



DEPARTMENT OF ECONOMICS
UNIVERSITY OF MILAN - BICOCCA

WORKING PAPER SERIES

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No. 123 - October 2007

Dipartimento di Economia Politica
Università degli Studi di Milano - Bicocca
<http://dipeco.economia.unimib.it>

Cooperation without Punishment

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Abstract. Our experiment is made by three treatments. The first one reproduces the classical public good game. The second environment represents a perfect competition market where the contribution of a representative player to the private good gives a positive rent if and only if it is not lower than the highest contribution of the other players in the group. In the third treatment we consider a winner-take-all market where we have only a winner per group. The aim is to test whether the level of cooperation is minimum under the hypothesis of perfect competition.

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1. Introduction

Experimental evidence shows that people usually cooperate more than would be expected in terms of the maximization of purely selfish utility functions. This conclusion is sustained by a lot of experiments in Ultimatum games (introduced by Guth *et al.*, 1982), gift-exchange games (Fehr *et al.*, 1993), Trust games (Berg *et al.*, 1995) and Third-Party Punishment games (Fehr and Fischbacher, 2004). We observe cooperation also in public goods games (Ledyard, 1995, for a survey) and its level increases if punishment of defectors is available (Fehr and Gächter, 2000 and 2002). The idea that fairness and/or altruistic concerns may be present in “normal” preferences (Fehr and Schmidt, 1999, Bolton and Ockenfels, 2000) produces a significant shift in mainstream economics.

According to Fehr and Schmidt (2000), traditional economics admit selfishness as the normal determinant of human behavior because it generalizes the typical behavior in perfectly competitive market environments to the whole set of human choices.¹

However, as we know that not all economic environments correspond to perfectly competitive markets, we may expect a *zero* level of cooperation if the environment is perfectly competitive but a *positive* level if it is not. To test this hypothesis is one of the aims of our paper. Moreover, we want to analyse whether the level of cooperation is higher in an environment where cooperation is induced by fairness or in a scenario where it is stimulated by the market structure.

Our experiment is made by three treatments. The first one (baseline) reproduces the classical public good game where the payoff generated by the private good for each player is not influenced by the behaviour of the others. The second environment represents a perfect competition market. In this version of the public good game the contribution of a representative player to the private good gives a positive rent if and only if it is not lower than the highest contribution of the other players in the group. In the third treatment we consider a winner-takes-all market where we have only a winner per group as in a all-pay-auction (i.e. a call for tender for the building of a bridge or in an election with a majority rule, Levin and Nalebuff, 1995). In this kind of market the comments about the cost of fairness are the same as in perfect competition, but agents face additional problems concerning risk and beliefs about the behaviour of the others. These features may lead to cooperation.

¹ A perfectly competitive market needs selfish behavior. In fact, a non-maximizing agent loses her/his “normal” profit in equilibrium and s/he is expelled from the market. In other words, a cooperative non-maximizing subject does not reduce her/his potential gain, but s/he faces a loss - potentially a total loss. And we know both from the experimental and from prospect theory (Kahneman and Tversky, 1979; Knetsch and Sinden, 1987) that subjects are much more averse to losses than to missed gains. In a previous experiment (Canegallo *et al.*, 2007), we show that a perfectly competitive market leads subjects to selfish behavior also in laboratory.

The Nash equilibrium for a selfish player in the no-competition environment and in the perfect competition market is straightforward. S/He always chooses not to cooperate. This is not true for the winner-takes-all environment. In this case the Nash equilibrium for each player depends on the level of his/her risk aversion and on the behavior of other players.

In the second section we show in details the experimental design. In the third we describe the experimental model and the Nash *equilibria*. In the fourth we present the data analysis and in the last section some conclusions are outlined.

2. Experimental design

The experiment took place in the Laboratory of Experimental Economics of the University of Milano Bicocca.² Each of the three treatments was run with 32 undergraduate students – every student participated in only one treatment – who were allocated in groups of 4 and played the game for ten periods. During the course of a treatment the composition of the groups remained the same. This means that we adopted a partner protocol. Each agent's payoff corresponded to the sum of his/her earnings over the ten rounds. Before the beginning of the game, participants were asked to answer some control questions to be sure that all the subjects understood the rules of the game and the way payments were computed. We respected the requirements of anonymity – players' identities were unknown even when the treatment ended.

