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## Private provision of public good: strategic and moral motivations<sup>1</sup>

D. Bougherara, S. Costa, G. Grolleau, L. Ibanez

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### 1. Introduction

From the prisoners' dilemma outcome, individuals should never contribute to finished public good games. Indeed, economic experiments show that individuals express voluntary participation in public good games. Since, economic theoretical models have been set up in which consumers' preferences have been adapted. Fehr & Falk (2002) argue that economic incentives should consider three important human motives: "*the motive to reciprocate, the desire for social approval and the desire to work on interesting tasks*". Falk & Fischbacher (2006) have introduced reciprocity behavior into economic theory. The theory supposes that an individual's utility is composed of a direct monetary gain and a « reciprocity gain ». This reciprocity gain depends on a equity parameter (do the other individuals participate as much as I do ?) as well as the intention of the individual's behavior on others outcomes (what are the possible choices ? did he intentionnally participate (or not participate) ?).

This reciprocity utility is not a material payoff, and refers to moral sentiments such as equity or fairness. Positive reciprocity might appear when the expected participation of others exceeds own participation. Negative reciprocity represents a decrease in an individual's utility when it feels to be harmed or suffers from inequity. The emotional state of the individual depends on experience and observed previous contributions by other players (Cox et al. (2007)). These models where consumer preferences include reciprocity behavior, all include beliefs regarding intentions of other players. In other words, the decision in terms of participation to the public good is based on the belief of the individual about the strategy chosen by all other players. Economic models are therefore very complex as it supposes expectations of individual reciproque preferences of players which are private information. In many cases this implies the existence of multiple equilibria. Levine (1998) solves the incomplete information problem by considering that each player is characterised by an altruistic parameter.

Reciprocity behavior is considered, as far as we know, in a context where individuals search for equity. However, social approval is not necessarily the request for an identical pay-off for all individuals. Social approval might also be the search for social status. The context of search for status implies that the relative performance rather than the absolute performance determines the individual utility (Congleton (1989)). There exists empirical evidence for positional aspects of income as well as

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of consumption of particular goods (Solnick and Hemenway, 1998; Alpizar et al., 2005). *If individuals care about their status, defined as their rank in the distribution of consumption of one "positional" good, then the consumer's problem is strategic as her utility depends on the consumption choices of others* (Hopkins and Kornienko, 2004).

This paper is organised as follows. First, we propose a theoretical framework with reciprocal preferences considering both strategic and moral motivations. The moral motivations are the search for social approval through positional goods. Second, we validate the strategic motivation assumption of the theoretical model by experimental data. Finally, we conclude and discuss future empirical research.

## 2. A model of consumer behaviour with reciprocal preferences

In our model, we suppose consumers to adopt reciprocal behavior. The reciprocity behavior includes both social distinction preferences as well as beliefs that other players' decisions are directly related to own participation. An individual might anticipate a higher future participation by other players in the case he increases his own participation or contrarily he might think other will have more incentives to free-ride.

We will write the utility function for individual  $i$  at date  $t$  as follows :

$$U_{i,t}(x_{i,t}, x_{j,t}) = \pi_{i,t} + \alpha_i \times \left( x_{i,t} - \frac{x_{j,t}}{N-1} \right)$$

Where the first term is the *monetary payoff* of individual  $i$  at date  $t$ , and the second term is the *reciprocity utility*. The monetary payoff  $\pi_{i,t}$  is induced by the experimenter, and is defined as :

$$\pi_{i,t} = D - px_{i,t} + \frac{G}{N}(x_{i,t} + x_{j,t})$$

Where  $D$  represents the monetary endowment,  $x_{i,t}$  is the amount of money individual  $i$  contributes to the public project at the date  $t$ , and  $p$  the cost of this contribution.  $G$  is the group marginal payoff,  $N$  is the number of individuals,  $\frac{G}{N}$  is the marginal per capita return of public project, and  $x_{j,t}$  is the total amount of other players' contributions.

