Endogenous threshold public goods: learning to contribute*

[*Preliminary version, please do not circulate*]

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Abstract

Environmental challenges like climate change and ecosystems degradation are social dilemma of public goods contribution, plagued by free-riding. In this project we expand on the idea of environmental club goods or 'crowdaction' as a viable solution based on endogenous cooperation driven by social influence. We propose a discrete choice model in a population framework, named the Garden Model, which allows to analyse analytically and experimentally possible learning pattern towards cooperation. We compare different settings: one is an entry game, where the externality of social interactions can work as an endogenous threshold - critical mass - for the decision to join the Garden club. A second version confronts the players with a double stage decision: joining the club and how much to contribute. The latter version allows for a general setting where contributions can be negative, and describe exploitation of the public good. The different settings of the model entail positive feedback scenarios, with possible multiple equilibria and negative feedback scenarios, with possible periodic dynamics. The ultimate goal of the project is to evaluate aggregate contributions, measured as the Garden beauty. The setting with positive feedback can present the counterintuitive scenario where for positive shocks on marginal contribution benefits, individual contributions increase, while the resulting Garden beauty decreases. The model is designed for the different equilibrium outcomes to be tested in laboratory experiments.

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1 Introduction

A significant trait of our society is that individual's actions may affect the actions and the quality of life of a large number of people. This is true in such many contexts as environmental pollution, automotive traffic, charitable giving. Often the solutions to our society's problems require a combined efforts of single individuals, that act both in the own and community interest. However when one consider a voluntary provision of a public good, people may be driven by individual interests which contrast common interest. The former are usually less costly but lead to free riding, while the latter is more costly but produces positive externalities (Andreoni, 1995). In general, the voluntary provision of public good appears as a problem of collective action (Olson, 1965).

Environmental sustainability is a main challenge of today, which builds on global as well as local shared goods. Human action is recognised to be the main cause of environmental degradation, which entails issues like waste management and ecosystems exploitation, and different scales, from small lakes to climate change. It is widely accepted that society must engage in pollution abatement in order to avoid future disasters. But if global warming is the result of our actions, why do not we change behaviours? Why we do not reduce consumption of fossil fuels, switch to clean technologies, and stop exploiting ecosystems? Why markets do not adjust, and prices do not internalise environmental damage, naturally leading consumption to sustainable levels?

Public goods have attracted a large stream of theoretical and experimental research (Ledyard, 1994), mainly devoted to solve the free-riding problem. Ecosystems are special public goods in at least three respects. First, there is a dis-proportion between individual action and aggregate outcome. Second, environmental public goods - or the dual problem of environmental damage - are often not 'salient' in people's perception of their welfare. Third, human actions towards environmental public goods is often prey of social influence feedbacks.

Often the contribution problem can be restricted from a public to a club good, where only contributors can access the good. From the mechanism design point of view, this decision setting is equivalent to a provision point mechanism, or assurance contract (Bagnoli and Lipman, 1989; Tabarrok, 1998; Rondeau et al., 1999; Falkinger et al., 2000). IN this paper we explore, both theoretically and experimentally, the effect of social influence embedded in the collective good, and the viable learning mechanism that can foster contribution behaviours.

The idea of a climate club has been recently proposed by Nordhaus (2015) and Hovi et al. (2016). Instead of countries in this article we focus on individual people behaviour, and we study how cooperation can be achieved in a generic population that has access to a collective good. We propose a discrete choice model to be tested experimentally - the Garden Model - in two different versions: a game of entry into the environmental club, and a two-stages game of entry and contribution. The latter version allows for a general setting where contributions can be negative, and describe exploitation of the collective good. We frame decisions in a population framework, and study how the aggregation of individual contributions feedbacks into individual behaviour. The model provides analytical results to be experimentally validated, from optimal individual and social contribution levels to conditions for multiple equilibria or periodic dynamics. The ultimate goal is to find *learning to contribute* conditions that enhance the collective good, measured by the Garden Beauty. The setting with positive feedback can present the surprising scenario where after a positive shock on the marginal contribution benefits, individual contributions increase, while the resulting Garden beauty decreases.

