprocators' beliefs and/or preferences are influenced by the message highlighted by the obligation of minimum contribution.

However, notice that the trend of average contributions from period 1 through 10 is decreasing at similar rates for the different levels of minimum contribution required[14]. This suggests that obligations affect the levels of cooperation but cannot sustain cooperation overtime when the monetary incentives are low. We can give this evidence the following explanation: whatever is the level of minimum contribution and then the initial levels of average contributions, in the presence of selfish individuals who never contribute, reciprocators notice that they are matched with free riders and refuse to be taken advantage of, then reducing gradually their contributions.[15]

The following two statements summarize the evidence discussed above:

Result 1

Obligations affect the levels of average contributions to a public good. In particular average contributions are significantly higher when the minimum contribution required by obligation is sufficiently higher than average contributions as emerging in the 'no obligation' case.

Result 2

Contributions tend to decline over time (at similar rates) for any minimum contribution required. This means that exogenously imposed obligations cannot sustain cooperation when incentives are such that free riding is the optimal strategy for self-interested individuals.

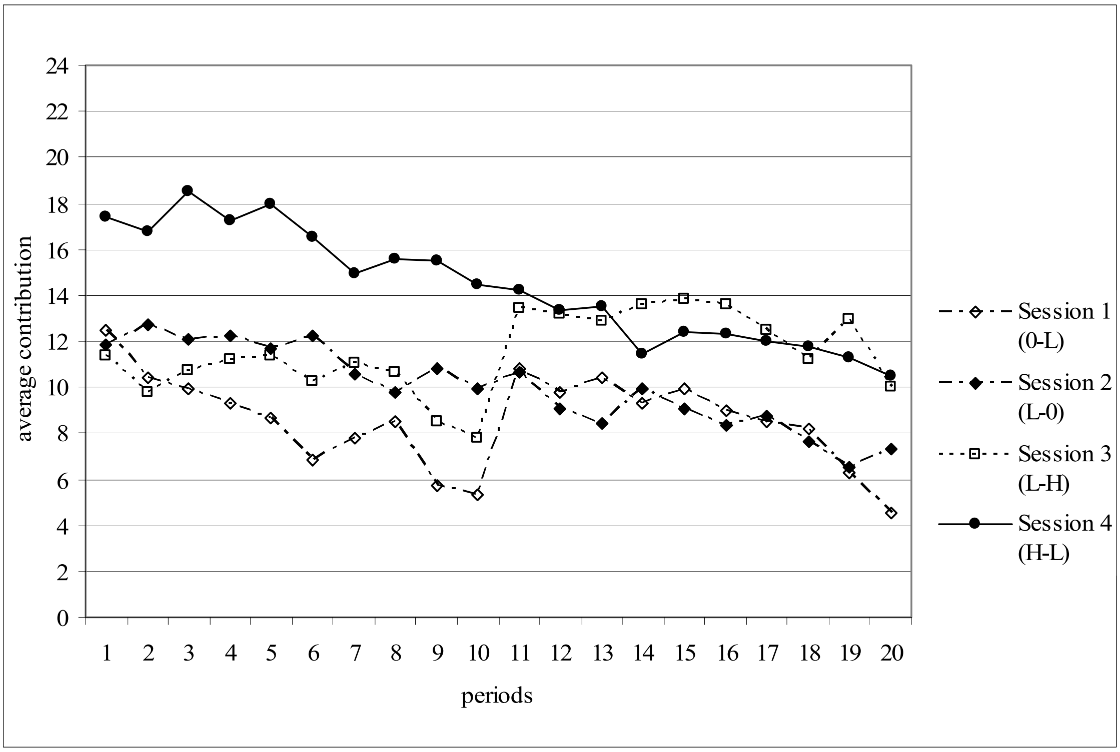
[14] This evidence confirms the standard result that in repeated linear public good games cooperation tends to deteriorate over time; see for example: Andreoni and Miller (1993), Isaac, Walker and Williams (1994), and Weimann (1994)

[15] This is the standard explanation of why cooperation tends to decay in voluntary public good games (see Camerer and Fehr, 2002).

3.2. Changes in Obligations and Cooperation Levels

In sessions 1-4 individuals play a first segment of 10 periods with a certain level of the minimum contribution. At the end of the 10th period, subjects are informed that they have to play a second segment of 10 periods of the same game, but with a different level of the minimum contribution. In figure 2 we report the time series of average contributions for the first segment (labelled as periods: 1 to 10) and the second segment (labelled as periods: 11 to 20) of sessions 1-4.

FIGURE 2
AVERAGE CONTRIBUTIONS IN PERIODS 1-20



It is worth noting that in sessions where the minimum contribution is reduced in the second segment of the game (in session 2, shifting from L to 0 and in session 4 from H to L), no re-starting effect is observed at the 11th round: average contributions in the 11th period of these sessions is very close to average contributions in the 10th period and the contribution rates keep on declining at the same rate.

Instead, in sessions where the minimum contribution is raised in the second segment, we observe a relevant upwards re-starting effect. In session 1 (from 0 to L), average contributions in the 11th period are higher than average contributions in the 10th period and very close to average contributions in the 1st period. In session 3 (from L to H), average contributions in the 11th period are not only higher than in the 10th, but they also make overshooting of the 1st period average contributions. Then, after the 11th period, contributions decline over time in both sessions.

