Framing Effects in Public Goods: Prospect Theory and Experimental Evidence*

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Abstract

This paper studies, both theoretically and experimentally, frame effects in the context of a public good game in which players have to make a costly contribution either *i)* to achieve or *ii)* not to lose a non excludable monetary prize. Our protocol leads to public good provision (not deterioration) only if a certain contribution level is achieved. Since both frames differ with respect to the reference point, we use Prospect Theory to derive testable predictions. In particular, Prospect Theory predicts more contribution in the "loss" frame for the range of parameters usually considered by the literature. Our evidence suggests that *a)* subjects' behavior is highly sensitive to frames and *b)* our prediction is confirmed except when the threshold is low. We also estimate the parameters which better suit our experimental evidence, partly confirming previous results in the literature.

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1 Introduction

When a society has to decide the level of provision of some public good, economic theory predicts that free-riding will lead to public good underprovision. This conclusion is partly mitigated by the extensive experimental evidence on the classic Voluntary Contribution Mechanism (VCM) protocol. Here it is found that, under a wide variety of experimental conditions, subjects initially set a contribution which is halfway between the efficient and the free-riding level. If the same protocol is repeated a finite number of times, average contribution declines over time, but stays always above the Nash equilibrium level. More efficient results are obtained in experiments in which the VCM is modified by introducing a threshold in the total contribution, below which the public good is not provided: the higher this threshold, the lower the incentives to free-ride (Ledyard, 1995). These experimental protocols -usually termed as Voluntary Contribution Threshold Games (VCTG)- have multiple equilibria, some of which are efficient (precisely, all strategy profiles where the sum of contributions meets the threshold exactly). In VCTGs these efficient equilibria are often *asymmetric*, in the sense that optimal free-riding relies on the sacrifice of others.

Consider now a slightly different set-up, in which there is a set of individuals *who already enjoy the public good.* However, they realize that at some point in the future the existing public good can deteriorate, or even disappear. To prevent this possibility they need to cooperate. We shall refer to this frame as *(prevention of) Public Good Deterioration* (PGD), as opposed to the more standard case of *Public Good Provision* (PGP). The crucial difference between PGP and PGD is just whether individuals have initially the public good.

Focusing on VCTGs, the aim of the paper is to answer, both theoretically and experimentally, to this very simple question:

Do people contribute more in PGD, rather than in PGP?

Different cognitive biases may induce individuals to contribute more in one setting, rather than the other. Under the *endowment effect* (Thaler, 1980), individuals value more a good they own, rather than one they do not. This would imply more contribution in PGD. Under the *omission bias* (Baron, 1988), individuals have the tendency to judge harmful actions as worse than equally harmful omissions. In our set-up, this -again- would imply more contribution in PGD, since not contributing can be seen as an harmful action (as it can yield the destruction of the public good), while in PGP not contributing can be seen as an harmful omission. However, strategic considerations may change these conclusions significantly. For example, it could be that some individuals contribute less in PGD if they believe that their mates are prone to suffer from either one of those biases and, therefore, the latter are expected to contribute more. It seems we need a careful analysis to draw sensible predictions.

As it turns out, under VNM preferences, both frames yield the same equilibrium prediction which only depends on the contribution threshold, as the unique (symmetric) Bayesian Nash equilibrium takes the form of a cutoff rule, by which an individual contributes if and only if her individual cost of contributing is below some threshold value, c^* (Palfrey and Rosenthal, 1991). However, given that both frames differ in terms of the initial position, it seems natural to use Prospect Theory to derive testable predictions, because this approach takes explicitly into account that individuals' preferences depend on the *reference point* they use to evaluate costs and benefits of different alternatives. In this sense, our paper can be seen as a crossing between Prospect Theory and Bayesian Nash equilibrium in Public Goods provision. To the best of our knowledge, this is the first paper which applies Prospect Theory to analyze strategic uncertainty.

One key element of Prospect Theory is *loss aversion*, that is, the behavioral assumption that postulates that individuals, from their reference viewpoint, value losses more than gains. Again, *this should imply more contribution in case of PGD.* The starting point of this paper is exactly to check this preliminary conjecture by carefully evaluating the "Prospect Equilibria" of our model, for the widest range of relevant parameters. In this respect, Section 2 discloses a set of conditions, both on the relevant parameters of Prospect Theory and the thresholds, for which more contribution is expected under one frame, rather than the other. This consideration notwithstanding, for the parameter range usually considered by the literature, *our original conjecture is validated, predicting more contribution in the case of PGD*, for all thresholds.

This is the theoretical conjecture we bring into the lab, for its empirical validation, in an experiment whose design is described in Section 3. The evidence we report in Section 4 partially confirms our conjecture, as we find that PGD yields higher contribution *unless the threshold is set to its minimum.* In this respect, our results contrast very much with previous experiments (on classic VCMs) that find more contribution when the problem is framed as a positive externality (like in our PGP treatment), rather than when it is framed as a negative externality -like in our PGD (Andreoni (1995), Sonnemans *et al.* (1998) and Dufwenberg *et al.*, 2006). Finally, in Section 4.2 we also estimate (by maximum likelihood) the basic parameters of Prospect Theory which better adjust to our experimental evidence, getting point estimates which confirm previous studies with similar experimental setups. Section 5 concludes, followed by an appendix containing proofs, additional statistical evidence and the experimental instructions.

2 The basic model

There is a group of N players, indexed by $i \in \{1, .., N\}$. Each player has one unit of input that she can either consume privately or contribute. The public good is provided if and only if at least k players contribute, where $1 \leq k \leq N$. The input of player i has a privately known value c uniformly distributed within the interval $[0, 1]$, which can be interpreted as the cost of contributing. We further assume that all players value equally the public good and we call this common value $g \leq 1$.

Table 1 describes player i's monetary payoffs when n is the number of players other than i that are contributing and k is the contribution threshold. We denote by C (NC) the action of (non) contributing, where $p = \Pr(n > k - 1)$, $q = \Pr(n = k - 1)$, and $r = \Pr(n < k - 1)$, respectively.

State probabilities are determined in equilibrium. A symmetric Bayesian

States of the world	$n > k-1$	$n = k-1$	$n < k-1$
Probabilities	p	q	r
C	g	g	0
NC	$g+c$	c	c

Table 1: Voluntary Contribution Threshold Game

Nash equilibrium (BNE) has the form of a *cutoff rule*, by which player i contributes if and only if her cost c is below some threshold value, c^*, common to all players, which we derive as the cost level that makes a player to be indifferent between C and NC:

$$g(p+q) = p(g+c^*) + qc^* + rc^*. \quad (1)$$

From (1) we get:

$$c^* = qg = \Pr(n = k-1)g. \quad (2)$$

In a BNE of the game of Table 1, a given player contributes whenever $c < c^*$ and does not contribute whenever $c > c^*$. Then, c^* is defined implicitly by the following condition:

$$c^* = \binom{N-1}{k-1} \left\{ (c^*)^{k-1} (1-c^*)^{N-k} \right\} g. \quad (3)$$

By analogy with our experimental conditions, we set $N = 3$ and $g = 10/11$. If $k = 1$ the unique BNE is $c^* = 0.365$; if $k = 2$ there are two equilibria, one with $c^* = 0$ and another one with $c^* = 0.45$; if $k = 3$ the only equilibrium is $c^* = 0$. Note that these equilibria are valid, not only for the case of PGP, but also for the case of PGD. The payoffs in the case of PGD are obtained by subtracting g from every cell in Table 1.

