Adhésion volontaire versus adhésion involontaire dans la production d'un bien collectif. Etude expérimentale.

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Contents

Introduction

International norms classify a country as "poor in water" if the potential water available is inferior to 1000m^3 per habitant. In Tunisia, this ratio is 450m3 per habitant. In order to face this constraint, Tunisian policy makers have adopted a supply-side policy: every shortage of water is compensated by an increase of the capacity of mobilizing the resource (dams, artificial lakes, etc.). After 50 years of independence, more than 90% of Tunisia's water resources were mobilized. However, as the policy began facing its limits, policy makers started to recommend better management of the demand side. Since 80% of the water resources are consumed by the agricultural sector, one of the main reforms concerned irrigation systems. The former centralized management system was reformed into a decentralized system where farmers were asked to self-organize (Bchir and Bachta, 2007). Existing irrigation systems can be partitioned into one or several self-governing sectors. It is the state that defines the membership of self-governing irrigation system i.e. associations of irrigators. This reform, carried out in a top down manner, obliged farmers to adhere to the associations created to manage the irrigation systems. Associations have to enable the maintenance and the management of the infrastructure[1] of the irrigation system. By 2007, 67% of the existent irrigation systems were transformed into self-governing systems. However, several field studies[2] pointed out that farmer's involvement was poor in many associations.

In this research we investigate whether a voluntary approach in the creation of self-governing irrigation systems affects a farmer's cooperative behaviour. When membership to an association is imposed (e.g. by the state), the context is one where the state implements the provision of a collective good in a decentralized manner. In contrast when farmers have the choice to adhere (or not) to an association, the collective good that is provided has the status of a club good. If voluntary adhesion is not feasible, the collective good has the status of a public good. Hereafter, we focus on the provision of club goods. Our research is divided into two areas of interest. First, we

[1] Code des eaux Art. 154

[2] (Bchir and Bachta, 2006; Chraga and Chemak, 2004; Faysse, 1999; Treyer, 2002)

examine the voluntarism of adhesion. An agent who decides to join a club, expects a net benefit as a member, through his consumption of the club good. Therefore, depending on his expectations he voluntarily decides whether or not to become a member of the club. Secondly, we are interested in the issue regarding the level of contribution. Field observations show that a critical level characterizes many club goods. Below this critical level, the club fails to exist, (e.g. a minimum number of members for the creation of an association, or a minimum contribution effort) while contributions in excess of this critical level, improve the club good (better quality, larger amount of goods and/or services).

In contrast to pure public goods, some club goods are also characterized by congestion. This is due to partial rivalry in the consumption of goods and services provided by the club (e.g. crowding in a swimming pool, traffic of the highway). In addition to the congestion issue, club goods are also characterized by an exclusion mechanism that monitors the utilization of the club (fine exclusion *vs.* coarse exclusion) (Cornes and Sandler, 1996). In this research, we do not address the consumption issue of the club and the instruments that regulates the club. Instead, we focus on the provision side of club goods.

In this research we rely strongly on the experimental methodology, which was chosen for its relevance for our investigation. Voluntary adhesion to an association is commonly observed in many fields (e.g. sport club, art association). However, in the specific case of the irrigation systems of Kairouan, all the associations are being created in a Top down strategy. There are no other examples to compare to. Field and lab experiments offer cheap alternatives to small-scale policy implementation. They also allow the experimenter to test different scenarios regardless of whether the examined case occurs in the real word (Barr, 2003). Besides, the voluntary adhesion to an association is a complex decision. Several factors can affect a farmer's choice (e.g. technical choices, political choices). The process of producing data in the lab permits to examine specifically the cooperative behaviour in the provision of the collective good *ceteris paribus*: relationships and hypotheses can be separated by design rather than by statistical methods. (Cardenas and Carpenter, 2005). Furthermore, the examination of the voluntary adhesion in our case is a hypothetical situation. Farmers are already in associations. Such investigation is therefore exposed to the *hypothetical bias* (Carpenter, 2002), according to which that individuals respond differently to

hypothetical and real situations. The experimental technique, in contrast to survey methods, allows for direct observation of participant's preferences or revealed preferences. Finally, many countries are committed to the decentralization of the management of their irrigation system. The experimental technique allows to share the results of such investigation thanks to its *comparability* and *replicability* characteristics (Camerer and Fehr, 2001). The highly controlled common protocols can be compared across nations. It therefore permits to create a consensus about the fact and its interpretation. Moreover, it permits to isolate the effects of cultural variables giving more robustness to the findings.

In this research we started from a field observation, examined it theoretically and experimentally in the lab, and finally, went back to the field. This approach is the specificity of this thesis. The remainder of the thesis is organized into four chapters, which report three experiments in the lab, and one in the field.

Chapter 2 starts by addressing the question of whether cooperative behaviour is affected by voluntarism in the provision of a collective good. This is accomplished by comparing the provision of a public good and the provision of a club good, both of them with a provision point. The chapter first presents a model of the provision of a club good. Next, we describe our experimental design; two treatments are compared, both of which are tested at three different threshold levels (low, medium and high). Our results reveal that voluntary adhesion increases group contributions, provision success and welfare. Furthermore, voluntary adhesion increases the number of contributors, and moderates "cheap riding". These findings are stronger in the low threshold than in the medium threshold. No difference is observed between the baseline and the voluntary adhesion treatments for the high threshold. The results are explained by the reduction of strategic uncertainty induced by voluntary adhesion as compared to a pure public good. Voluntary adhesion, through the achievement of a fraction of the Nash equilibrium, facilitates coordination among players. In a follow up experiment, we show that this hypothesis cannot be rejected.

Chapter three describes an experiment where we add a refund mechanism to the voluntary adhesion game, which eliminates the risk dimension by providing full insurance to the players. Using the experimental design found in chapter two, we capture the combined effect of voluntary adhesion and riskiness of the contribution decision. By removing the risky component with the use of a Money Back Guarantee mechanism (MBG), we are able to observe the effect of voluntary adhesion alone. Chapter three is organized as the previous one. First, we introduce the model then we describe the design and finally we present the results. Two comparisons are conducted in this chapter: One, we compare a step level game with MBG to a step level game with MBG and voluntary adhesion; and two, we compare the voluntary adhesion mechanism (without MBG) to the MBG mechanism (without voluntary adhesion). Our experiment reveals that voluntary adhesion no longer increase, neither group contributions, nor success of provision or welfare in comparison to a step level with MBG. The main effect shows a significantly lower variance of group contributions for the high and medium threshold levels. In addition, the number of contributors is larger under voluntary adhesion and cheap riding is lower for the low threshold level.

In chapter four, we address the provision of club goods with respect to the subject's origin. Many experiments found that demographic variables affect the outcome in various experimental settings, for instance gender and culture. For this particular research interest, we simply wanted to know whether the results obtained with a French student-subjects sample extends to a Tunisian student-sample. The finality was to gain some control before moving to the field. The experiment involves a comparison between public and club goods with Tunisian students and differences of the cooperative behaviour between Tunisian and French students in the provision of collective goods. The experiment reveals that the main findings are unchanged: voluntary adhesion increases significantly group contributions, provision of success, welfare and the number of contributors. There are however some subtle differences when comparing the two samples: in the French sample, voluntary adhesion does not lower the variance compared to the baseline, and there is no significant decrease of cheap riding in the voluntary adhesion treatment. This difference might be due to the significant increase of the number of contributors observed in the baseline treatment

with Tunisian subject. We conclude that the provision of club good is not dramatically affected by the origin of the subjects.

Chapter five provides a test of the external validity of the findings obtained in the laboratory. This was achieved by moving to a field experiment, related to the particular context of the Tunisian irrigation management system. Two important factors might affect the behavior of subjects who are exposed to the field context. First, the decentralization policy deals with a non-standard pool, and second, the decentralized irrigated systems involve farmers communities who are used to interact, in contrast to isolated individuals randomly selected from a large subject-pool of students. The chapter begins by explaining the selection of farmers. The second section describes how we managed to guarantee the internal validity of the experiment to the conditions of the field. The last section discusses the result. Three different samples participated to our experiment depending on their pre-existing interaction. Two samples from irrigated system and one *control* sample of independent farmers. Farmers were chosen with respect to the performance of the irrigation system. The performance is defined according to the Institutional Analysis Development (IAD) of Ostrom *et al.* (2004) (Tang, 1992). Data was collected through self-administrated surveys and expert opinion. The field experiment reveals that farmers exhibit a high level of sustainable cooperation over time. This is in line with other field experiments with farmers (Cardenas and Carpenter, 2008). However, none of the demographic variables had a significant impact on contributions, except the variable “farm ownership” which increases cooperation. Voluntary adhesion is more effective with farmers from low performing irrigation systems, followed by independent farmers and finally by high performing irrigation systems. Voluntary adhesion increases group contributions and – weakly- the success of provision only in the low performing irrigation system. It raises the number of contributors within the three samples of farmers. The field data is comparable to the lab data mainly for the low performing irrigation system

Chapter 2: Provision of club goods without refund

1 Introduction

The issue of public goods provision has received considerable attention by experimentalists. Most research was concerned with the case of pure public goods even though this is not the most relevant case in practice. Recently, a growing literature has started to investigate impure public goods by taking into account the possibility of exclusion. Different exclusion mechanisms have been examined so far. They are implemented in three ways: (i) a voting procedure (Gary and Chun-Lei, 2006; Margreiter, 2004), (ii) an institutional rule, such as an endogenous threshold (Kocher *et al.*, 2005), granting power to a leader (Levati et al., 2007), a serial cost share mechanism (Gailmard and Palfrey, 2005), or excluding the lowest contributors (Croson *et al.*, 2006), or (iii) a selection rule implemented by the experimenter himself, to sort out types of contributors (Gunnthorsdottir *et al.*, 2000).

In this research, we investigate another possibility of exclusion by means of club goods. Club goods (also called toll goods) are voluntary groups of individuals who derive mutual benefit from sharing at least one of the following: production costs, the members' characteristics or a good characterized by excludable benefits. (Cornes and Sandler, 1996). Among these features, voluntarism is an essential condition. "First, privately owned and operated clubs must be voluntary; members choose to belong

because they anticipate a net benefit." (Sandler and Tschirhart, 1997). With the club goods, the Marginal Rate of Substitution between the private and the collective good (MRS) cannot be negative because of the right of the costless exit. The club is rejectable. An individual who does not obtain a net positive benefit from his contribution can choose not to partake (Ng, 1973). On the contrary, in a public good setting, an individual cannot exclude himself from the consumption of the public good. He undergoes the public good. (e.g.: a pacifist has to "consume" the defense policy entirely).

Voluntary adhesion to a club good can be framed as a public good with an individual option to exit. A seminal experiment[3] based on such a mechanism was run by Swope (2002). He explored voluntary adhesion with a Voluntary Contribution Mechanism (VCM) in a linear public good game. A minimum individual amount of contribution was required for an individual to benefit from the club good. By introducing voluntary adhesion in a linear public good, the n-player prisoner's dilemma game is transformed into an n-player coordination game -a linear public good with minimum individual contribution-. Therefore, a subject's task in the baseline treatment (standard VCM) was different from his task in the test treatment (voluntary adhesion). As a result, the observed differences in the distribution of contributions can be attributed both to task differences and to exclusion per se. Furthermore, Swope (2002) mixes two forms of contributions: a fee and free amounts. Therefore, the design fails to isolate the voluntary adhesion effect. The aim of our research is to examine voluntary adhesion in relation to the size property of club goods. In order to provide their activity, many clubs require a minimum number of members (e.g. an association). Such minimum size is critical for a club's existence, and for maintaining a critical level of activity within an existing club. In both cases, either the club or its activity breaks down below this size. However, above the critical size, clubs can improve their services or their capacity (an association offers wider services, a swimming pool open longer).

The provision of such club goods can be framed as a step level mechanism whereby group contributions are required to meet a threshold in order to provide the club. Below

[3] Orbell and Dawes (1986) conducted an experiment with the option to adhere or not to prisoner dilemma game. They did not focus on the provision issue.

the threshold, the club good fails to exist. Several experiments relied on the step level mechanism to study fundraising and charitable giving. (Croson and Marks, 2001; List and Rondeau, 2003; Marks and Croson, 1998; Rondeau *et al.*, 2005; Rose *et al.*, 2002) In our experiment, this step-level mechanism will be interpreted as the minimum size of the club. In addition, we do allow for rebates beyond the target (Marks and Croson, 1998) but, rather we assume linear provision of the club good above the threshold. The existence of a minimum size raises the question of what happens when the group contribution does not meet the threshold. Fundraising experiments allowed for refund, providing thereby incentives for subjects to increase their contribution. This is not relevant in our case. In reality, an individual cannot recover – or with difficulty –the time or money spent when the club fails to exist (e.g. an investor looses his investment when the firm gets bankrupt). Therefore contributions are lost when the club fails to exist.

Finally, in addition to capture the size feature of club goods, the step-level component, permits the investigation of voluntary adhesion within two coordination games. Therefore, it rules out the heterogeneous setting of Swope's (2002) experiment. Besides, we suppressed the fee in our experiment. Therefore, we focus on a single form of contribution to the club good. Three levels of the threshold are compared in our experiment: low, medium and high. While the low threshold requires only one player for providing the club, two are required in the medium case, and three are required in the high threshold case.

Our experimental findings show that voluntary adhesion raises significantly group contributions, the success rate of provision and the groups' welfare (except for the high threshold). Voluntary adhesion also increases the number of contributors, moderates cheap riding and sustains longer group contributions over time.

The following section of this paper presents a model of voluntary adhesion to a club good and the theoretical predictions. Section 3 presents the experimental design and section 4 provides a discussion about our conjectures. Section 5 presents the results of the experiment. Section 6 discusses a possible explanation for our findings. The last section is a conclusion.

2 Theory

Let G be the amount of club good provided, x_i agent i's private good consumption, and w_i his endowment. We assume that agent i's utility is linear. Let us note $g_i = w_i - x_i$ agent i's contribution to the club good (with $w_i > 0$). Thus, $\frac{\partial U}{\partial x_i} > 0, \frac{\partial U}{\partial g_i} > 0$ and $\frac{\partial^2 U}{\partial^2 x_i} = 0, \frac{\partial^2 U}{\partial^2 g_i} = 0$. Agent i faces an exclusion mechanism, λ_i. If he contributes to the provision of the club good, i.e. $g_i > 0$, $\lambda_i = 1$,and $\lambda_i = 0$ otherwise. When agent i becomes a member of the club his utility is $U(x_i, G)$, *while* $U(w_i, 0)$ applies if he stays outside the club. Obviously, agent i chooses to become a member if $U(x_i, G) > U(w_i, 0)$. The existence of the club good is bound to a threshold level of provision T: $G = 0$ if $\sum_{i=1}^{n} g_i < T$ and $G = \sum_{i=1}^{n} g_i$ otherwise. T is common knowledge. If the threshold is not met, contributions are lost, i.e. there is no Money Back Guarantee mechanism. Finally, beyond the threshold, the club good is provided linearly. It is the improvement of the club. Agent i faces a social dilemma towards this improvement; the marginal return of the club good β is inferior to the marginal return of the private good α_i but $n\beta$ is larger than α_i, where n is the number of contributors ($0<n<N$). In our experimental setting, we consider the symmetric case, where $\alpha_i = \alpha$, and $w_i = w$ for all i.

$$U_i(g_i, G) = \alpha(w - g_i) + \lambda_i \beta G \quad \text{if } G \geq T$$
$$U_i(g_i, G) = \alpha(w - g_i) \quad \text{else}$$

$$\text{with } \lambda_i = 1 \text{ if } g_i > 0$$
$$\lambda_i = 0 \text{ if } g_i = 0$$

$$\alpha > \beta \; ; \; \alpha < n\beta$$

The contribution game admits multiple Nash equilibria, but only two Nash equilibria in aggregate contributions: $G = T$ and $G = 0$. In the case where $G = T$ all vectors of

contributions for which $\sum_{i=1}^{n} g_i = T$ with $g_i \leq \beta T$ and $g_i > 0$ are possible[4] equilibria. In the symmetric case, the equilibrium where $G = T$ Pareto-dominates the equilibrium where $G = 0$. Agent i chooses g_i as a best reply to the expected amount contributed by other players, g_{-i}. The multiple non pareto-ranked Nash equilibria differ with respect to the cost-sharing rule in providing the step-level good. In contrast to the standard linear public good game, the step level good involves coordination issue and cheap riding as opposed to free riding. However, the Pareto dominated equilibrium does not involve a coordination issue. It is a best reply for player i to choose $g_i = 0$ if he expects that $g_{-i} = 0$.

$$U' = -\alpha + \beta \quad \text{if } \sum_1^n g_i = T \text{ and } g_i > 0 \qquad (1)$$

The group optimum is achieved whenever all players contribute their endowment to the club good since $n\,\beta > \alpha$. A player has no incentive to contribute more than the Nash equilibrium because $\alpha > \beta$: the marginal return of one unit from the private good is superior to the marginal return of one unit from the club good (Equation 1). Since agents who do not contribute to the club good are excluded, contributing 0 no longer constitutes the free riding strategy. Instead, the player contributes the minimum unit in order to become a member of the club. Such behavior corresponds to “free riding” in the context of the provision of a club good: contribute, but the least possible amount, in order to benefit from the club. In our experiment, subjects allocate integer amounts. Therefore, the minimum contribution level is 1 token.

3 Experimental design

The baseline treatment is a linear public good game with a threshold. Each subject i has an initial endowment of $w = 20$ tokens that he can allocate (in integer amounts) between a private account and a collective account. The private account yields a marginal return $\alpha = 1$ per token invested. The collective account provides a marginal

[4] Depending on the choice of parameters. Section 2 *(Experimental design)* details the Nash equilibria of each level of threshold.

return $\beta = 0.5$ per token invested if the target T is met. If the target level is not met, subject's contributions are lost. If the group contributions are above the threshold, each contributor enjoys the total amount of the club good provided. We compare three levels of threshold: Low threshold (15 tokens), medium threshold (30 tokens) and high threshold (60 tokens). In the first case, a single subject can provide the club good, in the second one at least two subjects are required to reach the threshold and in the high threshold three members of the group are required to reach the 60 tokens. Note that, since we are considering a step level continuously provided above the threshold and that subjects homogenously value the provision of the club good, the step return does not vary between the thresholds (Croson and Marks, 2000). As a consequence, we are comparing the different thresholds within a homogenous return setting. Table 1 summarizes parameters of the experiment.

We compare the baseline treatment to the voluntary adhesion treatment. Treatments allowing for voluntary adhesion follow the same baseline design with a minor change: subjects are excluded from the benefit of the club good if they fail to contribute. Since we expect that voluntary adhesion can affect the level of contribution, careful attention was given to the instructions in order to prevent any design effect on contributions. Instructions were written in a neutral way, avoiding words like "investment" or "contributions". Instead we chose words like "put", "budget" and "account".

The experiment was run at the University of Montpellier I, with a large subject pool of volunteers from various disciplines: economics, law, art, psychology, literature, medicine, engineering, and sport. Care was taken to ensure that no subject participated in more than one session. 352 students participated to our experiment. The experiment was programmed and conducted with the software z-Tree (Fischbacher, 2007). Upon attending the experimental lab, the 16 participants of each session were randomly assigned to groups of 4 players in a partner design. A public reading of the instructions followed a private one in order to make the rules of the game common knowledge. Subjects had to make tow decisions: how many tokens to invest in their private account and how many tokens to invest in the collective account. The history of the past interactions was available for each subject at any time during the experiment. The constituent game was repeated 25 periods. Accumulated point earnings over the 25 periods were converted into Euros at the end of the experiment at a publicly announced rate.

Table 1

Experimental parameter

Treatment	Threshold		Required contributors [a]	Number of groups	Step return [b]	MBG [c]
Baseline	Low	15	1	6	2	No
	Medium	30	2	5	2	No
	High	60	3	4	2	No
Voluntary adhesion	Low	15	1	8	2	No
	Medium	30	2	6	2	No
	High	60	3	4	2	No

(a) Number of contributors required to reach the threshold ; (b) Benefit /cost = $\frac{n\beta T}{T}$; (c) Money Back Guarantee

For the high threshold, all contribution vectors that reach exactly the threshold are Nash equilibria. A player invests collectively whenever he predicts that the other members of his group will contribute at least 40 tokens. (15, 15, 15, 15) is therefore a symmetrical equilibrium ($gi = T/n$) around which a group of non-communicating people might be expected to coalesce. The contribution vector (1, 20, 20, 19) constitutes a Nash equilibrium that maximizes player's 1 Nash benefits. It yields 49 points. Player 2 and player 3 earn the minimum Nash benefits when a club good is provided, 30 points. The contribution vector (0, 20, 20, 20) is the equivalent vector maximizing Nash earning for player 1 in the public good case (50 points).

In the medium threshold, all contribution vectors equalling the threshold do not constitute Nash equilibria. A player does not invest more than 15 tokens in order to provide the threshold. For example, (16, 14, 0, 0) is not a Nash equilibrium since player 1 -who contributed 16 tokens - is better off if he deviates. Contributing 15 tokens yields

the minimum Nash earning for a player[5]: 12.5 points- when the step-level good is provided-. The maximum player earning from a Nash equilibrium is obtained whenever other members in the group contribute collectively 29 tokens and a player contributes 1 token: 34 points (for the baseline treatment, when the group contribute 30 tokens collectively and a player 0 token, 35 points). The symmetrical strategy is to invest 7.5 tokens[6] in the collective account.

Again, for the low threshold, all contribution vectors equalling 15 tokens do not constitute Nash equilibria. A player contributes to the collective account when other members of the group invest at least 8 tokens. The minimum Nash earning for a player is obtained when he contributes 7 tokens to the collective account. It yields 20.5 points – when the step level good is provided -. The maximum Nash earning is obtained when other members of the group invest 14 tokens (15 tokens for the baseline) and the player contributes 1 token (0 token for the baseline). It yields 26.5 points in the voluntary adhesion treatment and 27.5 points in the baseline treatment.

4 Conjectures

For the baseline and the voluntary adhesion treatment, the Nash prediction for selfish players is that the group contribution is either equal to the threshold level or to zero contributions. Since zero contribution is Pareto dominated by the threshold Nash equilibria, we expect that subjects will coordinate on the threshold in both treatments. Moreover, since the threshold is common knowledge the symmetrical equilibrium constitutes a focal point (Schelling, 1980). Our first conjecture is thus:

> *Conjecture 1 : Groups coordinate on the symmetric Pareto dominant Nash equilibrium in the baseline and in the voluntary adhesion treatments.*

[5] For a contribution vector of (15, 15, 0, 0) player 1 is indifferent between the earnings of the collective account or investing 15 tokens in the private account. Both strategies entail the same earning.

[6] In our experiment, subjects can invest only integer token. As a result, the symmetrical strategy (7.5, 7.5, 7.5, 7.5) was not feasible in the medium threshold. The same situation is observed for the low threshold (3.75, 3.75, 3.75, 3.75) but not for the high threshold (15, 15, 15, 15).

Increasing the threshold affects the risk associated with strategies consistent with the Pareto dominant equilibrium. Since larger contributions are required to reach the threshold, higher potential losses are involved because of the no refund rule. Thus, with a higher threshold, subjects might become more reluctant to contribute. This is known as the *assurance problem hypothesis* (Isaac et al., 1989). However, a higher threshold yields also larger benefits. In our setting the reward of provision is correlated to the threshold level: 7.5 points in the low threshold, 15 points for the medium and 30 points for the high threshold. The subject contributes more but earns more from the collective good. Hence, the threshold is likely to lead to larger contributions by subjects. Summarizing, there are two opposite effects when the threshold is increased: the assurance problem becomes more dramatic, leading to lower contributions, the reward of the club becomes larger leading to higher contributions.

Earlier experiments provide mixed evidence about these effects. Rapoport and Suleiman (1993) showed that the threshold has no effect on contributions when random endowments are assigned to subjects. Cadsby and Maynes (1999) found that contributions decline with the threshold level with a constant reward and no rebates setting. The main finding however, is a tendency for contributions to increase (decrease) with the threshold at low (high) threshold levels (Bougherara *et al.*, 2007; Dawes *et al.*, 1986; Isaac *et al.*, 1989; Suleiman and Rapoport, 1992). These findings are consistent with the fact that the assurance problem effect becomes relatively stronger for high threshold levels while the "earning effect" is relatively stronger for low threshold levels. Therefore, as the threshold increases, individuals first increase their contribution up to some level of the threshold where they move in the opposite direction, with a switching point that varies according to the individual's preferences.

> *Conjecture 2: Increasing the threshold from the low to the medium threshold increases group contributions. Increasing the threshold form the medium to the high level decreases contributions.*

Introducing voluntary adhesion excludes contribution vectors where players invest 0 tokens. As a consequence, the number of possible equilibrium contribution vectors is lower in the voluntary adhesion treatment than in the baseline. Actually the set of equilibria under voluntary adhesion is included in the larger set of equilibria of the

baseline treatment. As a result, a subject's expectation about others' contributions is affected: less uncertainty is involved and so there are fewer possibilities for coordination failure. The problem faced by our player is close to the tacit coordination experiment of Van Huyck et al. (1990) but in a context of non-Pareto ranked equilibria.

Furthermore, when all subjects of the group decide to adhere to the club i.e. 4 tokens contributed, subjects are guaranteed that at least 26.66% of the Nash equilibrium will be provided in the low threshold, 13.33% in the medium threshold and 6.66% in the high threshold. In contrast, subjects' expectations in the baseline treatment do not involve such guarantee in reaching the threshold. Thus, voluntary adhesion reduces the strategic uncertainty of the coordination task.

Conjecture 3 : Voluntary adhesion increases the success of provision.

The voluntary adhesion prediction differs from the baseline prediction by the exclusion of the contribution vectors where one or more players contribute 0 token. Therefore, the number of players in the voluntary adhesion equilibrium is always equal to 4 players. In the baseline treatment, contribution vectors with 2 or 3 players free ride[7] are possible Nash equilibria.

Conjecture 4 : Voluntary adhesion increases the number of contributors.

[7] Contribution vectors for which the group contribution is equal to the threshold and for which two or three players free-ride are not necessarily Nash equilibria. In the medium threshold, there exists only one equilibrium contribution vector where exactly two players free ride (15, 15, 0, 0). The contribution vectors (16, 14, 0, 0), (17, 13, 0, 0), (18, 12, 0, 0), (19, 11, 0, 0) and (20, 10, 0, 0) are not equilibria because player 1 is always better off if he deviates (a similar arguments holds for the permutation of these vectors). The same remark holds for the low threshold: (15, 0, 0, 0) , (14, 1, 0 , 0), (13, 2, 0 , 0), (12, 3, 0 , 0) , (11, 4, 0 , 0), (10, 5, 0 , 0), (9, 6, 0 , 0), (8, 7, 0 , 0) are not Nash equilibrium vectors. For the high threshold, all vectors for which the agregeate contribution is equal to the threshold are Nash equilibria. One player can free ride in the high threshold, i.e. is for the contribution vector (20, 20, 20, 0) and permutations of it.

In the next section, we present the results of our experiment with respect to these conjectures.

5 Results

We report in Table 2 the general pattern of the results. It depicts by treatment (baseline and voluntary adhesion) and for each threshold (low, medium and high) the individual and the group level of contribution, the success rate of provision and the welfare. The success rate of provision is the percentage of success of provision of the step-level good. It is equal to the number of times group contributions reach at least the threshold divided by the number of periods. Hereafter, we will call the success rate of provision simply "success rate". The welfare is equal to the final monetary payment of the subjects.

The econometric analysis conducted in this section follow this scheme. First, we compare the baseline treatment and the voluntary adhesion treatment using non-parametric tests: a two-sided Wilcoxon-Mann-Whitney test or a two-sided χ^2 test depending on the variable (qualitative or quantitative). Then, we control for the differences between the two treatments with a GLS panel[8] data regression with random effects[9]. The dependent variable is defined specifically for each analysis. When it is a binary variable, e.g. success of provision, we run a logit regression on panel data. Unless reported otherwise, the regressors are a dummy treatment taking value 1 for the voluntary adhesion (0 for the baseline) and a time variable. They are denoted *Voluntary adhesion* and *Period.* We correct for heteroskedasticity and auto-correlation each time it was detected[10]. We conclude for a significant statistical effect when both the non-

[8] We check the presence of unobserved individual heterogeneity with a Breusch and Pagan LM test before each panel data regression. The tests confirm the significant presence of individual effects and thus the relevance of the data as a panel structure.

[9] Random effects were preferred over fixed effects for two reasons: first, they allow for regressors that do not vary over time (dummy variable) and second, the GLS estimator corrects for multiple observations from a single group of subjects (Greene, 2003)

[10] For all regressions we check for the existence of auto-correlation and heteroskedasticity : If only heteroskedasticity was detected (White test) we correct by running FGLS with a variance covariance matrix of the errors allowing for heteroskedasticity. If only intra-individual autocorrelation (Breusch and

parametric tests and the panel data regression agree. Finally, the rejection threshold of the null hypothesis is at 5%.

Pagan LM test) or inter-individual autocorrelation was detected (Wooldridge test) or both simultaneously, we correct by a GLS random effects regression with a Durban-Watson coefficient. Finally, if both heteroskedasticity and any form of auto-correlation was detected, we correct by running a FGLS with a modified matrix of covariance of the errors allowing for autocorrelation and heteroskedasticity. See for a discussion of hetroskedasticity and autocorrelation under panel data. (Baltagi, 1995)

Table 2

Descriptive statistics

	Average individual contribution [(a)] (SD)		**Average group contributions (SD)**		**Success rate of provision [(b)]**		**Welfare [(c)] (SD)**	
	Baseline	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*
Low (T=15)	3.95 (6.48)	5.78 (5.68)	15.82 (19.13)	23.14 (15.64)	41.3%	73.5%	573.25 (109.13)	617.87 (101.52)
Medium (T=30)	6.44 (6.67)	7.83 (5.89)	25.79 (17.88)	31.35 (14.26)	39.7%	67.7%	558.48 (80.60)	626.4 (101.09)
High (T=60)	8.21 (8.23)	7.15 (8.22)	32.87 (29.09)	28.6 (26.13)	39.0%	30.0%	606.56 (188.86)	548.47 (180.02)

[(a)] The symmetrical equilibrium is 3.75 for the low threshold, 7.5 for the medium threshold and 15 tokens for the high threshold

[(b)] Success rate = Number of times groups reach the threshold / Number of periods

[(c)] Welfare = Total points accumulated at the end of the experiment. (1 token in the private account = 1 point ; 1 token in the collective account = 0.5 point)

Result 1: Mixed results are observed for the Nash prediction. Neither the baseline nor the voluntary adhesion are better described by the Pareto dominant equilibrium.