In table 5 we report the results of a nonparametric Wilcoxon matched-pairs test[16] applied, for each session, to test the difference in average contributions between the first segment (periods 1-10) and the second segment (periods 11-20) and between the last period of the first segment (period 10) and the first period of the second segment (period 11). As one can notice, in sessions 1 and 3 (where the minimum contribution increases in the second treatment), the differences in average contributions between periods 1-10 and periods 11-20 are not significant, whereas the difference in contributions between period 10 and 11 are significant. For sessions 2 and 4, the opposite result is obtained: there is a significant difference in average contributions between periods 1-10 and periods 11-20, whereas there is not a statistically significant difference in contributions between period 10 and period 11.

TABLE 5

WILCOXON MATCHED-PAIRS TEST RESULTS FOR DIFFERNCES IN AVERAGE CONTRIBUTIONS

	Session 1 MC1=0 - MC2=10	Session 2 MC1=10 - MC2=0	Session 3 MC1=10 - MC2=20	Session 4 MC1=20 - MC2=10
1st segment - 2nd segment	z=-0.314; p=0.7532	z=2.201; p=0.0277	z=1.365; p=0.1730	z=2.201; p=0.0277
10th period - 11th period	z=-2.201; p=0.0277	z=-0.943;p=0.3454	z=-2.201;p=0.0277	z=0.314; p=0.7532

MC1: minimum contribution required in the 1st 10-periods segment

MC2: minimum contribution required in the 2nd 10-periods segment

In order to better interpret the previous evidence, we analyse individual data by comparing the distributions of individual contributions respectively in the 10th and 11th period of sessions 1-4 (figures A7-A14 in Appendix 1). In sessions 1 and 3, characterised by an *increase* in the minimum contribution, the distributions of individual contributions tend to shift towards right when the new condition is implemented. In particular in session 1 individual contributions are concentrated around 0-2 tokens in the 10th period, when the level of minimum contribution is still 0 tokens, whereas they become concentrated around 10-13 tokens in the 11th period, when the level of minimum contribution is 10 tokens. Instead, in session 3, individual contributions tend to be concentrated around 0 tokens and 10 tokens in the 10th period (when the level of minimum contribution is 10 tokens), whereas they are polarised around 0 and 20 tokens in the 11th period. These results are consistent with the hypothesis that with the implementation of the new condition *some* reciprocators are pushed to contribute more and more closely to the level of minimum contribution set up by obligation.

Instead, in sessions 2 and 4, characterised by a *decrease* in the minimum contribution, we do not observe relevant changes in the distributions of individual contributions from period 10 to period 11. We can interpret this result as follows: when the new treatment is implemented, reciprocators are not pushed to re-start their conditional cooperative behaviour when a lower obligation is highlighted.

A last point deserves our attention. While we have found that having null or low obligation in the first 10 periods of a public good game does not have a relevant impact on the average level of cooperation, we have also found that shifting from a 10-periods treatment with no obligation to a 10-periods treatment with low obligation *is different*

[16] The unit of observation in the statistical test is the group average contribution.

than shifting from low obligation to null obligation. We interpret this result as follows: in the two treatments the reciprocators experience a similar pattern of decay of cooperation in the first 10-periods segment. However, when the new treatment is implemented, reciprocators are not pushed to re-start their conditional cooperative behaviour when a lower obligation is highlighted, whereas they are when an higher obligation is highlighted. Also this result suggests that *obligations matter*.

Summarizing, these results suggest that unexpected changes in the level of the minimum contribution required by obligation have asymmetric dynamic effects on the levels of cooperation. Lowering the minimum contribution does not alter the pattern of decay of cooperation, whereas increasing the minimum contribution makes cooperation to re-start (even with overshooting of the initial level when the minimum contribution passes from 10 to 20). Nevertheless, in both cases, in subsequent periods cooperation tends to decline over time.

The following statement summarizes the above evidence:

Result 3

An unexpected increase in the minimum contribution required by obligation triggers a temporary re-start in the cooperation deteriorated in the first 10 periods. Instead, an unexpected reduction in the minimum contribution does not alter the descending trend of cooperation.

3.3. Controlling for Differences in Risk Preferences

In table 6 we report the frequencies of subjects by class of risk preferences as obtained by running the experiment described in paragraph 2.3.

TABLE 6
FREQUENCIES OF SUBJECTS BY CLASSES OF RISK PREFERENCES

Classes of risk preferences/Session	Session 1	Session 2	Session 3	Session 4	Session 5	Session 6
Highly risk averse	4	6	5	3	5	9
Risk averse	6	5	5	5	8	4
Risk neutral	16	12	12	15	12	9
Risk lover	1	1	3	0	0	1
Highly risk lover	0	0	0	1	0	1
Inconsistent choices	9	12	11	12	11	6

It is worth noting that the frequencies are very similar for the samples of the different sessions, with the partial exception of session 6, where highly risk adverse subjects represent an higher proportion in the sample. Furthermore, we notice that the number of risk-lover or highly risk-lover individuals is very small.

In order to test whether or not differences in risk preferences are relevant in explaining differences in contributions, we have subdivided our sample in three groups: the first group is composed of risk-neutral individuals, the second is composed of risk-averse individuals and the third one is composed of highly risk-adverse individuals[17].