Overall, 96 students participated to the experiment. Each treatment lasted about two hours and the average payoff was € 16.7.

The Baseline Treatment (BT)

In each period subjects were endowed with 125 eurocents to spend in two different projects (A and B). In Project A each player received the sum invested multiplied by 1.2. Project B was a public good that yielded the same payoff to all participants, no matter their contribution were. In each group, the public fund to be equally distributed among participants was obtained by multiplying by 1.8 all the contributions.

The Competition Treatment (CT)

Also in this case, in each period subjects were endowed with 125 eurocents to distribute between Project A and Project B. Subjects who invested money in Project A participated to a competition where the winner(s) was(were) the player(s) who put the highest sum in the project. The winner(s)

² The program was written by the programmer of the AL.EX Laboratory (University of Eastern Piedmont), dr. Marie – Edith Bissey, by using Z-Tree (Fischbacher, 1999).

got all the money collected in the project, increased by 20%, while the losers lost all the money invested in the project. Project B was the same as in the BT.

The Winner – Take – All Treatment (WTT)

Again, in each period subjects were endowed with 125 eurocents to distribute between Project A and Project B. As in the CT, to win the competition in Project A – and obtain all the money collected in the project, increased by the 20% - it was necessary to invest the highest sum in the project. However, in this case, if more than one player invested the highest sum, the winner would be randomly chosen. All the other players lost the money invested in the project. Project B was the same as in the BT.

3.The experimental model

We analyse the payoffs of each player per round in each treatment.

In our model:

- W_i : player i 's pay-off in each round
- x_i : eurocent invested in project A by player i
- $g_{i,j}$ eurocent invested in project B by player i,j

1) *BT (Baseline Treatment)*

$$W_i = 1.2x_i + 0.45g_i + 0.45 \sum_{j=1}^3 g_j$$

s.t

$$x_i + g_i = 125 \tag{1}$$

2) *CT (Competition Treatment)*

$$W_i = 1.2 \left(\frac{x_i + \sum_{j=1}^3 x_j}{w} \right) + 0.45g_i + 0.45 \sum_{j=1}^3 g_j$$

where w is the number of winners

if player i is a winner or

$$W_i = 0.45g_i + 0.45\sum_{j=1}^3 g_j$$

if player i is a loser.

The payoffs are s.t the constraint expressed in equation (1).

3) *WTT (Winner – Take – All Treatment)*

$$W_i = 1.2\left(x_i + \sum_1^3 x_j\right) + 0.45g_i + 0.45\sum_{j=1}^3 g_j$$

if player i is the winner or

$$W_i = 0.45g_i + 0.45\sum_{j=1}^3 g_j$$

if player i is a loser

The payoffs are s.t the constraint expressed in equation (1).

3.1 The Nash Equilibria

The Nash equilibrium in **BT** and **CT** is always the allocation $x_i = 125$ and $g_i = 0$. In the **WTT** something changes. The Nash equilibrium depends on the level of risk. If all the players are risk-lover or risk-neutral, we have the same allocation as in **BT** and **CT** and the Nash equilibrium does not change. If this is not the case, there is something different.

Each player's choice about contribution depends on her level of risk aversion as well as on the other three players' risk aversion. Obviously, each player knows only her own level of risk aversion and has beliefs on risk aversion of the others.

In equation (2) we describe the maximization problem of the utility function of our representative player.

$$\max U_i(W_i) = f(r_i, r_j) \quad (2)$$

where:

r_i : level of risk aversion of player i (known by player i)

r_j : level of risk aversion of player $j = 1, 2, 3$ (unknown by player i)

This is the scenario in the first round. In this case we have multiple equilibria and the choice about the level of contribution to the public good, for a risk averse player, is quite a random choice. However, if we assume the presence of a risk neutral/risk lover player in each group or that the probability that at least one player allocates her whole endowment into the private good, the Nash equilibria are two: either to contribute to the public good or to the private one. In our treatment we observe that, from round 3 to round 10, 63 out of 64 times there is at least one player per group that contributes 0 to g . Consequently, it seems reasonable to assume that players consider that the probability that, at least, one player per-group plays $x = 125$ and $g = 0$ in each period is equal to 1. Then the problem of utility maximization for player i becomes:

$$\max U_i(W_i) = f(r_i, p) \quad (3)$$

where:

p : probability that at least one player plays $x = 125$ and $g = 0$.