Our approach is motivated by an increasing number of small scale initiative around the world, where people organise themselves around the objective of sustainability. There are garden clubs in Dutch cities, so-called eco-villages in European countrysides, agricultural cooperative that involve also living experiences, and consumers cooperative with the objective of reaching locally produced and eco-friendly food. In related but different contexts, cooperation initiative may involve forms of human capital like the Repair Cafe in many countries in Europe, or social initiatives with cultural objectives like public libraries that fight criminal organisations in the south of Italy. All these initiatives share a common denominator, which is the emergence of cooperation around a collective good which is restricted to the contributors, i.e. a social club.

In our model we intend to study the mechanism of the emergence of cooperation in this context where a collective good allows people to form a club. In particular, we focus on the decision feedback from social influence as a possible trigger (but also a hurdle) of learning patterns towards contribution. The observation of others' decisions may induce or prevent one's own decision about whether to join the club and contribute to it or not. Moreover, the visibility of others' contribution in the collective good provided creates in our model an 'endogenous' threshold of collective good provision. As a result, under this social influence there can be a threshold level of cooperation, a critical mass of contributors, that is necessary to achieve in order to establish a self-sustaining contribution equilibrium. We study the dynamics of repeated decisions, in order to see how different equilibrium outcomes are reached, and how it is possible to move towards higher levels of contributions. In summary, we search both theoretically and experimentally the following scenarios and their conditions:

- the multiple equilibria of cooperation, and the critical mass effect of contribution
- the negative externalities from the possibility of exploitation, with possible periodic dynamics of contribution behaviour

- possible learning paths from no-contribution towards self-sustaining cooperative behaviour.

Ultimately our goal is to find conditions that favours the establishment of cooperation through patterns of transition towards a self-sustaining equilibrium where the majority of the population engage in cooperative behaviour.

Public goods in general have been a widely studied arena for understanding the conditions that favour or prevent cooperation, and in particular to understand the motives behind this form of cooperative behaviour which is contribution to a collective good. Andreoni (1995) observes that in public goods experiments people contribute while it would be rational not to, but contributions decay over time. Burton-Chellew and West (2013) study pro-social preferences, and the effect of information about how contribution benefits others: they find that even if profitable, cooperation decreases when there is more information. Peysakhovich and Rand (2015) focus on behavioural spillovers, and find that cooperation is sustained when switching from more to less cooperative environments. Blasch and Ohndorf (2015) study 'guilt' in public 'bad' (pollution) contributions, with encounter probability in a static model, from which derive qualitative results to be tested on a survey. We have a dynamic setting with repeated choice and switching behaviour, instead. Besides, our model provides analytical findings that we can test in an experimental setting that implements faithfully the decision problems of the different versions of the model. Bischi et al. (2018) propose a non-linear dynamics model of a club good, focusing on congestion. But a club good is not-rival, and talking of congestion is then inappropriate. My and Chalvignac (2010) study a linear public-good game with an exit option. They observe that the decreasing rate of average contributions is less than half the decreasing rate without exit option (baseline treatment). The exit option is not neutral, but triggers even a reversal of the downwards spiral of declining contributions. This experiment with an exit option game is similar to one version of our model, where there is a two stages game. However, our framing is reversed, since the *default* is that one is out, and the decision is an entry decision. With our reversed framing of an entry stage followed by a contribution stage we want to explicitly find learning patterns to contribution. We also have an entry only game, where we focus on social influence and then multiple equilibria, and a version with negative contributions which represent exploitation of the collective good. Finally, we first study theoretically the decision problem with a discrete choice model, and then we compare theoretical findings to experimental results.

2 The Garden Models

Consider a community of individuals indexed by $j = 1, ..., n$, who may join and contribute to an *Environmental club*. An example can be a garden to which one contributes by suppling an amount of time. Another interpretation is that joining entails a money contribution. However we keep our model general and talk of a general contribution, in view of the experimental validation of the model. Then the individual decision variable of this problem is a generic amount of effort t devoted to the garden maintenance (watering, repairing, building, etc.). There is an effort budget T (e.g. 24 hours if we work with time). What remains for private activities is $T - t$, which is enjoyed only by the individual. Instead the contributed amount t is enjoyed by all garden users, the members of the club. The total contribution $\sum_{j=1}^{n} t_j$ is the club collective good enjoyed by all and only the n individuals that are members of the club.