[17] We have not considered risk-lover or highly risk-lover individuals, who represent a negligible fraction of subjects in the sample, nor individuals whose choices are inconsistent.

Moreover we compute for each subject an index given by the mean (for all periods) of the differences between her contribution and the minimum contribution required $\hat{a}$. Then we apply a Mann-Whitney rank-sum test of the difference in this index between each pair of groups. The Mann-Whitney rank-sum test of the difference in this index between risk neutral and highly risk adverse individuals yields z = -0.084, which is non statistically significant at conventional levels (p = 0.933). The same test applied to the difference in this index between risk neutral and risk adverse individuals yields z = 0.026, which is certainly non statistically significant (p = 0.979). Finally, the difference between highly risk adverse and risk adverse individuals is also found non statistically significant (z = -0.315, p = 0.753).

Hence, differences in subjects' risk preferences across the different samples do not affect our results for two reasons. First, the distribution of subjects by class of risk preferences is very similar in the different sessions. Second, there is no significant difference in individual behaviours with respect to the minimum contribution between highly risk adverse, risk-adverse and risk-neutral individuals. This last result can be explained by the fact that the probability to be audited in each round and the penalty rate are very low.

4. Concluding Remarks

In this paper we have tested whether or not in a public good game an obligation of minimum contribution affects individual behaviours independently on the economic incentives designed to enforce it. We have found that the level of minimum contribution set up by obligation affects average contributions. Nevertheless, obligations *per se* cannot sustain cooperation over time. Furthermore, our results show that unexpected changes in the level of minimum contribution set up by obligation have asymmetric dynamic effects on the levels of cooperation: a weakening in the obligation does not alter the pattern of deterioration of cooperation, whereas an increase induces a (provisional) re-start in cooperation.

These results support the idea that lawmaking can shape individual values and influence internalized norms and beliefs. Hence laws affect individuals' behaviour not only by modifying their material payoffs, but also by shaping their preferences and beliefs. Nonetheless the effect of obligations on individual values and beliefs is not enough to sustain cooperation and overcome social dilemmas. Indeed, law can exert these effects only on those subjects whose preferences are not purely self-interested. As far as the society consists of a significant proportion of self-interested individuals, exogenous or endogenous incentives able to direct the behaviour of these subjects are required in order to sustain cooperation. In this case the obligations set up by the law, shaping individual values and beliefs, can influence the emergence of social norms supported by sanctions and can contribute to determine the ultimate level of cooperation we observe in a certain community.

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Appendix 1: Tables and Figures

TABLE A1

AVERAGE CONTRIBUTIONS IN SESSIONS 1-6: ROUNDS 1, 1-10 (AVERAGE), 11, 11-20 (AVERAGE)

Session	Group	Period 1	Periods 1-10	Period 11	Periods 11-20
1	1	15.67	12.22	12.33	6.82
	2	8.17	6.42	13.33	9.17
	3	13.00	10.72	10.50	10.25
	4	12.83	9.47	9.00	9.08
	5	10.17	8.18	11.67	9.50
	6	15.00	4.00	8.00	7.20
	Overall Mean	12.47	8.50	10.81	8.67
2	1	9.17	8.97	11.00	7.63
	2	9.83	10.05	8.33	6.78
	3	10.00	8.23	7.50	3.53
	4	12.67	10.63	10.17	7.63
	5	12.17	10.10	7.50	8.27
	6	17.17	20.35	19.17	17.55
	Overall Mean	11.83	11.39	10.61	8.57
3	1	13.33	15.12	22.83	20.47
	2	9.50	6.88	6.17	2.57
	3	8.33	6.73	9.33	6.45
	4	13.67	12.93	14.17	15.78
	5	10.67	8.82	16.83	14.65
	6	12.50	11.12	11.17	16.30
	Overall Mean	11.33	10.27	13.42	12.70
4	1	12.67	9.17	8.50	6.07
	2	13.00	15.13	12.83	11.55
	3	22.17	20.55	20.67	19.72
	4	20.50	19.67	15.00	13.92
	5	18.33	17.83	18.33	13.38
	6	17.67	16.63	10.00	9.08
	Overall Mean	17.39	16.50	14.22	12.29
5	1	10.33	5.18		
	2	6.00	5.75		
	3	11.33	12.57		
	4	3.83	3.25		
	5	11.83	11.02		
	6	11.67	8.22		
	Overall Mean	9.17	7.66		
6	1	21.00	21.41		
	2	14.67	17.57		
	3	21.00	19.45		
	4	9.00	10.87		
	5	12.50	10.60		
	Overall Mean	15.63	15.98		

FIGURES A1-A6

DISTRIBUTION OF CONTRIBUTIONS IN THE SAMPLES (PERIOD 1)