As argued before, if we assume that $p = 1$, the utility function maximization problem in equation (3) becomes:

$$\max U_i(W_i) = f(r_i, 1) \quad (4)$$

Following equation (4), we have two Nash equilibria that we may analyse on the basis of the level of risk aversion of the players in each group.

Let us consider a simple example. We assume the presence of a risk-averse player and three risk-neutral players. We need to measure the level of risk aversion of our player. We consider one of the most used measure of expected utility: the Constant Relative Risk Aversion (CRRA) utility function.

We consider ten periods. At the beginning of each period, our risk-averse player decides his strategy on the basis of the value associated to his utility function. He has two rational choices: $x_i = 125$ and $g_i = 0$ or $x_i = 0$ and $g_i = 125$.

His CRRA utility function is as follows:

$$U_i = \frac{(0.45 \cdot 125)^{1-r}}{1-r} \quad (5)$$

if she decides for the strategy $x_i = 0$ and $g_i = 125$ in each period, and

$$U_i = \frac{\frac{1}{4}(4 * 1.2 * 125)^{1-r}}{1-r} \quad (6)$$

if she decides for the strategy $x_i = 125$ and $g_i = 0$.

He compares the value of his utility in equation (5) and in equation (6) and he chooses his strategy.

In particular, he chooses $x_i = 125$ and $g_i = 0$ if the value of r is lower than 0,415.

At the same time, if our player knows that two players (one player) are risk neutral and the other one is (two are) strongly risk averse (for example, $r = 3$), he chooses $x_i = 125$ and $g_i = 0$ if the value of r is lower than 1,05 (2,25). Otherwise he chooses $x_i = 0$ and $g_i = 125$.

The scenario where all the players put the whole endowment in the public good is not a Nash equilibrium. In fact, in this case the level of risk aversion should be $+\infty$ for each player (in fact, it never occurs in our treatment).

Table 1 shows the behaviour of player i according to her level of risk aversion in a certain scenario where she knows the behaviour of the other players.

Table 1

When n^* is ...	i contributes to the public good if r is greater than ...
0	0,41
1	1,05
2	2,25
3	$+\infty$

* n : number of contributors to the public good

To sum up, in the WTT we expect that risk-lover, risk-neutral and low-risk-averse ($r < 0.41$) play a pure strategy – to invest their whole endowment into the private good. On the other hand, if a player's r is higher that 0.41, we expect he will play mixed strategies – sometimes he will invest everything into the private good and some others into the public good.

4. Expected results

Hypothesis 1. Some players in the BT devote money to the public good.

The theoretical model assumes that subjects are self interested and, consequently, they won't contribute to the public good. However, the experimental literature provides the evidence that some players are ready to finance the public good at the beginning and to decline their contribution over time. We expect that in the BT some players are self interested and decide not to contribute, while some others are cooperative and devote money to the public good.

Hypothesis 2. Competition decreases cooperation.

According to some experimental results obtained in a previous work (Canegallo et al., forthcoming), we expect that competition decreases contributions. In particular, we expect that contributions in the CT are lower than in the BT.

Hypothesis 3. A winner – take – all scenario may enhance cooperation.

We do not have any experimental evidence concerning the effect of the winner-take-all market in a prisoner's dilemma scenario. According to the theoretical model, the situation changes. Subjects' relative contributions to the public good depend on their risk-aversion level.

5. Results

In our analysis we will consider two different datasets. The former will contain all the observations from round 1 to 6, while the latter will contain the observations from round 1 to 10 for all the groups but 2. This is due to the fact that in the BT we lost observations of two groups from round 7 to 10.

1) Descriptive statistics

We start by describing the evolution of the average contributions over the ten rounds in all the treatments (Figure 1, Table 2). In the BT the average contribution at round 1 is 41.58% of the endowment, while at round 10 declines to 3.7%. In the CT the average contribution at round 1 is 30.9% of the endowment, while at round 10 falls to 6.2%. Finally, in the WTT the average contribution at round 1 is 40.9% of the endowment, while at round 10 is still at 37%.