We assume that all individuals are identical in term of preference and effort budget, with individualistic (no altruism or envy) and convex (diminishing marginal rate of substitution) preferences. When an individual decides which action to take, he has to evaluate the payoff of his choice taking into account others' decisions. This is because a collective good where contributors are visible becomes a form of social influence which is no different to social interactions effect in a utility function (Brock and Durlauf, 2001). We also assume naive expectations (Hommes, 2013), which means a best-response decision strategy. Finally assuming a competitive behaviour and we take for granted that the amount of t provided is determined through a process in which the individual reacts independently to the behaviour of others in deciding how much of the time to provide by himself. There is voluntary contributions mechanism, such as there is no coercion or punishment for not contributing.

On the other side the 'social' part of welfare is the public good provided, named the *Garden Beauty*, and is the main objective of our study.

If total contribution in a period T (say a day) is $\Theta = \sum_{j=1}^{n} t_j$, we measure the garden Beauty as:

$$B = b\Theta \tag{1}$$

We consider three versions of the model. A first version where individuals only decide whether they want to join the environmental club or not (an entry game). A second version where the entry decision is also followed by a decision about the contributed amount. Finally, we study a third version where contributions can be negative, and describe possible exploitation decisions.

We consider a quantal response mechanism (McKelvey and Palfrey, 1995), and analyse decisions dynamics in the framework of discrete choice theory (McFadden, 1981). The utility from the binary decision of contributing to the environmental club or not is described by the following discrete choice utility:

$$W = \begin{cases} U_C & \text{if } \textit{join} \\ U_N & \text{if } \textit{not}. \end{cases}$$

Discrete choice theory is founded on the concept of *random utility.* In such framework, the utility (2) is the deterministic component of the 'true' utility experienced by an individual. The random component is a iid noise $\epsilon(i)$ which is known only to the individual i. The full random utility enjoyed by individual i is then $\tilde{W}_i = W + \epsilon(i)$. The noise terms has a double interpretation: it can express heterogeneous preferences (McFadden, 1981) or bounded rationality (Brock and Hommes, 1997). In both cases, a common assumption in discrete choice theory is that noise terms are independent and *extreme value* distributed across individuals. Accordingly, the probability of each choice option is distributed as a logit function. In particular, the probability of contribution - i.e. joining the environmental club - is

$$Prob(Contribute) = \frac{e^{\beta U_C}}{e^{\beta U_C} + e^{\beta U_N}} = \frac{1}{1 + e^{\beta(U_N - U_C)}}. \tag{2}$$

The parameter $\beta \in [0, \infty)$ is called *intensity of choice*, and is inversely related to the variance of the variability of random utility across agents. Within the interpretation of preferences shocks, a larger β means that decision makers are more similar to each other. Adopting the bounded rationality interpretation instead, a larger β means that agents are more capable of adopting the best choice option.

A population approach to the discrete choice of individuals allows to see the choice probability as the fraction of individuals who choose one of the two alternative options. This results an extremely useful setting whenever this fraction is also an endogenous variable that inhabits the utility function of agents, like in our model. If $\Delta W(x) = U_N(x) - U_C(x)$ is the utility difference between not-joining and joining the club, the fraction of contributors - those who join the club is then given by:

$$x = \frac{1}{1 + e^{\beta \Delta W(x')}}. \tag{3}$$

Equation (3) constitutes at the same time a *self-consistency* condition for an equilibrium value of the fraction of contributors x (Brock and Durlauf, 2001) or a *revision protocol* to describe how individuals update their choice in a dynamic setting that allows switching behaviour (Brock and Hommes, 1997). In the latter approach, the self-consistency condition is nothing different than the condition for a steady state of the fraction x.

In what follows we present and analyse different version of this model, referring to the three different specifications outlined above: first, a model of simple entry decision, where the contribution amount and the entry fee are fixed; second, a model where agents also decide how much they want to contribute, conditional on the entry decision; third, a model where agents can decide not only to contribute, but also to exploit the collective good of the environmental club.