2.1 Prospect Theory

A substantial body of evidence shows the failure of expected utility theory to predict actual behavior in simple individual choice problems under uncertainty. Starmer (2000) reviews this evidence as well as many of the theories that have been proposed to account for it. Among these theories, the best known is probably *Prospect Theory* (Kahneman and Tversky, 1979 and 1992), by which the various options available to a decision-maker are formulated as distributions of *gains* and *losses* with respect to some *reference point*. The overall value of a prospect, denoted by V, is expressed in terms of two functions: a probability weighting function w and a subjective value function v applied to gains and losses. Capturing *loss aversion*—"losses loom larger than corresponding gains"— the value function v is assumed to be steeper in losses than in gains, $v'(-x) > v'(x) > 0$, for $x > 0$. Reflecting the principle of *diminishing sensitivity* also observed in psychology —"the impact of a change diminishes with the distance from the reference point"— it is also assumed that the value function v is concave in gains and convex in losses, $v''(x) \leq 0 \leq v''(-x)$, for $x > 0$. For $x > 0$ we define the coefficient of loss aversion as $\lambda(x) := -v(-x)/v(x)$. In many applications it is assumed a constant coefficient. Furthermore, existing empirical evidence suggests a value of λ of around 2. No loss aversion corresponds to the case $\lambda = 1$.

The *weighting function* w is assumed to have an inverse-S shape, meaning that players are very sensible to changes in probabilities near the tails of the distribution. In particular, Kahneman and Tversky (1979) provide evidence that for small probabilities π the weighting function w is *subadditive*, $w(r\pi) > rw(\pi)$ for $0 < r < 1$ and *overweights* probabilities $w(\pi) > \pi$. However, there is evidence that suggests that for all $0 < \pi < 1$, $w(\pi) + w(1 - \pi) < 1$, a property called *subcertainty* by Kahneman and Tversky (1979).

In addition, the evidence also suggests that the weighting function is *i) regressive*, meaning that it intersects the diagonal from above, *ii) asymmetric*, i.e., with a fixed point below $\frac{1}{2}$, and *iii) reflective*, as it assigns equal weights to an equal probability of a gain or a loss (Prelec, 1998).

2.2 Frames

If players evaluate risky prospects in terms of gains and losses with respect to a reference point, x_0, there are four natural candidates in the context of our public good game: $x_0 = 0$, $x_0 = c$, $x_0 = g$, and $x_0 = g + c$, where g is the common value of the public good and c is the individual cost of contributing. In the first two cases, the successful provision of the public good can be seen as obtaining a gain (PGP); in the latter two, instead, as preventing a loss (PGD).

In the sequel, we focus only on two reference points, namely $x_0 = c$ and $x_0 = g$. The reason is that, with reference point $x_0 = 0$ (respectively, $x_0 = g + c$), players faces a choice between two prospects that involve only gains (respectively, losses) and, thus, loss aversion, a key ingredient of Prospect Theory, plays no role.[1]

Reference point $x_0 = c$ (Game G_c). In G_c the provision of the public good is seen as a gain. However, contributing to the public good involves losing c. This is the standard way of presenting a problem of PGP. In Table 2, the payoff matrix of Table 1 is modified by subtracting c from every cell.

States of the world	$n > k-1$	$n = k-1$	$n < k-1$
Probabilities	p	q	r
C	$g-c$	$g-c$	$-c$
NC	g	0	0

Table 2: Game G_c (PGP)

Player i has to choose between two prospects:

$$C = (g - c, p + q; -c, r) \text{ or } NC = (g, p). \tag{4}$$

Notice that the payoff $g-c$, corresponding to the payoff of contributing when a sufficient number of others also contribute, may yield a gain or a loss, since it may well be the case that $c > g$. In this latter case, C is strictly dominated.

Reference point $x_0 = g$ (Game G_g). If $x_0 = g$, the provision of the public good is not seen as a gain, but instead, as preventing a loss, while contributing is seen as not realizing a gain (PGD). As a consequence, payoffs

[1] The interested reader can find a detailed analysis of all four reference points in Iturbe-Ormaetxe *et al.* (2008).

for this case are obtained by subtracting from Table 1 the value of the public good g, as Table 3 shows.

States of the world	$n > k-1$	$n = k-1$	$n < k-1$
Probabilities	p	q	r
C	0	0	$-g$
NC	c	$-(g-c)$	$-(g-c)$

Table 3: Game G_g (PGD)

Here player i has to choose between two prospects:

$$C = (-g, r) \text{ or } NC = (c, p; -(g-c), q+r), \tag{5}$$

where C involves a risky loss, while NC may result in a gain or a loss, in the non trivial case of $g > c$.

2.3 One contribution is enough (Γ_1)

We start with the polar case where the public good is provided when $k = 1$. We focus on symmetric pure strategy equilibria.

Consider a cutoff strategy profile where each player i only contributes if $c < c^*$. The probability that no player other than i contributes is:

$$q(c) = (1-c)^{N-1}. \tag{6}$$

Note that $q'(c) < 0$, with $q(0) = 1$ and $q(1) = 0$.

We now identify the equilibria for the two reference points $x_0 = c$ and $x_0 = g$. Note that when $k = 1$, the last column of Tables 2 and 3 does not play any role.

(a) **Reference Point** $x_0 = c$: The two prospects are $C = (g-c, 1)$ and $NC = (g, 1-q)$, respectively. The equilibrium condition is

$$v(g-c) = w(1-q(c))v(g), \tag{7}$$

or:

$$\frac{v(g-c)}{v(g)} = w(1-q(c)). \tag{8}$$

Since the left-hand side of (8) is strictly decreasing in c, from $\frac{v(g)}{v(g)} = 1$ to $\frac{v(g-1)}{v(g)} \leq 0$ and the right-hand side is strictly increasing from 0 to 1, there is a unique symmetric equilibrium $c_c^* \in (0,1)$.

(b) **Reference Point** $x_0 = g$: The two prospects are $C = (0,1)$ and $NC = (c, 1-q; c-g, q)$, respectively. The equilibrium condition is:

$$0 = w(1-q(c))v(c) + w(q(c))v(c-g). \tag{9}$$

Since the right-hand side of (9) is strictly increasing in c, from $v(-g) < 0$ to $v(1) > 0$, there is a unique symmetric equilibrium $c_g^* \in (0,1)$. Our previous results are summarized in the following

Proposition 1 *Suppose the public good is provided as long as at least one player contributes, i.e.* $k = 1$. *Under Prospect Theory, for both reference points* $x_0 = c$ *and* $x_0 = g$*, there exists a unique symmetric equilibrium. These equilibria are interior to* $(0,1)$ *and are the unique solution to Equations (8) and (9), respectively.*

2.3.1 Ranking the probability of contribution by reference point

In this section, we rank the probabilities of contribution under both reference points. Note first that, if $g = 1$, all prospects at choice with reference point $x_0 = c$ are nonnegative and, thus, loss aversion plays no role. Also note that when payoffs are relatively small, as it is likely to be in an experimental setting, the value function can be taken as piecewise linear, with a kink at the reference point (Köbberling and Wakker, 2005).