If we consider only the first six rounds, the situation is almost the same – in the WTT, the average contribution remains at high levels. In particular, at round 6 it is 18.3% in the BT, 13.4% in the CT and 52.9% in the WTT.

If we run a Spearman correlation test to check the trend of the average contributions over time, it turns out that they significantly decline both in the *BT* and in the *CT* ($\rho = -0.943$ and $\rho = -0.829$, $p = 0.0048$ and $p = 0.0416$, when we consider only the first six rounds; $\rho = -0.988$ and $\rho = -0.77$, $p < 0.0001$ and $p = 0.0092$ when we consider all the 10 rounds). On the other hand, contributions in the *WTT* seem not to be sensible to time ($\rho = 0.2$, $p = 0.704$ when we consider only the first six rounds; $\rho = 0.248$, $p = 0.489$ when we consider all the 10 rounds). The implication is that contributions follow a declining pattern only in the *BT* and in the *CT*.

A Kruskal –Wallis test with the group means as observations rejects the null hypothesis that there are no differences among the treatments both when we analyse the first six rounds ($\chi^2(2) = 7.215$, $p = 0.027$) and when we consider all the 10 rounds ($\chi^2(2) = 9.682$, $p = 0.0079$). If we analyse this differences in details (Mann-Whitney tests), we find out that, at the beginning contributions are significantly lower in the *CT*, but over time contributions in the *BT* and in the *CT* show a similar pattern while they are significantly higher in the *WTT* (Table 3).

Figure 1

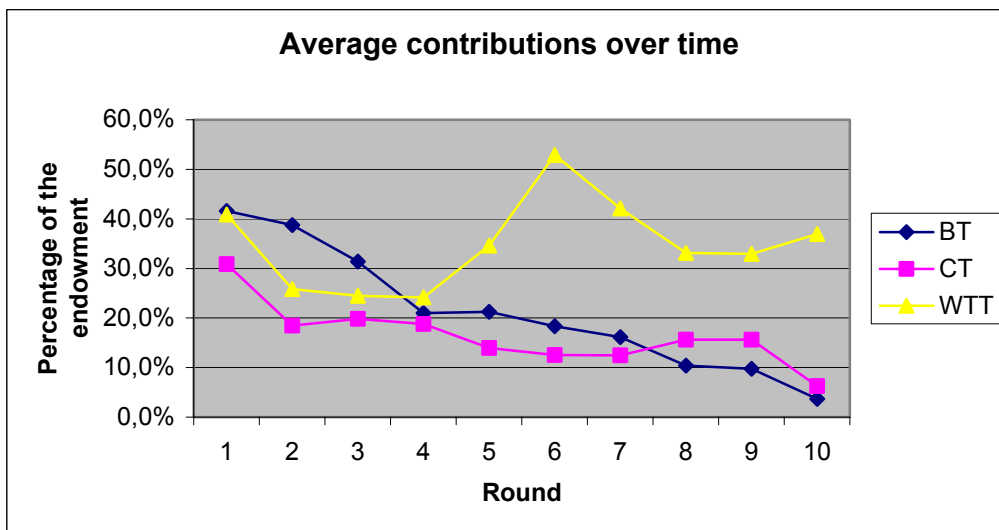


Table 2 – Average individual contributions

	Rounds		
	1	10	1-10
<i>BT</i>	51.9	4.6	26.53
<i>CT</i>	38.6	7.8	20.56
<i>WTT</i>	51.1	46.25	43.52

Table 3 – Mann-Whitney test

	Round		
	1	5	10
<i>BT vs CT</i>	Z = 1.86 (p = 0.06)	Z = 1.16 (p = 0.25)	Z = 0.45 (p = 0.65)
<i>BT vs WTT</i>	Z = 0.49 (p = 0.63)	Z = -1.68 (p = 0.09)	Z = -2.43 (p = 0.01)
<i>CT vs WTT</i>	Z = -1.42 (p = 0.15)	Z = -1.79 (p = 0.07)	Z = -2.65 (p = 0.008)

2) The random-effects Tobit model

Our observations are double censored – they are bounded between 0 (lower level) and 125 (upper level). Consequently, our dependent variable ($C_{i,t}^*$) is represented by each subject's desired contribution to the public good at round t . In particular:

$$\begin{aligned}
 C_{i,t} &= 125 & \text{if } C_{i,t}^* > 125 \\
 C_{i,t} &= C_{i,t}^* & \text{if } 0 \leq C_{i,t}^* \leq 125 \\
 C_{i,t} &= 0 & \text{if } C_{i,t}^* < 0
 \end{aligned}$$

This means that our latent variable is equal to the observed contribution when it lays between 0 and 125.