2.1 Version one: Simple entry model

Entry discrete choice decision with fixed contribution t_c:

$$W_i = \begin{cases} U_C = T - t_c + b\Theta - c & \text{if } \textit{contribute} \\ U_N = T & \text{if } \textit{not}. \end{cases}$$

where T is a budget and c a fee. Total contribution gives a *Garden Beauty* $B = b\Theta = \sum_{j=1}^{m} t_j = mt_c = nxt_c$. It is rational to contribute when contributors fraction is above $\tilde{x}' = \frac{t_c+c}{bnt_c}$.

With random utility (e.g. heterogeneous preferences) the fraction of contributors is

$$f(x) = \frac{1}{1 + e^{\beta[t_c(1-bnx)+c]}} \tag{4}$$

Now consider a diminishing marginal private utility

$$W_i = \begin{cases} U_C = \ln(T - t_c) + b\Theta - c & \text{if } \textit{contribute} \\ U_N = \ln T & \text{if } \textit{not}. \end{cases}$$

Now contributors fraction is

$$f(x) = \frac{1}{1 + e^{\beta[\ln \frac{T}{T-t_c} - bnt_c x + c]}} \tag{5}$$

This model presents multiple equilibria. A model with multiple equilibria contains intrinsically a *thresold*, which is the unstable steady state separating two stable equilibria. Here the threshold is a critical mass of *contributors*. This is an *endogenous* threshold, which we can compare to ‘exogenous’ threshold public goods Palfrey and Rosenthal (1984); Croson and Marks (2000); Cartwright and Stepanova (2015); Brekke et al. (2017). In general is not possible to compute the unstable equilibrium analytically. In the limit $\beta \to \infty$ the threshold is the *indifference point* x^*, where agents are indifferent since $\ln(T - t_c) + b\Theta(x^*) - c = \ln T$. Here the thresholds for number of contributors m, fraction $x = \frac{m}{n}$, and Beauty $\Theta = mt_c = nxt_c$.

$$\Theta \geq \frac{1}{b}\left(\ln \frac{T}{T-t_c} + c\right), \quad x \geq \frac{1}{nbt_c}\left(\ln \frac{T}{T-t_c} + c\right) \quad m \geq \frac{1}{bt_c}\left(\ln \frac{T}{T-t_c} + c\right)$$

- The larger the fee, the higher the indifference threshold.

- The larger the benefit b, the lower the threshold.

- The larger the contributed amount, the lower the threshold.

For β finite but large enough to have two equilibria, the indifference point is still a good proxy pf the threshold.

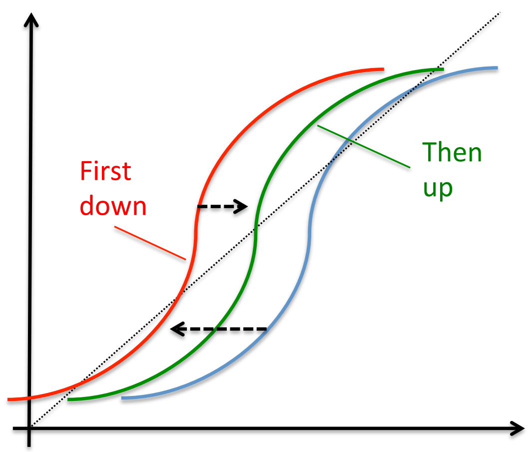
Increasing contribution t_c has opposite effects on private and collective part of utility difference ΔU. The indifference point

$$\tilde{x} = \frac{\ln \frac{T}{T-t_c} + c}{bnt_c} \tag{6}$$

moves initially *down* as far as t_c is below a critical $\hat{t}_c$, then up. The same non-monotonic effect concerns the equilibrium x^*, as one can see from the derivative of Eq. (7)

$$\frac{dx^*}{dt_c} = -\frac{\beta e^{\beta \Delta U}}{(1+e^{\beta \Delta U})^2} \frac{d\Delta U}{dt_c} \tag{7}$$

Larger contribution means more contributors up to a point and then less contributors:



crowding out. Regarding the effect on the collective good (eEffectBeauty), this can be similarly non-monotonic, as Eq. (8) shows.

$$\frac{dB}{dt_c} = \frac{d}{dt_c} bnt_c x^* = bnx^* - bnt_c \frac{\beta e^{\beta \Delta U(x^*)}}{(1+e^{\beta \Delta U(x^*)})^2} \frac{d\Delta U(x^*)}{dt_c} \tag{8}$$

The mechanism behind the non-monotonic behaviour of the collective good is a direct positive effect and a possibly negative indirect effect from increasing contributions. In particular, increasing the contribution level has the following result:

- For $t_c < \hat{t}_c^*$, $\Delta U'(t_c) < 0$ and the Beauty increases with t_c

- When $t_c > \hat{t}_c^*$, $\Delta U'(t_c) > 0$ and it may be that $B'(t_c) < 0$.