FIGURE A1: SESSION 1 (MC=0), ROUND 1

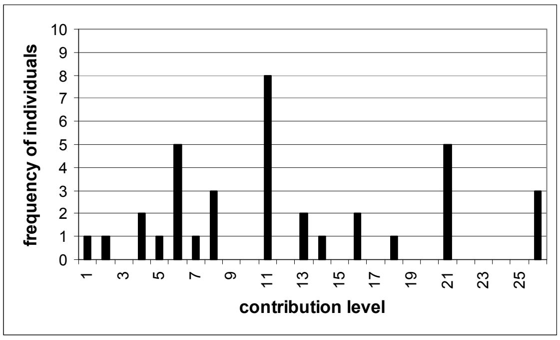


FIGURE A2: SESSION 2 (MC=10), ROUND 1

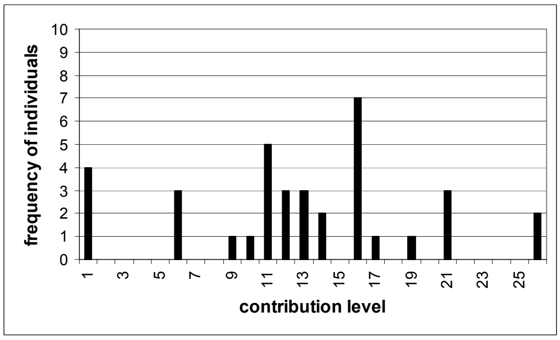


FIGURE A3: SESSION 3 (MC=10), ROUND 1

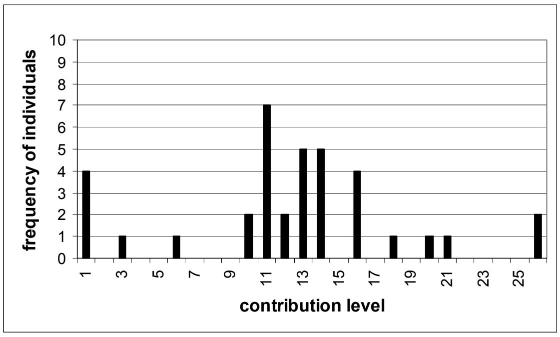


FIGURE A4: SESSION 4 (MC=20), ROUND 1

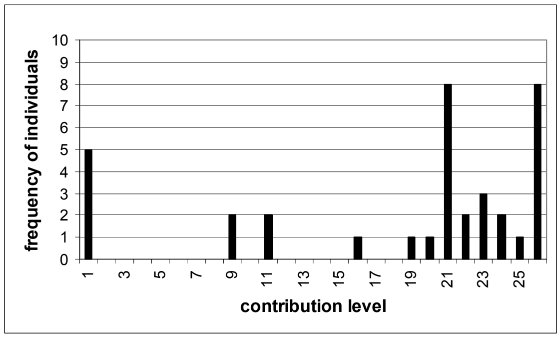


FIGURE A5: SESSION 5 (MC=10), ROUND 1

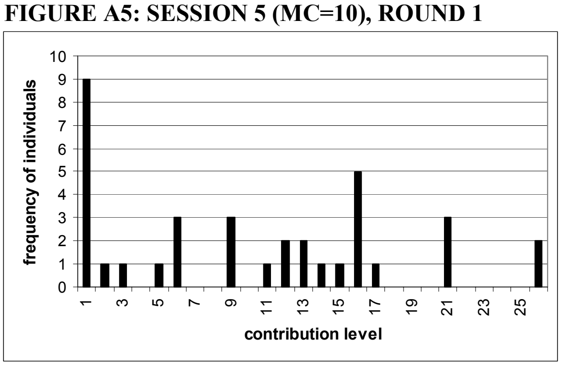
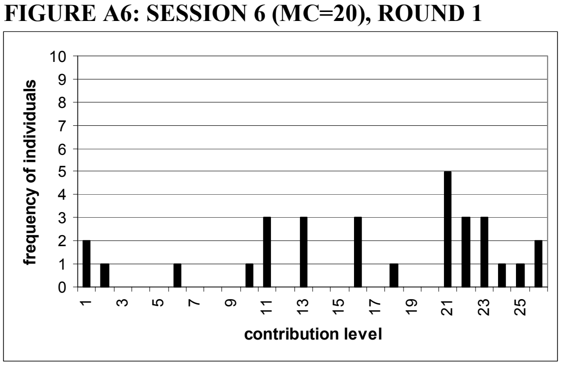


FIGURE A6: SESSION 6 (MC=20), ROUND 1



FIGURES A7-A14

DISTRIBUTION OF CONTRIBUTIONS IN THE SAMPLES (PERIODS 10 AND 11)

FIGURE A7: SESSION 1, ROUND 10 (MC=0)

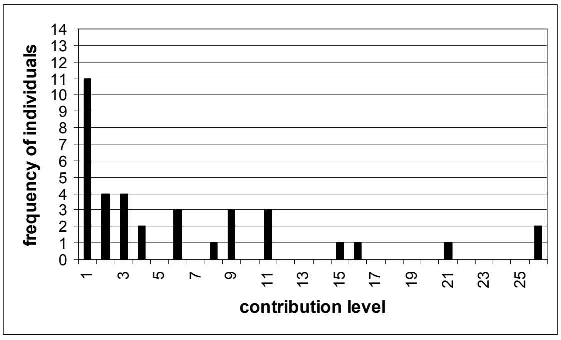


FIGURE A8: SESSION 1, ROUND 11 (MC=10)

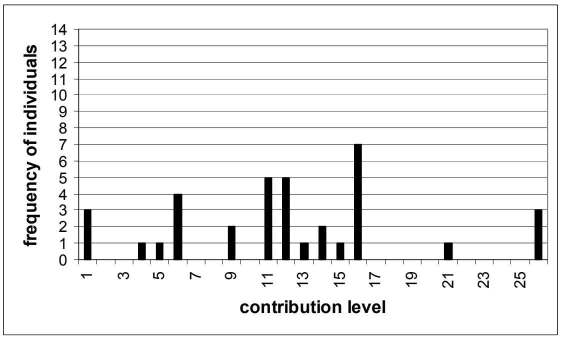


FIGURE A9: SESSION 2, ROUND 10 (MC=10)