We estimate our model as a random-effects Tobit³ censored at 0 and 125. In specification 1 (S1)

$$C_{i,t}^* = \alpha + \beta_1 period + \beta_2 C_{i,t-1} + \lambda_1 \Delta pos + \lambda_2 \Delta neg + d_1 competition + d_2 winner + \mu_i + \varepsilon_{i,t} \tag{S1}$$

while in specification 2 (S2) and in specification 3 (S3) we introduce some interaction terms

$$\begin{aligned}
 C_{i,t}^* &= \alpha + \beta_1 period + \beta_2 C_{i,t-1} + \lambda_1 \Delta pos + \lambda_2 \Delta neg + d_1 competition + d_2 winner + \\
 &+ \varpi_1 competition * period + \varpi_2 winner * period + \mu_i + \varepsilon_{i,t}
 \end{aligned} \tag{S2}$$

³ For completeness we estimate the model also with OLS (cluster option) and a Tobit regression.

$$\begin{aligned}
C_{i,t}^* = & \alpha + \beta_1 period + \beta_2 C_{i,t-1} + \lambda_1 \Delta pos + \lambda_2 \Delta neg + d_1 competition + d_2 winner + \\
& + \varpi_1 competition * period + \varpi_2 winner * period + \varpi_3 \Delta neg * winner + \varpi_4 \Delta pos * winner + \mu_i + \varepsilon_{i,t}
\end{aligned}
\tag{S3}$$

where:

- *period* represents the round played by subjects. We check the effect of the time on the contribution level because we know from previous works that an end effect exists and is crowded out only by punishment;
- $C_{i,t-1}$ is the contribution to the public good of each player in the previous period. This variable allows to understand whether people are sticky on their decisions as it turned out, for example, in Chaunduri et al. (2006);
- $\Delta pos_{i,t-1} = \max\left\{0, \frac{1}{24} \sum_{j=1}^{24} C_{j,t-1} - C_{i,t-1}\right\}$ and $\Delta neg_{i,t-1} = \max\left\{0, C_{i,t-1} - \frac{1}{24} \sum_{j=1}^{24} C_{j,t-1}\right\}$ are the distances of player i 's contribution from the average contribution of the group. They detect the influence of the group's behavior on each player's contribution. In particular, they check whether players are conditional cooperators and they level their contributions;
- *competition* and *winner* are dummy variables equal to 1 if the observation belongs to that specific treatment;
- *competition*period* ($CT*t$) and *winner*period* ($WTT*t$) are interaction terms to find out whether time effect is different according to the treatment;
- $\Delta pos*winner$ ($\Delta pos*WTT$) and $\Delta neg*winner$ ($\Delta neg*WTT$) are interaction terms to find out whether group's behavior has a different impact on players' decisions in the *WTT*;
- μ_i is the subject – specific error component.

Result 1. Competition deters cooperation while a winner-take-all scenario enhances it.

Both from Figure 1 and Table 4, it emerges that contributions decrease over time both in the BT and in the CT, while the opposite happens in the WTT. Moreover, in specification 1 (Table 4), contributions are significantly lower in the CT than in the BT, while they are significantly higher in the WTT. A chi-square test rejects the null hypothesis that contributions in the CT are equal to contributions in the WTT. According to specification 2 (Table 4), there is no significant difference between the BT and the CT, while contributions in the WTT are still significantly higher. The existence of a negative impact of competition on cooperation is confirmed by Canegallo et al. (2007). This result is not surprising. Since Adam Smith it is clear that competition promotes selfishness and reduces the private provision of public goods.