Conjecture 1 states that groups will play the symmetrical Pareto dominant Nash equilibrium. To examine this conjecture, we report in Table 3 the percentage of Nash equilibria in each treatment. It is equal to the number of times group contributions reach exactly the threshold divided by the number of times group contributions reach at least the threshold (*Cf.* Section 3 *Experimental design* for the vector of contribution constituting a Nash equilibrium) Clearly, groups coordinate few times on the threshold. We perform a two-sided [11] Student test (T test) to compare group contributions in each threshold and in each treatment to the threshold level. If the prediction was verified, we have checked if players opted for a symmetrical strategy as a solution of coordination on the threshold [12]. The T test shows that in the low threshold, group contributions in the baseline treatment are significantly equal to 15 tokens ($t=0.52$; $p=0.59$) and subjects coordinate around the symmetrical equilibrium ($t=0.52$; $p=0.59$). However, for the voluntary adhesion treatment, group contributions are significantly higher than the Nash equilibrium ($t=7.35$; $p<0.01$). For the medium threshold, group contributions are significantly lower than the Nash equilibrium in the baseline treatment ($t=-2.89$; $p<0.01$) and are significant equal in the voluntary adhesion treatment ($t=1.05$; $p=0.29$). Again, subjects do coordinate around the symmetrical Nash equilibrium ($t=1.28$; $p=0.09$). Lastly, in the high threshold, Nash prediction is not significant for both treatments: the baseline treatment ($t=-9.32$; $p<0.01$) and the voluntary adhesion ($t=-12.01$; $p<0.01$). Hence, mixed results are found when we compare group contributions to the Nash prediction. Neither the baseline nor the voluntary adhesion is better predicted by the Nash equilibrium. However, in both treatments when subjects coordinate on the threshold the symmetrical solution is selected. Conjecture 1 is therefore partially confirmed.

[11] If the two-sided T test shows that the group contributions is not equal to the Nash equilibrium, we conduct a one sided T test to determine if group contributions is significantly lower or higher than the Nash equilibrium.

[12] We run a two-sided T test to compare individual contribution to 3.75 tokens in the low threshold, 7.5 tokens in the medium and 15 tokens in the high.

Table 3

Percentage of Nash equilibria per treatment [(a)]

	Baseline	Voluntary adhesion
Low (T=15)	4.6 %	6.0%
Medium (T=30)	1.9%	4.8%
High (T=60)	4%	9%

[(a)] Percentage of Nash equilibria = Number of Nash equilibria[13] / Number of times group contributions reach at least the threshold

Result 2: Increasing the threshold from the low to the medium threshold increases significantly group contributions. However, contributions remain significantly unchanged from the medium to the high threshold.

Conjecture 2 states an increase of contributions from the low to the medium threshold and a decrease of contributions from the medium to the high threshold. We first examine the group contributions. Then, we address the success of provision. We conduct a Mann-Whitney Wilcoxon[14] test to compare the increase of group contributions from the low to the medium threshold and from the medium to the high threshold. We perform these tests separately for the baseline and for the voluntary adhesion treatment. The test shows that there is a significant increase from the low threshold to the medium threshold in the baseline ($U=-5.37$; $p<0.01$) and in the voluntary adhesion treatment ($U=-5.41$; $p<0.01$). However, there is no difference between group contributions of the medium and the high threshold in the baseline ($U= -1.40$; $p=0.15$) or in the voluntary adhesion treatment ($U=1.24$; $p=0.21$). We then conduct a panel data regression with group contributions as the dependent variable. The regressors are a

[13] *Cf. Experimental design*

[14] Hereafter we will call the Mann-Whitney Wilcoxon test the U test.

threshold dummy variable and time. We interpret our results with respect to the low threshold. The regression is conducted separately for the baseline and for the voluntary adhesion treatment. We report results in Table 4. It outlines that the increase of group contributions from the low to the medium threshold is significant whereas from the low to the high is not significant. This finding is observed for the baseline and the voluntary adhesion treatment. Thus, the regression confirms the U test. Mixed evidences are therefore observed for conjecture 2. The increase of contributions[15] from the low to the medium threshold is significant but contributions do not drop from the medium to high. Contributions in the high threshold remain equal to contributions of the medium threshold.

[15] We also examined the variation of the success rate with respect to the threshold level. Results are reported in Appendix 2.1.. In the baseline treatment, there is no significant difference of the success rate between the three levels of threshold. In the voluntary adhesion treatment, there is only a significant decrease of the success rate from the medium to the high threshold. Thus, in comparison to group contributions, the success rate seems little correlated to the threshold level (except for the voluntary adhesion treatment previously pointed out).

Table 4

Results from panel data regression explaining group contributions in the pooled sample (Low + Medium + High threshold) [(a)]

Regressors	**Baseline**	**Voluntary adhesion**
Intercept	23.79 (*)	34.96 (*)
	(9.24)	(23.78)
Threshold_med [(b)]	13.81 (*)	8.04 (*)
	(5.87)	(3.84)
Threshold_high [(b)]	--	--
Period	- 0.98 (*)	-0.90 (*)
	(-7.54)	(-9.46)
Log likelihood	-1404	-1466
Number of observation	400	425
Number of groups	16	17
Time periods	25	25

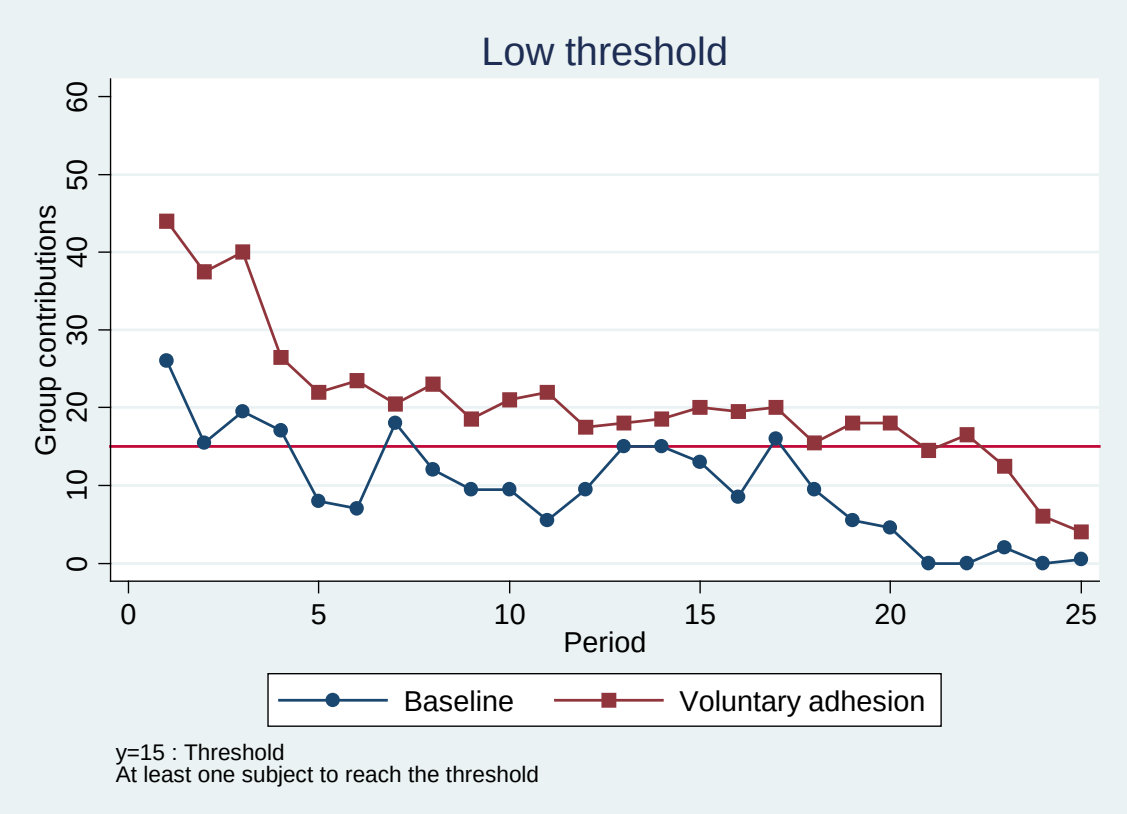
(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a) T-statistics are in parentheses; (b) The low threshold dummy variable is dropped ; Regressions are corrected for heteroskedasticity and autocorrelation.

Result 3: Voluntary adhesion significantly increases group contributions, success of provision and welfare, except for the high threshold.

Figures 1, 2 and 3 depict the evolution of group contributions over time. A visual inspection shows that voluntary adhesion increases group contributions in the low threshold and in the medium one. There is no clear effect for the high threshold: Average group contributions in the voluntary adhesion treatment are lower than average group contributions in the baseline treatment during the main part of the game (until the period 17). However, it rises during the 8 last periods and becomes higher than Average group contributions of the baseline treatment. Hereafter, we first wonder about the statistical significance of this graphical interpretation. Then about its consequences on the related outcomes: the success of provision and the welfare.

Figure 1

Median group contributions (T=15) [16]



[16] We display the median group contributions instead of the average group contributions because of the high level of group contributions in the baseline for one group at the beginning of the experiment that distort average contributions. The figure of average group contributions of the low threshold is an Appendix 2.3.

Figure 2

Average group contributions (T=30)

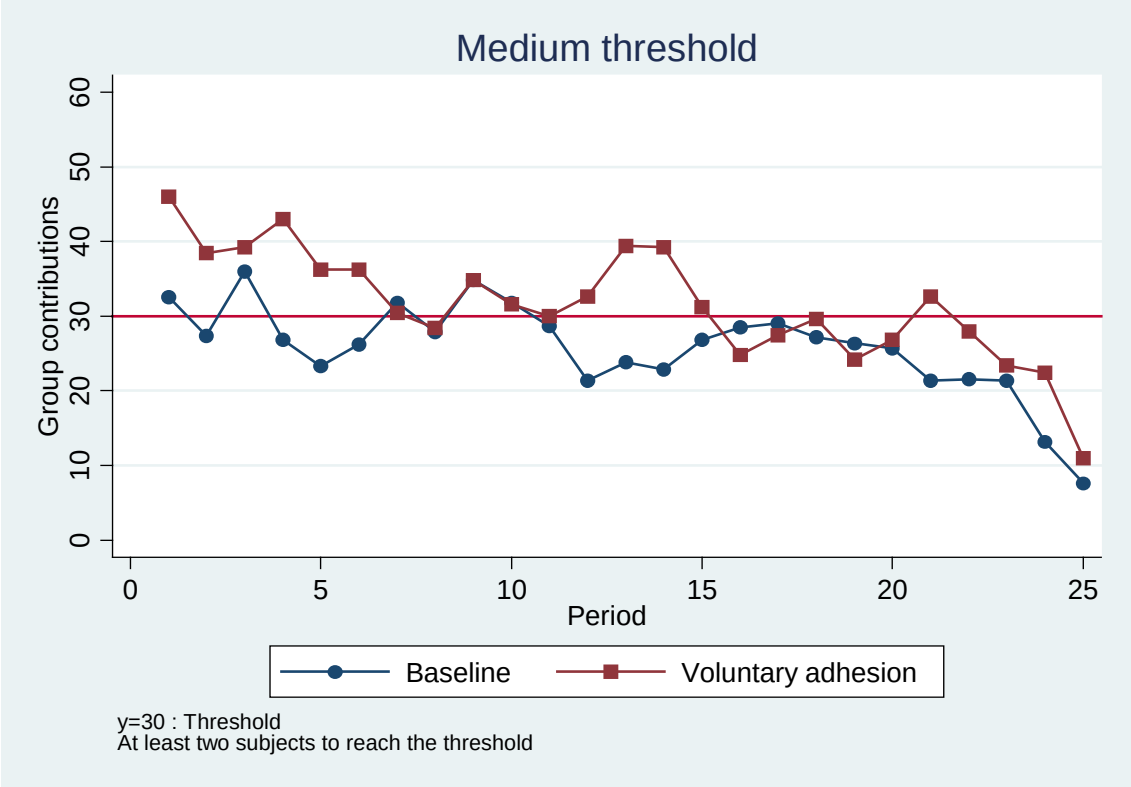
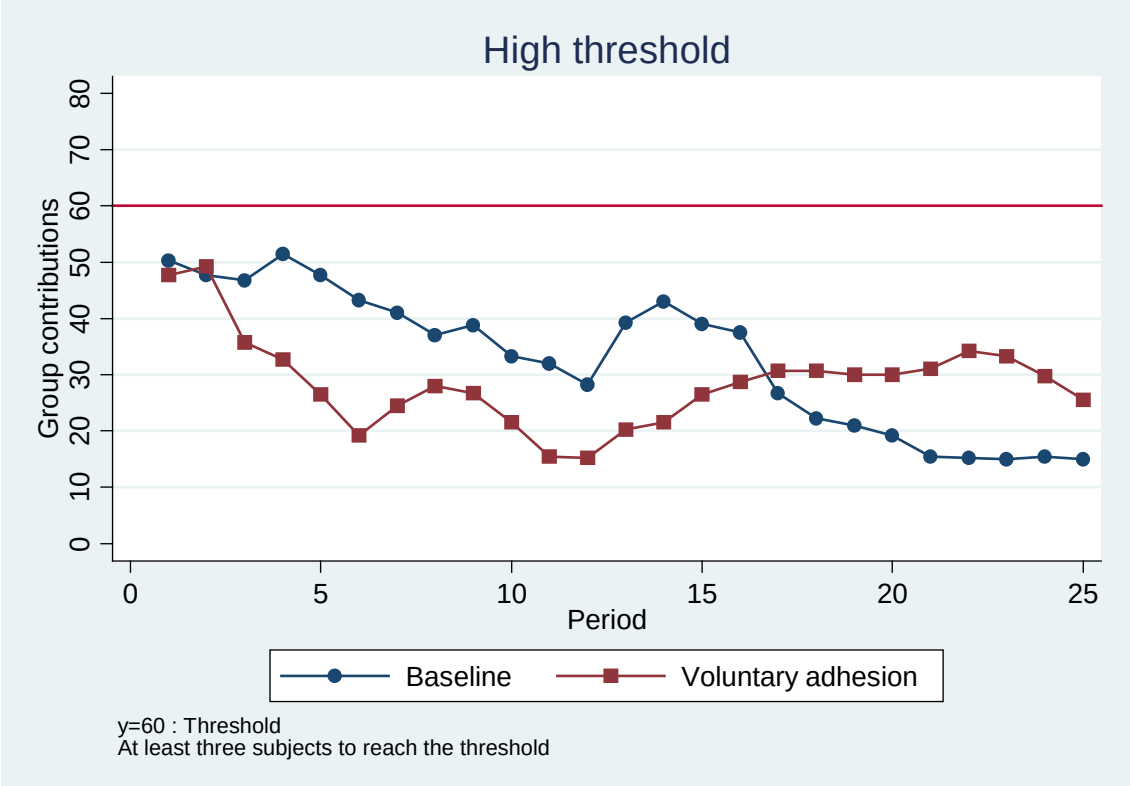


Figure 3

Average group contributions (T=60)



Starting this analysis with the variable group contributions, the U test shows that group contributions is significantly higher in the voluntary adhesion treatment for the low threshold ($U=-5.71$; $p<0.01$) and for the medium threshold ($U=-3.32$; $p<0.01$). In the high threshold, group contributions do not change between the two treatments ($U=1.27$; $p=0,20$). Then, we run the panel data regression. We explain group contributions –the dependent variable- by a dummy treatment V*oluntary adhesion* and we control for learning by introducing time with the variable period. V*oluntary adhesion* and *Period* are our regressors. A significant dummy regressor *Voluntary adhesion* indicates a significant increase – or decrease - of the group contributions. A significant regressor *Period* points out if the increase/decrease of the group contributions is stable or varies over time. Table 5 reports the results of the regression. It reveals that group contributions significantly increase in the low and the medium threshold but are not affected in the high threshold, thus confirming the U test results.

Table 5

Results from panel data regression explaining group contributions for each level of threshold [(a)]

Regressors	**T=15**	**T=30**	**T=60**
Intercept	25.01 (*)	37.52 (*)	36.40 (*)
	(18.82)	(18.93)	(4.19)
Voluntary adhesion	10.20 (*)	6.58 (*)	--
	(7.55)	(3.42)	
Period	- 0.88 (*)	-1.00 (*)	-0.97(*)
	(-13.34)	(-8.34)	(-3.55)
Log likelihood	-1118	-978	-643
Number of observation	350	275	200
Number of groups	14	11	8
Time periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a): T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

Next, we perform the same analysis with the success of provision. The success is a binary variable taking value 1 when group contributions reach at least the threshold and 0 when it is lower than the threshold. We recall that the success rate is the percentage of the success of provision of the step-level good. Table 2 outlines that the success of provision increases from the baseline to the voluntary adhesion treatment by 32.2% in the low threshold and by 28.0% in the medium threshold. In the high threshold, it decreases by 9.0%. A Chi2 test shows that voluntary adhesion increases significantly the success rate for the low threshold (χ^2 =36.86; p<0.01) and for the medium threshold. (χ^2 =22.33; p<0.01). In the high threshold, there is no significant change between the two treatments (χ^2 =1.79; p=0.18). We then run a logit regression with random effects. Success, the binary variable, is the dependent variable. The regressors are V*oluntary adhesion* and *Period*. Table 6 reports the output of the regression. It indicates that the significant sign of V*oluntary adhesion* is positive meaning that there is an increase of the success of provision in the voluntary adhesion. Table 6 also indicates that the success of provision declines over time since the sign of *Period* is negative. Hence, the regression confirms the results of the statistical test.

Table 6

Results from panel data regression explaining success of provision for each level of threshold [(a)]

Regressors	**T=15**	**T=30**	**T=60**
Intercept	1.34 (***)	--	--
	(1.74)		
Voluntary adhesion	2.36 (*)	1.45 (**)	--
	(2.36)	(2.25)	
Period	-0.15 (*)	-0.07 (*)	--
	(-6.35)	(-3.66)	
Log likelihood	-153.27	-164.78	--
Number of observation	350	275	200
Number of groups	14	11	8
Time periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a): T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

In the baseline treatment when the step level public good is reached, it benefits all the subjects. In the voluntary adhesion treatment, it benefits only the contributors. Does this exclusion of the benefactors have an effect on welfare? To test this proposition, we have considered final monetary payment as an indicator of the welfare difference. With a U test, we compare earnings of the subjects in the baseline and voluntary adhesion treatment. It shows that the increase of the welfare in the voluntary adhesion treatment compared to the baseline is statistically significant for the low (U=-3.30 ; p=0,00) and the medium threshold (U=-2.30 ; p=0.02). However, welfare in the high threshold is significantly higher in the baseline than in the voluntary adhesion threshold (U=2.72; p<0.01). Results of the regression explaining welfare – the dependent variable - with the same previous regressors are reported in Table 5. *Voluntary adhesion* is significant and positive indicating an increase of welfare in the regression of the low and the medium threshold. This finding confirms the statistical U-test and are consistent with the previous increase of the group contributions and the success rate. The panel regression reveals also that the welfare decreases for the high threshold. The statistical U test result is thus confirmed.

Thus, voluntary adhesion increases group contributions, success of provision and welfare when the threshold is low or medium. Conjecture 3 is therefore confirmed for these two levels of threshold. However, for the high threshold level conjecture 3 is not confirmed. See section 6 for a discussion of these findings.

Table 7

Results from panel data regression explaining welfare for each level of threshold [(a)]

Regressors	**T=15**	**T=30**	**T=60**
Intercept	96.54 (*)	95.54 (*)	78.48 (*)
	(30.38)	(28.67)	(-2.75)
Voluntary adhesion	12.49 (*)	9.36 (*)	-11,03(*)
	(5.07)	(4.19)	(2.17)
Period	- 0.83 (*)	-0.95 (*)	0,60(**)
	(-8.90)	(-4.56)	(16.65)
Log likelihood	-1286	-1193	-969
Number of observation	350	275	200
Number of groups	14	11	8
Time periods	25	25	25

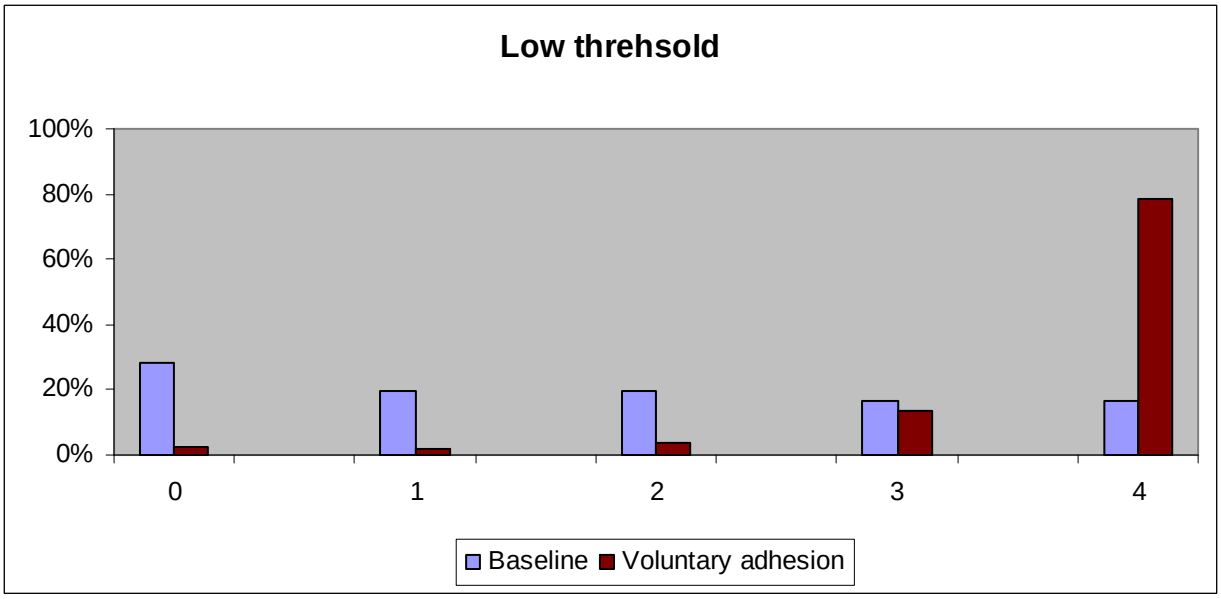
(*): significant at 1% level; (**) : significant at 5% level; (***): significant at 10% level; -- non significant ; (a) T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

Result 4: Voluntary adhesion increases the number of contributors and decreases cheap riding, except for the high threshold.

Hereafter we aim to examine Conjecture 4. Figure 4 depicts the number of contributor per group for each period for the low threshold[17]. Clearly, a visual inspection indicates more contributors per group in the voluntary adhesion treatment than in the baseline. A χ^2 test to comparison shows a significant increase in the low ($\chi^2 = 153.31$; $p<0.01$) and the medium threshold ($\chi^2 = 67.28$; $p<0.01$). However, the test reveals no significant difference in the high threshold ($\chi^2 = 6.26$; $p=0.18$). We run a regression explaining the number of contributors per group in each period. The regressors are *Voluntary adhesion* and *Period*. Table 8 reports the results of the regression. *Voluntary adhesion* is significant and positive in the low and the medium threshold. Voluntary adhesion increases by two players the number of contributors in the low threshold and by one player in the medium threshold. This increase is not significant for the high threshold. The statistical tests are thus confirmed by the regression. Our conjecture 3 is confirmed for the low and the medium threshold but not for the high threshold.

Figure 4

Percentage of contributors per group (T=15)



[17] See Appendix 2.9. and 2.10. for the medium threshold and 11 and 12 the high thresholds.

Table 8

Results from panel data regressions explaining the number of contributors per group for each level of threshold [(a)]

Regressors	**T=15**	**T=30**	**T=60**
Intercept	2.03 (*)	2.88 (*)	3.61
	(8.93)	(10.84)	(7.26)
Voluntary adhesion	2.00 (*)	1.06 (*)	--
	(8.93)	(3.77)	
Period	-0.02 (*)	0.02 (*)	-0.12 (*)
	(-4.56)	(-2.72)	(-5.00)
Log likelihood	-217. 71	-369.99	-175.43
Number of observation	350	275	200
Number of groups	14	11	8
Time periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a) : T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

Is this increase of the number of contributors is accompanied by a decrease of cheap riding[18]? To answer this question we first compare the individual contribution in the baseline and the voluntary adhesion treatment. Then, we compare strictly positive contributed amounts between the two treatments; that is we drop from the observations free riders in the baseline and subjects who excluded themselves in the voluntary adhesion treatment.

The U test shows that subjects contribute significantly more in the voluntary adhesion treatment than in the baseline treatment when consider positive amounts. We observe this

[18] See appendix 2.13. for the quantiles of individual contributions.

increase for the low (U=-12.63 ; p<0.01) and the medium threshold (U=-5.23 ; p<0.01) but not for the high threshold where there is no significant difference (U=0.95 ; p=0.33). When we consider strictly positive amounts, we find that individuals contribute significantly more in the baseline than in the voluntary adhesion treatment. (Low U =5.13 ; p<0.01) and medium U=4.88 ; p<0.01) In the baseline treatment, a few generous individuals provide the public good whereas in the voluntary adhesion treatment all the subjects provides the club good but with less effort. We report in Table 10 the results of the regression.[19] We explain individual contribution by the regressors *Voluntary adhesion* and *Period*. Table 9 indicates that voluntary adhesion decreases individual contribution by 1.30 tokens in the low threshold, and 1.69 tokens in the medium threshold. It does not have an effect in the high threshold as the U-test already indicated. This result suggests that the increase of the number of contributors is accompanied by a decrease of individual contributions. Subjects seem to coordinate better in the voluntary adhesion treatment.

[19] The number of the remaining observations is reported at the bottom of the table.

Table 9

Results from panel data regression explaining individual contribution for each level of threshold [(a)]

Regressors	T=15		T=30		T=60	
	Contribution	*Cheap_[(b)]*	*Contribution*	*Cheap_[(b)]*	*Contribution*	*Cheap_[(b)]*
Intercept	4.56 (*)	8.91 (*)	9.09(*)	10.58(*)	14.22(*)	14.57(*)
	(18.92)	(21.00)	(17.83)	(36.35)	(13.79)	(86.76)
Voluntary adhesion	2.89 (*)	- 1.30 (*)	1.84 (*)	-1.69 (**)	-3.63(*)	-1.36(*)
	(14.06)	(-3.18)	(3.99)	(-6.59)	(-3.82)	(-6.00)
Period	-0.17 (*)	-0.15 (*)	-0.21(*)	-0.04 (*)	-0.45(*)	0.04(*)
	(-12.82)	(-8.79)	(-7.41)	(-2.13)	(-7.60)	(3.04)
Log likelihood	-4029	-2949	-3199	-2368	-2293	-1202
Number of observation	1400	989	1100	799	800	433
Number of subjects	56	53	44	44	32	29
Time periods	25	25	25	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant;(a) : T-statistics are in parentheses; (b) : Strictly positive contributions (Free riders and auto-excluded subjects are dropped in each period) ; Regressions are corrected for heteroskedasticity and autocorrelation.

Result 5: Voluntary adhesion decreases weakly the variance of group contributions.

Do voluntary adhesion affects the variance of group contributions? Let G_{jt} denotes the group contributions. It depends on the group j 1,..,J and on the period t 1,…,T. Equation 2 represents the total variance of group contributions.

$$\sigma_G^2 = \sum_{j=1}^{J} \sum_{t=1}^{T} (G_{jt} - \overline{G}_{jt})^2 \qquad (2)$$

Equation 2 can be broken down as follow:

$$\sigma_G^2 = \sum_{t=1}^{T} \sum_{j=1}^{J} (G_{jt} - \overline{G}_{..})^2 = J \sum_{t=1}^{T} (G_{.t} - \overline{G}_{..})^2 + \sum_{j=1}^{J} \sum_{t=1}^{T} (G_{jt} - \overline{G}_{.t})^2 \qquad (3)$$

The total variance of group contributions is composed by intertemporal variance and intratemporal variance[20]. The first term of the equation 3 represents intertemporal variance. It is the variance of group contributions between periods. It yields 25 observations per treatment. The second one stands for intratemporal variance. It is the variance of group contributions for each period and for each group. It yields 150 observations per treatment (for a treatment with 6 groups).

To compare the intertemporal variance between the baseline and the voluntary adhesion treatment, we run a U test. It shows that voluntary adhesion does not affect the intertemporel variance of group contributions for the low (U=-0.98 ; p=0.32) and the medium threshold (U=-0.99 ; p=0.31). However, it decreases intertemporal variance of the high threshold (U=2.94; p<0.01). We do not have sufficient observations to run a panel data regression in order to confirm this analysis (only 25 observations). In the second case, - intratemporal group contributions variance – the U test shows that it is significant only for the medium

[20] Total variance can also be break down to intragroup variance and intergroup variance. See Sevestre (2002) for further discussion.

threshold (U=3.72; p<0.01). For the low (U= 1.54; p=0.12) and the high threshold (U=0.06; p=0.94) intratemporal variance does not vary. Then, we run a panel data regression with a dependent variable equal to the squared difference between the group contributions for each period and the total average group contributions[21]. The regressors are *Voluntary adhesion* and *Period.* Table 10 reports the results. *Voluntary adhesion* is negative and significant for the medium threshold and not significant for the low and the high threshold. Thus, the regression confirms the results of the statistical test. On the whole, voluntary adhesion affects the variance of group contributions only for the medium and the high threshold: it decreases the intertemporal variance of the high threshold and the intratemporal variance of the medium threshold. But it does not decrease the total variance of group contributions in any threhsold.

[21] Total average group contributions = $\frac{\sum_{t=1}^{T}\sum_{j=1}^{J} G_{jt}}{JT}$; t stands for the number of periods t=1,…,T and j for the number of groups per treatment j=1,…,J.

Table 10

Results from panel data regression explaining the intratemporal variance of group contributions for each level of threshold [(a)]

Regressors	**T=15**	**T=30**	**T=60**
Intercept	325.12 (*)	142.89 (*)	--
	(7.18)	(3.25)	
Voluntary adhesion	--	-101.65 (*)	--
		(-2.64)	
Period	-10.09 (*)	6.24 (*)	19.23
	(-4.59)	(2.68)	(2.33)
Log likelihood	-2143	-1817	-1376
Number of observation	350	275	200
Number of groups	14	11	8
Time periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a): T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

Result 6: Voluntary adhesion raises the asymptotic group contributions in the low and the medium threshold.

We aim to examine the convergence of group contributions. Do group contributions in the baseline treatment converge to the same level of group contributions in the voluntary adhesion treatment ? Do group contributions converge to the Nash equilibrium ? We carry out the following regression (Equation 4). It is inspired from Camera et al. (2003). We explain group contributions G_{jt} (the dependent variable) by an inverse function of time *1/t* (the regressor) where *j* stands for groups of players, *t* for time u_j for the group effect and ε_{jt} for the error term.

$$G_{jt} = G_{\infty} + G_0 \frac{1}{t} + u_j + \varepsilon_{jt} \qquad (4)$$

where $j = 1, 2, .., J$ and $t = 1, 2, .., 25$

As *t* becomes large, *1/t* gets negligible. Thus, the intercept, $G\infty$ represents the asymptotic group contributions. At the opposite, $G\infty + G_0$ represents the group contributions at the initial period. We report in Table 11 the results of the regression. Clearly, all the intercepts are different indicating a different level of asymptotic group contributions between the public good and the club good. Table 11 also points out a higher intercept for the voluntary adhesion treatment in the low (+6.84 tokens) and the medium threshold (+8.15 tokens) but a lower one for the high threshold (-2.08 tokens). Finally, the regression indicates that none of the treatments converge toward the Nash equilibrium except for the medium threshold in the voluntary adhesion treatment.