Proposition 2 *Suppose* $k = 1$. *Under Prospect Theory, at the symmetric equilibrium, there is more contribution with reference point* $x_0 = g$ *than with* *reference point $x_0 = c$ if and only if loss aversion is high enough:*

$$c_g^* > c_c^* \text{ if and only if } \lambda > \overline{\lambda}_c, \tag{10}$$

where the threshold $\overline{\lambda}_c$ is defined by (26). When the value function v is linear in gains, the threshold $\overline{\lambda}_c$ can be written as:

$$\overline{\lambda}_c = \frac{c_c^*}{w(q)g}, \tag{11}$$

where $q = q(c_c^*)$. If the probability weighting function is linear, then $\overline{\lambda}_c = 1$, so that $c_g^* > c_c^*$ as long as there is loss aversion, i.e. $\lambda > 1$.[2]

2.3.2 Comparison with expected utility

Let c_{eu} be the symmetric equilibrium probability of individual contribution for linear VNM utility in the game where a single contribution is enough for the public good to be provided. Clearly, c_{eu} is the unique solution to the equilibrium condition:

$$c_{eu} = q(c_{eu})g = (1 - c_{eu})^{N-1}g. \tag{12}$$

Since q is decreasing both in c and N, Condition (12) implies that c_{eu} is decreasing in N: the larger the group, the smaller the equilibrium probability of contribution for each individual.

Let c_f be the interior fixed point of the probability weighting function, i.e., $w(c_f) = c_f$, $0 < c_f < 1$. Prelec (1998) reports estimates of the fixed point c_f that range from .30 to .39. In the next proposition we compare c_c^* and c_{eu}^* for the case in which $c_f < g/(1+g)$. This condition requires that g cannot be too low. For instance, if $c_f = 1/3$, we need $g > 1/2$. Since we take $g = 10/11$ in our experiments, the condition becomes $c_f < 0.476$, which agrees with all empirical estimates.

[2]Hereafter, the interested reader can find all remaining proofs in Appendix A.

Proposition 3 *Suppose $k = 1$. Under Prospect Theory, at the symmetric equilibrium, the probability of contribution with reference point $x_0 = c$ is greater than according to Expected Utility Theory if the fixed point of the weighting function c_f is less than g/(1+g). That is:*

$$c_c^* > c_{eu} \text{ if } c_f < \frac{g}{1+g}. \tag{13}$$

This result also holds if the probability weighting function w is linear, but the value function v is strictly concave in gains.

Finally we compare c_g^* with c_{eu}. To do this, we use the results from Propositions 2 and 3 to obtain the following

Corollary 1 *Suppose $k = 1$. Under Prospect Theory, at the symmetric equilibrium the probability of contribution with reference point $x_0 = g$ is greater than according to Expected Utility Theory if and only if loss aversion is high enough and the fixed point of the weighting function c_f is less than g/(1+g). That is:*

$$c_g^* > c_{eu}^* \text{ if } \lambda > \overline{\lambda}_c \text{ and } c_f < \text{g/(1+g)}. \tag{14}$$

The proof is immediate since, under the above conditions $c_g^* > c_c^*$ and $c_c^* > c_{eu}$. To summarize the results for the case $k = 1$, we find more contribution with $x_0 = g$ (PGD) than with $x_0 = c$ (PGP), and more contribution in both cases than under Expected Utility.

2.4 All contributions required (Γ_N)

Now we turn to the other polar case, where the provision of the public good requires that all players contribute, $k = N$. The probability that player i is *pivotal*, i.e., the probability associated with $N-1$ group members (excluding i) contributing is $q(c) = c^{N-1}$. Clearly, $q(c)$ is increasing in c and decreasing in N, with $q(0) = 0$ and $q(1) = 1$.

According to Expected Utility Theory, the equilibrium c_{eu} is characterized by $(c_{eu})^{N-1}g = c_{eu}$. Then, if $g < 1$, the unique equilibrium is $c_{eu} = 0$. If $g = 1$ and $N = 2$, there is a continuum of equilibria in $[0, 1]$. If $g = 1$ and $N > 2$, there are only two equilibria, $c_{eu} = 0$ and $c_{eu} = 1$. Because of this, in the sequel we will consider that $g < 1$.

We now turn to analyzing the equilibrium under Prospect Theory for our two reference points. Note that when $k = N$ the first column in Tables 2 and 3 plays no role.

With reference point $x_0 = c$ the equilibrium condition is:

$$w(q)v(g - c) + w(1 - q)v(-c) = 0. \tag{15}$$

Clearly, $c = 0$ is always an equilibrium and $c = 1$ is also an equilibrium if and only if $g = 1$.

With reference point $x_0 = g$ the equilibrium condition is:

$$w(1 - q)v(-g) = v(c - g). \tag{16}$$

Again, $c = 0$ is always an equilibrium and $c = 1$ is also an equilibrium if and only if $g = 1$. However, these equilibria are not *stable*, in the sense that the best reply to a small deviation results in a further deviation. Besides, the equilibrium $c = 1$ is not *robust* in the sense that, even though it is an equilibrium when $g = 1$, there is no equilibrium close to it when g is slightly arbitrarily close to 1.

We are particularly interested in comparing interior equilibria, provided that they exist. The next proposition says that, if there is some interior equilibrium c_g^* with reference point $x_0 = g$, any equilibrium with reference point $x_0 = c$, namely c_c^*, is always lower than c_g^* as long as loss aversion is high enough.

Proposition 4 *Suppose $k = N$ and that there exists $c_g^* > 0$. Under Prospect Theory with loss aversion but linear value functions in gains and losses, there is more contribution at the symmetric equilibrium with reference point $x_0 = g$*

than with reference point $x_0 = c$ if and only if loss aversion is high enough:

$$c_g^* > c_c^* \text{ if and only if } \lambda > \overline{\lambda}_d, \tag{17}$$

where the threshold $\overline{\lambda}_d$ is defined by (32). When the value function v is linear in gains, the threshold $\overline{\lambda}_d$ can be written as:

$$\overline{\lambda}_d = \frac{w((c_g^*)^{N-1})g}{c_g^*}. \tag{18}$$

If the probability weighting function is linear, then $\overline{\lambda}_d < 1$, so that $c_g^* > c_c^*$ as long as there is loss aversion, i.e. $\lambda > 1$.

It follows from Proposition 4 that for the most efficient equilibrium involves more contribution with $x_0 = g$ than with $x_0 = c$. In particular, we see that $c_{eu} = 0 \leq c_c^* < c_g^*$.