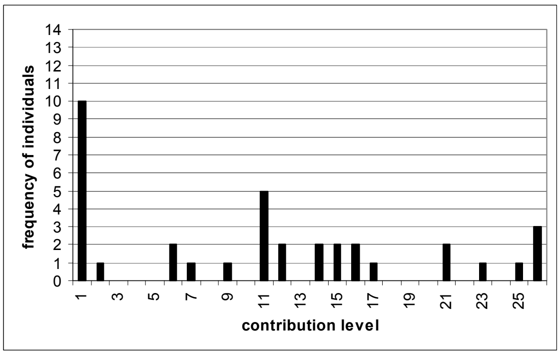


FIGURE A10: SESSION 2, ROUND 11 (MC=0)

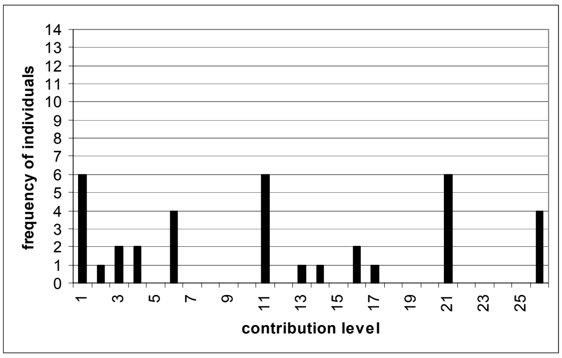


FIGURE A11: SESSION 3, ROUND 10 (MC=10)

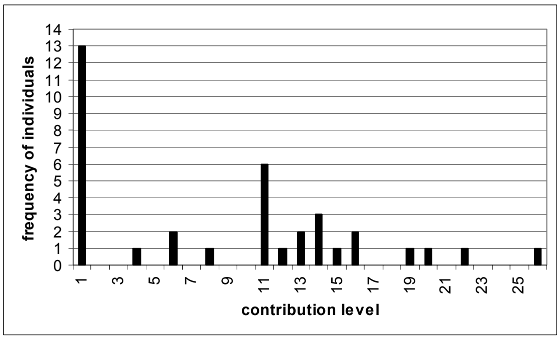


FIGURE A12: SESSION 3, ROUND 11 (MC=20)

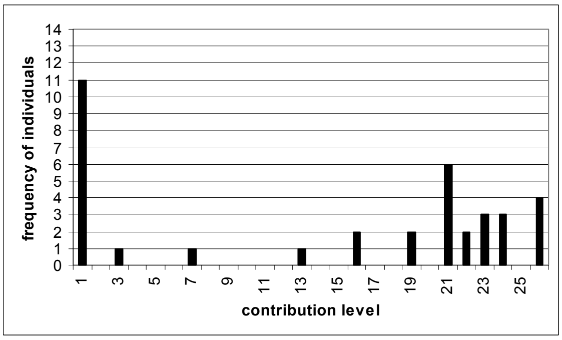


FIGURE A13: SESSION 4, ROUND 10 (MC=20)

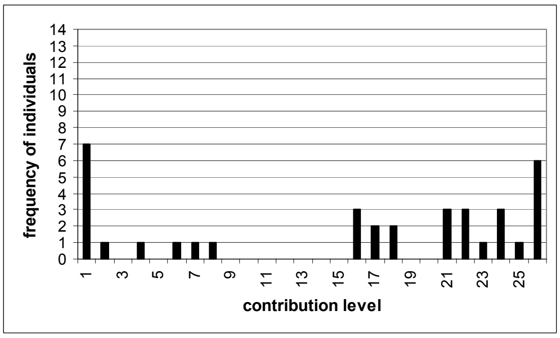
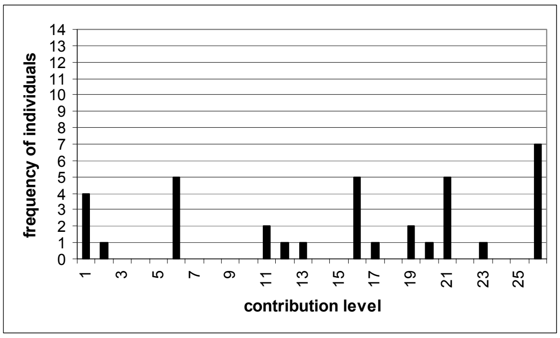


FIGURE A14: SESSION 4, ROUND 11 (MC=10)



Appendix 2: Instructions

The following instructions were originally written in Italian. We document the instructions used in session 3 (both for the public good game and the lottery).

2A - The public good game

2A1. Instructions for the first treatment (periods 1-10)

Instructions

Welcome in the Lab and thanks for participating in this experiment. You are now taking part to an economic experiment in which, depending on your decisions, you can earn a considerable amount of money.

From now on, it is prohibited to communicate with the other participants during the experiment. If you violate this rule you will be excluded from the experiment and from all payments.

Hereafter we describe the experiment in detail. Please, read the following instructions carefully. It is in your and our best interest that you fully understand the instructions, so please feel free to ask any question.