The reciprocity utility is composed of two terms :

- The constant  $\alpha$ , which we call *reciprocity behaviour*. This constant depends on the *strength* of reciprocal behaviour. For instance, if someone does not care about reciprocity,  $\alpha = 0$ . In that case, as stressed by Falk and Fischbacher (2006), "the player has *Homo economicus* preferences". This constant depends also on the *nature* of reciprocal behaviour. We consider two types of behaviour, the egoistic reciprocity ( $\alpha_i < 0$ ) and the positional reciprocity ( $\alpha_i > 0$ ). However, the response to

other players choices depends on the nature of reciprocal behaviour. Thus our parameter  $\alpha$  includes what Falk and Fischbacher called “the reciprocation term”.

- The second term is the difference between individual i’s contribution and the average contribution of all other players  $\left( x_{i,t} - \frac{x_{j,t}}{N-1} \right)$ . This term is closed to the “*outcome term*” of Falk and Fischbacher, which measures the kindness of other players towards player i. Falk and Fischbacher define this “outcome term” by the difference between monetary payoffs, whereas we assume that players judge the relative level of contribution by others to public good rather than the relative monetary pay-off. In a context of a public good contribution experiment, each individual observes directly the total amount of others’ contribution. Each player is informed on the own monetary payoff but has to calculate the monetary payoff of other players. In order to exclude a bounded rationality effect, we consider that the difference between contributions to public good matters for the choice instead of monetary payoffs. Falk and Fischbacher introduce also what they called an “intention factor”, which measures the intention of the action rather than the final result itself. If there are no reasonable alternative for other players, their choices do not really depend on their intention. When there are reasonable alternative, choices are made intentionally, in that case the “intention factor” is equal to 1. In our model and our experiment, we consider that the set of choices is large enough to put the intention factor equal to 1.

The model we consider here describes positional goals and therefore consider relative contribution to

influence utility levels.  $\left( x_{i,t} - \frac{x_{j,t}}{N-1} \right) > 0$  means that individual i contributes more than others, in

average. Then, if  $\alpha_i > 0$ , individual i’s utility is increased when he contributes more than others to public good. We call this behaviour the *positional reciprocity*. This behaviour is different from the warm-glow behaviour (Andreoni, 1990) because in the warm-glow behaviour individuals do not care about contributions of other players. More precisely, in our model, if someone contributes to public good at the same amount than all others (in average), her contribution will not give her other benefit than the monetary one. In the case (with  $\alpha_i > 0$ ), individual i contributes relatively more than others, the reciprocity utility will be positive which signifies that the individual i enjoys the distinction from other players and thus gains a non material pay-off.

If yet  $\alpha_i < 0$ , individual i’s utility is increased when he contributes relatively less than others to public good. We call this behaviour the *egoistic reciprocity*. In that case an individual enjoy benefiting from the public good without having paid for it. It is the pleasure “to make a good deal”, and moreover “to make a better deal than other players”.

So, whatever the sign of  $\alpha$ , the scope of the individual is to distinguish their behavior from others. We view in this model the reciprocity as a social distinction, and not as equity.

So, we may write the utility of individual  $i$ , at date  $t$ , as :

$$U_{i,t}(x_{i,t}, x_{j,t}) = D - px_{i,t} + \frac{G}{N}(x_{i,t} + x_{j,t}) + \alpha_i \left[ x_{i,t} - \frac{x_{j,t}}{N-1} \right]$$

Each individual must decide the amount of money ( $x_{i,t}$ ) to invest into the public project.

### 3. Optimal contribution choice

When a consumer chooses how much she contributes to the public good, she doesn't know what will be the choice of other consumers. We assume here that each consumer has subjective probabilities on others choices. We note  $f_{i,t}(x_{j,t})$  the subjective probability of consumer  $i$  at date  $t$  that others contribute  $x_{j,t}$  at the same date. We assume here that the subjective probability that other players contribute  $x_{j,t}$  at the date  $t$  depends on the contribution of consumer  $i$  at previous date  $x_{i,t-1}$ : a consumer anticipates that her choice at date  $(t-1)$  influences others' choice at date  $t$ . Moreover, we assume that the subjective probability that other players contribute  $x_{j,t}$  at the date  $t$  depends on her contribution at previous dates ( $x_{i,t-2}, x_{j,t-3}, x_{j,t-4}, \dots$ ). Indeed, players have some subjective ideas about how other players respond to their own contribution and these subjective probabilities may get modified after each period, when they observe the real response of others. More precisely, it is assumed that consumer knows that she may get more informed after each period and that her contribution at date  $t$  is also a way to gain information on others' behavior.