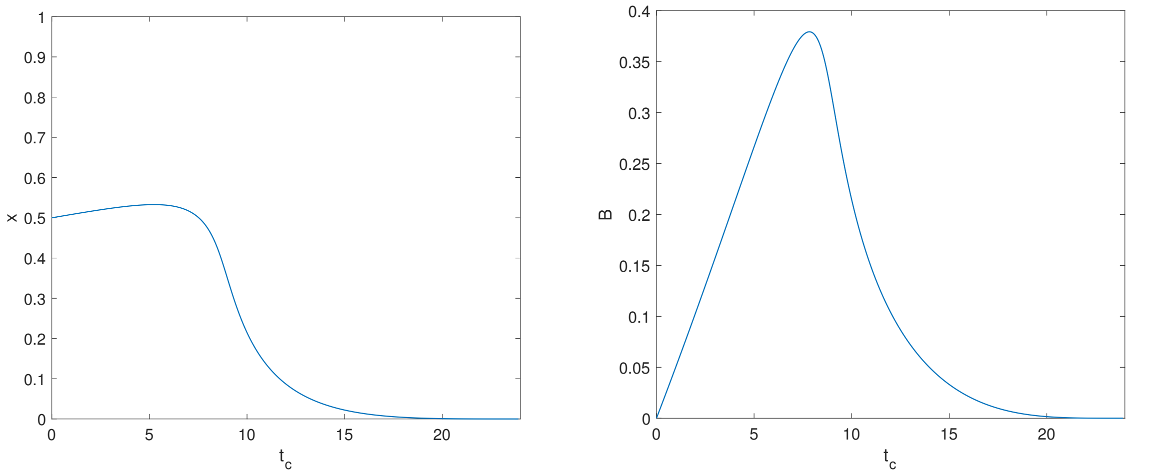


Figure 1: Long run simulations. Left: fraction x of contributors. Right: collective good value B. Parameters: $\beta = 4, T = 24, n = 10, b = 0.01$:

Figure 1 reports the long run value of the fraction of contributors (left) and collective good value (right) for different values of the contributed (optimal) amount t_c (horizontal axis). In this setting we observe a scenario characterised by a non-monotonic effect of contribution: *larger individual contributions can give lower total contribution in the aggregate and a lower amount of collective good provided.*

2.2 Version two: A two stage decision

This is an extended version of the model above where an individual decision in each period is divided into two stages: an entry decision stage, where she decides whether to contribute to the collective good (join the club); conditional on having decided to contribute, there is a second stage where the individual sets her optimal contribution amount (Figure 2).

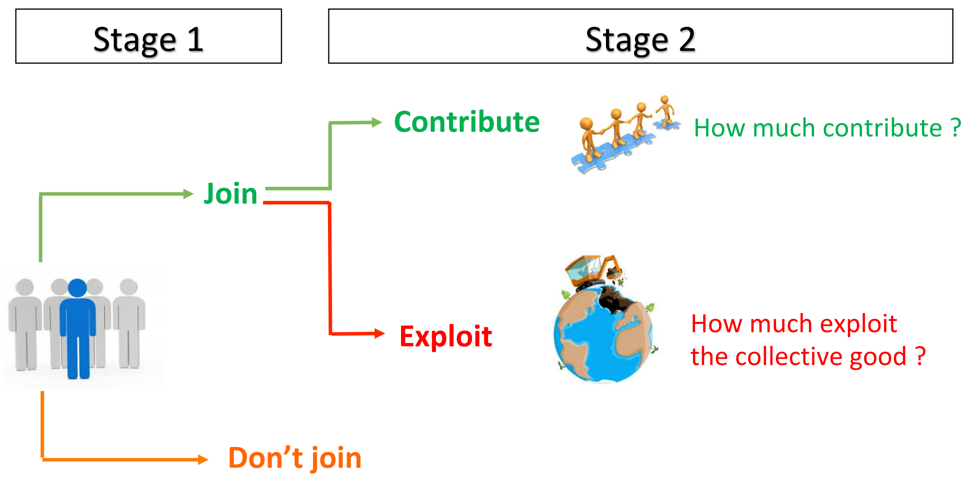


Figure 2: The second version of the model with two stages decision of contribution to the collective good.