How will your income be paid?

During the experiment your entire earnings will be calculated in tokens. At the end of the experiment the total amount of tokens you have earned will be converted to Euros at the following rate:

100 tokens = 1 Euro

Each participant receives a lump sum payment of 3 Euros for participating. At the end of the experiment your earnings and the 3 Euros for participating will be immediately paid to you in cash.

How long is the experiment? How many people do take part to it?

The experiment is divided into different periods. In all, the experiment consists of 10 periods. In each period the participants are divided into groups of six. Therefore you will therefore be in a group with 5 other participants. The composition of the groups will not change during the experiment. **Therefore in each period your group will consist of the same participants** (whose identity you do not know).

Which kind of decisions do you have to take during the experiment?

In each of the 10 periods of the experiment you have to decide the amount of your contribution to a ***common project***.

At the beginning of each period**,** as all your group members, you will receive an *endowment* of 25 tokens. Your task is to decide how to use your *endowment*. In particular, you have to decide how many of the 25 tokens you want to contribute to the *project* (notice that you have to choose a natural number between 0 and 25). The remaining tokens (25 - your contribution) are kept for yourself.

What is the aim of the project?

The project returns to the group a *common product*. The *common product* is an amount of tokens higher than the total sum of the contributions to the project made by the members of your group. The *common product* is divided equally among all the group members. Each group member obtains an *individual product*. In particular, the sum of the individual contributions to the project will be multiplied by 1.8 before being divided equally among the six group members.

The individual product can be represented by this simple expression:

$$\textit{individual product} = \frac{G \times 1{,}8}{6}$$

where:

G = sum of the individual contributions of all group members to the project;

6 = number of group members.

An example.

Suppose that the sum of the contributions to the project from all the group members is 60 tokens. The project returns a total amount of:

$$60 \times 1.8 = 108 \text{ tokens}$$

This amount of tokens will be equally redistributed among the group members. Hence, each member of the group earns from the project:

$$\frac{60 \times 1.8}{6} = 60 \times 0{,}3 = 18 \text{ tokens.}$$

Therefore, your contribution to the project also raises the income of the other group members. On the other hand, you earn an income from each token contributed by the other members. For each token contributed by any other member you will earn 0.3 tokens.

Remember that, in each period, your feasible contribution is any integer number between 0 and 25.

The minimum contribution

In each period, a *minimum contribution* to the project equal to 10 tokens is required to each individual. This is the minimum amount of tokens you *should* provide for the public project. The amount of tokens required as minimum contribution will not change during the experiment, remaining the same (10 tokens) for all the 10 periods.

The control

In each period there will be the possibility that the contribution of a group member will be audited. The choice will be random. The computer, after all members of your group have made their decision, will randomly select an even or odd number. The extraction of an even number implies that there will be an audit of the contributions; on the other hand if the result of the extraction is an odd number the contributions will not be audited. If the contributions within the group will be audited, the computer will randomly choose an integer between 1 and 6, corresponding to the identification number of the subject that will be audited. **For each member of the group the probability of being audited in a certain period** will be the probability of the extraction of an even number multiplied by the probability of being extracted in a group of six members, that is to say:

$$p = \frac{1}{2} \times \frac{1}{6} = \frac{1}{12} \cong 8{,}33\%$$

This procedure will be repeated in each period; notice that the probability of being audited in a certain period is independent from the probability of being audited in a former or following period.

What is the effect of the control?

If the contribution of the audited member is **equal to the minimum contribution required**, the control will not have any effect on her earnings.

If the contribution of the audited member is **lower than the minimum contribution required**, an amount of 1,2 tokens will be subtracted from her endowment for each token of difference between the minimum contribution and her actual contribution.

If instead the contribution of the audited member is **higher than the minimum contribution required,** an amount of 1,2 tokens will be added to her endowment for each token of difference between the minimum contribution and her actual contribution.

Notice that the tokens subtracted from the audited subjects who contribute less than the minimum contribution will not be added to the common project and the tokens received by the audited subject whose contribution is higher than the minimum one will not be subtracted from the common project.

An example

Suppose that the minimum contribution is fixed to 3 tokens

- Suppose that the subject contributes 1 token. In case her contribution is audited, 2,4 more tokens will be subtracted from her endowment, that is to say:

$1{,}2\times$(minimum contribution – actual contribution of the subject) $= 1{,}2\times(3-1) = 2{,}4$.

- Suppose now that the subject contributes 5 token. In case her contribution is audited, she will receive 2,4 more tokens, that is to say:

$1{,}2\times$(actual contribution of the subject–minimum contribution) $= 1{,}2\times(5-3) = 2{,}4$.

How will your income be calculated?