It is assumed that consumers make a sequential choice : they choose how much they contribute to the public good at the beginning of each period. It is assumed here that consumers prefer to take information on others behavior at date  $t$  before deciding how much they contribute at date  $t+1$ . So consumers adopt a feedback strategy rather than an open-loop one. At date  $t$ , each consumer maximises her expected utility function over the next periods, ie :

$$\text{Max}_{x_{i,t}} \left( \sum_{h=t}^T E_{i,h} U_{i,h} \right) = \text{Max}_{x_{i,t}} \sum_{h=t}^T \int_0^{(N-1)D} f_{i,h}(x_{j,h}) \times U_{i,h} \times dx_{j,h} .$$

Expected utility may be written as :

$$\sum_{h=t}^T E_{i,h} U_{i,h}(x_{i,h}, x_{j,h}) = TD + \sum_{h=t}^T \left( -p + \frac{G}{N} + \alpha_i \right) \times x_{i,h} + \sum_{h=t}^T \left( \frac{G}{N} - \frac{\alpha_i}{N-1} \right) \times E_{i,h} x_{j,h}$$

$$\text{Where } E_{i,h} x_{j,h} = \int_0^{(N-1)D} f_{i,h}(x_{j,h}) x_{j,h} dx_{j,h}$$

Optimal contributions of consumers are determined by backward induction. As usual, we determine firstly the optimal contribution at the last period.

**Proposition 1 : Optimal contribution to the public good at the last period, T, is such that**

$$x_{i,T}^* = 0 \text{ if } \frac{G}{N} < p - \alpha_i \text{ and } x_{i,T}^* = D \text{ if } \frac{G}{N} > p - \alpha_i$$

**Proof :**

The optimal contribution at the date T is such that :  $\text{Max}_{x_{i,T}} E_{i,T} U_{i,T}(x_{i,T}, x_{j,T})$

$$\text{From which, it can be deduced that : } \frac{\partial E_{i,T} U_{i,T}(x_{i,T}, x_{j,T})}{\partial x_{i,T}} = -p + \frac{G}{N} + \alpha_i > 0 \Leftrightarrow \frac{G}{N} > p - \alpha_i$$

**End of proof.**

Players choose to contribute to the public good if the benefit from the public good ( $\frac{G}{N}$ ) is higher than the loss of private good ( $p - \alpha_i$ ). Because of reciprocity behavior, ie when  $\alpha_i \neq 0$ , it may be optimal to contribute at the last period of the public good game. The marginal rate of substitution between public good and private good is equal to  $\frac{G}{(p - \alpha_i)N}$ . It will be equal to  $\frac{G}{p \times N}$  as in Ledyard (1995) if there is no reciprocity ( $\alpha_i = 0$ ).

**Proposition 2 : Optimal contribution to the public good at the before last period T-1 is such that**

$$x_{i,t}^* = 0 \text{ or } x_{i,t}^* = D \text{ or } 0 < x_{i,t}^* < D, \text{ and depends}$$

- on reciprocity behavior ( $\alpha_i$ ) and

- on expectations on futur monetary return of others behavior  $\frac{\partial E_{i,T} x_{j,T}}{\partial x_{i,T-1}}$ .

**Proof.**

At date T-1, the optimal choice of the consumer is such that :

$$\text{Max}_{x_{i,T-1}} \sum_{T-1}^T E_{i,h} U_{i,h}(x_{i,h}, x_{j,h}) = \text{Max}_{x_{i,T-1}} \left( 2D + \left( -p + \frac{G}{N} + \alpha_i \right) (x_{i,T-1} + x_{i,T}^*) + \left( \frac{G}{N} - \frac{\alpha_i}{N-1} \right) (E_{i,T-1} x_{j,T-1} + E_{iT} x_{jT}) \right)$$