Nevertheless, the most interesting point is that, from our data, the introduction of a winner-take-all market makes cooperation more attractive. A winner-take-all market leads subjects to start with high levels of contribution and sustains cooperation over time. This may be due to the fact that in a winner-takes-all scenario any investment in the private good becomes more risky. The consequence is that players may decide to cooperate even more than in absence of competition (*BT*). This seems to suggest that punishment is not the only instrument available to enhance cooperation in such a situation.

Result 2. Group's behavior influences members and contributions converge over time.

Both in the *BT* and in the *CT*, if a subject's contribution is higher (lower) than the average contribution of the group, he/she decreases (increases) his/her investment in the public good in the next round. This seems to support the idea that reciprocity is a relevant determinant of human behavior and that fair-minded players are conditional cooperators (see, for instance, Bardsley and Moffatt, 2005).

A slightly different result emerges in the *WTT* where subjects reduce their contribution to the public good as the average contribution of the group is higher. This is in line with the idea that, the higher the contribution level of the other players to the public good, the higher the probability of being the winner in the competition to obtain the private good.

Result 3. Subjects are sticky on their decisions.

As we found out in our previous work (Canegallo et al., 2006), the way players behave at time $t-1$ influences their decisions at time t . An increase/decrease in contribution to the public good at time $t-1$ increases/decreases contribution at time t .

Result 4. Players tend to converge to the Nash equilibria in the last round.

In Table 7, the minimum and the maximum contributions in the first and in the last rounds are reported for each group. In the last round this values are closer than in the first one both in the *BT* and in the *CT*. The opposite is true in the *WTT*. Moreover, in the *BT* 4 groups over 8 converge to the Nash equilibrium where all the players contribute nothing to the public good. In the *CT* this is the case for 6 groups over 8, while in the *WTT* this occurs only in one group. This may be due to the fact that in the *WTT* two possible strategies are optimal: contribute nothing or contribute everything. If we analyse the contribution of each player in groups from 17 to 24 (*WTT*) at round 10, it turns out that, in fact, 19 players out of 32 decided to contribute nothing, 10 contribute

everything and 3 invest at least 50 eurocents into the public good (Table 8). In the WTT treatment 29 players choose a Nash equilibrium in the last period and 24 in the sixth one.

Table 4 - Random-effects Tobit regression – Dependent variable: individual contribution to the public good

	Specification 1	Specification 2	Specification 3
$C_{i,t-1}$	1.59*** (0.29)	1.38*** (0.31)	1.44*** (0.3)
t	-3.15* (1.89)	-8.06** (3.27)	-7.07** (3.31)
CT	-45.74*** (13.9)	-46.91* (25.97)	-46.6* (26.27)
WTT	24.67** (12.09)	-32.85 (23.71)	-9.09 (25.73)
$CT*t$		0.16 (4.7)	-0.16 (4.77)
$WTT*t$		11.67*** (4.32)	11.38*** (4.37)
$\Delta neg_{i,t-1}$	-1.65*** (0.42)	-1.48*** (0.42)	-1.31*** (0.46)
$\Delta pos_{i,t-1}$	1.01*** (0.34)	0.81** (0.34)	1.43*** (0.46)
$\Delta neg*WTT$			-0.46 (0.33)
$\Delta pos*WTT$			-1.48** (0.69)
Constant	-35.01** (15.15)	-4.58 (21.26)	-18.84 (21.21)
Log likelihood	-1954.6346	-1953.2887	-1944.7666
Wald χ^2	83.5***	77.51***	87.33***
$CT = WTT$	29.79***		
σ_e	111.33*** (6.65)	107.63*** (8.46)	109.39*** (6.86)
σ_u	13.62*** (3.5)	18.61* (10.6)	14.82*** (4.81)
Number of observations	832	832	832
Number of uncensored	249	249	249
Number lower censored	470	470	470
Number upper censored	113	113	113
Standard errors in parentheses			
* significance at 10%			
** significance at 5%			
*** significance at 1%			

Table 5 - OLS regression (cluster option) – Dependent variable: individual contribution to the public good