In each period, after all group members have decided how much to contribute to the common project and after a possible control, your income is calculated by summing three components**:**

1. The tokens you have kept for yourselves, that is to say:

$$Endowment - your\ contribution$$

2. The *individual product* from the common project:

$$Total\ group\ contributions \times \frac{1{,}8}{6}$$

3. The effect of a possible audit:
   a. 0, if you have not been audited or if you have been audited but you have contributed exactly 10 tokens (the minimum contribution).
   b. if you have been audited and you have contributed less than the minimum contribution required, your income will be reduced by:

$$(minimum\ contribution - your\ actual\ contribution)\times 1{,}2$$

   c. if you have been audited and you have contributed more than the minimum contribution, your income will be increased by:

$$(your\ actual\ contribution - minimum\ contribution)\times 1{,}2$$

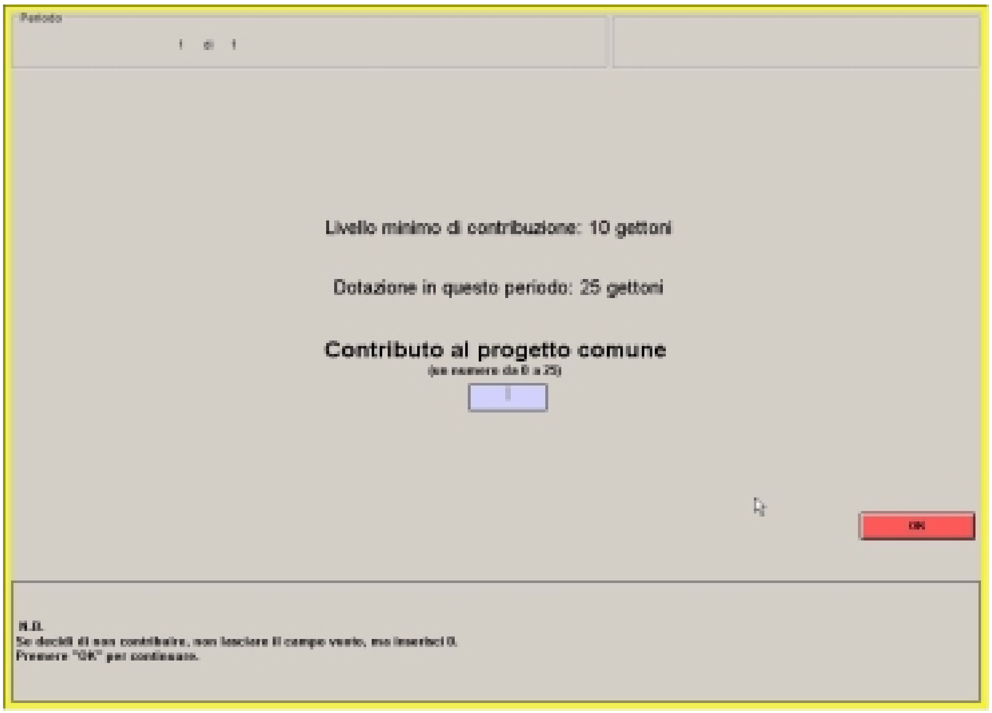
The income in each period can be expressed by the following expression:

$$s = D - c + \frac{G\times 1{,}8}{6} + (c-m)\times 1{,}2$$

where: s = income in each period; D = initial endowment; c = your contribution to the project; G =total group contribution to the project; m = minimum required contribution.

The input screen

Hereafter we describe the screens that you will see during the experiment. At the beginning of each period the following input screen will appear:



The number of the period appears in the top left corner of the screen. In the top right corner you can see how many more seconds remain for you to decide about your contribution. In the first 2 periods you have 45 seconds, whereas in the remaining 8 periods you have 30 seconds. Your decision must be made before the time displayed is 0 seconds. In the middle of the screen, it appears the minimum contribution. Below it, you can see your endowment and then the input field where you have to write a number between 0 and 25. On the right down corner there is the button OK to confirm your choice.

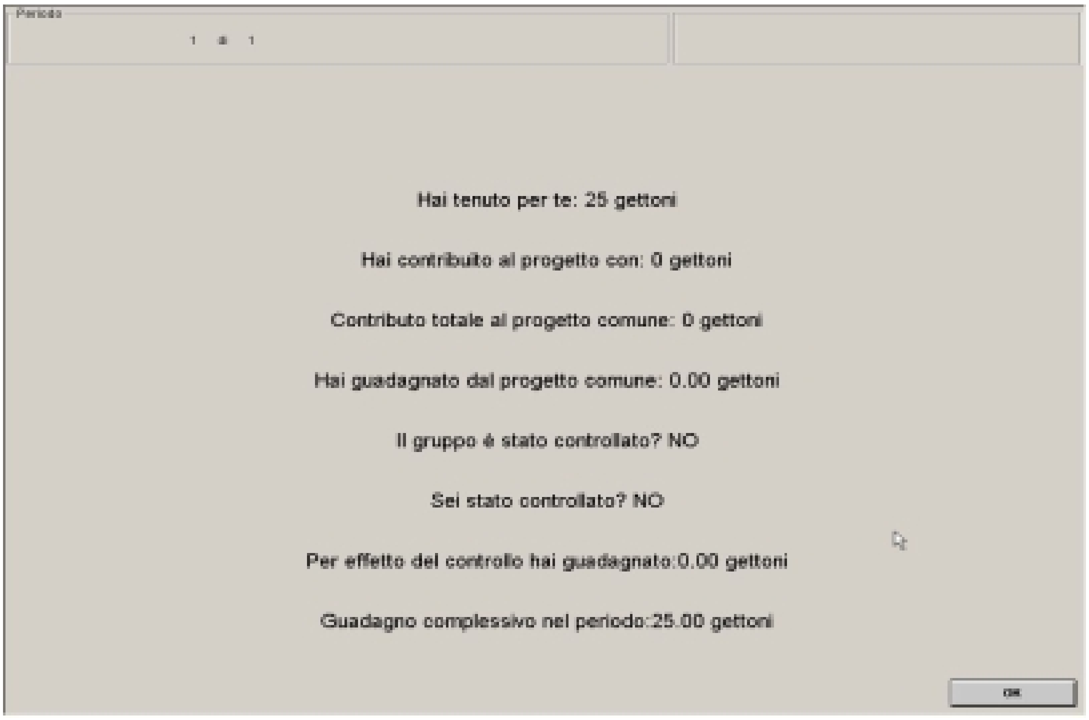
Let's sum up the procedure. You have to decide how much to contribute to the project by writing a number between 0 and 25 in the input field. By deciding how much to contribute you decide also how much you keep for yourself, that is to say: (25 – your contribution). After having written your contribution, you have to click on the OK button. Once you have done this, your decision can no longer be revised.