Stage 2: Optimal contribution

In a given time period an individual optimises her contributed effort:

$$U(t_i) = \ln(T - t_i) + b\left(\sum_{j\neq i} t_j + t_i\right) - c$$

F.o.c. gives an *optimal contribution* $t_i = t_c^o = T - \frac{1}{b}$.This individually optimal contribution level falls below what would be a socially optimal level. Total welfare is

$$\begin{aligned} W &= \sum_i U(t_i) = \sum_i \left[\ln(T - t_i) + b\left(\sum_{j=1}^{m} t_j\right) - c\right] \\ &= nx\ln(T - t_c) + nxbnxt_c - nxc \end{aligned} \tag{9}$$

and the *social optimum* is $t_c^s = T - \frac{1}{nxb}$.

Stage 1: Discrete Choice

Discrete choice welfare in the optimal t_c^o is

$$W_i = \begin{cases} U_C = \ln(1/b) + b\Theta - c & \text{if } \textit{contribute} \\ U_N = \ln T & \text{if } \textit{not}. \end{cases}$$

and the fraction of contributors becomes

$$x = f(x') \equiv \frac{1}{1 + e^{\beta[\ln bT - nx'(bT-1)+c]}} \tag{10}$$

- if $bT \geq 1$ there is *positive feedback*, $f' \geq 1$;
- if $bT < 1$ there is *negative feedback*, $f' < 1$.

Proposition 2.1. *Sufficient condition for a unique equilibrium is* $n\beta(bT - 1) < 4$.

Here, a change in a parameter entails smooth transitions.

Proposition 2.2. *Necessary condition for two equilibria is* $n\beta(bT - 1) > 4$.

The conditions for one or two equilibria identify different scenarios of long run dynamical attractors that depend on the value of the parameters of the model. The condition of unique equilibrium $n\beta(bT - 1) < 4$ is met when

- the intensity of choice β is small (large heterogeneity of preferences or very limited attention);
- the population size n is small;
- the garden marginal beauty b is small

- the individual budget T is small.

In all these cases, a change in one of the parameter entails smooth transitions. The opposite conditions give two equilibria.

- a large β makes the map f like a 'step' function
- b and T do the same, but also shift the map f to the left.

In this case there is an *unstable* fixed point $x^* = f(x^*)$ such that $|f'(x^*)| > 1$ that separates the two *basins of attraction* of the cooperative and non-cooperative equilibria:

- when $x > x^*$ all individuals contribute to the garden;
- when $x < x^*$ nobody contributes to the garden.

Thresholds for contribution

If one equilibrium is populated, the unstable equilibrium is an *endogenous* 'threshold' for agents to 'tip' into cooperation. The indifference point works as a 'proxy' of this thresholds:

$$B \geq \ln bT + c \quad m \geq \frac{\ln bT + c}{bT - 1}, \quad x \geq \frac{\ln bT + c}{n(bT - 1)}.$$

The thresholds depend on $B = bT$: *the larger the marginal benefit b or the budget T, the lower the contribution threshold.*. An extensive literature focuses on the effect of thresholds in public good contributions (Croson and Marks, 2000). Our model implement endogenously the threshold, through the feedback of others' action externality, described by the fraction x.

In laboratory controlled experiment we intend to elicit this endogenous threshold effect, by studying the multiple equilibria feature of the contribution decision mechanism represented by the environmental club. In particular, we will be running different experimental treatments with higher and lower values of the threshold, related to wider or smaller basins of attraction of the two equilibria with few or many contributors.