2.5 Intermediate contribution: $1 < k < N$

Finally we focus now on the intermediate case when $1 < k < N$. We have the following

Proposition 5 *When $1 < k < N$, under Prospect Theory the set of symmetric equilibria with loss aversion but linear value functions in gains and losses, and linear weighting function, the maximum equilibria satisfy:*

$$c_c^* < c_{eu}^* < c_g^*, \tag{19}$$

with weak inequality whenever the maximum is zero.

So again we obtain more contribution when $x_0 = g$ (PGD) than when $x_0 = c$ (PGP).

3 Experimental design

3.1 Sessions

Six experimental sessions were run at the Laboratory for Theoretical and Experimental Economics (LaTEx) of the Universidad de Alicante. A total of 144 students (24 per session) were recruited among the undergraduate student population of the Universidad de Alicante.

All sessions were run in a computer lab. Instructions were provided by a self-paced, interactive computer program that introduced and described the experiment.[3] Subjects were also provided with a written copy of the experimental instructions -identical to the ones they were reading on the screen- which was read aloud by the session monitor at the beginning of each session. In each session, subjects were assigned to one *matching group* of 12, with subjects from different matching groups never interacting with each other throughout the session.[4]

3.2 Treatments

As explained in Section 2.2, a treatment is uniquely defined by a reference point. Let call T_c and T_g the contribution game in which the reference point is equal to c and g, respectively. In each session, subjects play 24 rounds of each treatment, for a total of 48 rounds. To control for order effects, in half of the sessions subjects play either treatment (T_c or T_g) first.

Within each round, after being communicated the current value of k and c, each group member has to:

1. Choose whether to contribute or not for that round;

2. Elicit her belief on the number of contributors in her own group (excluding herself), receiving a fixed ("small" compared with the contribution

[3]The experiment was programmed and conducted with the software *z-Tree* (Fischbacher, 2007).

[4]We shall therefore read our experimental data under the assumption that the history of each individual matching group corresponds to an independent observation of our experimental environment.

game payoffs) prize in case of a correct guess.[5]

After each round, subjects are informed of the contribution decisions of the other group members (i.e. the outcome for that round), together with her payoff (on both dimensions: belief and contribution game) and the average payoff of her group members (only as for the contribution game). The same information is also given in the form of a *History table*, so that subjects could easily review the results of all the rounds that have been played so far.

3.3 Financial rewards

As for financial rewards in the experiment, all monetary values in the experiment are expressed in Spanish Pesetas (€ 1 is worth approximately 166 Pesetas).[6] The value of the prize g is fixed to 50 Pesetas, where the cost for contributing is, for all subjects and rounds, an independent draw $c \sim U[0, \overline{c}]$, with $\overline{c} = 55$ Pesetas. At the beginning of each treatment, subjects receive 1.000 Pesetas as initial endowment. As for T_c, subjects would gain $g = 50$ Pesetas if the number of contributors in their group reached the target k, with c being subtracted from their initial endowment when contributing; in T_g subjects would lose g from their initial endowment if the numbers of contributors did not reach the target, gaining c in case of non contribution. As for the belief elicitation stage, every correct guess would pay off 5 Pesetas. Overall, subjects received, on average, €15 for a 45' experimental session.

[5] We borrow this design feature from Nyarko and Schotter (2002). See also Gächter and Renner (2006).

[6] It is standard practice, for all experiments run in Alicante, to use Spanish Pesetas. as experimental currency. The reason for this design choice is twofold. First, it mitigates integer problems, compared with other currencies (USD or Euros, for example). On the other hand, although Spanish Pesetas are no longer in use (substituted by the Euro in the year 2002), Spanish people still use Pesetas to express monetary values in their everyday life. In this respect, by using a "real" (as a opposed to an artificial) currency, we avoid the problem of framing the incentive structure of the experiment using a scale (e.g. "Experimental Currency") with no cognitive content.

4 Experimental Results

In Section 2 we have just seen that, in general,

$$c_c^* < c_g^*, \tag{20}$$

that is, the highest equilibrium contribution results at reference point $x_0 = g$. Only when $k = 1$, loss aversion must be sufficiently high for (20) to hold. We have also seen that BNE predicts the highest contribution schedule when $k = 2$, and the lowest otherwise.

We are now in the position to use our experimental evidence to validate our theoretical conjectures. In this respect, remember that c is uniformly distributed in $[0, 1]$. Therefore, c^* can be directly used as prediction about the relative frequency of contributors, under the assumption that everybody conforms to the predicted equilibrium strategy.

In what follows, we shall report our experimental findings in detail. Section 4.1 provides some descriptive statistics, while in Section 4.2 we report a structural estimation of the Prospect Theory parameters that best suit our experimental evidence.

4.1 Descriptive Statistics

The upper part of Table 4 reports the relative frequency of contributing subjects across treatments and thresholds, while in the lower part we report the relative frequency of cases in which the public good is provided (or its deterioration is prevented).

Table 4 yields the following immediate conclusions:

1. *T_g yields higher levels of both average contribution (.44 vs. .35) and public good provision/non deterioration (.42 vs .37).*

2. *The latter evidence does not hold uniformly across threshold levels, k.* In particular, when $k = 1$, the above conclusions are reversed.

3. *In T_g, average frequency of contribution increases with k.* By contrast, in T_c, it fluctuates around its average value with no identifiable trend.

		$k=1$	$k=2$	$k=3$	**Mean**
Frequency of contribution	T_c	.36	.39	.31	**.35**
	T_g	.28	.46	.57	**.44**
Mean		**.32**	**.43**	**.44**	**.40**
Frequency of provision	T_c	.74	.35	.04	**.37**
	T_g	.63	.44	.21	**.42**
Mean		**.69**	**.40**	**.13**	**.40**

Table 4: Frequency of contribution and provision across treatments and thresholds

4. *Public good provision/non deterioration declines with* k, with a much stronger effect in T_c, where public good provision is basically zero when $k = 3$.

In Figures A1-2 (in the Appendix) we refine the evidence of the upper part of Table 4, by disaggregating contribution profiles for cost levels, c (Figure A1) and over time (Figure A2). The overall impression we draw from Figures A1-2 is that contribution is highly sensitive to c in both treatments, while it is confirmed that, in T_g, contribution is also sensitive to k (the higher k, the higher average contribution), with only marginal changes over time in both cases. Another striking difference across frames we draw from Figure A1 refers to the relative frequency of "dominated" contributions, i.e. positive contributions by players for whom $c > g$. In this respect, among the 604 out of 6,912 cases in which $c > g$ -and, therefore, contributing was a dominated action, independently on $k-$ subjects in T_g contribute 3 times as much as in T_c (with overall relative frequencies equal to .25 *vs.* .08, respectively; .41 vs. .07 when $k = 3$).[7] In this sense, subjects are much more willing to "sacrifice" their own material payoff (since public good provision/non deterioration, even if successful, will never compensate their own effort) in the loss (PGD) frame.