We further our analysis by examining more specifically convergence toward the threshold. We conducted a similar analysis to that of Marks and Croson (1998). We calculate the squared distance of the threshold of each group for each period. It is our dependant variable. We explain this difference by a non-linear function of time *Period* + *Period_squared*. A negative significant coefficient of the regressor *Period* means the existence of a convergence to the threshold while a significant positive sign means the existence of a divergence from the

threshold. In addition, a significant coefficient of *Period_squared* means that the convergence/divergence is non linear. Table 12 outlines the result of the regression per treatment. *Period* is significant for all the voluntary adhesion treatments. It is negative for the low and the medium threshold - indicating a convergence to the Nash equilbrium - and positive for the high threshold –indicating a divergence-. *Period_square* is positive meaning that the convergence slows over time. The divergence is linear since *Period_square* is not significant. For the baseline treatment, all the regressors *Period* are not significant. Group contributions do not significantly converge to the threshold.[22]

[22] We run the same convergence analysis toward 0 (the Pareto dominated Nash equilibrium) for the high threshold. We find that in both treatments, convergence toward 0 is significant for the high threshold. This is consistent with the divergence from the threshold pointed out in Table 11.

Table 11

Results from panel data regression explaining asymptotic group contributions for each treatment [a]

Regressors	T=15		T=30		T=60	
	Baseline	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*
Intercept	12.80(*)	19.64 (*)	22.00(*)	30.15(*)	29.64(*)	27.56 (*)
	(2.30)	(17.05)	(7.45)	(21.39)	(2.63)	(2,79)
Period_inverse	15.49(**)	15,11 (*)	13.01(**)	23.09 (*)	--	12.87(***)
	(2.64)	(4.18)	(2.07)	(3.89)		(1,74)
Log likelihood	6.5%[c]	-662	-564	-491	6.2%[c]	4.1%
Number of observation	150	200	150	125	100	100
Number of groups	6	8	6	5	4	4
Time periods	25	25	25	25	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant ; (a) : T-statistics are in parentheses (b) $G_{jt}=G_{\infty}+G_{0^*}\left(\frac{1}{t}\right)+u_j+\varepsilon_{jt}$ where j=1,2,..,J and t=1,2,..,25 ; (c) R2 overall GLS regressions; Regressions are corrected for heteroskedasticity and autocorrelation.

Table 12

Results from panel data regression explaining threshold convergence for each treatment [(a)]

Regressors	T=15		T=30		T=60	
	Baseline	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*
Intercept	--	580.13 (*)	234.73(***)	281.37(*)	709.14(**)	--
		(5.08)	(1.95)	(2.97)	(2.07)	
Period	--	-59.52 (*)	--	-46.49 (*)	--	282.19(**)
		(-3.12)		(-2.86)		(2.10)
Period square	--	1.67 (**)	1.62 (**)	2.19 (*)	--	-7.95(***)
		(2.40)	(2,11)	(3.68)		(-1.68)
Log likelihood	--	-1349	-1024	-713	-1487	-764
Number of observation	150	200	150	125	100	100
Number of groups	6	8	6	5	4	4
Time periods	25	25	25	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a): T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

6 Discussion

We aim in this section to support that the reduction of the strategic uncertainty by voluntary adhesion is the origin of the higher effective results observed in the voluntary adhesion treatment.

Our experiment reveals that voluntary adhesion improves success of provision, group contributions and welfare in the low and the medium threshold. However, in the high threshold, there is no difference between the baseline and the voluntary adhesion treatment. Conjecture 3 states that when all subjects of the group decide to adhere to the club i.e. 4 tokens contributed, subjects are guaranteed that at least 26.66% of the Nash equilibrium will be provided in the low threshold, 13.33% in the medium threshold and 6.66% in the high threshold. As a consequence, it is in the lowest threshold that the voluntary adhesion reduces the maximum strategic uncertainty. This is consistent with our findings: The most effective results are observed first with the low threshold, then with the medium threshold and finally with the high threshold.

To support our hypothesis we ran another experiment where we stressed the reduction of the strategic uncertainty: we imposed a minimum contribution level (10 tokens) to benefit of the club good in the high threshold setting (Recall in the high threshold the baseline and the voluntary adhesion get the same results). Now, subjects need to add “only” 5 tokens to reach the symmetrical equilibrium whereas they previously needed 14 tokens. The same experimental design is replicated. Figure 5 depicts the average group contributions over time. Clearly, a visual inspection shows that voluntary adhesion with a minimum level of 10 tokens increases the level of group contributions. We perform the same panel data regression as previously to examine group contributions, success of provision and welfare. The output is reported in the Table 13. *Voluntary adhesion* is positive and significant confirming statistically the visual inspection of the figure. The voluntary adhesion treatment does increase the group contributions, the success of provision in the high threshold. Hence, manipulating the minimum contribution parameter permits us to vary the strategic level of uncertainty of the game and to support our hypothesis.

Figure 5

Average group contributions (T=60)

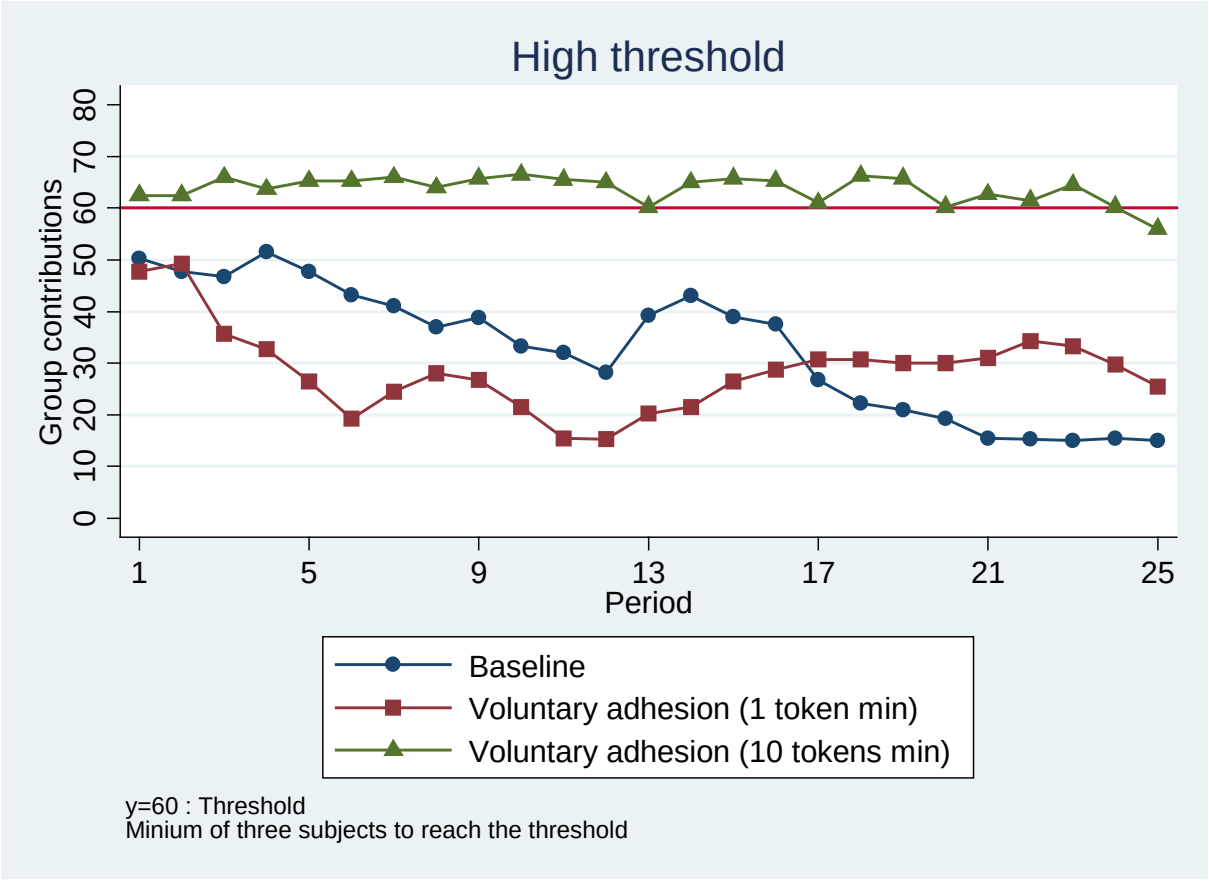


Table 13

Results from panel data regressions explaining group contributions, success of provision and welfare for the high threshold (with minimum contribution) [(a)]

Regressors	**Group contributions**	**Success of provision [(b)]**	**Welfare**
Intercept	35.42 (*)	--	22.05 (*)
	(9.22)		(33.29)
Voluntary adhesion [(c)]	35.21 (*)	2.06 (*)	10.73 (*)
	(9.22)	(6.06)	(16.57)
Period	-0.49 (*)	--	--
	(-3.50)		
Log likelihood	-652	-111	- 2965
Number of observation	200	200	200
Number of groups	8	8	8
Time periods	25	25	25

(*): Significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a): T-statistics are in parentheses (b): Logit regression ; (c) dummy variable taking value 1 for the voluntary adhesion treatment. ; Regressions are corrected for heteroskedasticity and autocorrelation.

Conclusion

Club goods are characterized by voluntarism. An individual has the option to exclude himself from the provision of the club. Club goods are also characterized by their size. It fails to exist when there are not enough members or contributions, and, above this critical size, the club can improve its services or capacity. In this work, we investigate voluntary adhesion through the size issue by introducing a step-level mechanism. Our setting permits us to examine voluntary adhesion within two coordination games. We compare three levels of threshold, each time with and without voluntary adhesion.

Our experiment reveals that voluntary adhesion significantly increases group contributions, success of provision and welfare (except for the high threshold). Besides, our findings are consistent with the theoretical prediction; voluntary adhesion does increase the number of contributors. The use of step-level goods raises the additional issue of "cheap riding." *–i.e.* the implicit cost-sharing rule in reaching the provision point-. Our experiment shows that voluntary adhesion reduces cheap riding; while in the baseline treatment a few generous subjects contribute the bulk of the group contributions, in the voluntary adhesion treatment the effort to provide the threshold is more fairly distributed among the subjects. Finally, the experiment reveals that group contributions sustain longer in time in the voluntary adhesion treatment than in the baseline treatment. In particular, group contributions in the voluntary adhesion treatment of the medium threshold converge to the Nash equilibrium.

A possible explanation to our result is the decrease of the strategic uncertainty by voluntary adhesion. Voluntary adhesion guarantees the achievement of a percentage of the Nash equilibrium when members decide to adhere to the club. This percentage is maximal when the threshold is low (26.66% of the provision of the Nash equilibrium). The most effective results are observed for this setting. Imposing a minimum level of contribution to stress the reduction of the strategic uncertainty (66.66% of the provision of the Nash equilibrium) confirms our hypothesis. It raises the success rate of provision in the high threshold from 30.0% to 83.0%. Voluntary adhesion is an incentive to decrease the coordination failure.

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Appendix

Appendix 2.1.

Variation of the success rate with respect to the threshold level

Appendix 2.2.

Group contributions (T=15)

Appendix 2.3.

Average group contributions (T=15)

Appendix 2.4.

Group contributions (T=30)

Appendix 2.5.

Median group contributions (T=30)

Appendix 2.6.

Group contributions (T=60)

Appendix 2.7.

Median group contributions (T=60)

Appendix 2.8.

Number of contributors per group over time (T=15)

Appendix 2.9.

Number of contributors per group over time (T=30)

Appendix 2.10.

Percentage of contributors per group (T=30)

Appendix 2.11.

Number of contributors per group over time (T=60)

Appendix 2.12.

Percentage of contributors per group (T=60)

Appendix 2.13.

The instructions. (Voluntary adhesion treatment, medium threshold)

Appendix 2.1.: Variation of the success rate with respect to the threshold level

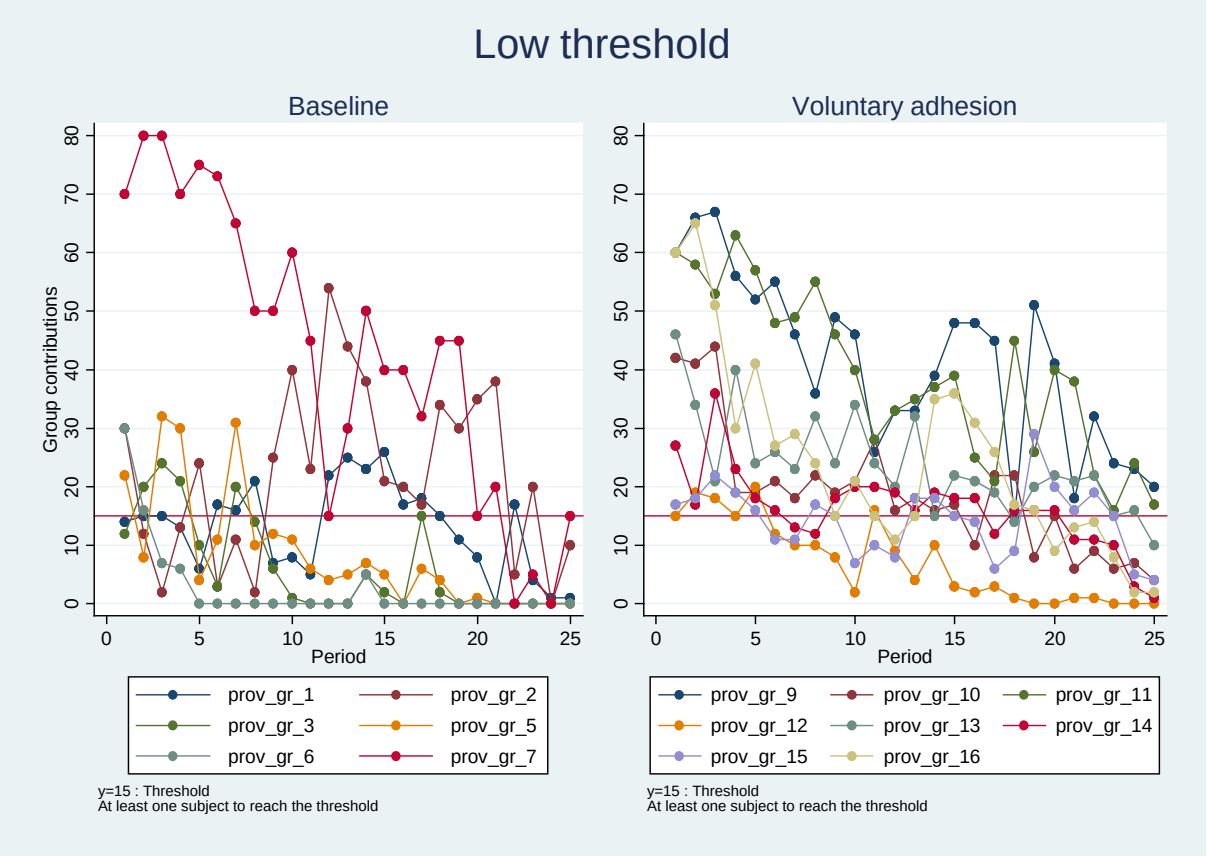
We examine the variation of the success rate with respect to the level of the threshold. We conduct the same analysis than for the group contributions but with a χ^2 test and a logit regression – the success of provision is a binary variable-. The χ^2 test shows that the success rate does not vary in the baseline treatment. The decrease in the success rate from 41.3% (the low threshold) to 39.7% (medium threshold) is not significant. (χ^2 =0.07; p=0,77) and also from 39.7% to 39.0% (high threshold) is not significant (χ^2 =0,01 ; p=0,90). For the voluntary adhesion treatment, the decrease of the success rate from the low (73.5%) to the medium threshold (67.7%) is not significant (χ^2 =1.24; p=0.26). However, the decrease from the medium (67.7%) to the high threshold (30.0%) is significant (χ^2 =31.55; p<0.01). The results of the regression are reported in the Table below. The decrease of the success of provision from the low to the medium threshold is not significant in both treatments. The decrease of the success of provision from the high to the medium is not significant in the baseline but it is significant in the voluntary adhesion treatment. The regression confirms the statistical results test. In the baseline treatment the success rate does not vary with respect to the threshold. In the voluntary adhesion treatment, it does vary only for the high threshold.

Results from panel data regression explaining success of provision for the pooled sample (Low + Medium + High threshold) [(a)]

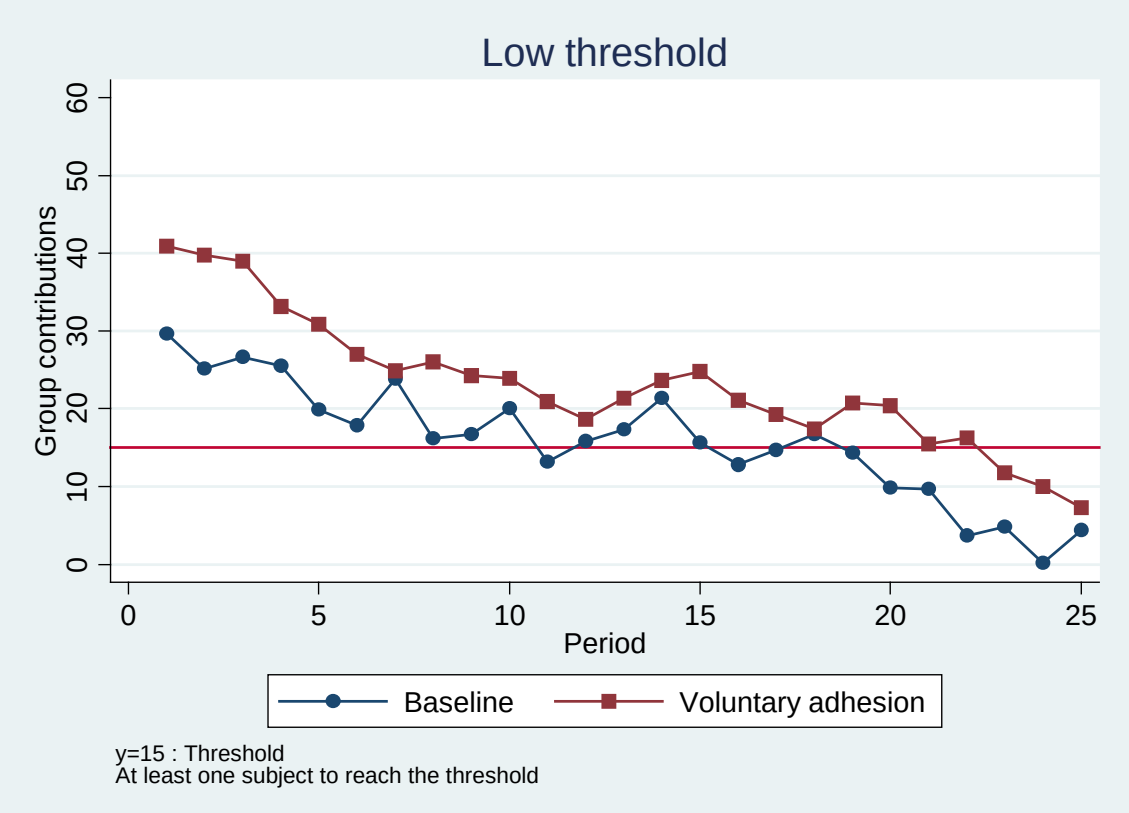
Regressors	**Baseline**	**Voluntary adhesion**
Intercept	--	3.13 (*)
		(4.30)
Threshold_med[(b)]	--	--
Threshold_high[(b)]	--	-3.56(*)
		(-3.17)
Period	- 0.08 (*)	-0.90 (*)
	(-4.79)	(-5.21)
Log likelihood	-211	-1466
Number of observation	400	425
Number of groups	16	17
Time periods	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant; (a) T-statistics are in parentheses. (b) The low threshold dummy variable is dropped ; Regressions are corrected for heteroskedasticity and autocorrelation.

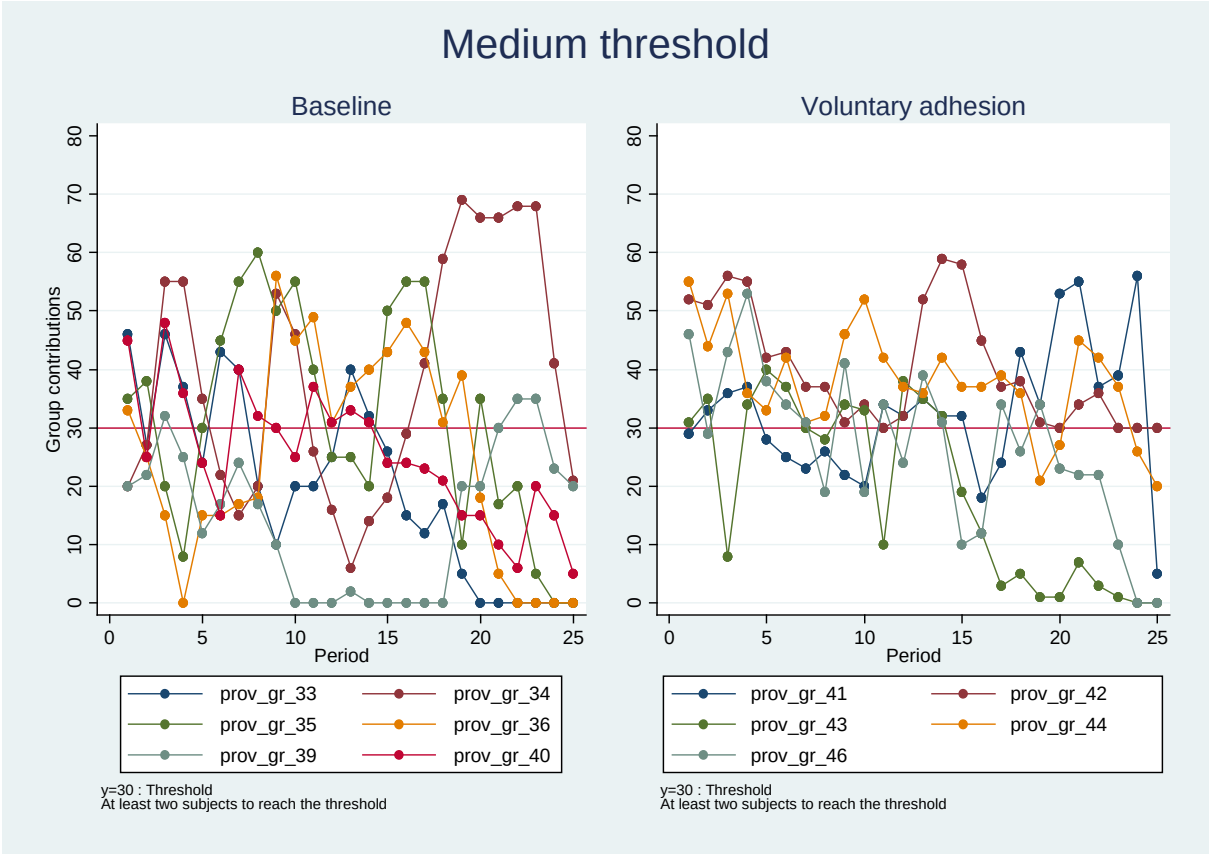
Appendix 2.2.: Group contributions (T=15)



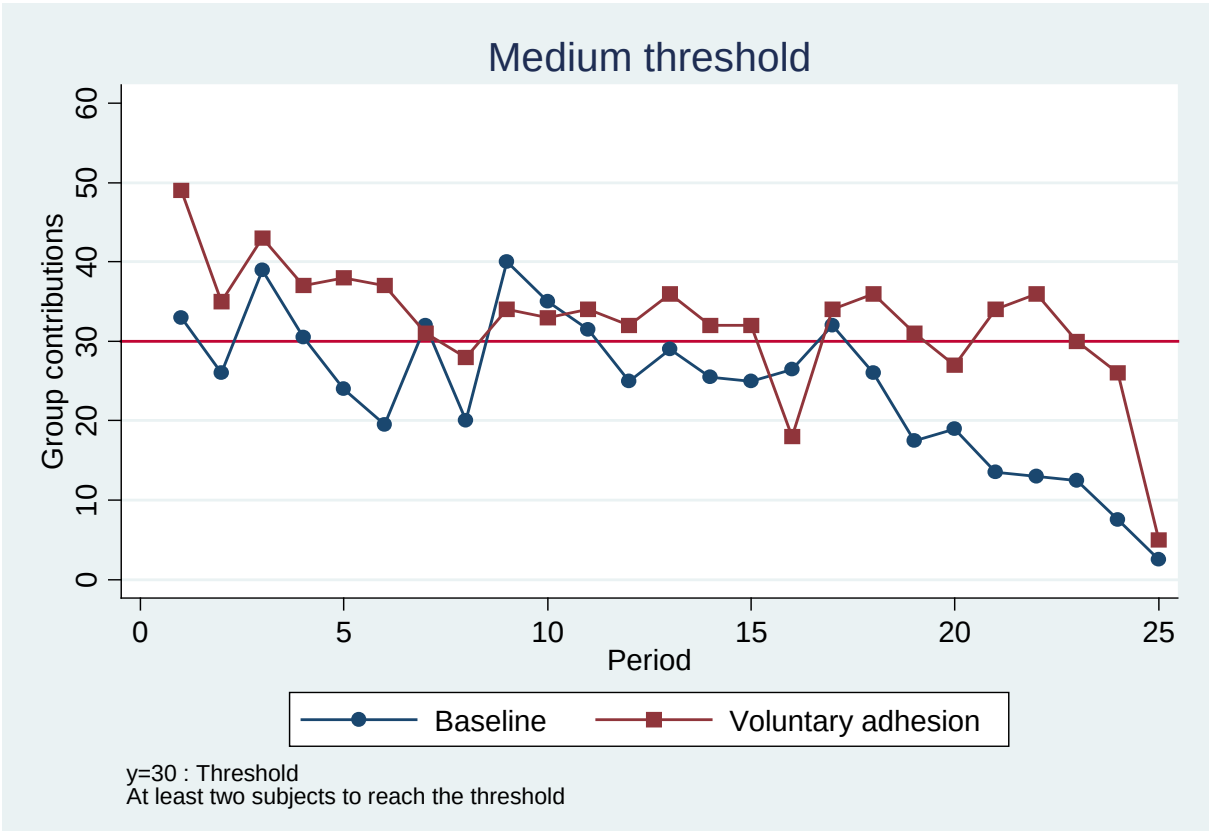
Appendix 2.3.: Average group contributions (T=15)



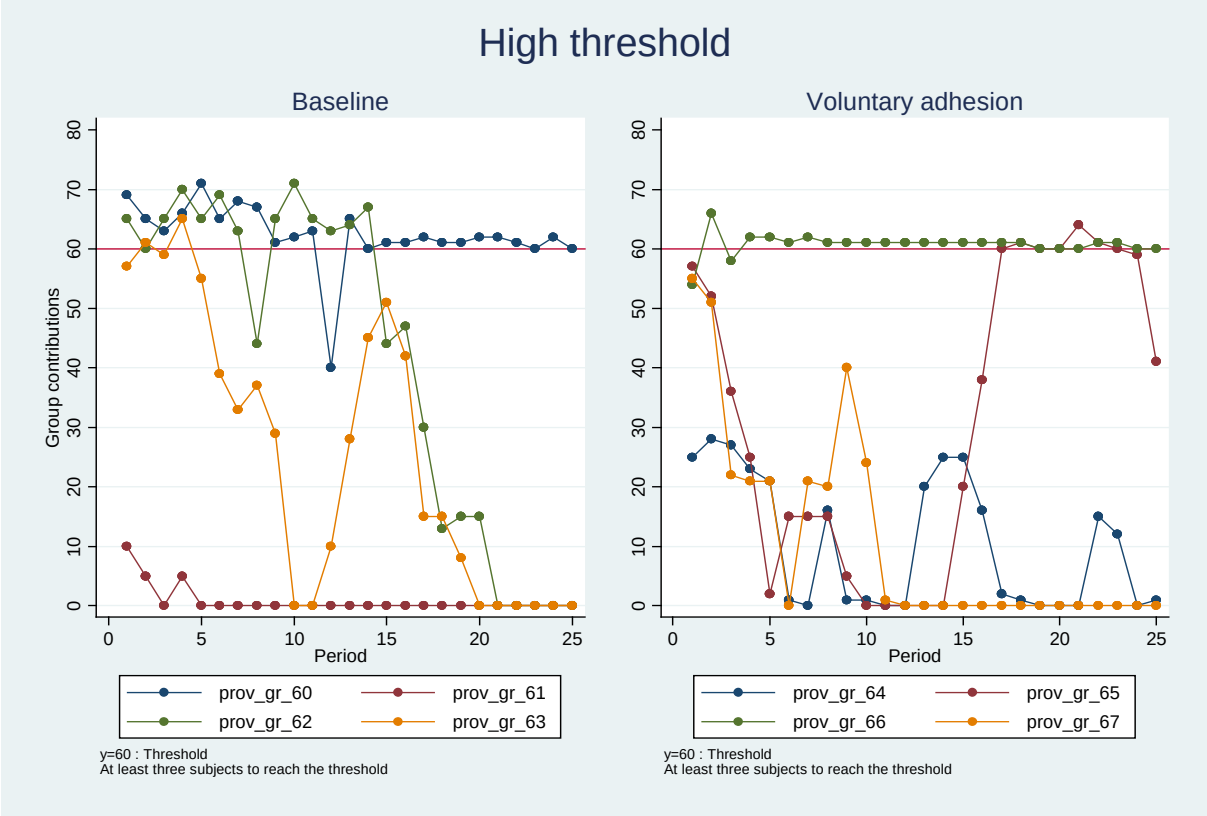
Appendix 2.4.: Group contributions (T=30)