	Specification 1	Specification 2	Specification 3
$C_{i,t-1}$	0.61*** (0.12)	0.55*** (0.12)	0.55*** (0.12)
t	-0.24 (0.56)	-2.42*** (0.73)	-2.24*** (0.76)
CT	3.67 (4.72)	-4.46 (7.1)	-4.55 (7.2)
WTT	21.63*** (4.45)	0.21 (7.54)	5.08 (8.26)
$CT*t$		1.54 (0.94)	1.55 (0.94)
$WTT*t$		4.34*** (1.32)	4.36*** (1.33)
$\Delta neg_{i,t-1}$	-0.65*** (0.15)	-0.59*** (0.16)	-0.54*** (0.17)
$\Delta pos_{i,t-1}$	0.24* (0.14)	0.18 (0.14)	0.32* (0.19)
$\Delta neg*WTT$			-0.11 (0.13)
$\Delta pos*WTT$			-0.35 (0.27)
Constant	10.97* (5.64)	25.21 (7.49)	22.71*** (7.9)
F	16.57***	20.77***	17.18***
$CT = WTT$	10.52***		
Number of observations	832	832	832

Standard errors in parentheses

* significance at 10%

** significance at 5%

*** significance at 1%

Table 6 - Tobit regression – Dependent variable: individual contribution to the public good

	Specification 1	Specification 2	Specification 3
$C_{i,t-1}$	1.66*** (0.29)	1.53*** (0.29)	1.54*** (0.29)
t	-3.09 (1.94)	-7.63** (3.4)	-6.78** (3.4)
CT	-45.37*** (13.66)	-46.69* (26.8)	-47.14* (26.81)
WTT	23.82** (11.98)	-29.55 (24.52)	-7.69 (26.29)
$CT*t$		-0.21 (4.91)	-0.037 (4.92)
$WTT*t$		11.22** (4.51)	11.06** (4.5)
$\Delta neg_{i,t-1}$	-1.65*** (0.43)	-1.54*** (0.43)	-1.35*** (0.47)
$\Delta pos_{i,t-1}$	1.02*** (0.35)	0.83** (0.35)	1.5*** (0.46)
$\Delta neg*WTT$			-0.44 (0.34)
$\Delta pos*WTT$			-1.57** (0.7)
Constant	-34.97** (16.52)	-5.3 (23.6)	-17.29 (24.18)
Log likelihood	-1912.1615	-1907.9623	-1905.2799
LR χ^2	122.78***	131.17***	136.54***
CT = WTT	31.03***		
Number of observations	832	832	832
Number of uncensored	249	249	249
Number lower censored	470	470	470
Number upper censored	113	113	113

Standard errors in parentheses

* significance at 10%

** significance at 5%

*** significance at 1%

Table 7

Group	First round		Last round	
	Min	Max	Min	Max
1*	25	100	10	50
2	5	100	0	0
3	25	100	0	35
4	45	125	0	0
5	25	75	0	1
6	45	125	0	0
7	0	100	0	30
8*	0	25	0	0
9	0	125	0	0
10	0	125	0	0
11	0	125	0	0
12	0	75	0	0
13	0	65	0	0
14	1	125	0	125
15	0	100	0	0
16	0	0	0	125
17	0	125	0	125
18	0	123	0	50
19	0	125	0	0
20	12	125	0	125
21	65	125	0	125
22	0	75	0	125
23	0	100	0	125
24	25	125	0	125

*For these groups, the last period is round 6.

Table 8

	First round	Last round
	Group 17	
Player 1	125	125
Player 2	0	0
Player 3	0	0
Player 4	5	125
	Group 18	
Player 1	0	0
Player 2	0	0
Player 3	25	0
Player 4	123	50
	Group 19	
Player 1	125	0
Player 2	0	0
Player 3	25	0
Player 4	49	0
	Group 20	
Player 1	50	0
Player 2	12	125
Player 3	125	0
Player 4	24	0
	Group 21	
Player 1	65	125
Player 2	120	0
Player 3	75	65
Player 4	125	125
	Group 22	
Player 1	25	0
Player 2	75	115
Player 3	0	0
Player 4	0	125
	Group 23	
Player 1	0	0
Player 2	0	0
Player 3	100	125
Player 4	100	125
	Group 24	
Player 1	50	125
Player 2	125	125
Player 3	25	0
Player 4	5	0

5. Conclusions

The aim of this paper was to test if it is true that the level of cooperation is minimum under the hypothesis of perfect competition. The theoretical assumption was that both in the *BT* and in the *CT*, the Nash equilibrium was the absence of cooperation, while in the *WTT* this depends on the risk-aversion level as well as on players beliefs. However, from previous works, it was clear that: 1) in the *BT* some players tend to cooperate during the first periods and then reduce their contributions over time; 2) perfect competition crowds-out cooperation. At the same time, we do not have any evidence concerning the effect of the a winner-take-all market competition on cooperation.