By derivation, it comes :

$$\frac{\partial \sum_{T-1}^T E_{i,h} U_{i,h}}{\partial x_{i,T-1}} = \left( -p + \frac{G}{N} + \alpha_i \right) + \left( \frac{G}{N} - \frac{\alpha_i}{N-1} \right) \frac{\partial E_{i,T} x_{j,T}}{\partial x_{i,T-1}}$$

If,  $(-p + \frac{G}{N} + \alpha_i) + \left(\frac{G}{N} - \frac{\alpha_i}{N-1}\right) \frac{\partial E_{i,T} x_{j,T}}{\partial x_{i,T-1}} > 0$ , then  $x_{i,T-1}^* = D$

If,  $(-p + \frac{G}{N} + \alpha_i) + \left(\frac{G}{N} - \frac{\alpha_i}{N-1}\right) \frac{\partial E_{i,T} x_{j,T}}{\partial x_{i,T-1}} < 0$ , then  $x_{i,T-1}^* = 0$

If we have  $(-p + \frac{G}{N} + \alpha_i) + \left(\frac{G}{N} - \frac{\alpha_i}{N-1}\right) \frac{\partial E_{i,T} x_{j,T}}{\partial x_{i,T-1}} = 0$ , then there exists at least one interior solution

$$0 < x_{i,T-1}^* < D \text{ such that: } \frac{\partial E_{i,T} x_{j,T}}{\partial x_{i,T-1}} = \frac{p - \frac{G}{N} - \alpha_i}{\frac{G}{N} - \frac{\alpha_i}{N-1}}.$$

**End of proof.**

If a consumer expects his decision at date T-1 not to influence other players' choices in the last period

T,  $\left(\frac{\partial E_{i,T} x_{j,T}}{\partial x_{i,T-1}} = 0\right)$ , his contribution decision at the period (T-1) depends only on his reciprocity

behavior ( $\alpha_i$ ). In that case the same equilibrium conditions hold as in proposition 1.

Inversely, if  $\left(\frac{\partial E_{i,T} x_{j,T}}{\partial x_{i,T-1}} \neq 0\right)$ , the equilibrium condition is modified and depend simultaneously on two

parameters, the positional reciprocity preference as well as the expected reaction of other players' behavior. Two effects can then be distinguished: the direct monetary effect (impact of decision on futur monetary pay-offs) and the indirect non monetary rank effect (impact of decision on position with respect to other players).

**Proposition 3 : Optimal contribution to the public good at period  $t < T-1$  is such that  $x_{i,t}^* = 0$  or**

**$x_{i,t}^* = D$  or  $0 < x_{i,t}^* < D$ , and depends**

- **on reciprocity behavior ( $\alpha_i$ ),**

- **on expectations on futur monetary return of others behavior**  $\frac{\partial E_{i,T} x_{j,T}}{\partial x_{i,T-1}}$  **and**

- **on learning processus of observed reactions by other players**  $\sum_{h=t+2}^T \frac{\partial E_{i,h} x_{j,h}}{\partial x_{i,t}}$ .

**Proof.**

At date T-2, the optimal choice of the consumer is such that :

$$\text{Max}_{x_{i,T-1}} \sum_{h=T-2}^T E_{i,h} U_{i,h}(x_{i,h}, x_{j,h})$$

By derivation, it comes :

$$\frac{\partial \sum_{h=T-2}^T E_{i,h} U_{i,h}}{\partial x_{i,T-2}} = (-p + \frac{G}{N} + \alpha_i) + \left( \frac{G}{N} - \frac{\alpha_i}{N-1} \right) \left( \frac{\partial E_{i,T} x_{j,T}}{\partial x_{i,T-2}} + \frac{\partial E_{i,T-1} x_{j,T-1}}{\partial x_{i,T-2}} \right)$$

Where  $\left( \frac{\partial E_{i,T-1} x_{j,T-1}}{\partial x_{i,T-2}} \right)$  denotes the impact that consumer i thinks to have on others choice at the next

period, and  $\left( \frac{\partial E_{i,T} x_{j,T}}{\partial x_{i,T-2}} \right)$  denotes the impact of her own choice on her future knowledge of others

behavior. As consumer i thinks that she may influence others behavior et the next period, she also think that her choice is a way to get more informed for the future periods.