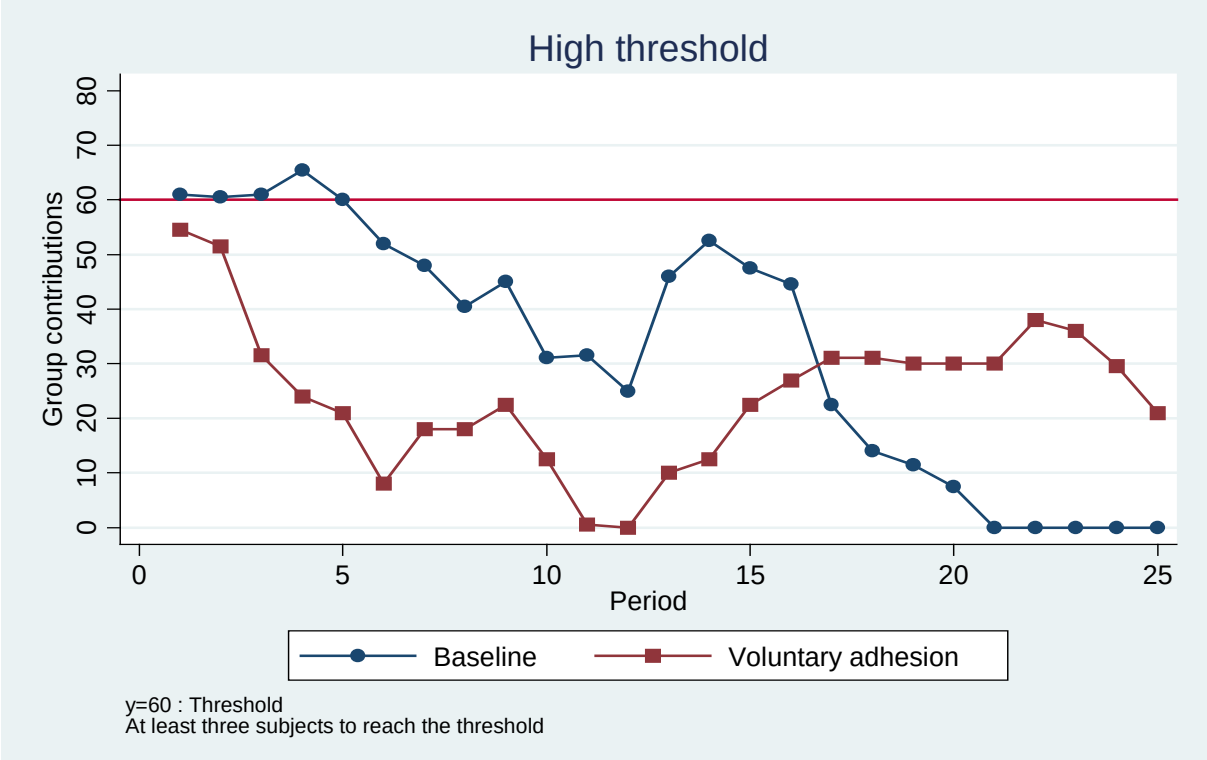
Appendix 2.5. : Median group contributions (T=30)



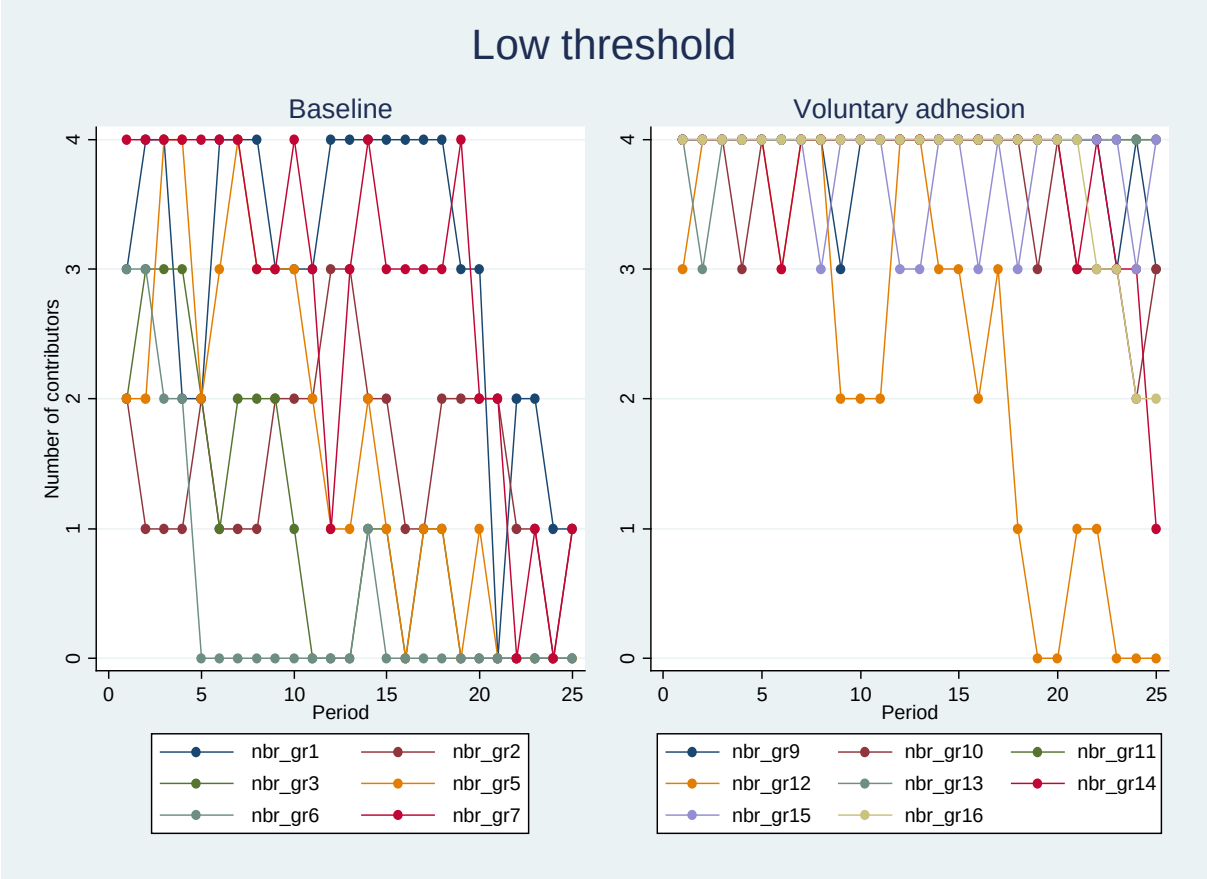
Appendix 2.6.: Group contributions (T=60)



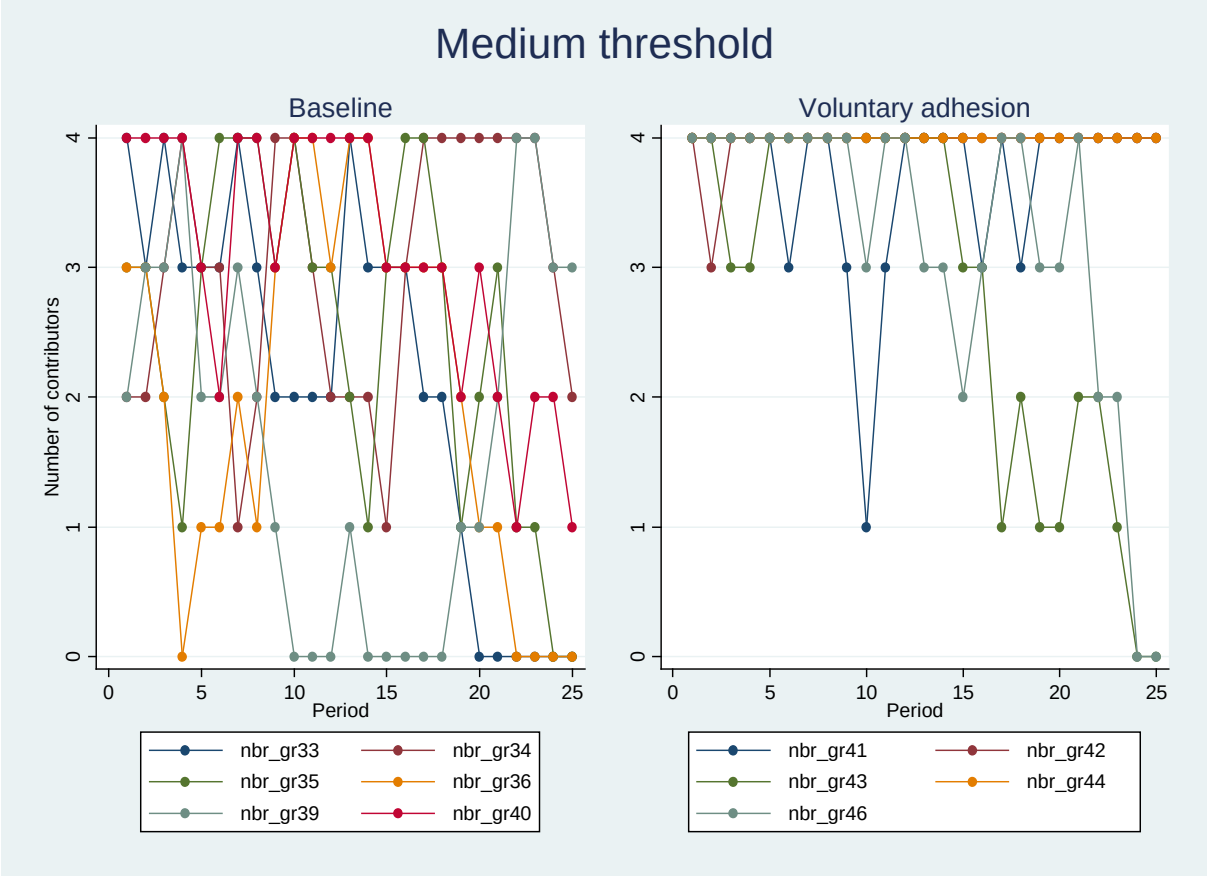
Appendix 2.7.: Median group contributions (T=60)



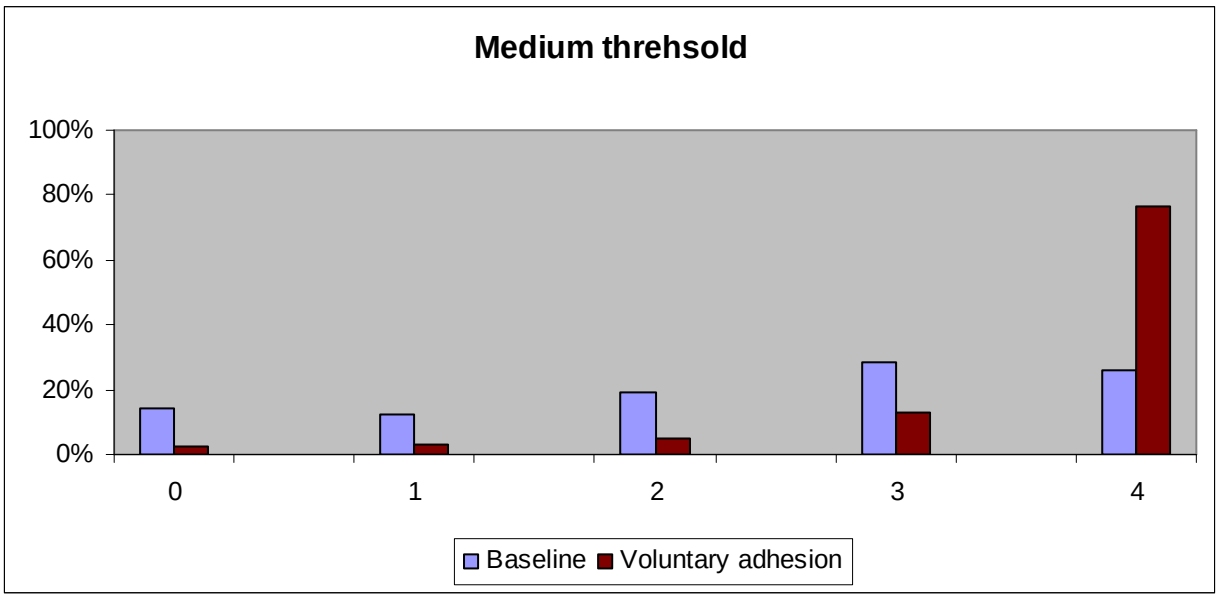
Appendix 2.8.: Number of contributors per group over time (T=15)



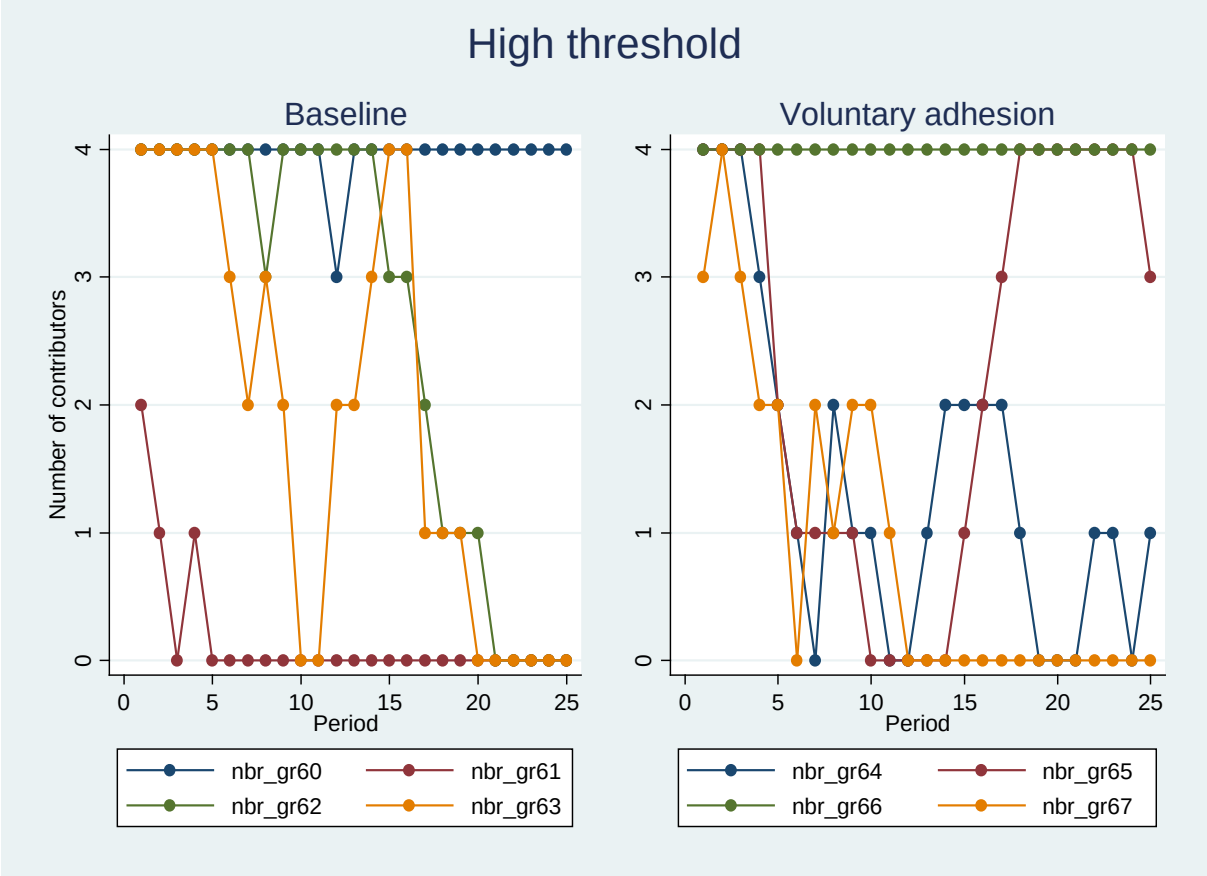
Appendix 2.9.: Number of contributors per group over time (T=30)



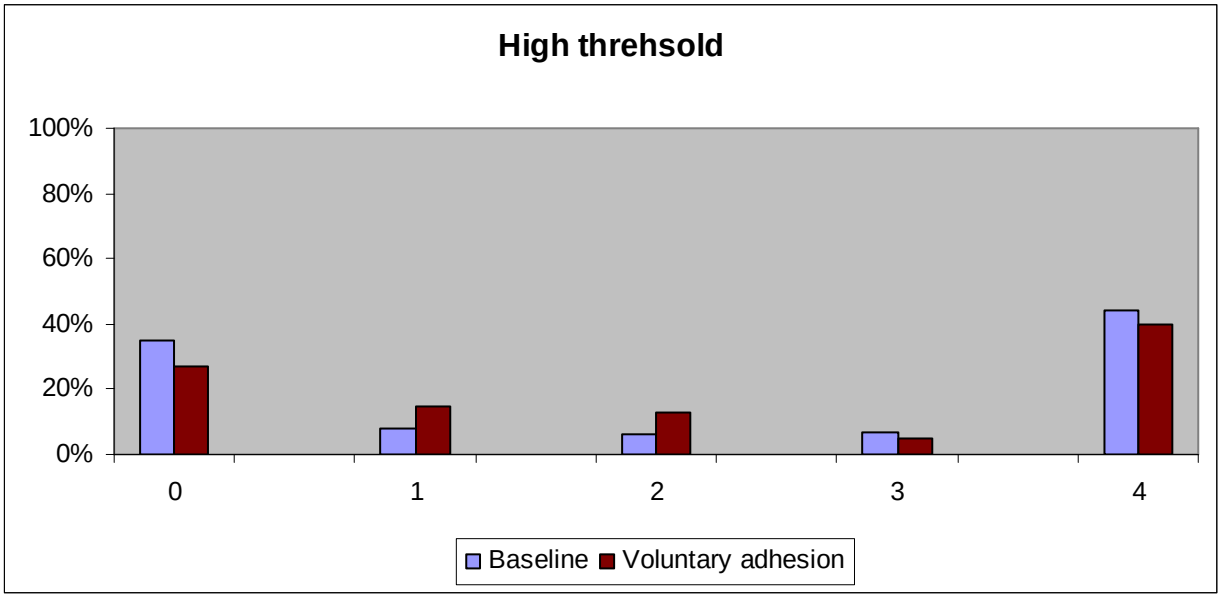
Appendix 2.10.: Percentage of contributors per group (T=30)



Appendix 2.11.: Number of contributors per group over time (T=60)



Appendix 2.12.: Percentage of contributors per group (T=60)



Appendix 2.14.: The instructions (Voluntary adhesion treatment, Medium threshold)

INSTRUCTIONS

Bienvenue

L'expérience à laquelle vous allez participer est destinée à l'étude des décisions. Vous allez être confrontés à une décision de répartition de jetons entre deux comptes : un compte individuel et un compte collectif. Les instructions sont simples. Si vous les suivez scrupuleusement et que vous prenez de bonnes décisions de placement, vous pourrez gagner une somme d'argent non négligeable. Toutes vos réponses seront traitées de façon anonyme et seront recueillies au travers d'un réseau informatique. Vous indiquerez vos choix à l'ordinateur devant lequel vous êtes assis et celui-ci vous communiquera vos gains réalisés au fur et à mesure du déroulement de l'expérience.

La somme totale d'argent gagnée pendant l'expérience vous sera versée, en liquide, à la fin de celle-ci.

CADRE GENERAL DE L'EXPERIENCE

16 personnes participent à cette expérience. **Vous êtes membre d'un groupe constitué de 4 personnes choisies au hasard parmi les 16 personnes présentes dans la salle. La composition de votre groupe restera la même tout au long de l'expérience.** Vous ne pouvez pas connaître l'identité des personnes faisant partie de votre groupe parmi celles présentes dans la salle.

Les gains que vous réaliserez dépendront à la fois des décisions que vous prendrez et des décisions prises par les 3 autres membres qui composent votre groupe. Chaque décision de placement que vous prendrez se traduira par un gain en points plus ou moins important. Ce gain en points sera converti, à la fin de l'expérience, en Euros. La procédure de conversion des points en euros est détaillée à la fin des instructions.

La suite des instructions va vous permettre de comprendre de quelle manière vos gains sont calculés.

LES TYPES DE PLACEMENT

L'expérience comporte **25 périodes**. Au début de chaque période, chaque membre de votre groupe est doté d'un budget de 20 jetons. A chaque période vous, ainsi que les 3 autres membres de votre groupe, serez amenés à répartir votre budget entre 2 types de comptes possibles: votre compte individuel et votre compte collectif.

1. Règles du compte individuel :

Chaque jeton que vous placez dans votre compte individuel vous rapporte 1 point. De même, si un membre de votre groupe place un jeton dans son compte individuel, il lui rapportera 1 point.

Les gains des autres membres du groupe ne sont pas affectés par le nombre de jetons que vous décidez de placer dans votre compte individuel. De même votre gain n'est pas affecté par le nombre de jetons placés par les autres membres du groupe dans leur propre compte individuel. Illustrons cela au moyen de 3 exemples:

1- Quelles que soient les décisions de placement des autres membres du groupe, si vous placez 5 jetons dans votre compte individuel, votre gain résultant de cette décision sera de 5 points. Les gains des autres membres du groupe ne seront pas affectés par votre décision.

2- Supposons que l'un des membres du groupe décide de placer 10 jetons dans son compte individuel, quelle que soit votre décision de placement, son gain résultant de cette décision sera de 10 points; votre gain ne sera pas affecté par cette décision.

3- Votre budget = 20 jetons
Votre placement individuel = 6 jetons
Votre compte individuel vous rapporte = $1 \times 6 = 6$ points

Au gain de votre placement individuel s'ajoute le gain résultant du placement collectif. La manière dont est déterminé le gain du placement collectif fait l'objet de la suite des instructions.

2- Règles du compte collectif :

Il existe un seul compte collectif pour tout le groupe. Le gain que vous réalisez dépend du nombre total de jetons que vous et les autres membres du groupe placent dans ce compte. Plus le groupe place de jetons dans le compte collectif, plus les gains réalisés par chacun seront importants (*Cf.* page annexe : Tableau des gains). En effet, chaque jeton placé dans le compte collectif rapporte 0,5 points à chaque membre du groupe.

Cependant, vous toucherez un gain du compte collectif si et seulement si les deux conditions suivantes sont satisfaites :

i. Vous devez avoir effectué un placement collectif positif. Si votre placement collectif est nul (0 jeton) votre gain du compte collectif sera nul (0 point) quel que soit le placement collectif des autres membres de votre groupe.
ii. Le placement collectif total du groupe doit être supérieur ou égal à 30 jetons. Si le placement collectif des 4 joueurs du groupe est inférieur à 30 jetons, le compte collectif rapporte à chaque joueur 0 point.

Par conséquent, pour que le compte collectif rapporte des gains il faut être au moins deux à y placer des jetons (votre budget est de 20 jetons < 30). Si vous êtes le seul à placer dans le compte collectif, vous ne pouvez pas réaliser un gain et ce même lorsque vous placiez dans le compte collectif la totalité de votre budget.

Illustrons les règles du placement collectif au moyen de trois exemples:

Exemple 1 : Calcul de vos gains lorsque le seuil de 30 jetons est atteint

Votre budget étant de 20 jetons, vous décidez de placer 12 jetons dans votre compte individuel et 8 jetons dans le compte collectif. Supposons que les trois autres joueurs de votre groupe choisissent de placer en totalité 25 jetons dans le compte collectif.

Votre compte individuel vous rapporte = $1 \times 12 = 12$ points

Le compte collectif vous rapporte = 0,5 × (8+25) = 16,5 points

De même, le gain du compte collectif pour les membres de votre groupe ayant placé plus que 0 jeton est égal à 16,5 points.

Votre gain total de la période = 12 + 16,5 = 28,5 points.

Exemple 2 : Calcul de vos gains lorsque le seuil de 30 jetons n'est pas atteint

Votre budget étant de 20 jetons, vous décidez de placer 10 jetons dans votre compte individuel et 10 jetons dans votre compte collectif. Supposons que les trois autres joueurs de votre groupe choisissent de placer en totalité 8 jetons dans le compte collectif.

Votre compte individuel vous rapporte = 10 × 1 = 10 points

Le compte collectif vous rapporte = 0,5 × (8+10) = 0 point car le placement collectif total, 18 jetons, est inférieur à 30 (vos 10 jetons plus les 8 jetons des trois autres joueurs).

De même, le gain du compte collectif pour les membres de votre groupe ayant placé plus que 0 jeton est égal à 0 point.

Votre gain total de la période = 10 points.

Exemple 3 : Calcul de vos gains lorsque le seuil de 30 jetons est atteint et vous avez placé 0 jeton dans le compte collectif :

Votre budget étant de 20 jetons, vous décidez de placer 20 jetons dans votre compte individuel et 0 jeton dans votre compte collectif. Supposons que les trois autres joueurs de votre groupe choisissent de placer en totalité 30 jetons dans le compte collectif.

Votre compte individuel vous rapporte = 1× 20 = 20 points

Le compte collectif vous rapporte = 0 point

Le gain pour chacun des autres membres de votre groupe ayant placé dans le compte collectif est égal à : 0,5× (0 + 30) = 15 points

Votre gain total de la période = 20 + 0 = 20 points.

En résumé, à chaque période, chaque membre de votre groupe (vous inclus) dispose de deux sources de gain: le gain du compte individuel et le gain du compte collectif.

LE DEROULEMENT DE L'EXPRIENCE

A chaque période, vous devrez prendre deux décisions de placements ; plus précisément vous devrez répartir entièrement votre budget de 20 jetons entre votre compte individuel et votre compte collectif. Vous êtes libre quant au choix de cette répartition et vous pouvez, par exemple, décider de placer la totalité des 20 jetons dans votre compte individuel ou vice-versa (placer l'ensemble des 20 jetons dans le compte collectif).

L'ordinateur, à chaque période, vous demandera d'indiquer le nombre de jetons que vous souhaitiez placer dans chacun des comptes. Vous devez placer à chaque période la totalité de votre budget. En d'autres termes, la somme des jetons placés dans le compte individuel et les jetons placés dans le compte collectif doit être égale à votre budget. Notez, que vous n'avez pas la possibilité de reporter une partie ou la totalité de votre budget d'une période à l'autre.

Tous les membres de votre groupe (vous y compris) prendront leur décision de placement simultanément. Dès que tous les membres de votre groupe auront pris leur décision, l'ordinateur calculera votre gain pour la période en cours. L'ordinateur vous communiquera le nombre de points que vous avez obtenus pour chacun des deux placements à la période en cours. **Il vous communiquera également le placement collectif total de votre groupe et ce que vous ayez placé dans le compte collectif ou pas**. Un historique de vos décisions apparaîtra sur votre écran à la fin de chaque période. La période suivante pourra alors démarrer. A chaque nouvelle période vous connaîtrez votre gain cumulé sur l'ensemble des périodes précédentes.

Lorsque la 25ème période sera achevée, l'ordinateur vous communiquera le montant total de vos gains en points réalisés au cours des 25 périodes. Le facteur de conversion est de 0.40 Euro pour 20 points.

Exemple :

Si votre gain cumulé à la fin de l'expérience est de 800 points, votre paiement sera de 16 € en liquide.

Taux de conversion : 20 points = 0.40 Euro

Questionnaire

Encerclez la bonne réponse.

1 - Vous êtes dans un groupe de :

* 2 joueurs + vous * 4 joueurs + vous * 3 joueurs + vous

2- L'expérience

* Dure 25 périodes * Dure 15 périodes

3 - Est-ce que le gain issu de votre compte privé dépend des autres joueurs ?

* Oui, il dépend * Non il ne dépend pas

4 – Si votre placement collectif est nul, pouvez-vous bénéficier des gains du compte collectif ?

* Oui, je peux * Non, je ne peux pas

5- Si le placement collectif total de votre groupe est égal à 20 jetons, pouvez-vous bénéficer des gains du compte collectif si vous avez placé 5 jetons dans le compte collectif ?

* Oui, je bénéficie * Non, je ne bénéficie pas

6- Supposons que vous avez placé 4 jetons dans votre compte collectif. Supposons que le placement collectif total de votre groupe s'élève à 35 jetons. Calculez votre gain <u>total</u> de la période.

35 points - 19 points – 33,5 points

7- Vous décidez de placer tout votre budget dans le compte collectif. Le placement collectif total de votre groupe s'élève à 29 jetons. Calculez votre gain total de la période.

20 points – 0 points – 14.5 points

8- Vous décidez de ne pas placer de jetons dans le compte collectif. Le placement collectif total de votre groupe s'élève à 30 jetons. Calculez votre gain total de la période.

35 points – 20 points – 30 points

Poste N°……

Fiche de renseignement

* Date de naissance : 19…

* Sexe : Masculin / féminin

* Etat civil : célibataire / marié

* Année d'étude : Bac + ….

* Formation : Economie et Gestion / autre (ex : biologie, agronomie, etc) .

* Vous avez déjà participé à une expérience en économie expérimentale : oui / non

Feuille de commentaires

Veuillez préciser vos remarques sur le déroulement de l'expérience ainsi que la stratégie que vous avez suivi(e).

Chapter 3: Provision of club goods with a refund mechanism

1 Introduction

Club goods are characterized by voluntary adhesion. Agents have the possibility to decide whether to adhere or not to the club. Field observations also show that many club goods require a minimum level of contribution in order to be provided (e.g. an association). Above this threshold the club is provided, whereas below this critical size it fails to exist. This step level component allows exploring the size feature of clubs. It also allows in contrast to Swope (2002) the investigation of voluntary adhesion in homogeneous treatments raising the same coordination issue.

Nonetheless, the step-level design is characterized by multiple Nash equilibria (a Pareto dominant equilibrium, the threshold, and a Pareto dominated one with zero contributions). Players have to find out how to coordinate on the threshold even if they risk the loss of their contributions. As a result, when one player anticipates that his group will not reach the required level of contributions, he is better off not contributing. The higher the threshold the greater is the risk of loss and therefore the deviation to the Pareto dominated equilibrium. This issue was first raised by Isaac *et al.* (1989) and identified as the assurance problem. Actually, the experimental design used to study voluntary adhesion in the experiment of Chapter 2 combines two different tasks for a subject: firstly the required contribution to reach the

threshold level and secondly, dealing with the assurance problem. Earlier findings showed that ruling out the assurance problem by refunding contributions when the threshold is not met dramatically changes subject's cooperative behaviour (Bagnoli and McKee, 1991; Cadsby and Maynes, 1999; Isaac *et al.*, 1989) It significantly increases contributions and the success of provision. Additionally, theoretical models, also showed that refunding contributions permits an efficient provision of the step level public goods (Bagnoli and Lipman, 1989).

In this chapter, we introduce a Money Back Guarantee mechanism (MBG) in order to isolate the voluntary adhesion effect from the assurance effect. Adding MBG changes the theoretical prediction of the step-level game. The agent is no longer better off when he deviates when the threshold is not met. Aggregate contributions below the threshold become Nash equilibria. Our tested treatment combines MBG and voluntary adhesion. Adding voluntary adhesion to a step-level public good game excludes free riders from vectors of equilibria. The whole group (4 players) always compose the vectors of contributions of Pareto dominant Nash equilibria (there is no equilibrium where one or more players do not adhere). As a consequence the combination of MBG and voluntary adhesion provides a very high level of assurance for players: first, there is no loss in contributing, and second all players make a strictly positive contribution at equilibrium.

Our experimental results reveal that adding voluntary adhesion to a MBG mechanism does not affect group contributions, success of provision and welfare. However, it decreases the variance of group contributions especially when the threshold is high. Also, the voluntary adhesion treatment increases the number of contributors as predicted. It decreases cheap riding in the low threshold.