After all members of your group have made their decision, the computer will extract an even or odd number in order to decide whether or not a member group will be audited. If it is decided to audit a contribution in the group, another extraction will determine which member of the group will be audited.

In case of control, if the contribution of the audited member is equal to the minimum contribution, her earnings will not be affected. If the contribution of the audited member is lower than the minimum contribution, some tokens will be taken from her endowment. If the contribution of the audited member is higher than the minimum required, some tokens will be added to her endowment.

The income screen

After this procedure, the following screen ('income screen') will appear:



On the income screen, you will see the sum of the contributions of the members of your group to the common project (including your contribution) and you will know if the contributions of a member of the group have been audited or not.

The income screen shows you also your total income including the possible reduction or increase of tokens in case your contribution has been audited. Notice that if your contribution is audited, the other members of the group know that there has been an audit within the group but they do not know which specific person has been audited.

In the first two periods you have 45 seconds and in the remaining periods 30 seconds to see the income screen. If you have finished with it before the time is expired, please press the OK button.

2A2. Instructions for the second treatment (periods 11-20)

<u>Instructions</u>

Now you will participate to a **second experiment**. This second experiment is analogous to the first except for a change. The experiment lasts 10 periods as before. In each period you have to decide how much to contribute to a *common project*. At the beginning of each period your endowment is equal to 25 tokens.

The aim and the return from the common project does not change with respect to the first experiment.

The minimum contribution

Nonetheless there is a change with respect to the first experiment. In each period the minimum contribution required to the common project is now set up at the level of 20 tokens. The minimum contribution required will not change during the experiment, remaining the same (20 tokens) for all the 10 periods.

The control

As before, in each period there is the possibility that the contribution of *one member* of the group is audited. In particular, as before, for each subject the probability of being audited in a certain period is equal to $\frac{1}{12}$ (about 8,33 %).

What is the effect of the control?

If the contribution of the audited member is equal to the minimum contribution required, the control will not have any effect on her earnings.

If instead the contribution of the audited member is lower than the minimum contribution required, an amount of 1,2 tokens will be subtracted from her endowment for each token of difference between the minimum contribution and her actual contribution.

If instead the contribution of the audited member is higher than the minimum contribution required, an amount of 1,2 tokens will be added to her endowment for each token of difference between the minimum contribution and her actual contribution

Thank you for participating!

2B - The lottery

<u>Instructions</u>

You are now taking part to a last experiment in which, depending on your decisions, you can earn an additional sum of money. **We ask you not to talk with others until the end of the experiment.** Hereafter the experiment is described in detail.

If you do not have perfectly understood the rules of the experiment, do not hesitate to ask for further explanations to the experimenters.

What is the income from the experiment?

In the experiment your income is calculated in tokens. At the end of the experiment, your income in tokens will be converted to euros at the rate of:

100 tokens = € 1

The income will be paid to you in cash together with the show up fee of € 3 and the income gained in the previous experiment.

In this experiment you are not part of any group. Your decisions do not influence others' income and others' decisions do not influence your income.

What do you have to decide in the experiment?

Hereafter you will see a screen with **a sequence of 5 choices you have to take**. **For each choice you have to indicate if you prefer a lottery A or a lottery B.**

Let's give an example of the possible choice:

	Lottery A	Lottery B
CHOICE 1	70% 50 tokens	50% 90 tokens
	30% 200 tokens	50% 100 tokens

Lottery A gives a gain of 50 tokens with a probability of 70% and a gain of 200 tokens with a probability of 30%. **Lottery B** gives a gain of 90 tokens with a probability of 50% and a gain of 100 tokens with a probability of 50%. **You have to indicate if you prefer the lottery A or the lottery B.**

You must take 5 choices, where each choice is between a lottery A and a lottery B.

How your earnings are calculated?

Once you have taken the five choices (and so indicated five lotteries, one for each pair A-B), the computer will randomly extract one of the five lotteries you have chosen. At this point, given the chosen lottery, the computer will extract your gain accordingly to the probability indicated by this lottery.

Example. Suppose the computer extracts the following lottery (one of those you have chosen):

60% 100 tokens

40% 180 tokens

At this point the computer will extract your gain from the experiment: with a probability of 60% it will extract a gain of 100 tokens, whereas with a probability of 40% a gain of 180 tokens.

The equivalent in euros of your gain will be paid to you in cash at the end of the experiment together with the show up fee (€ 3) and your income from the previous experiment.