At date t, the optimal choice of the consumer is such that :

$$\text{Max}_{x_{i,t}} \sum_{h=t}^T E_{i,h} U_{i,h}(x_{i,h}, x_{j,h})$$

By derivation, it comes :

$$\frac{\partial \sum_{h=t}^T E_{i,h} U_{i,h}}{\partial x_{i,t}} = (-p + \frac{G}{N} + \alpha_i) + \left( \frac{G}{N} - \frac{\alpha_i}{N-1} \right) \left( \frac{\partial E_{i,t+1} x_{j,t+1}}{\partial x_{i,t}} + \sum_{h=t+2}^T \frac{\partial E_{i,h} x_{j,h}}{\partial x_{i,t}} \right)$$

Where  $\left( \frac{\partial E_{i,t+1} x_{j,t+1}}{\partial x_{i,t}} \right)$  denotes the impact that consumer i thinks to have on others choice at the next

period, and  $\left( \sum_{h=t+2}^T \frac{\partial E_{i,h} x_{j,h}}{\partial x_{i,t}} \right)$  denotes the impact of her own choice on her future knowledge of others

behavior.

$$\text{If } (-p + \frac{G}{N} + \alpha_i) + \left( \frac{G}{N} - \frac{\alpha_i}{N-1} \right) \left( \frac{\partial E_{i,t+1} x_{j,t+1}}{\partial x_{i,t}} + \sum_{h=t+2}^T \frac{\partial E_{i,h} x_{j,h}}{\partial x_{i,t}} \right) > 0 \text{ then } x_{i,t}^* = D.$$

$$\text{If } (-p + \frac{G}{N} + \alpha_i) + \left( \frac{G}{N} - \frac{\alpha_i}{N-1} \right) \left( \frac{\partial E_{i,t+1} x_{j,t+1}}{\partial x_{i,t}} + \sum_{h=t+2}^T \frac{\partial E_{i,h} x_{j,h}}{\partial x_{i,t}} \right) < 0 \text{ then } x_{i,t}^* = 0.$$

$$\text{If } (-p + \frac{G}{N} + \alpha_i) + \left( \frac{G}{N} - \frac{\alpha_i}{N-1} \right) \left( \frac{\partial E_{i,t+1} x_{j,t+1}}{\partial x_{i,t}} + \sum_{h=t+2}^T \frac{\partial E_{i,h} x_{j,h}}{\partial x_{i,t}} \right) = 0 \text{ then } 0 < x_{i,t}^* < D \text{ and is such that :}$$

$$\left( \frac{\partial E_{i,t+1} x_{j,t+1}}{\partial x_{i,t}} + \sum_{h=t+2}^T \frac{\partial E_{i,h} x_{j,h}}{\partial x_{i,t}} \right) = \frac{p - \frac{G}{N} - \alpha_i}{\frac{G}{N} - \frac{\alpha_i}{N-1}}$$



### **End of proof.**

Consumers anticipate another effect when there are more than two periods left: the information on others' behavior according to their contribution decision. Information on realised realised futur monetary pay-offs by other players' contribution might modify subjective probabilities (Bontems, Thomas, 2006).

## **4. Experimental design and data analysis**

Experiments were run using the REGATE program in the experimental economics laboratory at the ENGREF in Nancy in November 2006. Experimental subjects were undergraduate students from all sorts of disciplines. We conducted four sessions of 20 periods. Each session included 16 subjects which were randomly separated into four groups. Each group of four subjects played together during all 20 periods. Subjects played a classical public good game : simultaneoous decision of the number of tokens each subject wants to contribute to a public project. At the beginning of each period, half of the subjects were endowed with 20 tokens whereas the other half possessed 40 tokens. Each session last for about 60 minutes. Each subject was paid in cash according to the number of tokens during the 20 periods (0,015€per token) as well as a fixed amount of 4€

In all sessions the marginal per capita return was set at 0,4 and the group marginal pay-off to 1,2. The private participation cost to the public good is equal to 1.