The rest of the chapter is organized as follows. Section 2 is devoted to the presentation of the theoretical predictions. We describe the experimental design in section 3 and discuss the experimental results in section 4. Section 5 concludes the chapter.

2 Theoretical predictions

We use the same conditions on variables and on parameters as in the model without MBG. Let us denote G the amount of the club good provided, g_i agent i's contribution to the club and w_i his endowment ($w_i>0$). We assume that agent i's utility is linear. Agent i faces an exclusion mechanism, λ_i: if he contributes to the club good ($g_i > 0$) then $\lambda_i = 1$, else $\lambda_i = 0$.

The provision of the club good is bounded to a threshold *T*. Thus, for the club good to be provided the aggregate contributions must reach the threshold T, otherwise *G=0.* Contributions are refunded whenever the threshold is not reached: if $g_i>0$ but $\sum_{i=1}^{n} g_i < T$ agent *i* is refunded, leaving him with a constant utility level $U_i(w_i,0)$. Above the threshold agent *i* faces a social dilemma: the marginal return of the club good β is lower than the marginal return of the private good α_i but $n\beta > \alpha_i$. (where *n* is the number of contributors $0<n<N$). Finally, we consider only the symmetric case in our experiment, i.e. $w_i=w$ and $\alpha_i = \alpha, \forall i \in N$. The model can be rewritten as following:

$$U_i(g_i, G) = \alpha(w - g_i) + \lambda_i \beta G \qquad \text{if } G \geq T$$
$$U_i(g_i, G) = \alpha w \qquad \text{else}$$

$$\text{with } \lambda_i = 1 \text{ if } g_i > 0$$
$$\lambda_i = 0 \text{ if } g_i = 0$$

$$\alpha > \beta \; ; \; n\beta > \alpha$$

Introducing the MBG mechanism leave the Nash equilibrium *G=T unaffected* (with $g_i<\beta T$ and $g_i>0$). However aggregate contributions that are below the threshold become Nash equilibria. The refunding of contributions drops the incentive of unilateral deviation. Agents get the same earning when the threshold is not reached and when they invest their whole endowment in their private account. As a result, players in the MBG setting are more likely to coordinate around the Pareto dominant Nash equilibrium than of players the setting without MBG. Indeed, the best reply to unilateral moves yields another -Pareto dominated -Nash equilibrium. Without the MBG mechanism the best reply jumps to an equilibrium where each agent invests nothing (0,0,0,0). This is enforced in the high threshold treatment because deviation can lead to important losses. We therefore expect a higher increase in the rate of success of provision when MBG is available. Second, cheap riding becomes a weakly dominant strategy. Under no refund cheap riding is not a dominant strategy, because if all players cheap ride, the threshold cannot be attained for sure. With refund it is a weakly dominant strategy to cheap ride, since any token contributed will be refunded if the target level is not reached (which leaves private consumption unchanged). Voluntary adhesion with

MBG has the same consequences as that than without MBG: it eliminates vectors of contribution including free riding. Only cheap riding is permitted in the club good. As a consequence, equilibria are characterized by generalized contribution by all members of the group (all players adhere at equilibrium).

3 Experimental design

We use the same design than in the experiment without MBG (25 periods, groups of size 4, 20 tokens of endowment and $\beta=0.5$). The club good is provided whenever the total amount of group contributions reaches the threshold. The experiment consists of two treatments: a baseline treatment and a treatment with voluntary adhesion. In the baseline treatment, all group members benefit from the collective good whenever it is provided, i.e. even a player who does not contribute. In the voluntary adhesion treatment, only contributors can enjoy the club good. The only difference in the design is the refunding of contributors when the aggregate contributions are lower than the threshold. (See Appendix 3.14 for the instructions).

For both treatments we compare three levels of threshold: a low threshold (15 tokens), a medium threshold (30 tokens) and a high threshold (60 tokens). With the low threshold a single subject can provide[23] the club good. With the medium threshold at least two individuals are required to reach the threshold and with the high threshold three members of the group are required to reach the 60 tokens. In the high threshold, every contributions vectors leading to a total amount of contributions equal to 60 are Nash equilibrium. This is not the case with the medium and the low threshold: A player does not invest more than 15 tokens in order to provide the step-level good in the medium threshold and more than 7 tokens when the threshold is low. Treatments are summarized in table 14.

[23] But it is not a Nash equilibrium.

Table 14

Experimental parameter

Treatment	Threshold		Required contributors (a)	MBG (b)	Number of groups	Step return (c)
Baseline	Low	15	1	Yes	6	2
	Medium	30	2	Yes	6	2
	High	60	3	Yes	6	2
Voluntary adhesion	Low	15	1	Yes	7	2
	Medium	30	2	Yes	3	2
	High	60	3	Yes	7	2

(a) Number of contributors required to reach the threshold ; (b) : Money Back Guarantee ; (c) Benefit /cost = $\frac{n\beta T}{T}$

4 Results

The presentation of the results is divided in to parts; first we compare the baseline treatment ' a public good with refund) to the voluntary adhesion treatment (a club good with refund). Second, we compare the provision of a public good with refund to the provision of a club good without refund. Table 15 shows the general pattern of the results. It depicts by treatment – the baseline and the voluntary adhesion treatment - and for each threshold – low medium and high- the individual and the group level of contribution, the success rate of provision, and the welfare. The success rate of provision, thereafter called success rate, is calculated as the number of times where the club good is provided divided by the total number of periods. The welfare is measured by the final payment of subjects.

4.1 Public good with refund vs. club good with refund

In this subsection, we aim to compare the baseline treatment, public good with refund, to the voluntary adhesion treatment, club good with refund: In *Result 1*, we compare the Nash prediction between the two treatments. In *Result* 2, we compare the level of group

contributions, the success rate and the welfare. In *Result 3*, we compare variance of group contributions and finally in *Result 4* the number of contributors between the two treatments.

Table 15

Descriptive statistics

	Average individual contribution [(a)] (SD)		**Average group contributions (SD)**		**Success rate of provision [(c)]**		**Welfare [(d)] (SD)**	
	Baseline	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*
Low (T=15)	5.94 (4.78)	6.07 (4.00)	23.76 (10.76)	24.31 (9.73)	80.0%	86.2%	635.12 (65.74)	641.92 (57.16)
Medium (T=30)	8.92 (5.63)	9.08 (5.37)	35.69 (13.12)	37.46 (9.58)	69.3%	80.0%	679.08 (79.87)	685.62 (68.04)
High (T=60)	14.80 (4.56)	14.96 (4.52)	58.73 (9.55)	60.47 (5.21)	58.8%	66.8%	548.37 (180.02)	743.85 (90.48)

(a) The symmetrical equilibrium is 3.75 for the low threshold, 7.5 for the medium threshold and 15 tokens for the high threshold

(b) Success rate of provision = Number of times groups reach the threshold / Number of periods

(c) Welfare = Total points accumulated at the end of the experiment. (1 token in the private account = 1 point ; 1 token in the collective account = 0.5 point)

Our statistical analysis follow this scheme: We first compare the baseline and the voluntary adhesion treatment by non-parametric test: a Wilcoxon-Mann-Whitney[24] two-sided test or a χ^2 two-sided test depending on the variable (qualitative or quantitative). Then, we control for the differences between the two treatments with a GLS panel data[25] regression with random effects[26]. The dependent variable is specified each time. When it is a binary variable, e.g. success of provision, we run a logit regression on panel data. Unless reported otherwise, the regressors are a dummy treatment taking value 1 for the voluntary adhesion - 0 for the baseline - and a time variable. They are denoted *Voluntary adhesion* and *Period.* We correct for heteroskedasticity and auto-correlation each time it was detected[27]. We conclude for significant statistically effects when both the non-parametric tests and the panel data regression agree. Finally, the rejection threshold of the null hypothesis is at 5%.

Result 1: When the threshold is high, group contributions are equal to the Nash prediction and players coordinate around the symmetrical equilibrium. When the threshold is medium or low, group contributions are significantly higher than the Nash prediction.

Hereafter, we aim to examine whether the Nash prediction describes group contributions (group contributions equals the threshold, Table 16) and whether subjects opted for the

[24] Throughout the paper, we call the Wilcoxon-Mann-Whitney test U test in the rest of the chapter.

[25] We check the significant presence of individual effects with a Breusch and Pagan LM test before each panel data regression. The test confirms the significant presence of unobserved individual heterogeneity.

[26] Random effects were preferred over fixed effects for two reasons: first, they allow for regressors that do not vary over time (dummy variable) and second, the GLS estimator corrects for multiple observations from a single group of subjects (Greene, 2003)

[27] For all regressions we check for the existence of auto-correlation and heteroskedasticity : If only heteroskedasticity was detected (White test) we correct by running FGLS with a variance covariance matrix of the errors allowing for heteroskedasticity. If only intra-individual autocorrelation was detected (Breusch and Pagan LM test) or inter-individual autocorrelation was detected (Wooldridge test) or both simultaneously, we correct by a GLS random effects regression with a Durban-Watson coefficient. Finally, if both heteroskedasticity and any form of auto-correlation was detected, we correct by running a FGLS with a modified matrix of covariance of the errors allowing for autocorrelation and heteroskedasticity. See for a discussion of hetroskedasticity and autocorrelation under panel data (Baltagi, 1995).

symmetrical equilibrium or not [28]. We run a two-sided T test to perform the analysis. It shows that the group contributions are significantly higher than the Nash equilibrium for the baseline and for the voluntary adhesion treatment in the low and the medium threshold (Low threshold : baseline (t=9.97 ; p<0.01) ;exclusion (t=12.65 ; p-value < 0.01) ; Medium threshold baseline (t=6.18 ; p<0.01) ; exclusion (t=5,09 ; p<0.01). Obviously, players do not coordinate on the symmetrical equilibrium. However, in the high threshold, the Nash prediction is significant for both treatments: the baseline (t=-1.04 ; p=0.29) and the voluntary adhesion. Moreover, players significantly coordinate around the symmetrical equilibrium (t=-1.03 ; p=0.30 for the baseline and t=-0.20 ; p=0.30 for the voluntary adhesion treatment).

Table 16

Percentage of Nash equilibria

	Baseline	Voluntary adhesion
Low (T=15)	5.3%	6.2%
Medium (T=30)	5.3%	4.0%
High (T=60)	15.4%	15.7%

Percentage of Nash equilibria = Number of Nash equilibria / Number of times group contributions reach at least the threshold

Result 2: Voluntary adhesion has no effect on group contribution, success of provision and welfare.

Appendix 3.2., 3.4., and 3.5. depict the evolution of the average group contribution per treatment and per threshold. The visual inspection reveals no differences between the baseline

[28] When group contributions is equal to the Nash equilibrium we run a two sided T test to compare individual contribution to 3.75 tokens in the low threshold, 7.5 tokens in the medium and 15 tokens in the high.

and the voluntary adhesion treatment. The statistical tests also confirm[29] the absence of the significant differences between group contributions in the baseline and in the voluntary adhesion treatments, for the three thresholds (low (U=-0.74 ; p = 0.45), medium (U=-0.86 ; p = 0.38) and high (U=-0.56 ; p = 0.57)).

The success rate of provision does also not differ significantly between the baseline treatment and the voluntary adhesion treatment for the three levels of threshold[30] (χ^2 =2,30 ; p = 0.12, χ^2 =2.87 ; χ^2 = 2.87 ; p = 0.09 and χ^2 =0,03 ; p = 0,84 respectively).

Finally, we compare the welfare between the two treatments. The welfare is measured by the final monetary payment of the subjects. The U test reveals no significant change within the three levels of threshold Low (U=-0,64 ; p=0,54) Medium (U=0,94 ; p=0,49) High (U=0,97 ; p=0,50).[31]

Result 3: Voluntary adhesion decreases the variance of group contributions for the medium and the high threshold.

Figure 6, Appendix 3.1. and Appendix 3.3. depict the evolution of group contributions over time for the three thresholds. A visual inspection shows a decrease in the variance of group

[29] This result is also confirmed by a panel data regression (Appendix 3.11). We conduct a regression explaining group contributions -the dependent variable- by *Voluntary adhesion* and *Period* –the regressors-. Appendix 3.11. reports the results. It indicates that the increase of group contributions is significant in the low and the high threshold at only 10% error level. Therefore, we reject the existence of a significant increase of the group contributions for each threshold level.

[30] This result is also confirmed by a panel data regression (Appendix 3.12.). We perform a logit regression with the binary variable success of provision as the dependent variable. The regressors are *Voluntary adhesion* and *Period*. Appendix 3.12. reports the results. The logit regression indicates that the increase of the success of provision is not significant in the low and the high threshold. However, the regression reveals that the increase of success is significant for the medium threshold at 5% level. Thus, the statistical U test and the regression disagree. Therefore, we reject the existence of an increase of the success of provision for the medium threshold. .

[31] This result is also confirmed by a panel regression (Appendix 3.13.). The results of the regression explaining the welfare – the dependent variable - by *Voluntary adhesion* and *Period* are reported in Appendix 3.13.. They confirm the U test; Adding voluntary adhesion to a mechanism of Money Back Guarantee has no effect on the welfare.

contributions in the high and the medium threshold but not in the low threshold. To compare the variance of group contributions we break down the global variance into intertemporal variance and intratemporal variance[32] (Sevestre, 2002) as following:

$$\sigma_G^2 = \sum_{t=1}^{T}\sum_{j=1}^{J}(G_{jt} - \overline{G}_{..})^2 = N\sum_{t=1}^{T}(G_{.t} - \overline{G}_{..})^2 + \sum_{j=1}^{J}\sum_{t=1}^{T}(G_{jt} - \overline{G}_{.t})^2 \quad (3)$$

where G_{jt} is the total contribution of group j in period t. A U test reveals that the intertemporal variance decreases in the high threshold (U=2.47 ; p= 0.01) but not in the medium (U=0.63 ; p = 0.52) or the low threshold (U= - 0.61 ; p=0.54). To examine the intratemporal variance we first run a U test. It shows that the intratemporal variance of group contributions decrease in the high threshold (U=3.09 ; p<0.01) the medium threshold (U=3.12 ; p<0.01) but not in the low threshold (U=0.64 ; p=0.51). Then we run a panel data regression. The dependent variable in the regression is the difference between the group contributions and the average group contributions for each period. The regressors are *Voluntary adhesion* and *Period.* The results are reported in Table 17. The coefficients of *Voluntary adhesion* are negative and significant in the medium and the high threshold. The regression supports the results of the statistical test. Thus, cumulating the results of the intertemporal and intratemporal variance of group contributions reveals that variance decreases mainly in the high threshold then in the medium one. No effects are observed in the low threshold.

[32] *Cf.* Chapter 2 section 5.4. for further explanations.

Table 17

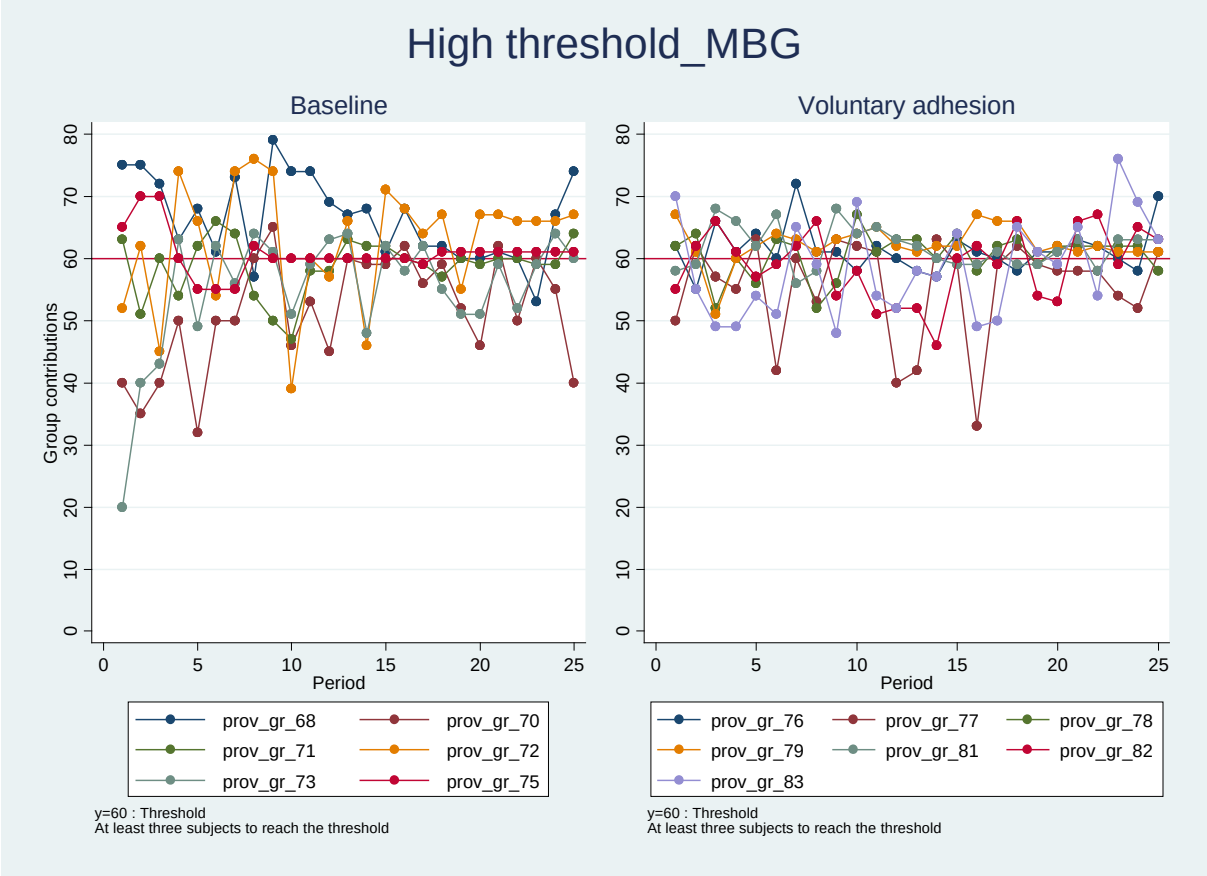
Results from panel data regression explaining the intratemporal variance of group contributions for each level of threshold [(a)]

Regressors	**T=15**	**T=30**	**T=60**
Intercept	-121,26 (*)	-111,80 (*)	103.36 (*)
	(5.38)	(5.38)	(15.24)
Voluntary adhesion	--	-35.97 (**)	-35.39 (*)
		(-1.99)	(-6.81)
Period	-2.32 (*)	-2.29 (***)	-2.99 (*)
	(-2.22)	(-1.95)	(-7.99)
Log likelihood	2.9% [(b)]	-1369	-1716
Number of observation	325	225	325
Number of groups	13	9	13
Time periods	25	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant ; (a) : T-statistics are in parentheses (b) : R2 overall ; Regressions are corrected for autocorrelation and heteroskedasticity

Figure 6

Group contributions (T=60)



Result 4: Voluntary adhesion increases the number of contributors whatever the threshold. It decreases cheap riding only in the low threshold.

We aim in this part to compare the number of contributors between the baseline and the voluntary adhesion treatment. Figure 7 depicts the percentage of the number of contributors per group for the low threshold. Clearly, voluntary adhesion increases the number of contributors[33]. We run a χ^2 test to compare the number of contributors for each threshold. It confirms the visual inspection[34]. Next, we perform a panel data regression. The dependent variable is the number of contributor per group for each period. The regressors are *Voluntary*

[33] Figures depicting the number of contributors per group for the medium and the high threshold are in the appendix (3.6 – 3.10).

[34] Low threshold (χ^2 =110.16 ; p<0.01), Medium (χ^2 =14.33 ; p<0.01) and High (χ^2 =16.94 ; p<0.01).

adhesion and *Period*. The output is reported in Table 18. *Voluntary adhesion* is significant and positive for three levels of threshold confirming the χ^2 test. Besides, this increase is stable over time. *Period* is not significant with the low and the medium threshold. It is weakly affected by time in the high threshold (the coefficient of the regressor is equal to 0.00). Thus, the results are consistent with the theoretical predictions in the three thresholds.

Table 18

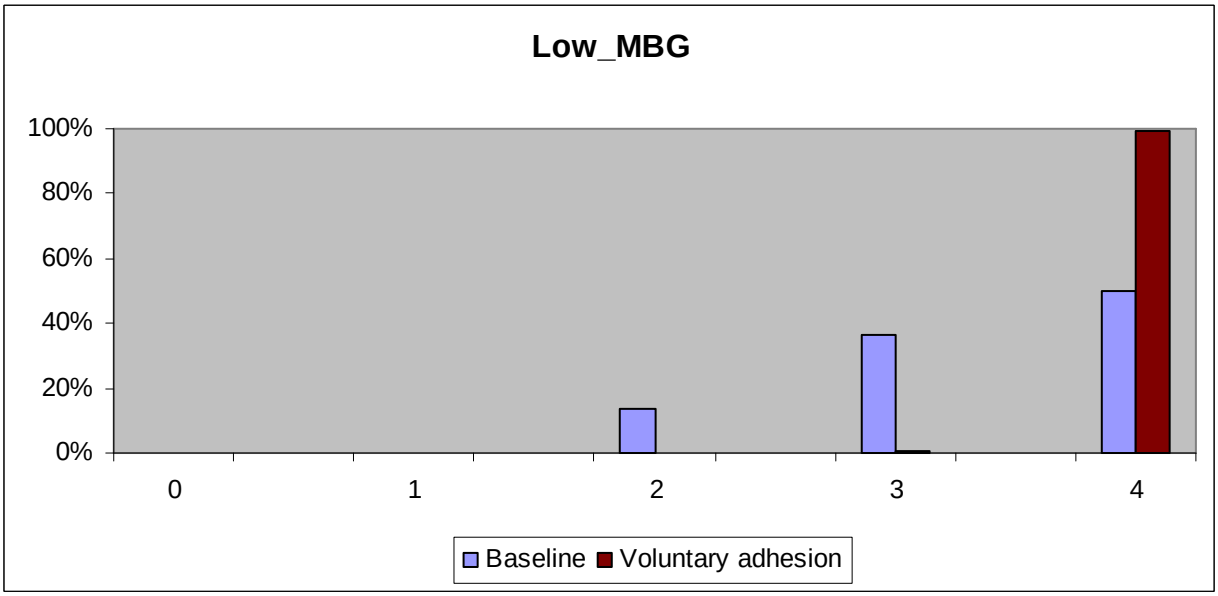
Results from panel data regression explaining the number of contributors per group for each level of threshold [(a)]

Regresssors	**T=15**	**T=30**	**T=60**
Intercept	3.35 (*)	3.69 (*)	3.95(*)
	(74.03)	(71,41)	(215.43)
Voluntary adhesion	0.64 (*)	0.30 (*)	0.03 (*)
	(14.12)	(6.47)	(3.73)
Period	--	--	0.00
			(2.77)
Log likelihood	377	-84	193
Number of observation	325	225	325
Number of groups	13	9	13
Time periods	25	25	25

(*): Significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant ; (a) : T-statistics are in parentheses ; Regressions are corrected for autocorrelation and heteroskedasticity

Figure 7

Number of contributors per group (T=15)



Then, we aim to compare cheap riding between the two treatments. A U test shows that the individual contribution does not change between the baseline and the voluntary adhesion treatment[35]. When we consider strictly positive contribution (we drop free riders and auto-excluded subjects) we find the same result for the medium (U=0.71 ; p=0.47) and the high threshold (U=0.12 ; p=0.90), except for the low threshold where cheap riding decreases in the voluntary adhesion treatment (U=3.80 ; $p < 0.01$). Then we perform two regressions. The dependent variable is the individual contribution and strictly positive individual contributions. The regressors are *Voluntary adhesion* and *Period* for both regressions. Table 19 reports the results. It shows a significant decrease of the cheap riding in the low threshold confirming the result of the statistical test. Table 19 points out also a significant increase of the individual contribution in the high threshold without a decrease in the cheap riding. Thus it suggests that individual contribution is higher in the baseline treatment in the high threshold. However, this result is not robust since the U test reports a different result. We ruled it out.

[35] Low threshod (U=-1.54 ; p=0.12) Medium threshold (U=-1.12 ; p=0.26) High threshold (U=-0.45 ;p=0.65)

Table 19

Results from panel data regression explaining individual contributions [(a)]

Regressors	T=15		T=30		T=60	
	*Contrib_*	*Cheap_*[(b)]	*Contrib_*	*Cheap_*[(b)]	*Contrib_*	*Cheap_*[(b)]
Intercept	7.40 (*)	8.37 (*)	10.53(*)	10,06(*)	14.93	15.09(*)
	(14.70)	(28.20)	(64.50)	(14.23)	(118.50)	(26.91)
Voluntary adhesion	--	-1.32	--	--	0.82	--
		(-5.02)			(4.76)	
Period	-0,09 (*)	-0.11 (*)	-0.12(*)	--	--	--
	(-3.33)	(-6.70)	(-13.30)			
Log likelihood	-1147	-3780	--	0.0%[(c)]	-3886	0.0%[(c)]
Number of observation	1600	1468	900	833	1600	1567
Number of subjects	64	64	36	36	64	64
Time period	25	25	25	25	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant

(a) T-statistics are in parentheses ; (b) Strictly positive contributions (Free riders and auto-excluded subjects are dropped in each period); (c) R2 overall GLS regression ; Regressions are corrected for heteroskedasticity and autocorrelation

4.2 Public good with refund vs. club good without refund

In this subsection, we aim to compare two incentives, the MBG and voluntary adhesion, with respect to their effects on the provision of a collective good. More specifically, we compare a setting with no assurance problem thanks to the MBG mechanism to a setting with an

assurance problem but with a voluntary adhesion incentive. The *Result 1* shows that there is no significant difference between the level of group contributions reached by each incentive in the low and the medium threshold. The *Result 2* shows that voluntary adhesion increases the number of contributors more than the MBG incentive.

Result 1: In the low and the medium threshold, there is no significant differences for the group contributions and the success of provision between the public good with a refund mechanism and the club good without refund. However, the welfare is higher in the public good with a refund.

Voluntary adhesion seems to act as a guarantee in assuring the contribution of other member of the group. We aim to compare the results of the provision of a public good with refund to a club good without refund. We report in Table 20 the results of individual contributions, group contributions, success of provision and welfare for each threshold. Clearly, in the high threshold, where the assurance problem is exacerbated, the MBG incentive gets more effective results than the voluntary adhesion one: it increases the success of provision by 28.8% and double (2.05) group contributions in comparison to the voluntary adhesion incentive. However, for the low and the medium threshold there is no clear difference. We therefore focus on this case. We perform an analysis to examine the statistical significance of the difference between the MBG and the voluntary adhesion in the low and the medium threshold. We compare group contribution, success of provision and welfare in each treatment.

Table 20

Descriptive statistics

	Average Individual Contribution [a] (SD)		**Average group contributions (SD)**		**Successful provision [b]**		**Welfare [c] (SD)**	
	Baseline MBG	*Voluntary adhesion (d)*	*Baseline MBG*	*Voluntary adhesion (d)*	*Baseline MBG*	*Voluntary adhesion (d)*	*Baseline MBG*	*Voluntary adhesion (d)*
Low	5.94 (4.78)	5.78 (5.68)	23.76 (10.76)	23.14 (15.64)	80.0%	73.5%	635.12 (65.74)	617.85 (101.52)
Medium	8.92 (5.63)	7.83 (5.89)	35.69 (13.12)	31.35 (14.26)	69.3%	67.7%	679.08 (79.87)	626.4 (101.09)
High	14.80 (4.56)	7.15 (8.22)	58.73 (9.55)	28.6 (26.13)	58.8%	30.0%	548.37 (180.02)	744.54 (110.08)

(a) The symmetrical equilibrium is 3.75 for the low threshold, 7.5 for the medium threshold and 15 tokens for the high threshold.

(b) Successful provision = Number of times groups reach the threshold / Number of periods

(c) Welfare = average number of accumulated points at the end of the experiment. (1 token= 1 point private account ; 1 token = 0.5 point collective account)

(d) Without MBG

A U test shows that group contribution and success of provision do not change between the two treatments in the low and the medium threshold (U=1.18 ; p=0.23)[36]. However, welfare does increase in the public good with refund case in the low (U=3.66 ; p<0.01) and in the medium threshold (U=3.92 ; p<0.01). To confirm our test analysis we run a regression for group contribution, success of provision and welfare[37] – the dependent variables-. The regressors are a dummy mechanism -taking value 1 for the voluntary adhesion treatment and 0 for the MBG - and time. They are denoted *dummy_mechanism* and *Period*. The regressions are performed for the low threshold (Table 21) and the medium threshold (Table 22). *dummy_mechanism* is not significant for the group contribution and the success of provision for the low and the medium threshold. On contrary, the welfare varies significantly between the voluntary adhesion and the MBG mechanism. It is significantly higher within the MBG treatment confirming thus the result of the U test.

[36] Group contribution : Low (U=1.6 ; p=0.10) Medium (U=1.18 ; p=0.23) ; Success of provision : Low (χ^2 =2.00 ; p=0.15) Medium (χ^2 =0.07 ; p=0.77)

[37] We remind that the welfare is measured by the earning of the subjects at the end of the experiment.

Table 21

Results from panel data regression explaining the number of contributors, the success of provision and welfare in the low threshold [(a)]

Regresssors	**Group contribution**	**Success of provision**	**Welfare**
Intercept	35.66 (*) (30.44)	2.78 (*) (7.43)	28.39(*) (80.82)
Dummy_mechanism[(b)]	--	--	-1.26(*) (-3.71)
Period	-0.84 (*) (-16.47)	0.09 (*) (-4.95)	-0.22(*) (-10.08)
Log likelihood	-1134	-177	-4013
Number of observation	350	350	1400
Number of groups	14	14	56 [(c)]
Time periods	25	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant ; (a) : T-statistics are in parentheses ; (b) dummy taking value 1 for the voluntary adhesion mechanism and 0 for the MBG mechanism. ; (c) number of subjects ; Regressions are corrected for autocorrelation and heteroskedasticity

Table 22

Results from panel data regression explaining the number of contributors the success of provision and welfare in the medium threshold [(a)]

Regresssors	**Group contribution**	**Success of provision**	**Welfare**
Intercept	35.91 (*)	3,69 (*)	28.53(*)
	(11.29)	(71.41)	(215.43)
Voluntary adhesion	--	--	-0.93 (**)
			(-2.35)
Period	--	-0.06 (*)	-0.16 (*)
		(-3.27)	(-6.11)
Log likelihood	0.02% [(c)]	-164	-3663
Number of observation	325	250	1100
Number of groups	13	10	44 [(d)]
Time periods	25	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant ; (a) : T-statistics are in parentheses ; (b) dummy taking value 1 for the voluntary adhesion mechanism and 0 for the MBG mechanism. ; (c) R2 overall ; (d) number of subjects ; Regressions are corrected for autocorrelation and heteroskedasticity

Result 2: In the low and the medium threshold, voluntary adhesion increases the number of contributors more than the MBG.