Table 5 complements the information of the lower part of Table 4 by reporting relative frequencies of game outcomes (i.e. the number of group

[7] Both these differences are highly statistically significant according with Mann-Whitney non parametric statistics (z = -5.416 and z = -5.708, respectively, $p = 0$ in both cases).

contributors).

n		0	1	2	3
$k=1$	T_c	.26	.45	.26	.03
	T_g	.37	.45	.16	.02
$k=2$	T_c	.24	.41	.27	.08
	T_g	.16	.40	.35	.09
$k=3$	T_c	.33	.46	.17	.04
	T_g	.09	.30	.40	.21

Table 5: Group contribution distributions

First notice that, for $k = 1$, higher contribution in T_c is mainly due to "inefficient overprovision" (i.e., $n > k$: .29 in T_c vs. .18 in T_g), since the frequency of outcomes where only one group member contributes (i.e. group contribution exactly meets the required threshold) is constant across frames (45% of total observations). On the other hand, 29-18=11% is exactly the difference in the relative frequencies of public good provision/not deterioration across treatments (see Table 4). As for $k = 2$, efficient provision is higher in T_g (.35 vs. .27), while, for those cases in which group contribution does not reach the target, the relative frequency of 0-contribution groups (i.e. those group in which contribution is not "waisted" by any group member) is higher in T_c. Finally, it is again the case of $k = 3$ in which we find the most striking difference across frames. In this latter case, T_c collects three times as much zero-contribution outcomes (.33 *vs.* .09) , as opposed to T_g, which collects four times as much full contribution outcomes (.21 *vs.* .04).

These considerations yield the construction of an (ex-post) *efficiency index*, $\eta \in [0, 1]$, which measures how close is group cumulative payoff to the maximum attainable for that group and round. Let $\delta_i = 1$ ($\delta_i = 0$) denote i's decision (not) to contribute, with $\delta = (\delta_i, \delta_{-i})$ the group's strategy profile. If $\mu_i(\delta)$ is player i's monetary payoff (given the group strategy profile and cost realization, c_i) and $\mu(\delta) = \sum_i \mu_i(\delta)$ is cumulative group payoff, then:

$$\eta(\delta) = \frac{\mu(\delta) - \min_\delta [\mu(\delta)]}{\max_\delta [\mu(\delta)] - \min_\delta [\mu(\delta)]}$$

measure the share of the available cumulative payoff the group is able to attain, given the group's strategy profile. Maximal efficiency is attained (i.e., $\eta(\delta) = 1$), for example, by $\delta = (0, 0, 0)$ when $k = 3$ and $\sum_i c_i > 3g$, or when $k = 1$ and only the player with the lowest cost c contributes. Table 6 reports average efficiency levels, disaggregated for treatment and thresholds.

		$k = 1$	$k = 2$	$k = 3$	**Mean**
	T_c	.80	.59	.51	**.63**
	T_g	.76	.66	.55	**.66**
Mean		**.78**	**.63**	**.53**	**.65**

Table 6: Mean efficiency across treatments and thresholds

Table 6 shows that average efficiency is aligned with average contribution, being higher in T_g except when $k = 1$. Also notice that difference in efficiency across thresholds is the highest when $k = 2$. By contrast, higher contribution in T_c (T_g) does not yield a significant increase in efficiency for $k \neq 2$, basically due to overprovision (when contributing is dominated in case of $k = 3$), as we already noted. Also notice that increasing the threshold, on average, yields a decrease in mean efficiency.

To further explore frame and threshold effects on the overall outcome efficiency, we apply a double-censored Tobit model:

$$\eta_t = \psi_0 + \psi_1 I(T_g)_t + \psi_2 I(k = 2)_t + \psi_3 I(k = 3)_t + v_t, \qquad (21)$$

where ψ_0 is a constant term and parameters ψ_1 to ψ_3 measure treatment and threshold effects using dummy variables (i.e., $I(\cdot) = 1$ if condition $(\cdot)$ is met). Table 7 reports the partial maximum likelihood estimates of the parameters of (21), where the reported estimated standard errors take into account matching group clustering.

As Table 7 shows, frame and threshold effects are always significant, with more overall efficiency reached in T_g and low thresholds. As for the latter, not only we detect more efficiency when $k = 1$ (omitted dummy) compared when $k = 2$ and $k = 3$ (see the corresponding p-values of ψ_2 and ψ_3), but we also see that, when $k = 3$, overall efficiency is significantly smaller than when $k = 2$ ($z = .111$, std. err. .026, $p = 0$).

Dep. var.: η	*Coeff.*	*Std. err.*	*p-value*
ψ_0	.815	0.014	.000
ψ_1	.032	.014	.032
ψ_2	-.171	0.018	.000
ψ_3	-.282	.020	.000
Left censored		.1%	
Uncensored		79.3%	
Right censored		20.6%	

Table 7: Tobit regression

We now turn our attention to subjects' elicited (point) beliefs on the other group members' contributions, $\beta_{it} \in \{0,1,2\}$, whose descriptive statistics are reported in Table 8.

	Beliefs in treatment T_c				Beliefs in treatment T_g			
β_{it}	0	1	2	**Mean**	0	1	2	**Mean**
$k=1$	.23	.59	.18	**0.94**	.26	.60	.14	**0.87**
$k=2$	.20	.58	.22	**1.01**	.14	.57	.29	**1.15**
$k=3$	.41	.30	.29	**0.87**	.21	.24	.55	**1.34**
Mean	**.28**	**.49**	**.23**		**.20**	**.47**	**.33**	

Table 8: Elicited beliefs in Stage 2

Each row (column) in Table 8 corresponds to one particular k (point belief, β_{it}). We also report the value of mean beliefs conditional on threshold. As Table 8 shows, in both treatments, when $k \leq 2$, the modal belief is 1 (around 60% of total observations). By stark contrast, when $k = 3$, the modal belief is 0 in T_c and it is 2 in T_g. We also find that the mean belief in treatment T_g is higher than in T_c for $k = 2$ and (especially) $k = 3$, and it is lower for $k = 1$. More precisely, when $k = 3$, there is a striking difference between the frequency of subjects forecasting that 2 group members are contributing (28.73% in T_c *vs.* 55.12% in T_g) rather than 0 (41.15% and 20.75%, respectively).[8]

As Table 8 shows, the frequency with which subjects feel that they are

[8]Standard χ^2 tests reject the null hypothesis of no difference in belief distributions across treatments, for all thresholds, with significant level of 5%.

pivotal is much higher in T_g (46% vs 37% overall, 55% vs. 29% when $k = 3$).[9] This is in clear contrast with the VNM prediction, as the unique Bayesian Nash Equilibrium should imply beliefs concentrated at 0 in both treatments. In general, we find a positive and highly significant correlation between the probability of cooperating and the belief of being pivotal (.2987 and .4418 in T_c and T_g respectively, p-value of 0 in both cases). This result coincides with the one obtained in similar experiments by Offerman *et al.* (1996).

Table 9 analyses whether there is consistency between elicited beliefs and actual behavior in both treatments. Each row (column) of Table 8 corresponds to a particular contribution level of i's teammates, n, (i's point belief).