The main results are the following: 1) at the beginning, contributions are significantly lower in the *CT*, but over time contributions in the *BT* and in the *CT* show a similar decreasing pattern while they are significantly higher in the *WTT*; 2) in all the treatments in the last rounds, players tend to converge towards the Nash *equilibria*.

Appendix – Instructions⁴

Instructions for Baseline Treatment

1⁵. Welcome to the experiment and thank you for participating. There are neither difficulties nor tricky questions. You are only required to follow the instructions that will appear on your screen. Your answers will be absolutely anonymous. It will not be possible to the experimenter to match the answers with the person who provided them.

Your answers will be absolutely anonymous. It will not be possible for the experimenters to match the answers with the person that provided them. During the experiment you will know other participants' choices, but these too will be absolutely anonymous. Silence during the experiment is required.⁶

2. The experiment is made up by 10 periods.

At the beginning of the **first** period, groups of 4 participants will be randomly created. The subjects in each group will be the same over the 10 periods.

In **each** period, each participant will be endowed with 125 eurocents. This sum must be allocated between two different projects (A and B), according to your free choice. In other words you may

⁴ This is a translation; actual instructions were in Italian. We omit the after-the-job screens and the interactive screens.

⁵ Numbers refer to screen displays.

⁶ Participants were sitting in separate box-places, not allowing involuntary communication.

choose to allocate from **0** to **125** eurocents in each of the two projects, for a total of **125** eurocents. You are asked to use all your 125 eurocents in each period.

3. Since the sum earned in each period affects your final payment, we advise you to think carefully about decisions you will take in **each** period.

The overall sum due to each participant will be calculated as the **sum** of what will be obtained from the two projects in each period.

4. Here is the description of the two projects:

PROJECT A

Each participant obtains the sum invested in this project, increased by 20%.

PROJECT B

In each group, the overall sum allocated in this project by **all** participants will be increased by 80% to form the fund that will be divided **in equal shares among all participants of the group**, whether they contributed to this project or not, and independently of how much each of them had contributed.

5. We are now distributing on paper the same instructions you have just read on your computer. You have a few minutes to go through them. We advise you to consult them during the experiment, whenever you feel you need to⁷.

6. Before the experiment can begin, you will be asked some control questions, to check whether you have understood the rules. As soon as you finish, raise your hand. The assistants will check your answers and, in case of mistakes, they will help you to answer in the correct way. The experiment will begin as soon as every participant has successfully answered all control questions.

7. Thanks to the control questions, rules should be clear.

At the end of the tenth period, the experiment will end, and you will be asked to go to the next room to receive your payment. Participants will be called one at a time, through the number of the computer; therefore no one will know the results achieved by the other participants, nor other participants' names.

⁷ At this point the assistants distribute the instructions on paper.

Instructions for the Competition Treatment

The instructions are the same as for the Baseline Treatment, except for project A, which reads

PROJECT A

In each group, the overall sum allocated in this project by **all** participants will be increased by 20%, and the amount thus obtained **will be entirely assigned to the participant who has allocated the highest sum in this project. All other participants will lose all the money they allocated in this project.** If more than one participant in the group allocates the highest sum, the sum increased by 20% will be equally divided among them.

Instructions for the Winner-Take-All Treatment

The instructions are the same as for the Baseline Treatment, except for project A, which reads

PROJECT A

In each group, the overall sum allocated in this project by **all** participants will be increased by 20%, and the amount thus obtained **will be entirely assigned to the participant who has allocated the highest sum in this project. All other participants will lose all the money they allocated in this project.** If more than one participant in the group allocates the highest sum, the sum increased by 20% will be randomly assigned to one of them.

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