Hereafter we aim to compare the capacity of each incentive– MBG and the voluntary adhesion - to increase the number of contributors and to decrease cheap riding. We perform a χ^2 test to compare the number of contributors between the two treatments. It reveals that voluntary adhesion increases significantly the number of contributors in the low (χ^2 =47.63 ; p<0.01) and the medium threshold (χ^2 =18.51 ; p<0.01). Then, we run a panel data regression explaining the number of contributor per group in each period – the dependent variable- by a dummy threshold and time. Table 23 reports the output of the regressions. *Dummy_mechanism* is positive and significant in the low and the high threshold. Thus, the number of contributors is higher in the voluntary adhesion treatment.

Table 23

Results from panel data regression explaining the number of contributors per group in the low and the medium threshold [(a)] [(b)]

Regresssors	**Low**	**Medium**
Intercept	3.68 (*)	3.77 (*)
	(87.15)	(46.13)
Dummy_mechanism[(c)]	0.29 (*)	0.15 (**)
	(8.81)	(1.94)
Period	-0.04 (*)	-0.00 (***)
	(-10.12)	(-1.70)
Log likelihood	-187	-264
Number of observation	350	275
Number of subjects	14	11
Time periods	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant ; (a) : T-statistics are in parentheses ; (b) dummy taking value 1 for the voluntary adhesion mechanism and 0 for the MBG mechanism. ; Regressions are corrected for autocorrelation and heteroskedasticity

To examine cheap riding we conduct the same analysis as the 4.1.4. Result : we first compare individual contributions then we drop the free riders and the subjects who auto-excluded from the observations. The U test shows that individual contribution is significantly higher in the public good with refund than in the club good without refund in the low (U= 2.08 ; p=0.03) and the medium threshold (U=2.97 ; p<0.01). A regression explaining the individual contribution by *Dummy_mechanism* and *Period* reveals a non-significant regressors for both thresholds. Thus mixed evidences are observed for the increase of the individual contribution between the voluntary adhesion treatment and the MBG treatment. The effect is not strong enough to be captured by the regression. As a consequence, we cannot conclude that the

decrease of strictly positive contributions is due to less cheap riding. It can also be due to a lower individual contribution. Nonetheless, we follow the analysis. The U test shows that strictly positive contributions are higher within the MBG[38]. We then run a regression with strictly positive individual contribution as dependent variable and *Dummy_mechanism* and *Period* as regressor. Table 24 reports the results. It confirms the U test: when we drop free riders and auto-excluded subjects individual contributions are lower in the voluntary adhesion treatment. Therefore, this result can suggest the existence of less cheap riding in the voluntary adhesion treatment. However, as individual contribution do not seem to be equal, even if we can argue that group contribution are significantly equal and also the success of provision, the cheap riding cannot be addressed by this analysis.

[38] Low threshold ($U=5.18$; $p<0.01$) Medium threshold ($U=2.86$; $p<0.01$)

Table 24

Results from panel data regression explaining individual contribution and cheap riding [a]

Regressors	Low		Medium	
	Contribution	Cheap_[b]	Contribution	Cheap_[b]
Intercept	5.96 (*)	7.91 (*)	8.94 (*)	10.32 (*)
	(15.00)	(24.06)	(15.00)	(25.10)
Dummy_mechanism[c]	--	-1.05 (*)	--	-1.28 (*)
		(-3.55)		(-3.39)
Period	--	-0.12 (*)	--	-0.08 (*)
		(-6.74)		(-3.62)
Log likelihood	0.0% [d]	-3236	0.0%[d]	-2694
Number of observation	1400	1232	1100	981
Number of subjects	56	56	44	44
Time period	25	25	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant

(a) : T-statistics are in parentheses ; (b): Free riders and auto-excluded subjects are dropped in each period ; (c) : R2 overall ; (c) dummy taking value 1 for the voluntary adhesion mechanism and 0 for the MBG mechanism. (d) ; R2 overall ; Regressions are corrected for heteroskedasticity and autocorrelation

Conclusion

The aim of our experiment is to test the effect of voluntary adhesion in the provision of a club good when avoiding the assurance problem. For that purpose, we allowed for refund of contributions whenever the provision point was not reached. We compare contributions of three different levels of the threshold (low, medium and high) with and without voluntary adhesion.

The experiment reveals that voluntary adhesion does not increase group contributions, success of provision and welfare. However, it decreases the variance of group contributions in the medium and mainly in the high threshold. Voluntary adhesion also increases the number of contributors in the low, the medium and the high threshold in comparison the baseline treatment with MBG. This is consistent with the theoretical predictions. Finally, voluntary adhesion moderates cheap riding in the low threshold.

This experiment offers also the possibility to compare the MBG incentive to the voluntary adhesion one. That is a setting of a step level mechanism where the assurance problem has been ruled out thanks to the MBG to a setting of step level with an assurance problem combined to the voluntary adhesion. In the low and the medium threshold i.e. when the assurance problem is not highly exacerbated, the experiment reveals similar results between these two incentives. It shows that they reach the same level of group contributions and of success of provision. However, the welfare is higher in the case of the public good with refund whereas the number of contributors is higher among the voluntary adhesion treatment.

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Appendix

Appendix 3.1.

Group contributions (MBG T=15)

Appendix 3.2.

Average group contributions (MBG T=15)

Appendix 3.3.

Group contributions (MBG T=30)

Appendix 3.4.

Average group contributions (MBG T=30)

Appendix 3.5.

Average group contributions (MBG T=60)

Appendix 3.6.

Number of contributors per group over time (MBG T=15)

Appendix 3.7.

Number of contributors per group over time (MBG T=30)

Appendix 3.8.

Percentage of contributors per group (MBG T=30)

Appendix 3.9.

Number of contributors per group over time (MBG T=60)

Appendix 3.10.

Percentage of contributors per group (MBG T=60)

Appendix 3.11.

Results from panel data regression explaining group contributions for each level of threshold

Appendix 3.12.

Results from panel data regression explaining success of provision for each level of threshold

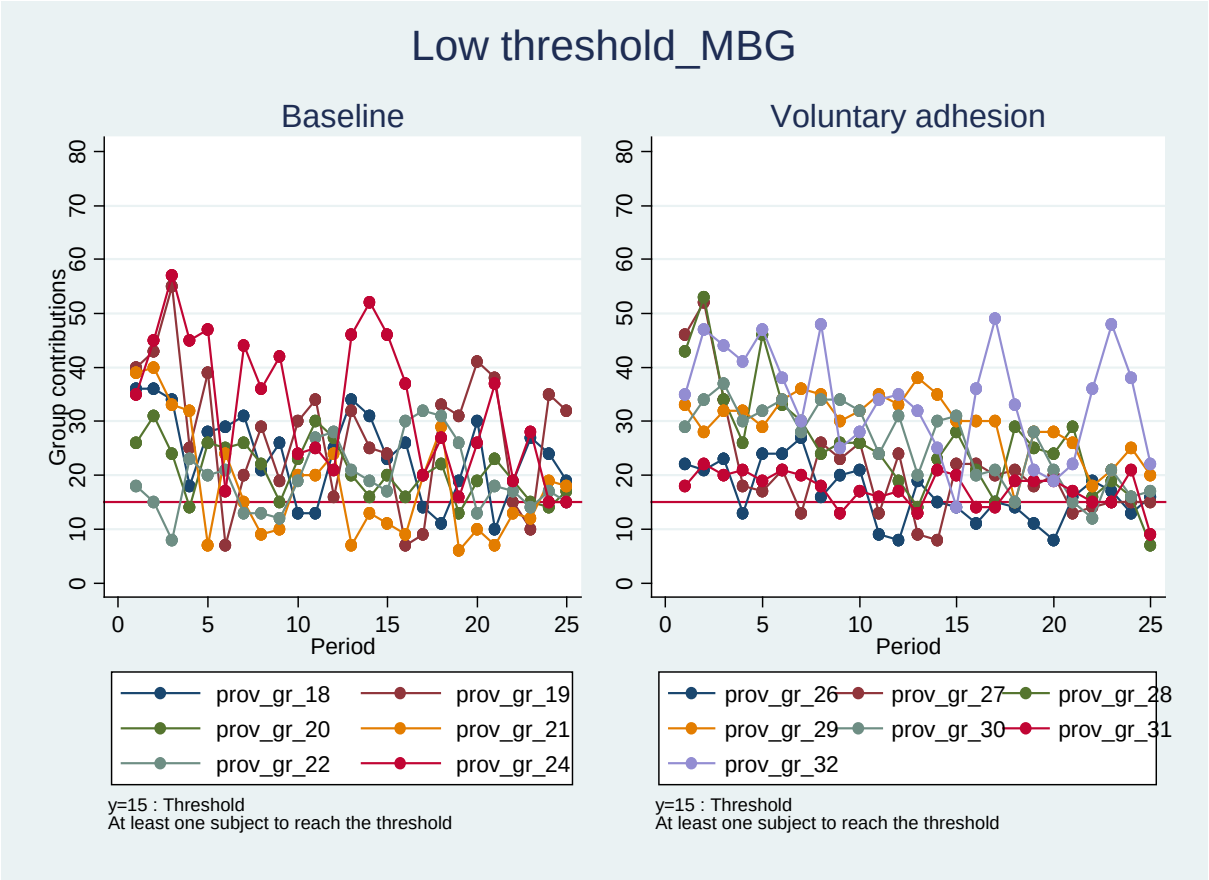
Appendix 3.13.

Results from panel data regression explaining welfare for each level of threshold

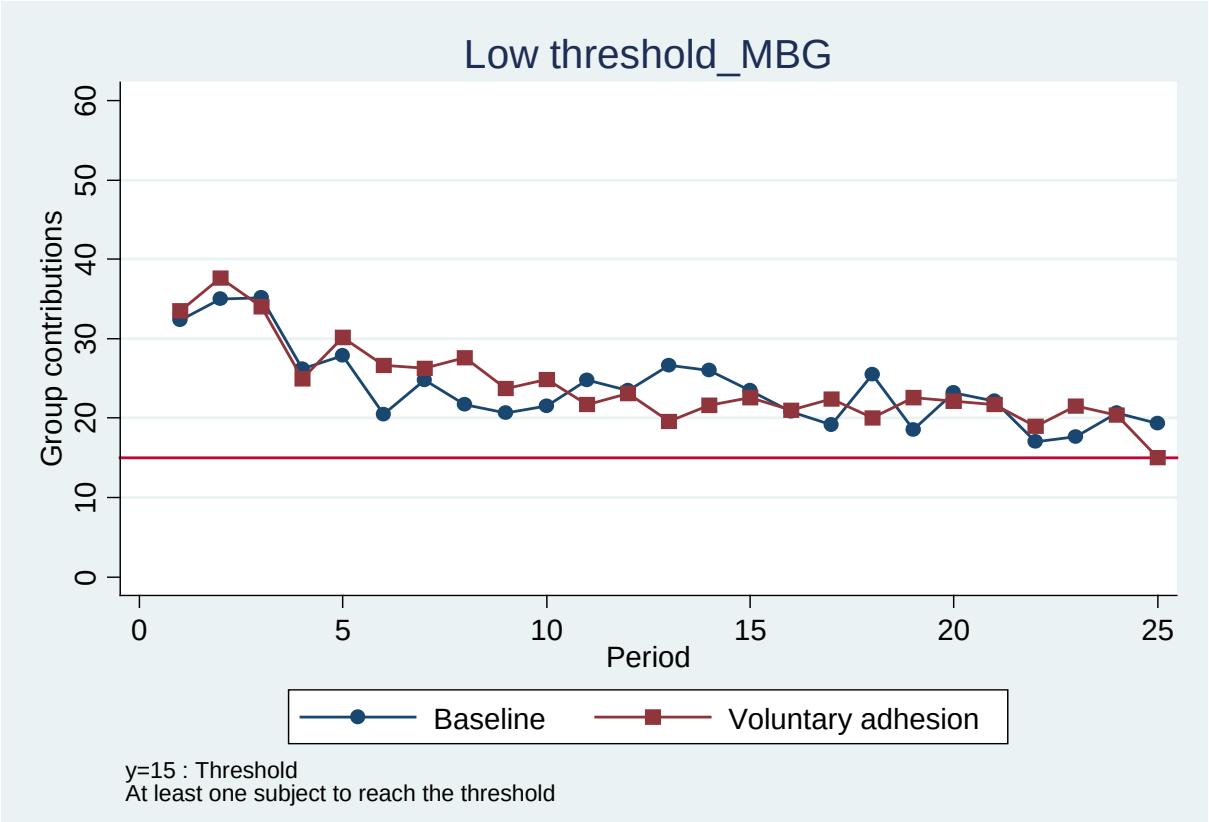
Appendix 3.14.

The instructions (Voluntary adhesion treatment, Low threshold, MBG)

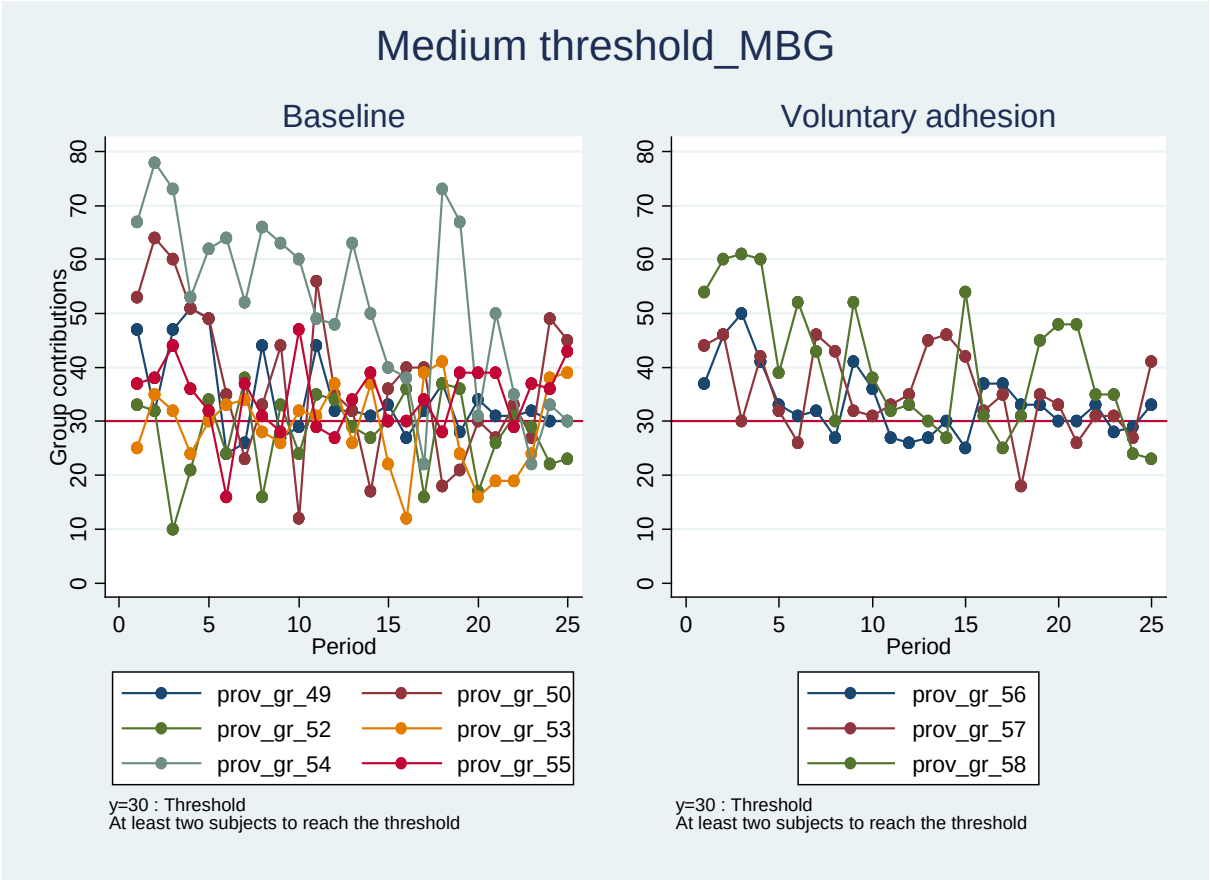
Appendix 3.1.: Group contributions (MBG T=15)



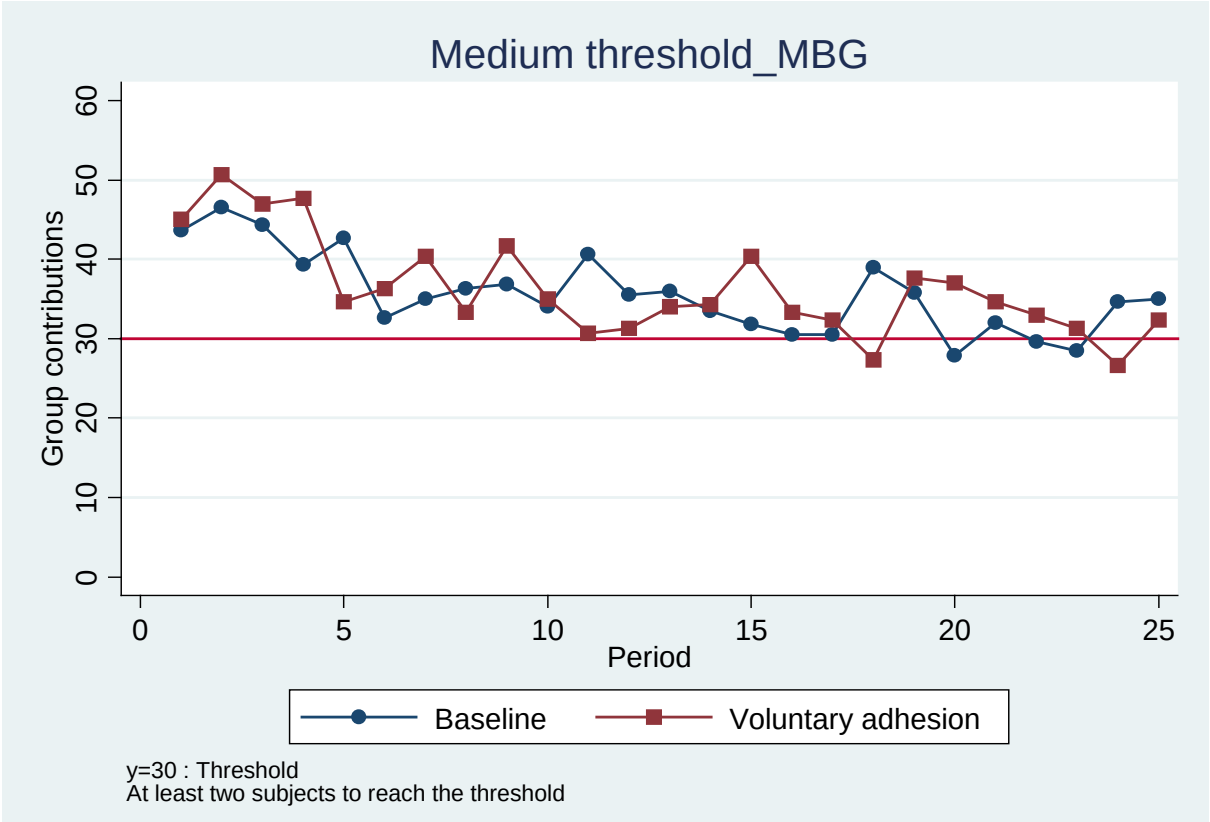
Appendix 3.2.: Average group contributions (MBG T=15)



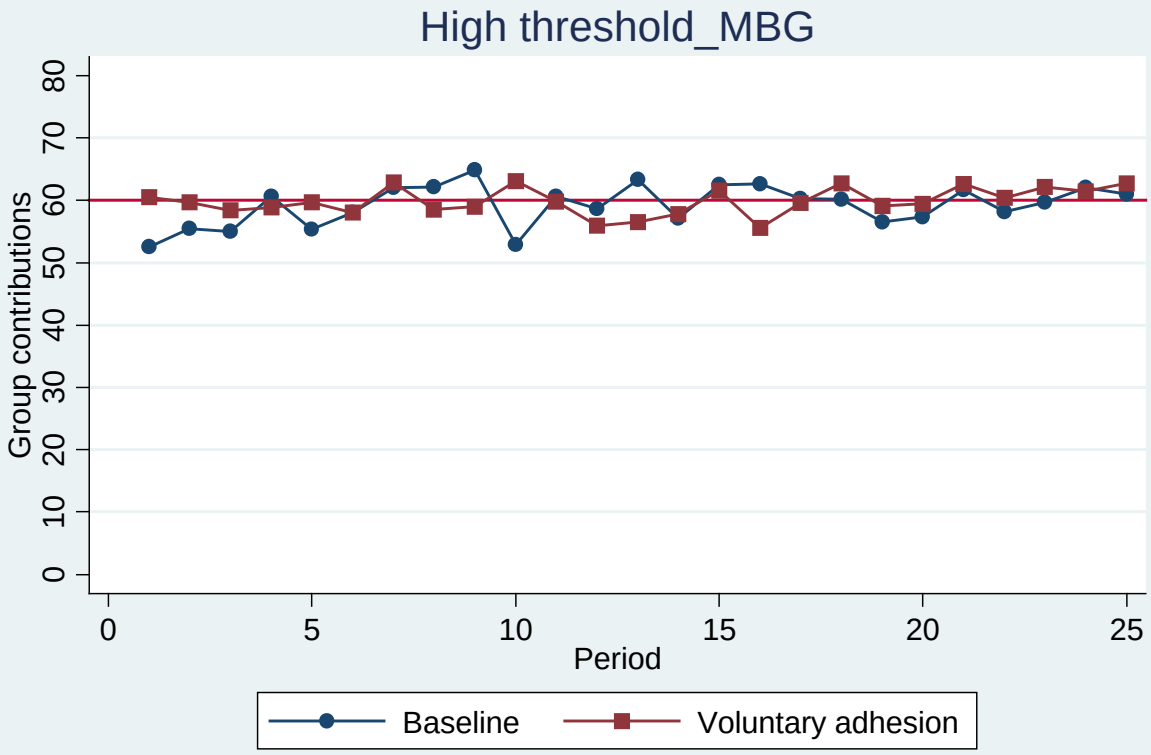
Appendix 3.3.: Group contributions (MBG T=30)



Appendix 3.4.: Average group contributions (MBG T=30)

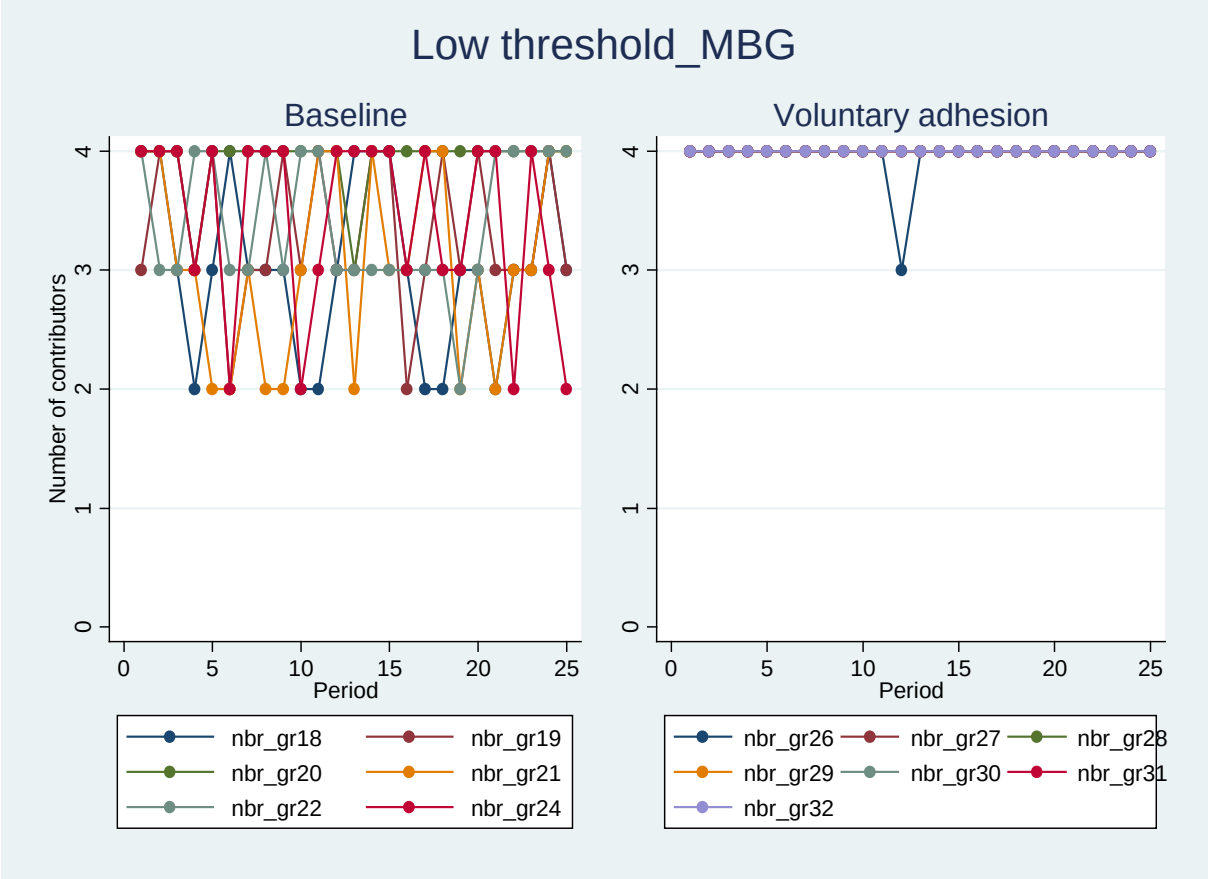


Appendix 3.5.:Average group contributions (MBG T=60)

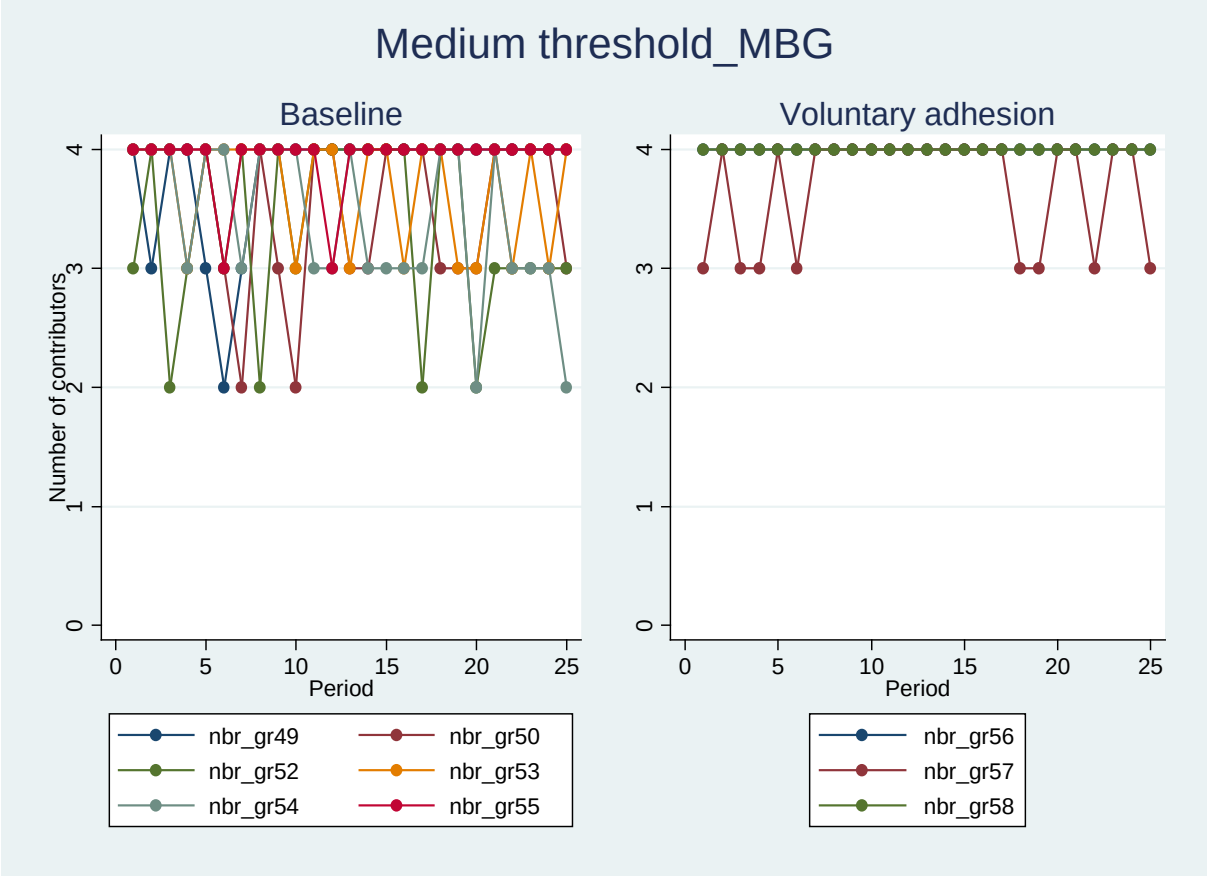


y=60 : Threshold
At least three subjects to reach the threshold

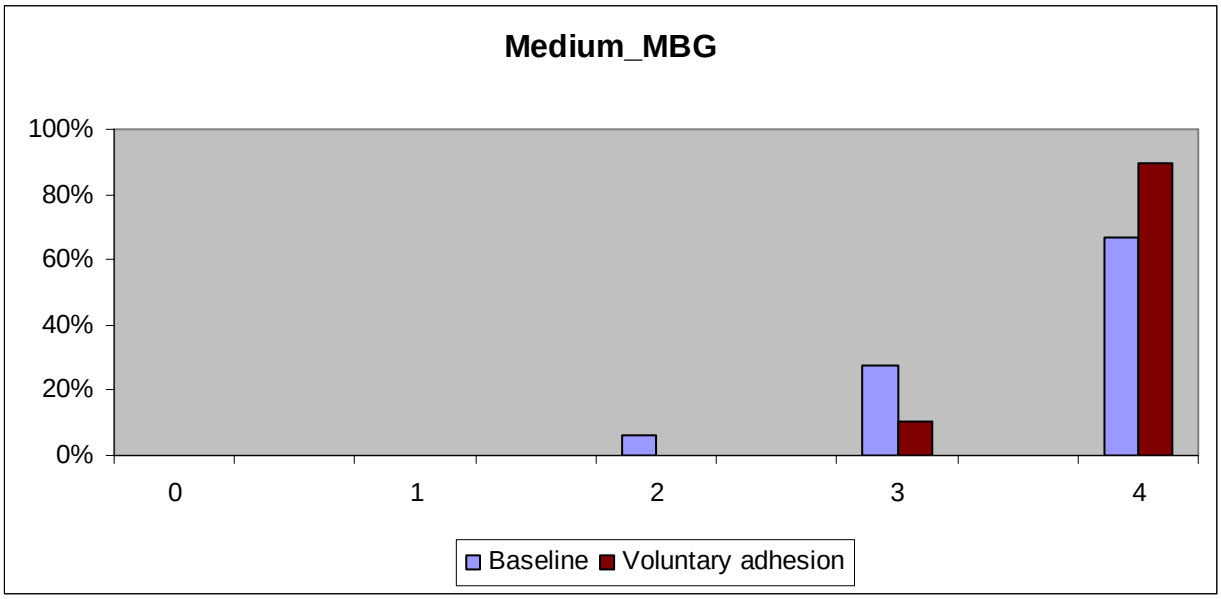
Appendix 3.6.: Number of contributors per group over time (MBG T=15)