	Beliefs in treatment T_c				Beliefs in treatment T_g			
Others	0	1	2	Total	0	1	2	Total
0	449	689	306	1,444	283	565	306	1,154
	31.09	**47.71**	**21.19**		**24.52**	**48.96**	**26.52**	
1	425	745	372	1,542	297	771	514	1,582
	27.56	**48.31**	**24.12**		**18.77**	**48.74**	**32.49**	
2	102	234	102	438	129	281	310	720
	23.29	**53.42**	**23.29**		**17.92**	**39.03**	**43.06**	
Total	976	1,668	780	3,424	709	1,617	1,130	3,456
	28.50	**48.71**	**22.78**		**20.52**	**46.79**	**32.70**	

Table 9: Beliefs

The cells on the main diagonal correspond to those situations in which beliefs turn out to be correct. We observe that subjects tend to be overoptimistic in both treatments (overall, 40.28% of total observations, against 38.48% of correct beliefs and 21.24% of underoptimistic ones).[10] When we further disaggregate across thresholds, we see that the only noticeable difference across treatments is when $k = 1$, where subjects in T_c underestimate their teammate aggregate contribution 5% more than in T_g (20.83% *vs.* 15.80%).

[9] Both these difference are statistically significant according to the corresponding Mann-Whitney tests: z=-7.914 and z = -12.832, respectively, $p = 0$ in both cases.

[10] This result is in line with those obtained by Palfrey and Rosenthal (1991).

In Table 10 the probability of any possible elicited belief (an integer from 0 to 2) and belief precision, i.e. $\delta = \beta - n$ (an integer from -2 to 2) are estimated by two ordered Logit regressions using the same set of regressors as in (21) -excluding the constant.[11]

Dep. var.: β	*Coeff.*	*Std. err.*	*p-value*
ψ_1	.470	.086	.000
ψ_2	.425	.086	.000
ψ_3	.560	.211	.008
Dep. var.: δ			
ψ_1	.029	.041	.473
ψ_2	-.079	.102	.434
ψ_3	-.089	.062	.148

Table 10: Ordered logit regressions

As Table 10 shows, (significant) differences in average contribution/public good provision across treatments are not due to differences in belief precision, but -rather- in significant differences in average belief levels, which also grow significantly with the threshold.

4.2 Estimating Prospect Theory

In this section we use the data we have obtained in our experiment to estimate the parameters of Prospect Theory. We will outline briefly our empirical strategy in which we use a similar approach to that of Harrison and Rutström (2006) and Harrison (2007).

We use a simple stochastic specification to specify likelihoods conditional on our model. Every time that an agent has to choose between contributing and not contributing, we assume that the subject uses Prospect Theory to evaluate the two alternatives. Call $V(C)$ and $V(NC)$ the values that the subject assigns to the two alternatives under Prospect Theory, and call $\Delta V = V(C) - V(NC)$, the difference between these two values. For each individual decision we calculate this difference. Using ΔV we define the cumulative

[11] By analogy with Table 7, also the estimated standard errors of Table 10 take into account matching group clustering.

probability of the choice that we observe using the logistic function $\Lambda(\Delta V)$ as:

$$\Lambda(\Delta V) = \frac{\exp(\Delta V)}{1 + \exp(\Delta V)}. \tag{22}$$

Now the likelihood, given Prospect Theory, depends on the estimates of the parameters of the model and the observed choices. We will restrict ourselves to the simplest version of Prospect Theory where the value function is linear for gains and losses. The value function is described, therefore, by just one parameter, λ, that captures the degree of loss aversion. Regarding the weighting function and since only a few probability values enter in the prospects players have to evaluate, we estimate directly the weights of those probabilities, instead of estimating a parametric weighting function as the one proposed by Kahneman and Tversky.

The conditional log-likelihood is, therefore:

$$\ln L(\lambda, W; y, X) = \sum_i \left[(\ln \Lambda(\Delta V) \mid y_i = 1) + (\ln(1 - \Lambda(\Delta V)) \mid y_i = 0) \right], \tag{23}$$

where $y_i = 1$ (respectively, $y_i = 0$) means that the agent decides to contribute (not to contribute), X are individual characteristics, and W is the vector of weights of the relevant probabilities.

However, it remains to describe how we compute the values $V(C)$ and $V(NC)$ for each individual decision. Suppose, for example, that a given subject faces the problem described in Table 1. To compute $V(C)$ and $V(NC)$, we need not only the values assigned to the different payoffs and the reference point from which to compute gains and losses, *but also the probabilities that the subject assigns to how many of the other subjects she believes are contributing.* That is to say, we treat each decision within the frame of individual choice under uncertainty, where *uncertainty is only strategic.* In the notation of Table 1, we need to assign values to p and q. Unfortunately, we do not have that information. The only information we have is what we call the "elicited beliefs" on the number of other group members contributing for that round. Here we explain how we derive the values of p and q using these beliefs.

Consider the viewpoint of player i and call π the probability that she assigns to the fact that anyone of the others is contributing. Given that group size is 3 in our experimental setup, the probabilities that i assigns to the events that 0, 1, or 2 subjects are contributing are then $(1-\pi)^2$, $2\pi(1-\pi)$, and π^2, respectively. When we ask about beliefs, subjects can only answer 0, 1, or 2. If a subject reports a belief of 0, this means that $(1-\pi)^2$ is higher than both $2\pi(1-\pi)$ and π^2, which implies that $\pi \in [0, 1/3]$. If her belief is 1, then $2\pi(1-\pi)$ is higher than both $(1-\pi)^2$ and π^2, implying that $\pi \in [1/3, 2/3]$. Finally, if her belief is that 2 subjects will contribute, we have $\pi \in [2/3, 1]$.

Given these restrictions imposed on π for the different beliefs elicited from subjects, we need to go a step further in order to estimate our model. In particular, we need to fix the values of π for the different stated beliefs. Among the various possibilities, we shall assume that π takes the values $1/6, 1/2$, and $5/6$ when the stated beliefs are 0, 1, and 2, respectively. These values correspond to the midpoints of the corresponding intervals above. This implies that when an subject declares a belief 0, she believes that the events that 0, 1, or 2 subjects are contributing occur with probabilities 25/36, 10/36, and 1/36, respectively. If her belief is 1, these probabilities are 1/4, 1/2, and 1/4, respectively. When her belief is 2, probabilities are 1/36, 10/36, and 25/36. Table 11 reports estimates for λ and for the weights of the six relevant probabilities given our estimation strategy.[12]

We observe that subjects over-estimate very small probabilities (1/36), while they under-estimate all remaining probabilities, except for $27/36 = 3/4$, whose weight is not significantly different from itself. Our estimation of λ suggest that the degree of loss aversion is quite low, something we already inferred from our descriptive statistics.

[12] These are the relevant probabilities since, for the different values of k and the different beliefs, the alternatives involve many times the same payoff for different values of n.