In other words, the monetary payoff function of each subject  $i$  depends on the number of tokens put into the public project at each period  $t$ ,  $x_{i,t}$ , and can be written as follows :

$$U_{i,t} = D - x_{i,t} + 0,4 \sum_{i=1}^4 x_{i,t} = D - x_{i,t} + 0,4(x_{i,t} + x_{-i,t}) \text{ where } D=20 \text{ or } 40$$

In the case where we suppose that individuals consider only monetary payoff and that they don't consider their contributions to increase group contributions in the next period, the unique subgame perfect equilibrium in the repeated game is the free-rider outcome, ie. each subject contributes zero tokens to the public project.

The objectif of our experiments is to explain the observed deviation behavior. We argue that the individual behavior is rational and optimal, and that it corresponds to positional reciprocity as stated in section 3.

### **4.1 Data**

The observed variables are the contribution level by each subject  $i$ , during the 20 periods,  $x_{i,t}$ .

From these, we determine the rest of the group contribution level,  $x_{i,t}$ , at each period.

We calculate a variable that integrates both the expectation on futur monetary return realised by all other players and the learning process of this reaction variable. This variable represents the expected futur monetary gain from one extra unit of contribution at date t and is calculated as follows :

$$f'_{i,t} = \frac{x_{-i,t-1} - x_{-i,t-2}}{x_{i,t-2} - x_{i,t-3}}$$

#### **4.2 Heterogenous strategic contribution behavior**

Based on the theoretical model, we carry out a simple OLS regression for each individual i in order to study in how far futur expectations determine actual contribution levels:

$$x_{i,t} = a_{0i} + a_{1i}f'_{i,t} + a_{2i}period_t + \varepsilon_{i,t}$$

where period takes on values from 3 to 20. Indeed we don't consider the two first period as it is impossible to determine the variable  $f'$  for these periods.

The regression model allows to show thar for 25 individuals, the observed contribution level is explained by futur monetary gains through increased participation by other players.

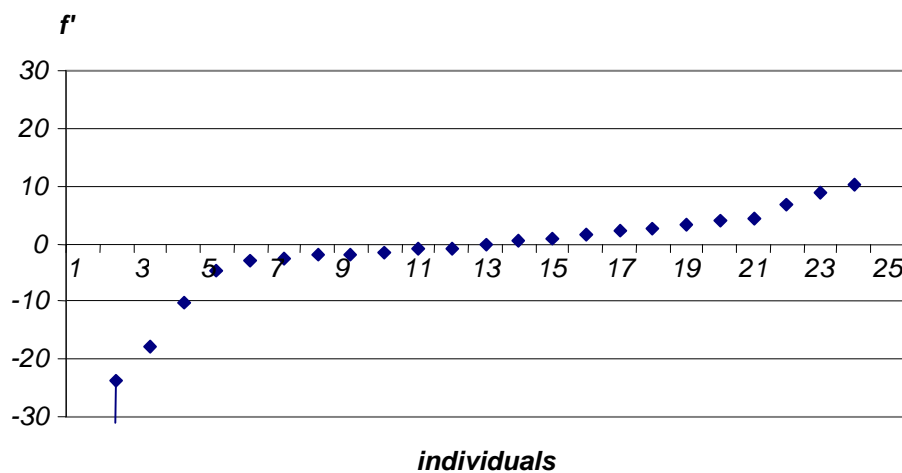


Figure 1 : Expected futur pay-off for one unit of contribution

With the present data it was impossible to determine a representative behavior of players. By carrying out the same regression over time for all individuals, expected futur pay-off doesn't explain significantly the contribution level. One of the explanations might be the diversity and heterogeneity of this behavior. In figure 1 we see that individuals are heterogenous in expectations, and that these

expectations fluctuate from negative to positive levels. There seems to be as many individuals that expect their contribution to have a positive impact on futur pay-off, as individuals that expect the inverse.

## 5. Conclusions

A theoretical model allows to explain a voluntary contribution to public good provision. We supposed consumers to adopt reciproque behaviour.

Our data isn't enough to analyse correctly the validity of the theoretical model. Futur research in experimentations will focus on what we called in our model positionnal reciprocity and that might explain voluntary provision of public goods.

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