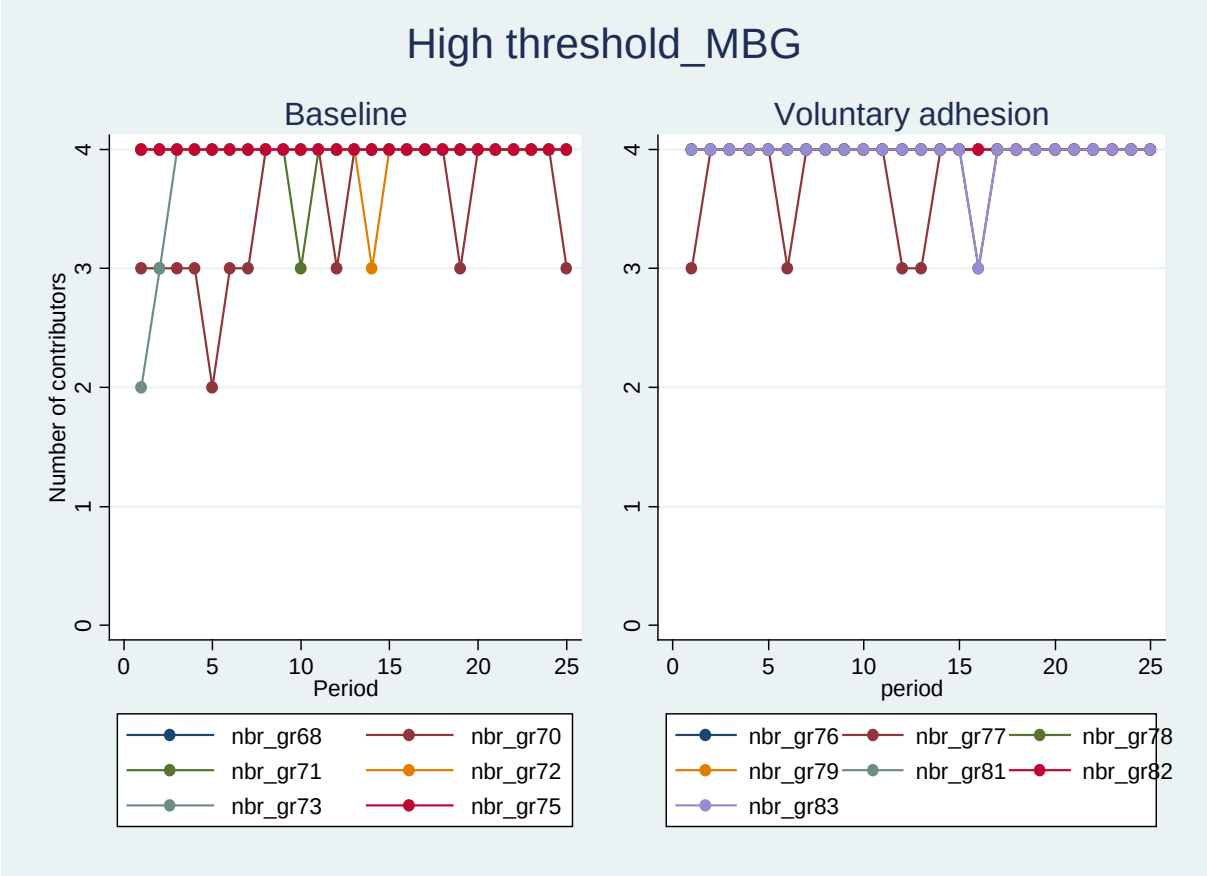
Appendix 3.7.: Number of contributors per group over time (MBG T=30)



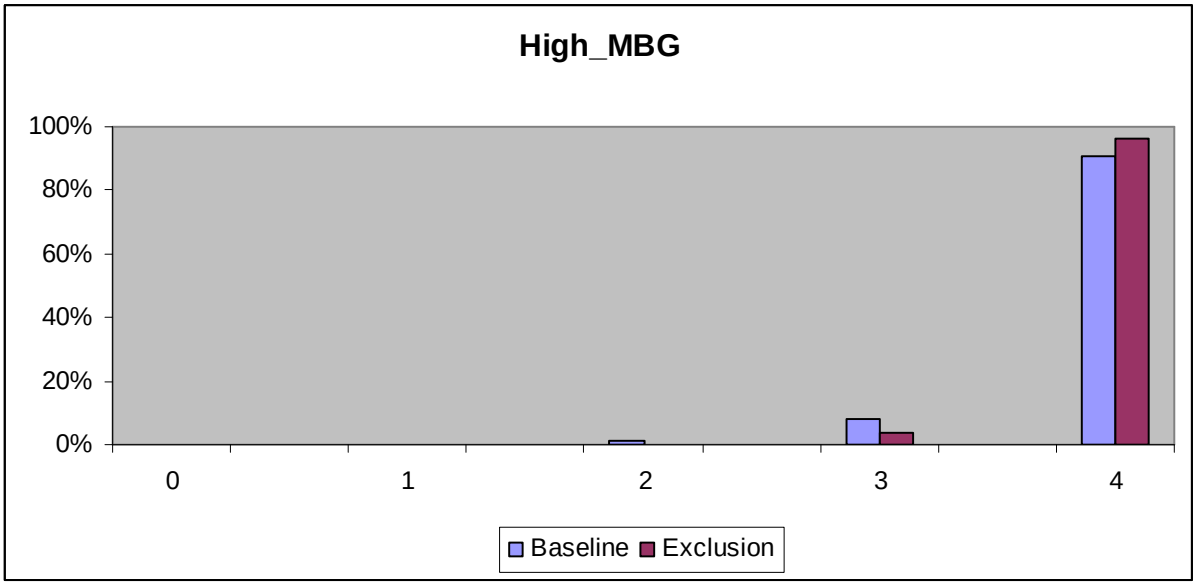
Appendix 3.8.: Percentage of contributors per group (MBG T=30)



Appendix 3.9.: Number of contributors per group over time (MBG T=60)



Appendix 3.10.: Percentage of contributors per treatment (MBG T=60)



Appendix 3.11.: Results from panel data regression explaining group contributions for each level of threshold [(a)]

Regressors	T=15	T=30	T=60
Intercept	32,21 (*)	40,39 (*)	59,08 (*)
	(37,34)	(30,31)	(80,53)
Voluntary adhesion	1,80 (***)	--	1,04 (***)
	(1,77)		(1,68)
Period	- 0,62 (*)	-0,47 (*)	--
	(-12,80)	(-6,07)	
Log likelihood	-1118	-784	-643
Number of observation	325	225	325
Number of groups	13	9	13
Time periods	25	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant

(a) : T-statistics are in parentheses ; Regressions are corrected for autocorrelation and heteroskedasticity

Appendix 3.12.: Results from panel data regression explaining success of provision for each level of threshold [(a)]

Regressors	**T=15**	**T=30**	**T=60**
Intercept	1,42 (*)	--	--
	(4,42)		
Voluntary adhesion	--	1,45 (**)	--
		(2,25)	
Period	-0,03 (*)	-0,07 (*)	0,16 (***)
	(-2,67)	(-3,66)	(0,32)
Log likelihood	-133	-164	-197
Number of observation	325	225	325
Number of groups	13	9	13
Time periods	25	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant

(a) : T-statistics are in parentheses ; Regressions are corrected for autocorrelation and heteroskedasticity

Appendix 3.13.: Results from panel data regression explaining welfare for each level of threshold [(a)]

Regressors	**T=15**	**T=30**	**T=60**
Intercept	27.78 (*) (88,86)	116,31 (*) (42,65)	117,56 (*) (29,71)
Voluntary adhesion	-0.64 (0.032)	--	--
Period	-0,61 (-8,31)	-0,69 (*) (-4,10)	--
Log likelihood	-1143	-978	-1573
Number of observation	1600	225	325
Number of groups	64	9	13
Time periods	25	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant

(a) : T-statistics are in parentheses ; Regressions are corrected for autocorrelation and heteroskedasticity

Appendix 3.14.: The instructions (Voluntary adhesion treatment, Low threshold, MBG)

INSTRUCTIONS

Bienvenue

L'expérience à laquelle vous allez participer est destinée à l'étude des décisions. Vous allez être confrontés à une décision de répartition de jetons entre deux comptes : un compte individuel et un compte collectif. Les instructions sont simples. Si vous les suivez scrupuleusement et que vous prenez de bonnes décisions de placement, vous pourrez gagner une somme d'argent non négligeable. Toutes vos réponses seront traitées de façon anonyme et seront recueillies au travers d'un réseau informatique. Vous indiquerez vos choix à l'ordinateur devant lequel vous êtes assis et celui-ci vous communiquera vos gains réalisés au fur et à mesure du déroulement de l'expérience.

La somme totale d'argent gagnée pendant l'expérience vous sera versée, en liquide, à la fin de celle-ci.

CADRE GENERAL DE L'EXPERIENCE

16 personnes participent à cette expérience. **Vous êtes membre d'un groupe constitué de 4 personnes choisies au hasard parmi les 16 personnes présentes dans la salle. La composition de votre groupe restera la même tout au long de l'expérience.** Vous ne pouvez pas connaître l'identité des personnes faisant partie de votre groupe parmi celles présentes dans la salle.

Les gains que vous réaliserez dépendront à la fois des décisions que vous prendrez et des décisions prises par les 3 autres membres qui composent votre groupe. Chaque décision de placement que vous prendrez se traduira par un gain en points plus ou moins important. Ce

gain en points sera converti, à la fin de l'expérience, en Euros. La procédure de conversion des points en euros est détaillée à la fin des instructions.

La suite des instructions va vous permettre de comprendre de quelle manière vos gains sont calculés.

LES TYPES DE PLACEMENT

L'expérience comporte **25 périodes**. Au début de chaque période, chaque membre de votre groupe est doté d'un budget de 20 jetons. A chaque période vous, ainsi que les 3 autres membres de votre groupe, serez amenés à répartir votre budget entre 2 types de comptes possibles: votre compte individuel et votre compte collectif.

1- Règles du compte individuel :

Chaque jeton que vous placez dans votre compte individuel vous rapporte 1 point. De même, si un membre de votre groupe place un jeton dans son compte individuel, il lui rapportera 1 point.

Les gains des autres membres du groupe ne sont pas affectés par le nombre de jetons que vous décidez de placer dans votre compte individuel. De même votre gain n'est pas affecté par le nombre de jetons placés par les autres membres du groupe dans leur propre compte individuel. Illustrons cela au moyen de 3 exemples:

3- Quelles que soient les décisions de placement des autres membres du groupe, si vous placez 5 jetons dans votre compte individuel, votre gain résultant de cette décision sera de 5 points. Les gains des autres membres du groupe ne seront pas affectés par votre décision.

4- Supposons que l'un des membres du groupe décide de placer 10 jetons dans son compte individuel, quelle que soit votre décision de placement, son gain résultant de cette décision sera de 10 points; votre gain ne sera pas affecté par cette décision.

3- Votre budget = 20 jetons
Votre placement individuel = 6 jetons
Votre compte individuel vous rapporte = 1×6 = 6 points

Au gain de votre placement individuel s'ajoute le gain résultant du placement collectif. La manière dont est déterminé le gain du placement collectif fait l'objet de la suite des instructions.

2- Règles du compte collectif :

Il existe un seul compte collectif pour tout le groupe. Le gain que vous réalisez dépend du nombre total de jetons que vous et les autres membres du groupe placent dans ce compte. Plus le groupe place de jetons dans le compte collectif, plus les gains réalisés par chacun seront importants (*Cf.* page annexe : Tableau des gains). En effet, chaque jeton placé dans le compte collectif rapporte 0,5 points à chaque membre du groupe.

Cependant, vous toucherez un gain du compte collectif si le placement collectif total du groupe est supérieur ou égal à 15 jetons. Dans ce cas, chaque joueur du groupe, ayant placé ou pas des jetons dans le compte collectif, touche un gain. Dans le cas où le placement collectif des 4 joueurs du groupe est inférieur à 15 jetons, le compte collectif rapporte à chaque joueur 0 point.

Enfin notez que si le placement collectif total du groupe est inférieur à 15 jetons, les jetons que vous avez placez dans le compte collectif vous seront restitués. Ces jetons sont automatiquement placés dans le compte individuel pour chacun des membres du groupe. Comme mentionné précédemment (*Cf.* Règles du compte individuel) chacun de ces jetons rapporte 1 point. Illustrons les règles du placement collectif au moyen de trois exemples:

Exemple 1 : Calcul de vos gains lorsque le seuil de 15 jetons est atteint

Votre budget étant de 20 jetons, vous décidez de placer 12 jetons dans votre compte individuel et 8 jetons dans le compte collectif. Supposons que les trois autres joueurs de votre groupe choisissent de placer en totalité 25 jetons dans le compte collectif.

Votre compte individuel vous rapporte = $1 \times 12 = 12$ points

Le compte collectif vous rapporte = $0{,}5 \times (8+25) = 16{,}5$ points

De même, le gain du compte collectif pour chacun des autres membres de votre groupe est égal à 16,5 points.

Votre gain total de la période = $12 + 16{,}5 = 28{,}5$ points.

Exemple 2 : Calcul de vos gains lorsque le seuil de 15 jetons n'est pas atteint

Votre budget étant de 20 jetons, vous décidez de placer 15 jetons dans votre compte individuel et 5 jetons dans votre compte collectif. Supposons que les trois autres joueurs de votre groupe choisissent de placer en totalité 8 jetons dans le compte collectif.

Votre compte individuel vous rapporte = $1 \times 15 = 10$ points

Le compte collectif vous rapporte = $0{,}5 \times (5 + 8) = 0$ point car le placement collectif total, 13 jetons, est inférieur à 15 (vos 5 jetons plus les 8 jetons des trois autres joueurs).

De même, le gain du compte collectif pour chacun des autres membres de votre groupe est égal à 0 point.

Votre gain total de la période = 20 points. (les jetons placés dans le compte collectif vous sont restitués)

Exemple 3 : Calcul de vos gains lorsque le seuil de 15 jetons est atteint et vous avez placé 0 jeton dans le compte collectif :

Votre budget étant de 20 jetons, vous décidez de placer 20 jetons dans votre compte individuel et 0 jeton dans votre compte collectif. Supposons que les trois autres joueurs de votre groupe choisissent de placer en totalité 15 jetons dans le compte collectif.

Votre compte individuel vous rapporte = $1 \times 20 = 20$ points

Le compte collectif vous rapporte = $0{,}5 \times (0 + 15) = 7.5$ points

De même, le gain pour chacun des autres membres de votre groupe est égal à 7.5 points.

Votre gain total de la période = $20 + 7.5 = 27.5$ points.

En résumé, à chaque période, chaque membre de votre groupe (vous inclus) dispose de deux sources de gain: le gain du compte individuel et le gain du compte collectif.

LE DEROULEMENT DE L'EXPRIENCE

A chaque période, vous devrez prendre deux décisions de placements ; plus précisément vous devrez répartir entièrement votre budget de 20 jetons entre votre compte individuel et votre compte collectif. Vous êtes libre quant au choix de cette répartition et vous pouvez, par exemple, décider de placer la totalité des 20 jetons dans votre compte individuel ou vice-versa (placer l'ensemble des 20 jetons dans le compte collectif).

L'ordinateur, à chaque période, vous demandera d'indiquer le nombre de jetons que vous souhaitiez placer dans chacun des comptes. Vous devez placer à chaque période la totalité de votre budget. En d'autres termes, la somme des jetons placés dans le compte individuel et les jetons placés dans le compte collectif doit être égale à votre budget. Notez, que vous n'avez pas la possibilité de reporter une partie ou la totalité de votre budget d'une période à l'autre.

Tous les membres de votre groupe (vous y compris) prendront leur décision de placement simultanément. Dès que tous les membres de votre groupe auront pris leur décision, l'ordinateur calculera votre gain pour la période en cours. L'ordinateur vous communiquera le nombre de points que vous avez obtenus pour chacun des deux placements à la période en cours. **Il vous communiquera également le placement collectif total de votre groupe et ce que vous ayez placé dans le compte collectif ou pas**. Un historique de vos décisions apparaîtra sur votre écran à la fin de chaque période. La période suivante pourra alors démarrer. A chaque nouvelle période vous connaîtrez votre gain cumulé sur l'ensemble des périodes précédentes.

Lorsque la 25ème période sera achevée, l'ordinateur vous communiquera le montant total de vos gains en points réalisés au cours des 25 périodes. Le facteur de conversion est de 0.40 Euro pour 20 points.

Exemple :

Si votre gain cumulé à la fin de l'expérience est de 800 points, votre paiement sera de 16 € en liquide :

Taux de conversion : 20 points = 0.40 Euro

Questionnaire

Encerclez la bonne réponse.

1 - Vous êtes dans un groupe de :

* 2 joueurs + vous * 4 joueurs + vous * 3 joueurs + vous

2- L'expérience

* Dure 25 périodes * Dure 15 périodes

3 - Est-ce que le gain issu de votre compte privé dépend des autres joueurs ?

* Oui, il dépend * Non il ne dépend pas

4 – Si votre placement collectif est nul, pouvez-vous bénéficier des gains du compte collectif ?

* Oui, je peux * Non, je ne peux pas

5- Si le placement collectif total de votre groupe est égal à 20 jetons, pouvez-vous bénéficer des gains du compte collectif si vous avez placé 5 jetons dans le compte collectif ?

* Oui, je bénéficie * Non, je ne bénéficie pas

6- Supposons que vous avez placé 4 jetons dans votre compte collectif. Supposons que le placement collectif total de votre groupe s'élève à 35 jetons. Calculez votre gain <u>total</u> de la période.

35 points - 19 points – 33,5 points

7- Vous décidez de placer la moitié de votre budget dans le compte collectif. Le placement collectif total de votre groupe s'élève à 10 jetons. Calculez votre gain total de la période.

5 points – 20 points – 10 points

8- Vous décidez de ne pas placer de jetons dans le compte collectif. Le placement collectif total de votre groupe s'élève à 30 jetons. Calculez votre gain total de la période.

35 points – 20 points – 30 points

Poste N°……

Joueur N°……

Fiche de renseignement

* Date de naissance : 19…

* Sexe : Masculin / féminin

* Etat civil : célibataire / marié

* Année d'étude : Bac + ….

* Formation : Economie et Gestion / autre (ex : biologie, agronomie) .

* Vous avez déjà participé à une expérience en économie expérimentale : oui / non

Feuille de commentaires

Veuillez préciser vos remarques sur le déroulement de l'expérience ainsi que la stratégie que vous avez suivi(e).

Chapter 4: Does subject's origin matter in the provision of club goods?

1 Introduction

The investigation of the provision of club goods in the lab shows an increase of group contributions, an improvement of the success of provision and welfare in comparison to the provision of public goods. The experiment also reveals an increase in the number of contributors and a decrease of the variance of group contributions. Finally, the experiment in the lab shows that the level of convergence of group contributions is higher in the voluntary adhesion treatment than in the baseline treatment. The aim of this work is to check whether theses findings are also available with respect to subject's origin.

Indeed, several previous experimental results indicated differences when subject's characteristics are manipulated. (For instance in the public goods experiment see (Chen *et al.*, 2007; Finocchiaro Castro, 2008; Gächter *et al.*, 2004)) . In particular, the existence of two equilibria of different nature in the step level design – providing the threshold and not contributing - revealed to be a suitable setting to express differences depending on the subject's characteristic; Cadsby and Maynes (1998a) found that nurses behave differently than economic students. They are less likely to free ride than students. Similarly, Cadsby and Maynes (1998b) found that gender affects contributions in the step- level setting. Females contribute significantly more than males at the beginning of the experiment and show higher capacity to coordinate around an equilibrium.

In this work, we investigate whether Tunisian students behave differently from students in France. We replicate the experiment of the provision of club goods performed in the University of Montpellier with students from the Tunisian National Institute of Agronomy. We compare the provision of a step-level collective good (with and without voluntary adhesion) for one level of threshold. There is no Money Back Guarantee mechanism.

The experiment does not reveal a dramatic change between the two samples of subjects. We do observe an increase of group contributions, the success of provision and welfare. However, some differences are observed. First, within the Tunisian sample, voluntary adhesion does not moderate cheap riding. Also, it does not decrease the variance of group contributions. Second, the comparison between the Tunisian students and the French students reveals a higher number of contributors within the Tunisian sample and also a lower group contributions variance. The level of individual contribution is not modified between the two samples.

This chapter is organized as follows: section 2 describes the experimental design, section 3 discusses the results and section 4 concludes.

2 Experimental design

The experiment performed at the Tunisian National Institute of Agronomy, is a replication of the threshold linear public good game experiment that was run earlier at the university of Montpellier. Only the condition was tested, under two treatments. In the baseline treatment, a public good is provided whenever the subjects' contributions meet the target level. In the test treatment, a club good is provided for contributors whenever their contributions meet the target. Non-contributors are excluded from the consumption of the club good if it is provided. Each participant was endowed with w = 20 tokens that he had to allocate (in integer amounts) between a private account and a collective account. The private account yields a private marginal return $\alpha = 1$ per token invested. If the target (T) is met, the collective account provides a marginal return $\lambda=0.5$ per token invested and for each member of the group (in the baseline treatment). If the target level is not met, individual contributions are lost. There is no Money Back Guarantee (MBG) mechanism. If the group contributions is above the threshold, each member of the group (in the baseline) enjoys the total amount of the club good provided.

The first part of the experiment was run at the University of Montpellier I, with a large subject pool of volunteers from various disciplines: economics, law, art, psychology, literature, medicine, engineering, and sport. This sample will be denoted the M-sample. The second part

of the experiment was run at the Tunisian National Institute of Agronomy (Table 25), with subjects from various subdisciplines of agronomic engineering, especially students majoring in agricultural economics and hydrology. This sample will be denoted the T-sample. As the Tunisian students of the TNIA are fluent in French, the experiment could be conducted with the same instructions than in Montpellier. The instructions were read aloud after a private reading. A short questionnaire to check the subject's understanding (the same one than in Montpellier) was submitted after the reading stage. The constituent game was repeated for 25 rounds in a partner design. Accumulated point earnings over the 25 rounds were converted into Tunisian Dinars at the end of the experiment at a publicly announced rate.

There is no experimental lab at the TNIA. An experimental class was crafted and equipped for the need of the experiment. Upon attending the experimental classroom, the 24 students of each session were randomly assigned to groups of 4 subjects for the total duration of the experiment. Care was taken to ensure that no subject participated in more than one session. All sessions were conducted by "paper and pencil". 9 assistants were recruited for the experiment: 6 assistants for the calculation of the earnings (1 per group) and the 3 for the collect and the distribution of the spreadsheets. The spreadsheets were filled out period by period, so that each participant had a complete record of the outcome of his past decisions and interactions. At the end of each period, once the calculation of the earnings achieved, the experimenter asked the 3 assistants to mix the spreadsheet before getting them back to the subjects. The purpose is to avoid that subjects guess which of the participants belong to their group.

A pilot experiment was conducted in order to control for the efficiency of the experimental design: implementation of anonymity and avoiding communication among subjects. One of the 3 assistants was assigned to the task to avoid communication among subjects. The pilot was also useful to control for incentives effect, by changing the currency from Euro to Dinar and adjusting the conversion rate of experimental points into currency. The show up fee was equivalent to 2.75 euros and the average earning 3.00 in the baseline treatment and 3.42 € in the voluntary adhesion treatment. Finally, the pilot also helped calibrating the timing of the experiment so that it does not exceed 1 hour and a half.

Table 25

Experimental parameter

Location	Treatment	Threshold	Required contributors [(a)]	Number of observation	Step return [(b)]	MBG [(c)]
Montpellier	Baseline	30	2	6	2	No
	Voluntary adhesion	30	2	5	2	No
Tunis	Baseline	30	2	6	2	No
	Voluntary adhesion	30	2	6	2	No

(a) Number of contributors required to reach the threshold; (b) Benefit /cost = $\frac{n\beta T}{T}$; (c) Money Back Guarantee

3 Results

In the sub-section 3.1, we examine the effects of voluntary adhesion within the Tunisian participants. The aim is to check whether we observe the same results with the Tunisian students than with the students in Montpellier. In sub-section 3.2, we address the differences between the two samples; we compare the cooperative behaviour among subjects of the baseline in Tunis and in Montpellier and similarly subjects of the voluntary adhesion treatment in the two samples.

Table 26 summarizes the general pattern of the results. It depicts by the location of the experiment (Montpellier and Tunis) and for each treatment (baseline and voluntary adhesion) the individual and the group level of contribution, the success rate of provision and the welfare[39]. The success rate of provision is the percentage of success of provision of the step-

[39] A control for demographic variable (sex, age, marital status, level of education) and the discipline of students (economics, agronomy, arts, literature) shows no significant correlation with contribution behaviour.

level good[40]. It is equal to the number of times group contributions reach at least the threshold divided by the number of periods. The welfare is equal to the final monetary payment of the subjects.

3.1 Provision of club goods with Tunisian subjects

The analysis conducted in this section follow this scheme. First, we compare the baseline treatment and the voluntary adhesion treatment using non-parametric tests: a two-sided Wilcoxon-Mann-Whitney test or a two-sided χ^2 test depending on the variable (qualitative or quantitative). Then, we control for the differences between the two treatments with a GLS panel[41] data regression with random effects[42]. The dependent variable is defined specifically for each analysis. When it is a binary variable, e.g. success of provision, we run a logit regression on panel data. Unless reported otherwise, the regressors are a dummy treatment taking value 1 for the voluntary adhesion (0 for the baseline) and a time variable. They are denoted *Voluntary adhesion* and *Period.* We correct for heteroskedasticity and auto-correlation each time it was detected[43]. We conclude for a significant statistical effect when both the non-parametric tests and the panel data regression agree. Finally, the rejection threshold of the null hypothesis is at 5%.

[40] Hereafter, we will call the success rate of provision simply "success rate".

[41] We check the presence of unobserved individual heterogeneity with a Breusch and Pagan LM test before each panel data regression. The tests confirm the significant presence of individual effects and thus the relevance of the data as a panel structure.

[42] Random effects were preferred over fixed effects for two reasons: first, they allow for regressors that do not vary over time (dummy variable) and second, the GLS estimator corrects for multiple observations from a single group of subjects (Green, 1993).

[43] For all regressions we check for the existence of auto-correlation and heteroskedasticity : If only heteroskedasticity was detected (White test) we correct by running FGLS with a variance covariance matrix of the errors allowing for heteroskedasticity. If only intra-individual autocorrelation (Breusch and Pagan LM test) or inter-individual autocorrelation was detected (Wooldridge test) or both simultaneously, we correct by a GLS random effects regression with a Durban-Watson coefficient. Finally, if both heteroskedasticity and any form of auto-correlation was detected, we correct by running a FGLS with a modified matrix of covariance of the errors allowing for autocorrelation and heteroskedasticity. See (Baltagi, 1995) for a discussion of hetroskedasticity and autocorrelation under panel data.

Table 26

Descriptive statistics

	Average individual contribution (SD)		**Average group contributions (SD)**		**Success rate of provision [(c)]**		**Welfare [(d)] (SD)**	
	Baseline	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*
Montpellier	6.44 (6.67)	7.83 (5.89)	25.79 (17.88)	31.35 (14.26)	39.7%	67.7%	558.48 (80.60)	626.4 (101.09)
Tunis	6.86 (6.04)	8.66 (5.51)	27.42 (12.97)	34.66 (10.72)	45.3%	69.3%	546.5 (93.01)	623.12 (91.63)
Nash prediction [(a)]	7.5[(b)]	7.5[(b)]	30	30	--	--	--	--

(a) Pareto dominant Nash prediction [(b)] The symmetrical equilibrium is 7.5

(b) Success rate of provision = Number of times the groups reach the threshold / Number of periods

(c) Welfare = Total points accumulated at the end of the experiment. (1 token in the private account = 1 point; 1 token in the collective account = 0.5 point)

Result 1: Voluntary adhesion induces higher group contributions, higher provision success and higher welfare compared to the baseline treatment.

Hereafter we compare the level of group contributions, the success of provision and welfare between the baseline and the voluntary adhesion treatment. Table 26 shows that in the voluntary adhesion treatment group contributions increases by 7.24 tokens (also supported by a visual inspection of average group contributions in figure 8), the success rate by 24% and the welfare by 76.62 points in comparison to the baseline treatment. This is confirmed Non parametric test indicate that these improvements are significant: (group contributions U= -4.98; p <0.01 success of provision χ^2 =17.65; p <0.01 and welfare U=-5.85; p <0.01). We then conduct a panel data regression. The regressors are the treatment dummy (*voluntary adhesion)* and time (*Period).* Table 27 reports the regressions for three alternatives. The statistical test and the panel data regression are consistent. Therefore, the increase of group contributions, success of provision and welfare by voluntary adhesion does not depend on the subject's origin.