	Coefficient	Std. error	95% conf. interval
$\widehat{\lambda}$	1.1101	.0739	[.9652, 1.255]
$\widehat{w}(\frac{1}{36})$	.10804	.0201	[.0685, .1475]
$\widehat{w}(\frac{9}{36})$	.1969	.0106	[.1760, .2178]
$\widehat{w}(\frac{11}{36})$	.1901	.0167	[.1573, .2229]
$\widehat{w}(\frac{25}{36})$	.5833	.0289	[.5266, .6399]
$\widehat{w}(\frac{27}{36})$	.7728	.0140	[.7451, .8004]
$\widehat{w}(\frac{35}{36})$	.8036	.0210	[.7524, .8449]

Number of observations: 6,880.
Standard errors adjusted for clustering

Table 11: Estimated Prospect Theory parameters

5 Conclusions

Inspired by the seminal works of Kahnemann and Tversky (dated more than 30 years from now), economists have learned that *frames matter* since they affect the way in which people understand problems and plan to solve them. In our paper, we study frame effects in the classic problem of public good provision, a problem which has important policy implications. To this aim, we applied Prospect Theory to get different equilibrium distributions in the four possible different problems that differ with respect to the reference point. Our basic theoretical conjecture would call for: *a*) Different contribution probabilities in the two frames T_c and T_g tested in the lab with *b*) more contribution in T_g (basically, because of loss aversion). In this respect, our experimental evidence backs definitely up the first working hypothesis. In particular, we find that the biggest difference happens when $k = 3$; as for the second, this is true when k, the threshold below which public good is not provided/not maintained, is high. In this respect, our results contrast with other previous experiments (such as those of Andreoni (1995) and Sonnemans *et al.* (1998)) that find more contribution when the problem is framed as a positive externality (T_c) than when it is framed as a negative externality (T_g). By contrast, we obtain this result only when k=1.

One lesson from our experimental evidence is that, if unanimity is needed, it is better to frame the problem as prevention of a bad than as provision of a public good. On the contrary, when the threshold is low and the temptation to free ride is highest, it is better to frame the problem as public good provision.

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6 Appendix

6.1 Proof of Proposition 2

To save notation we call $b = c_c^*$. Evaluating the right-hand side of (9) at $b = c_c^*$ and using (8):

$$R(b) = w(1 - q(b))v(b) + w(q(b))v(b - g) = \frac{v(g - b)v(b)}{v(g)} + w(q(b))v(b - g). \tag{24}$$

Since $\lambda(g - b) = -v(b - g)/v(g - b)$:

$$R(b) = \frac{v(g - b)v(b)}{v(g)} - \lambda(g - b)w(q(b))v(g - b). \tag{25}$$

Since the expression above is linear and decreasing in $\lambda(g - b)$ and $R(b)$ is increasing in b, it follows that for $\lambda(g - b)$ greater than the threshold:

$$\overline{\lambda}_c = \frac{v(c_c^*)}{v(g)w(q(c_c^*))}, \tag{26}$$

we have $R(b) < 0$ so that $c_g^* > b = c_c^*$, while the inequality is reversed if $\lambda(g - b)$ is less than $\overline{\lambda}_c$. If v and w are linear, from (8) we get $q = c/g$ and, therefore, $\overline{\lambda}_c = 1$.■

6.2 Proof of Proposition 3

To compare c_c^* with c_{eu}, we evaluate the left- and right-hand sides of the equilibrium condition (8) at c_{eu}:

$$L(c_{eu}) = \frac{v(g - c_{eu})}{v(g)} \geq \frac{g - c_{eu}}{g}, \tag{27}$$

by concavity of v in gains, and with equality if v is linear in gains. Using (12), we write the right-hand side as:

$$R(c_{eu}) = w\left(\frac{g - c_{eu}}{g}\right). \tag{28}$$

Suppose that $\frac{g-c_{eu}}{g} > c_f$. Then $\frac{g-c_{eu}}{g} > w\left(\frac{g-c_{eu}}{g}\right)$, which implies $L(c_{eu}) > R(c_{eu})$ and, thus, $c_c^* > c_{eu}$. To prove that $\frac{g-c_{eu}}{g} > c_f$, we see that when $N = 2$, using (12) we obtain $c_{eu} = g/(1+g)$. Then, $\frac{g-c_{eu}}{g} = \frac{g}{1+g} > c_f$. When $N > 2$, it is also true that $\frac{g-c_{eu}}{g} > c_f$, since c_{eu} is decreasing in N.■

6.3 Proof of Proposition 4

An interior equilibrium c_g^* must satisfy the equilibrium condition (16):

$$w(1 - q(c_g^*))v(-g) = v(c_g^* - g), \tag{29}$$

where $q(c_g^*) = (c_g^*)^{N-1}$. With linear value functions in gains and losses this is:

$$w(1 - q(c_g^*))g = g - c_g^*. \tag{30}$$

We now evaluate the left-hand side of Condition (15) at c_g^*. Using (30) we have:

$$\begin{aligned} & w(q(c_g^*))(g - c_g^*) - w(1 - q(c_g^*))\lambda c_g^* \\ = \; & w(1 - q(c_g^*)) \left[w(q(c_g^*))g - \lambda c_g^* \right] \end{aligned} \tag{31}$$

Since $w(1 - q(c_g^*)) > 0$, this expression will be negative and, thus, lower than the right-hand side of condition (15) if the term in brackets is negative. This will be the case as long as:

$$\lambda > \overline{\lambda}_d = \frac{w(q(c_g^*))g}{c_g^*}. \tag{32}$$

When w is linear, since $q(c_g^*) = (c_g^*)^{N-1}$, the condition becomes $\lambda > (c_g^*)^{N-2} g$ which is always true as long as there is loss aversion, i.e., $\lambda \geq 1$. For a general weighting function, when $N = 2$ the condition is true as long as $c_g^* \geq c_f$ since in that case $\frac{w(q(c_g^*))}{c_g^*} = \frac{w(c_g^*)}{c_g^*}$ which is lower than 1. For $N > 2$, the condition always holds for the case of the parametric weighting function proposed by Kahneman and Tversky (1992) since then it is always the case that $\frac{w((c_g^*)^{N-1})}{c_g^*} \leq 1.$■

6.4 Proof of Proposition 5

As above, let $q(c)$ be the probability that exactly $k-1$ players other than i have a cost less than c (i.e., i is pivotal):

$$q(c) = \begin{pmatrix} N-1 \\ k-1 \end{pmatrix} c^{k-1}(1-c)^{N-k}, \tag{33}$$

Under Expected Utility Theory, the symmetric equilibrium condition is:

$$q(c_{eu})g = c_{eu}. \tag{34}$$

It follows that $c = 0$ is an equilibrium and $c = 1$ is not an equilibrium. Any other equilibrium has to satisfy:

$$\begin{pmatrix} N-1 \\ k-1 \end{pmatrix} c^{k-2}(1-c)^{N-k} - \frac{1}{g} = 0. \tag{35}$$