2.3 Version three: the model with exploitation

The model presented above is actually more general, if we allow for exploitation. This is formally equivalent to a negative contribution $t_c < 0$. An optimal contribution $t_c^o = T - \frac{1}{b}$ can be negative as soon as we have $bT < 1$. This is a condition of negative decision feedback.

The social utility becomes a collective *bad* if $B = b\sum_i t_i < 0$ (e.g. environmental damage).

With negative feedback we can have periodic dynamic from *overshooting* of choices.

Proposition 2.3. *Sufficient condition for a unique equilibrium is* $n\beta|bT - 1| < 4$.

Proposition 2.4. *Necessary condition for periodic dynamics is* $n\beta|bT - 1| > 4$.

In Figure 3 we have simulations (bifurcation diagrams) of the long run value of the fraction of contributors (left) and the collective good value (right) as a function of different values of the contributed amount t_c. We observe that reducing the contributed

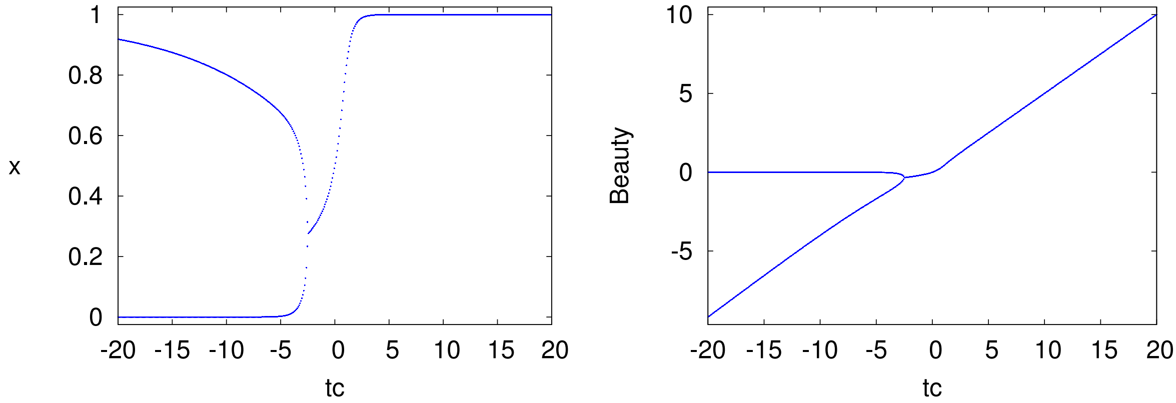


Figure 3: Contributors (left) and collective good (right) as a function of $t_c = T - \frac{1}{b}$ by changing $T \in (0, 40]$ with $\beta = 4, n = 10, b = 0.05$.

amount is 'destabilising', as it leads to periodic dynamics. In this scenario an increasingly large fraction of agents switch behaviour between contribution and no-contribution. On the other hand, the is a critical value (bifurcation value) of the contributed amount t_c above which the decision system becomes stable, converging to an equilibrium which is characterised by an ever increasing number of contributors and an ever larger value of the collective good.

3 Planned experiments

We plan three experiments to test the three versions of the model (Figure 4).

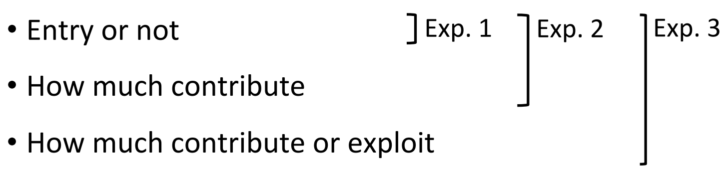


Figure 4: The three versions of the model are tested in separate experiments.

In all experiments we ask to subjects to choose between contribution (joining the environmental club) and no-contribution (not join), for twenty decision rounds, with 2 minutes time to make a decision in each round. The contribution decision in a period consists in giving a fixed quantity in Experiment 1, while it is a free control variable in Experiments 2 and 3. In each period contributions are summed up to constitute the collective (club) good. Subjects receive the following information after each round:

- their payoff updated with contributions and the value of the collective good;
- the collective good value;
- the number of contributors;

With a laboratory capacity of 24 players, we divide subjects into three groups of size 8. Different treatments are performed keeping the groups fixed.