In particular, when $N = 3$ and $k = 2$ as in our experiment, the unique equilibrium under expected utility is:

$$c_{eu} = 1 - \frac{1}{2g}. \tag{36}$$

We prove the first inequality of the proposition, that is, $c_c < c_{eu}$. For reference point $x_0 = c$ the equilibrium condition making indifferent the prospects at choice (4), becomes:

$$w(p+q)v(g-c) + w(r)v(-c) = w(p)v(g). \tag{37}$$

With linear value function both in gains and losses and linear probability weighting function, the condition (37) becomes:

$$(p+q)(g-c) - \lambda rc = pg, \tag{38}$$

so:

$$q(c)g = [1 + (\lambda - 1)r(c)]\, c. \tag{39}$$

Suppose that there exists a solution $c_c \in (0, 1)$ to (39). Then, since for $k > 1$, $r(c_c) > 0$, and by loss aversion $\lambda > 1$:

$$q(c_c)g = [1 + (\lambda - 1)r(c_c)]\, c_c > c_c. \tag{40}$$

So that at c_c the left-hand side of the equilibrium condition (34) is greater than the right-hand side, $L_0(c_c) > R_0(c_c)$. Since at $c = 1$, for that equilibrium condition the inequality is the opposite, $L_0(1) = 0 < R_0(1) = 1$, and both sides are continuous, it follows that there exists an equilibrium $c_c < c_{eu}$.

We finally show the second inequality of the proposition, $c_g > c_{eu}$. For reference point $x_0 = g$ the equilibrium condition making indifferent the prospects at choice (5), is:

$$w(r)v(-g) = w(p)v(c) + w(q + r)v(-g + c). \tag{41}$$

With linear value function both in gains and in losses and linear probability weighting function, the equilibrium condition (41) becomes:

$$-\lambda gr = pc - \lambda(q + r)(g - c). \tag{42}$$

So:

$$q(c)g = c\left[1 - \left(1 - \frac{1}{\lambda}\right)p(c)\right]. \tag{43}$$

Suppose that there exists a solution $c_g \in (0, 1)$ to (42). Then, since for $k < N$, $p(c_{eu}) > 0$, and by loss aversion $\lambda > 1$:

$$q(c_{eu})g = c_{eu} > c_{eu}\left[1 - \left(1 - \frac{1}{\lambda}\right)p(c_{eu})\right]. \tag{44}$$

So that at c_{eu} the left-hand-side of the equilibrium condition (43) is greater than the right-hand side $L_1(c_{eu}) > R_1(c_{eu})$. Since at $c = 1$, for that equilibrium condition the inequality is the opposite, $L_1(1) = 0 < R_1(1)$, and both sides are continuous, it follows that there exists an equilibrium $c_g > c_{eu}$.■

6.5 Additional statistical evidence

6.5.1 Aggregate contribution

The two diagrams of Figure A1 report, one for each treatment (T_c and T_g), the relative frequency of contribution for each possible threshold level, k. We partition the cost levels into 11 subintervals of size 5 in the x axis, averaging out contribution frequencies for each subinterval.

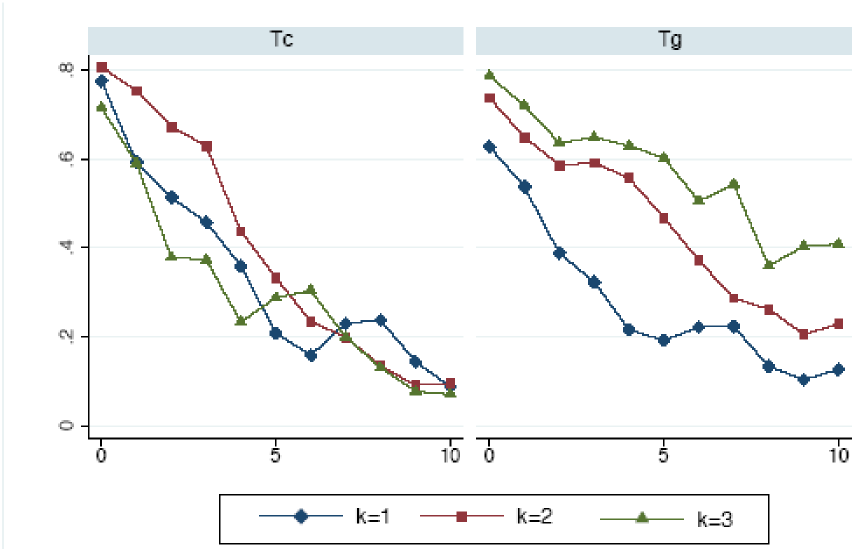

Fig. A1. Frequency of contributors and cost levels

As Figure A1 shows, average frequencies of contribution are (not surprisingly) decreasing in c, with this effect much more pronounced in T_c. Also notice that, in T_g, for any given cost interval, average contribution increasess with k, while the same does not happen for T_c.

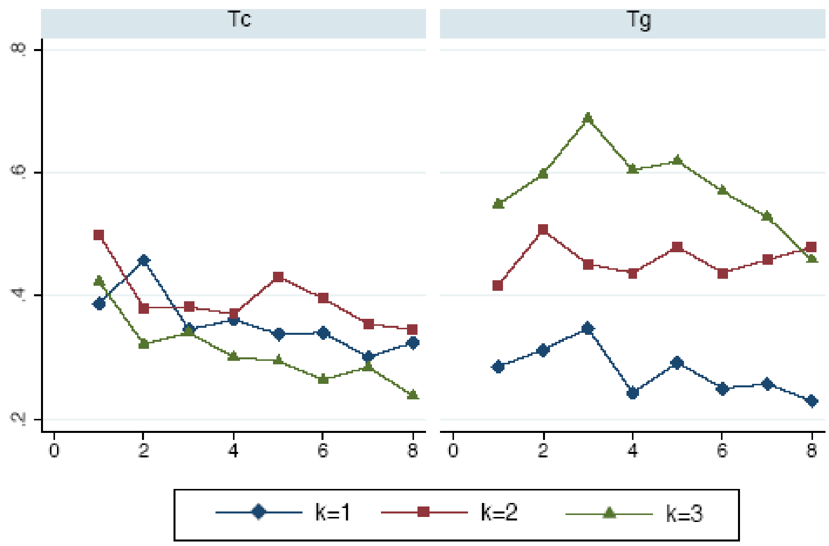

Fig. A2 : Contributions over time

Let *time interval* $\tau_p = \{3(p-1) < t \leq 3(p)\}$, $p = 1, ..., 8$, be the subsequence of the $p-th$ 3 rounds of each treatment. Within each time interval τ_p, subjects experience (in a random order) each and every possible $k \in \{1, 2, 3\}$. We do so to collect the same number of observations for each threshold game, keeping as well under control the time distance between two rounds characterized by the same threshold k.

The two diagrams of Figure A2 report, one for each treatment (T_c and T_g), the relative frequency of contribution for each possible time interval, $\tau_p, p = 1, ...8$ (see Section 3). As Figure A2 shows, relative frequencies basically stay constant over time. We observe some "endgame effects" only when $k = 3$. In T_c, we observe a moderately decreasing time trend in contribution, while in treatment T_g the trend displays an inverted U-shape, as contribution frequency rises until the middle of the session, declining later on.