In Experiment 2 each round entails two decision stages: an entry decision and a contribution amount decision (Figure 5). In Experiment 3 there are still two decision

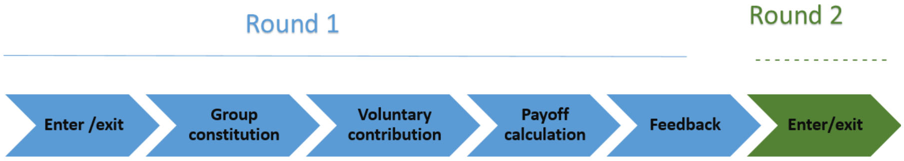


Figure 5: The 2 stages decision with contribution.

stages, but the second stage allows an exploitation decision (Figure 6). All the rest of the setting stays the same.

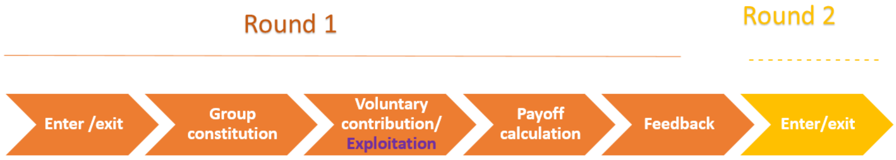


Figure 6: The 2 stages decision with contribution/exploitation.

In Experiment 1 and 2 we plan four (or six) treatments based on the combinations of two (or three) values of the club entry fee c and two values of the collective good marginal benefit b (Figure 7).

In Experiment 3 we consider running two different treatments for two different groups sizes n (Figure 8).

4 Conclusions

We study how contribution to a collective good can be achieved through a learning path informed by social influence. Our model is based on a feedback mechanism where the best-response decision environment of agents is shaped by a collective good that contains the

	Small nbT (population size, marginal collective good benefit and/or individual budget)	Large nbT (population size, marginal collective good benefit and/or individual budget)
Low entry fee c	• One equilibrium with relatively MANY contributors • SMALL individual contributions	• Two equilibria where only the cooperative one is populated, and EVERYBODY contribute • LARGE individual contributions
High entry fee c	• One equilibrium with relatively FEW contributors • SMALL individual contributions	• Two equilibria where only the non-cooperative is populated, and NOBODY contribute • LARGE individual contributions

Figure 7: Treatments for Experiments 1 and 2

	Small n (population size) and/or bT ≈ 1 (marginal collective bad damage and individual budget)	Large n (population size) and/or bT≈0 (marginal collective bad damage and individual budget)
Low entry fee c	• Oscillations towards an equilibrium with MANY contributors • SMALL individual exploitations	• Periodic dynamics • LARGE individual exploitations
High entry fee c	• Oscillations towards an equilibrium with FEW contributors • SMALL individual exploitations	• Periodic dynamics • LARGE individual exploitations

Figure 8: Treatments for Experiment 3

number of contributors as an endogenous factor. This mechanism creates endogenously a threshold in the collective good objective function. As a result, a cooperative equilibrium can be achieved by reaching the critical mass of contributors, which we can compute analytically. Our planned experiments intend to study this critical mass effect in different treatments that implement higher or lower levels of this endogenous threshold.

We also predict theoretically a counterintuitive effect of positive contribution shocks: under certain circumstances, for an increased contribution amount we obtain a lower value of the collective good. The reason behind this surprising outcome resides in the opposition between two factors, the contributed amount and the number of contributors. If the collective good does not compensate enough the loss in private utility from an increased contribution, a lower number of agents choose to contribute. If this second effect is stronger, the overall contribution decreases. This finding can also be turned into a positive result: in a given range pf parameters, reduced contribution amount lead to larger values of the collective good provided.

The model version with exploitation of the collective good is a more general decision framework which can describe a wide number of real collective goods. Environmental public goods, such as ecosystems, for instance. are collective good whose quality and services are not only built but also enjoyed through usage. In this case a negative feedback from the decisions' externalities of social influence may lead to periodic dynamics. In this case, lower contribution amounts give oscillatory patterns of contribution decisions, with increasing amplitude. On the other hand, larger contribution amounts are stabilising, with a critical level above which a stable steady state is reached, and the value of the collective good increases afterwards.

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