Table 27

Results from panel data regression explaining group contributions, success of provision and welfare (T-sample) [(a)]

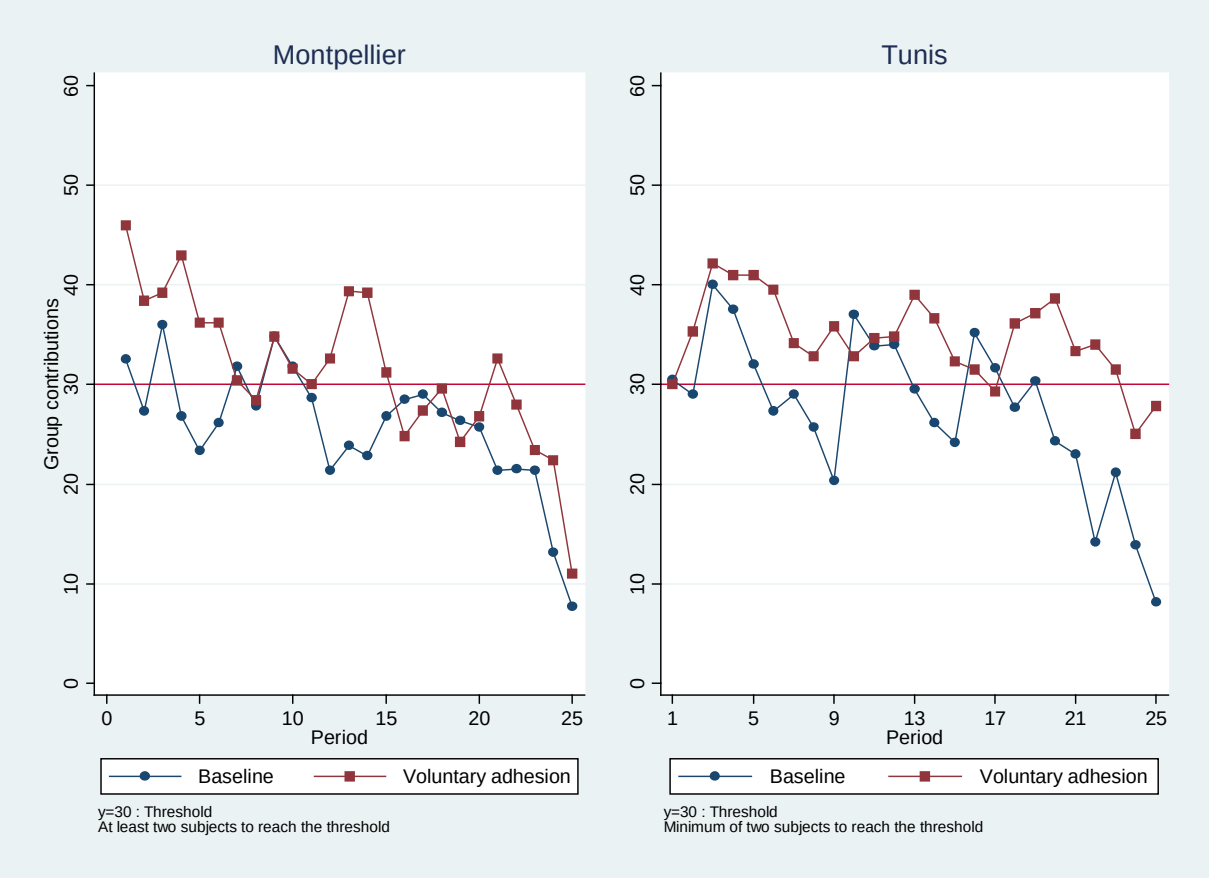
Regressor	**Group contributions**	**Success of provision [(b)]**	**Welfare**
Intercept	33.74(*)	0.61 (*)	3.52(*)
	(17.38)	(1.64)	(7.40)
Voluntary adhesion[(c)]	6.11 (*)	1.11 (*)	3.52(*)
	(3.74)	(2.62)	(-5.01)
Period	-0.51 (*)	-0.06 (*)	-0.16 (*)
	(-4.74)	(-3.51)	(42.78)
Log likelihood	-1117	-185	-4268
Number of observation	300	300	300
Number of groups	12	12	12
Time periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b): Logit regression on panel data with random effects (c) : Dummy taking value 1 for voluntary adhesion treatment ; Regressions are corrected for heteroskedasticity and autocorrelation.

Figure 8

Average group contributions within the M-sample and the T-sample



Result 2: Voluntary adhesion does not affect the variance of group contributions.

The variance of group contributions can break down as intratemporal[44] group variance and intertemporal group variance (Sevestre, 2002). The experiment performed in Montpellier showed that voluntary adhesion decreases the intratemporal group contributions but does not affect intertemporal group contributions. Table 28 reports the results of the panel data regressions explaining the dependent variable intratemporal group contributions with the regressors V*oluntary adhesion* and *Period*. The coefficient of the regressor V*oluntary adhesion* is not significant indicating that there is no difference between the baseline and the voluntary adhesion treatment. With a U test we compare the intertemporal group

[44] $\sigma_G^2 = \sum_{t=1}^{T}\sum_{j=1}^{J}(G_{jt}-\overline{G}_{..})^2 = J\sum_{t=1}^{T}(G_{.t}-\overline{G}_{..})^2 + \sum_{j=1}^{J}\sum_{t=1}^{T}(G_{jt}-\overline{G}_{.t})^2$ with G denotes for group contributions, *j* stands for the *group* and *t* for the period.

contributions between the two treatments. It shows no significant difference (U=1.28; p=0.20). Thus, despite the fact that standard deviation of group contributions and individual contribution decrease (Table 26), voluntary adhesion does not significantly decrease group contributions variance.

Table 28

Results from panel data regression explaining intratemporal variance of group contributions in Montpellier and in Tunis [(a)]

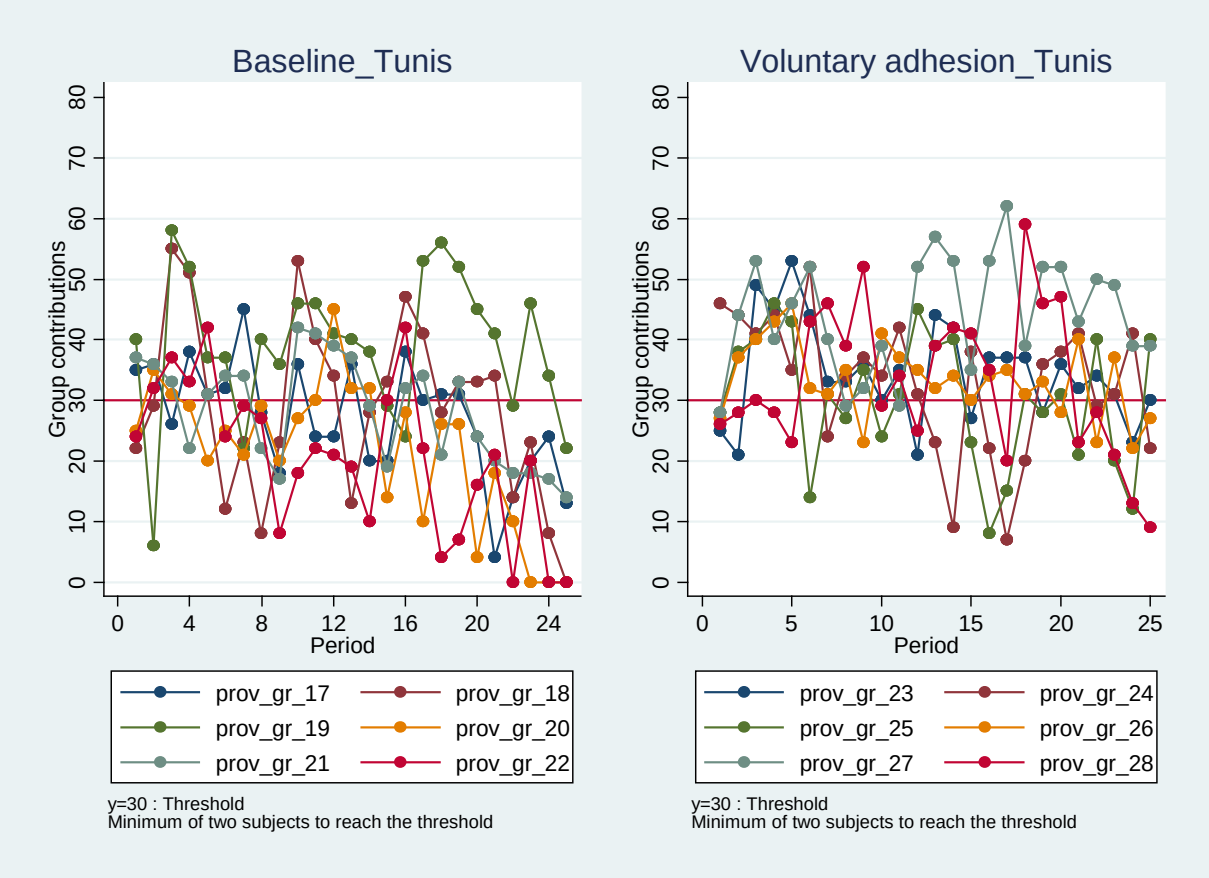
Regressors	**Montpellier**	**Tunis**
Intercept	143.64 (*)	59.63 (*)
	(3.27)	(2.75)
Voluntary adhesion[(b)]	-115.33 (*)	--
	(-3.48)	
Period	7.25 (*)	2.84 (**)
	(2.95)	(2.15)
Log likelihood	-1780	-1900
Number of observation	275	300
Number of groups	11	12
Time periods	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) : Dummy taking value 1 for voluntary adhesion treatment ; Regressions are corrected for heteroskedasticity and autocorrelation.

Figure 9

Group contributions (T-sample)



Result 3: Voluntary adhesion raises the level of convergence of group contributions

To analyse the convergence of the group contributions we conduct two analyses: first, we analyse the quadratic difference between group contributions and the threshold (Marks and Croson, 1998); We calculate the squared distance of the level of group contributions to the threshold. It is our dependent variable. We explain it by a non-linear function of time. If the coefficient of the variable "period" is significant and negative it implies that the group contributions converges to the threshold. Besides, if the squared period is significant (of any sign) it will indicate that the convergence is non-linear. Table 29 reports the results of the regression. It indicates that group contributions do not converge to the threshold in both

treatments.[45] This result holds even if we drop the 3 last periods to avoid the endgame effect. (Figure 9 depicts an important endgame effect for the baseline treatment).

In addition to this convergence to the threshold, we examine the asymptotic level of group contributions[46] (Camera *et al.*, 2003). We explain group contributions by an inverse function of time. As *t* becomes large, $\frac{1}{t}$ gets negligible. The asymptotic group contributions is thus estimated by G_∞, the intercept. Table 30 reports the result of the regression. It indicates a higher level of group contributions in the voluntary adhesion treatment (33.39 tokens) than in the baseline treatment (26.15 tokens). Note also that the asymptotic group contributions is lower than the threshold in the baseline treatment and higher than the threshold in the voluntary adhesion treatment. These findings are therefore consistent with the results of Table 29; for the voluntary adhesion treatment, group contributions do not converge to the threshold but to a value slightly higher. Similarly, for the baseline treatment, the long time convergence is rather under the threshold than equal the to threshold.

In Montpellier, the baseline converges to 22.0 tokens and voluntary adhesion raises it to 30.15 tokens. With the T-sample, the baseline converges to 26 tokens and voluntary adhesion raises it to 33 tokens. Thus, in both cases voluntary adhesion raises significantly asymptotic group contributions.

[45] We have also examined the convergence to the 0 contribution equilibrium with a same regression. It is not significant in both cases.

[46] $G_{jt} = G_\infty + G_0\frac{1}{t} + u_j + \varepsilon_{jt}$ with where $j = 1, 2,.., J$ and $t = 1, 2,.., 25$

Table 29

Results from panel data regression explaining group's contributions convergence to the threshold (T-sample) [(a)] [47]

Regressors	**Baseline**	**Voluntary adhesion**
Intercept	138.39 (*)	94.58 (***)
	(2.75)	(1.65)
Period	-17.16 (***)	--
	(-1.92)	
Period_squarre	1.00 (*)	--
	(3.01)	
Log likelihood	-1007	-981
Number of observation	150	150
Number of groups	6	6
Time periods	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

[47] See Appendix 4.2 for the group contributions convergence to the threshold of the M-sample

Table 30

Results from panel data regression explaining asymptotic group contributions (T-sample) [(a) (b) 48]

Regressor	**Baseline**	**Voluntary adhesion**
Intercept	26.15 (*)	33.39 (*)
	(1.19)	(25.18)
Period_inver	--	--
Log likelihood	-571	-552
Number of observation	150	150
Number of groups	6	6
Time periods	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) : $G_{it}=G_{\infty}+G_{0^*}\left(\frac{1}{t}\right)+u_i+\varepsilon_{it}$ with $\varepsilon_{it}=\rho\varepsilon_{it-1}+v_{it}$ where i=1,2,..,6 and t=1,2,..,25 ; Regressions are corrected for heteroskedasticity and autocorrelation.

Result 4: Voluntary adhesion increases the number of contributors but does not decrease cheap riding.

Introducing voluntary adhesion excludes contribution vectors where players contribute 0. Therefore, all the Pareto efficient equilibria involve all the group members (4 players). In contrast, in the baseline treatment, players can free ride. Equilibria consist of at least two players. As a result, we expect that within the voluntary adhesion treatment the number of contributors will be higher than in the baseline treatment. Figure 10 depicts the percentage of the number of contributors in a group per treatment. Clearly, a visual inspection reveals that in

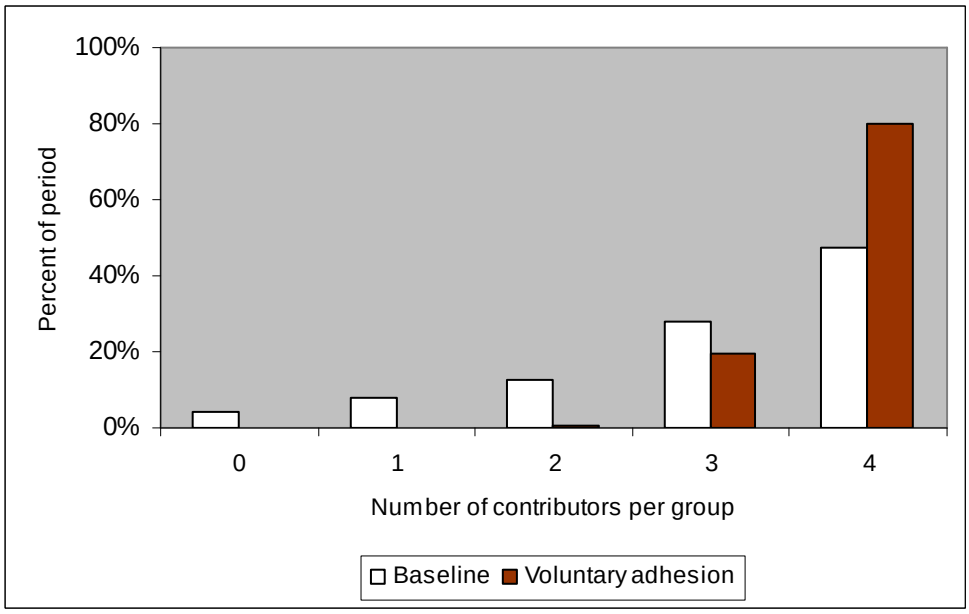
[48] See Appendix 4.3. for asymptotic group contribution of the M-sample

the voluntary adhesion treatment, there are more contributors. In 80% of the periods all members of the group contribute, which happen only in 47% of the periods in the baseline treatment. We conduct a χ^2 test to compare the number of contributors per group in each treatment. The difference is statistically significant (χ^2 =49.51; p<0.01). The result of the regression explaining the number of contributors per group (the dependent variable) by *Voluntary adhesion* and *Period (*the regressors*)* are reported in Table 31. The coefficient of *voluntary adhesion* is significant and positive indicating an increase of the number of contributors. Moreover, the coefficient of *Period* is quasi-null suggesting that this increase is stable over time. Thus, we observe, as for the M-sample, that the number of contributors increases within the T-sample. This finding is consistent with theoretical prediction.

In addition to the increase of the number of contributors, we observe in Montpellier that voluntary adhesion decreases cheap riding. We run a Mann Withney test and a panel data regression to check the statistical significance of this observation within the T-sample. Cheap riding is measured by the comparison of strictly positive contributions between the two treatments. We find that voluntary adhesion increases the individual contribution (U=-6.38 ; p<0.01) but do not decrease cheap riding (U=-1.14 ; p=0.25). We run two panel data regressions. The first one explains the individual contribution by *Voluntary adhesion* and *Period*. The second regression explains individual contribution of only contributors i.e. we drop contribution equal to 0 in the dependant variable. Table 32 reports the results of the two regressions. It confirms that cheap riding among contributors does not decrease in the voluntary adhesion. This result is different from the finding with the M-sample. A possible explanation is the significant higher number of contributors in the baseline treatment in the T-sample in comparison to the baseline treatment of the M-sample (See Result 3.2.2.)

Figure 10

Percentage of contributors per group (T-sample) [49]



[49] See Appendix 4.4. for the percentage of contributors per group in the M-sample.

Table 31

Results from panel data regression explaining the number of contributors per group in Montpellier and in Tunis. [(a)]

Regressor	**Montpellier**	**Tunis**
Intercept	2.88 (*)	3.50(*)
	(10.84)	(23.03)
Voluntary adhesion[(b)]	1.06 (*)	0.52 (*)
	(3.77)	(3.85)
Period	0.02 (*)	-0.01 (*)
	(-2.72)	(-2.64)
Log likelihood	-369	-245
Number of observation	275	300
Number of groups	11	12
Time periods	25	25

(*): Significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) : Dummy taking value 1 for voluntary adhesion treatment ; Regressions are corrected for heteroskedasticity and autocorrelation.

Table 32

Results from panel data regression explaining individual contribution in Montpellier and in Tunis [(a)]

Regressor	Montpellier		Tunis	
	Contribution	Cheap_[(b)]	Contribution	Cheap_[(b)]
Intercept	9.09(*)	10.58(*)	7.02 (*)	8.87(*)
	(17.83)	(36.35)	(22.79)	(35.07)
Voluntary adhesion [(c)]	1.84 (*)	-1.69 (**)	2.75 (*)	0.85(*)
	(3.99)	(-6.59)	(10.31)	(-3.21)
Period	-0.21(*)	-0.04 (*)	-0.09 (*)	-0.05 (*)
	(-7.41)	(-2.13)	(-5.32)	(3.40)
Log likelihood	-3199	-2368	-3647	-3050
Number of observation	1100	799	1200	1028
Number of subjects	44	44	48	48
Time periods	25	25	25	25

(*): Significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) Strictly positive contributions (Free riders and auto-excluded subjects are dropped in each period). (c) Dummy taking value 1 for the voluntary adhesion treatment; Regressions are corrected for heteroskedasticity and autocorrelation.

3.2 Comparison between subject's cooperative behaviour in Montpellier and in Tunis

In the previous subsection, we examined the provision of the club goods with the Tunisian subjects. Hereafter we investigate whether subject's cooperative behaviour differ between the T-sample and the M-sample; first we compare the variance of group contributions, then the number of contributors and finally the individual level of contribution. These comparisons are conducted between the baseline of the T-sample and the M-sample and between the voluntary adhesion treatment of the T-sample and the M-sample.

Result 1: There is less variance of group contributions within the T-sample in comparison to the M-sample.

Figures 11 and 12 suggest that there is less variance among group contributions within the T-sample. To test this visual inspection we conduct an analysis of the variance of group contributions similar to the section 3.1.2. We break down the variance of group contributions into intratemporal variance and intertemporal variance. Table 33 reports the result of the intr-temporal variance for the baseline and the voluntary adhesion treatment. The regressors are a dummy for the location of the experiment (taking value 1 for Tunis and 0 for Montpellier) and time. The coefficient of the regressor *Location* of the two regressions is significant and negative. Thus, the regression supports the graphical interpretation: there is significantly less variance among group contributions of the T-sample. Note, however, that the coefficient of "period" is positive suggesting that the decrease of variance tends to decrease over time. The comparison of the intertemporal variance with a Mann Whitney test shows that group contributions does not change between Montpellier and Tunis for the baseline treatment ($U=1.92$; $p=0.06$) and the voluntary adhesion treatment ($U=1.27$; $p=0.20$).

Table 33

Results from panel data regression explaining intra-temporal variance of group contributions in the pooled sample (M-sample + T-sample) [(a)]

Regressors	**Baseline**	**Voluntary adhesion**
Intercept	189.80 (*)	83.56 (*)
	(5.16)	(4.06)
Location[(b)]	-131.67 (*)	-47.17 (*)
	(1.76)	(-2.70)
Period	2.74 (***)	2.41 (**)
	(-3.97)	(2.12)
Log likelihood	-1929	-1766
Number of observation	300	275
Number of groups	12	11
Time periods	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) : Dummy taking value 1 for Tunis; Regressions are corrected for heteroskedasticity and autocorrelation.

Figure 11

Group contributions in the baseline treatment of the M-sample and the T-sample.

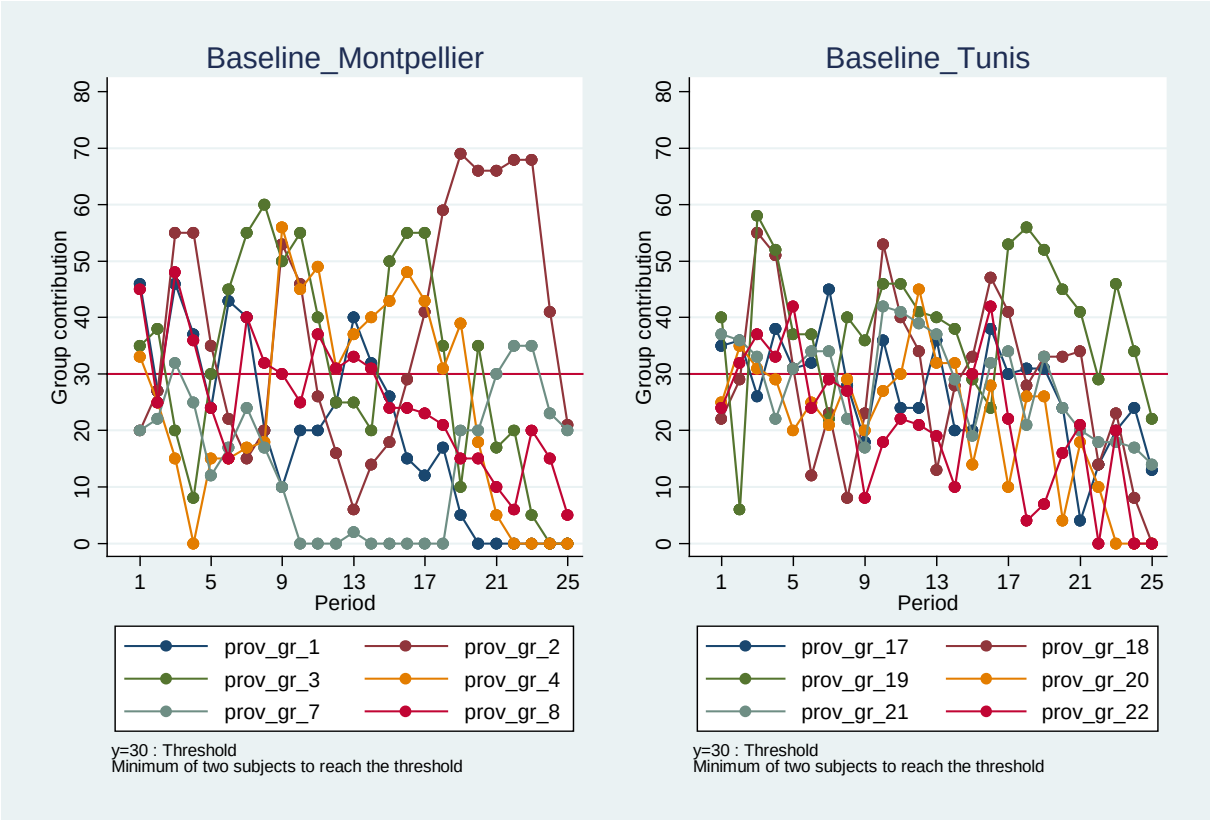
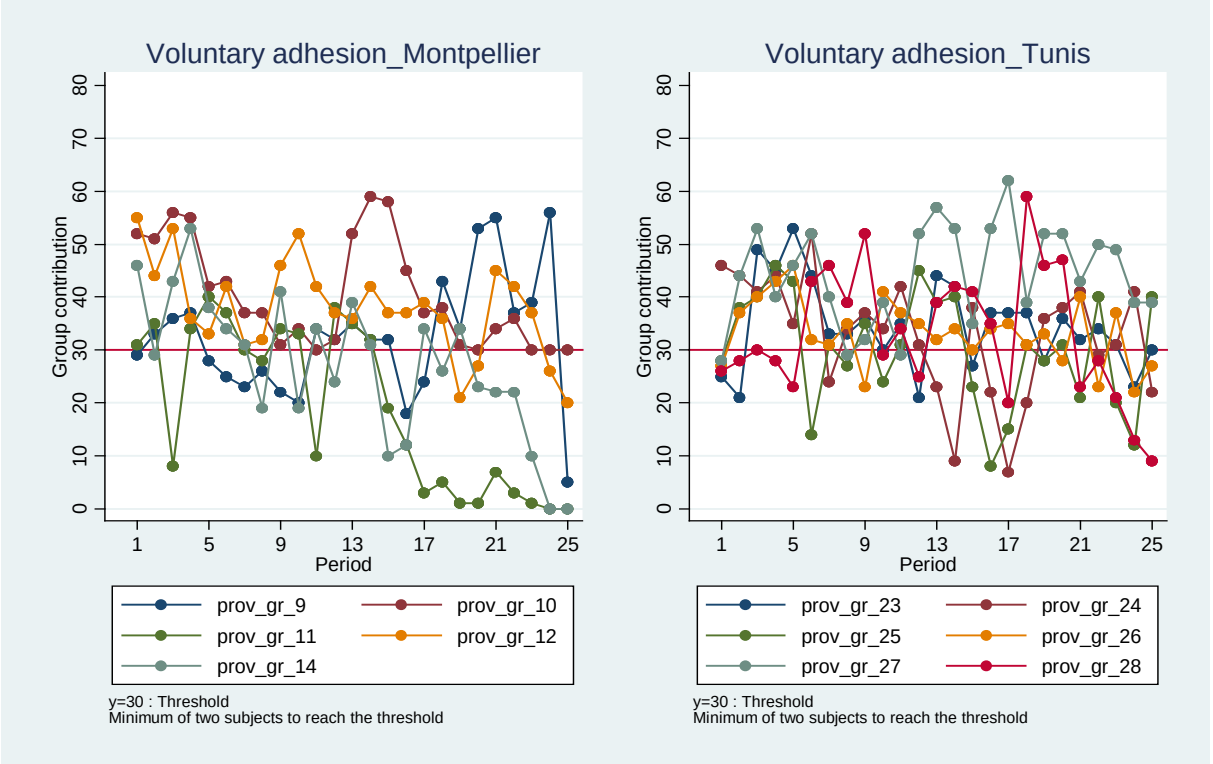


Figure 12

Group contributions in the voluntary adhesion treatment of the M-sample and the T-sample.



Result 2: There are more contributors in the baseline treatment of the T-sample in comparison to the baseline treatment of the M-sample.

Both experiments in Montpellier and in Tunis show an increase in the number of contributors under voluntary adhesion. Hereafter, we wonder whether the number of contributors is similar between the two samples. Table 34 reports the average number of contributors for each treatment. The increase of the number of contributions in the T-sample in comparison to the baseline treatment of the M-sample is significant (χ^2 =21.99; p <0.01). The same finding is observed for the voluntary adhesion treatment (χ^2 =17.35; p <0.01)

Table 34

Average number of contributors per treatment

	Montpellier (SD)	**Tunis** (SD)	**Group size**
Baseline	2.46 (1.38)	3.06 (1.13)	4
Voluntary adhesion	3.35 (1.20)	3.79 (0.42)	4

We run three regressions to examine more precisely this increase of contributors. First, a regression on a pooled sample (T-sample + M-sample) explaining the number of contributors – the dependant variable- by a dummy variable for the location of the experiment (taking value of 1 for Tunis), a dummy for treatment (taking value of 1 for the voluntary adhesion treatment) and time. Table 35 reports the results of the regression. The regressors *Location* and *Treatment* are positive and significant: there is an increase of the number of contributors. The regression on the pooled sample confirms the results of the statistical test. Second, we run a regression explaining the number of subjects within each treatment separately. The same regressors are used (except for the dummy treatment). The results are reported in the same table 35. For the baseline treatment, the panel data regression reveals a significant increase of

the number of contributions in Tunis in comparison to Montpellier. For the voluntary adhesion treatment, the regression shows that the increase is not significant. This result contradicts the non-parametric χ^2 test. We therefore reject the existence of an increase of the number of contributors in the voluntary adhesion treatment.

Table 35

Results from panel data regression explaining the number of contributors per group in the pooled sample (M-sample + T-sample) [(a)]

Regressor	**Pool[(b)]**	**Baseline**	**Voluntary adhesion**
Intercept	3.14 (*)	3.56 (*)	3.96 (*)
	(23.12)	(13.29)	(83.98)
Location[(c)]	0.26 (**)	0.72 (*)	--
	(2.11)	(2.99)	
Period	-0.02 (*)	-0.08 (*)	--
	(-4.28)	(-6.96)	
Treatment[(d)]	0.72 (*)		
	(5.71)		
Log likelihood	-453	- 363	-35
Number of observation	575	300	275
Number of groups	23	12	11
Time periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) : Baseline+ voluntary adhesion in Montpellier and Tunis. (c) : Dummy taking value 1 for Tunis (d) : Dummy taking value 1 for voluntary adhesion treatment ; Regressions are corrected for heteroskedasticity and autocorrelation.

Result 3: The level of the individual contribution is the same in the M-sample and the T-sample.

In the voluntary adhesion treatment, the Tunisian student contributed 1.17 tokens more to the collective account than the students of Montpellier. For the baseline treatment, the contribution increases by 0.42 tokens. Is this increase statistically significant? To answer this question we conduct a Mann Withney test comparing individual contribution in the voluntary adhesion treatment between Montpellier and Tunis. We perform the same test to compare individual contribution in the baseline treatment between the M-sample and the T-sample. It shows that the increase is statistically significant ($U=-2.80$; $p<0.01$ and $U= - 2.11$; $p=0.03$ respectively). Then, we conduct a panel data regression on the pooled sample (T-sample + M-sample) explaining individual contribution by the location of the experiment, the treatment and time. We run a regression within only subjects of the baseline treatment (M-sample and the T-sample) explaining individual contribution by a dummy variable Location and time. The same regression but for the voluntary adhesion treatment was also conducted. Table 36 reports the results of the three regressions. In the three cases, the regressor *Location* is not significant indicating that there is no difference in individual contribution with respect to the origin of the subjects. As a result, we have mixed evidence. The regression does not confirm the result of the statistical test. We therefore reject the hypothesis of differences in individual contributions[50].

[50] Group contributions and welfare do not vary between the two samples. Subjects earnings are similar (Appendix 4.5.)

Table 36

Results from panel data regression explaining individual contribution in the pooled sample (M-sample + T-sample) [(a)]

Regressor	**Pool [(b)]**	**Baseline**	**Voluntary adhesion**
Intercept	8.00 (*)	8.45 (*)	10.13 (*)
	(22.32)	(17.18)	(21.59)
Location [(c)]	--	--	--
Period	-0.13 (*)	-0.16 (*)	-0.12 (*)
	(-7.71)	(-6.18)	(-4.90)
Treatment [(d)]	1.94 (*)		
	(7.19)		
Log likelihood	-6694	-3576	-3279
Number of observation	2300	1200	1100
Number of subjects	92	48	44
Time periods	25	25	25

(*): Significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses. (b) : Baseline + voluntary adhesion treatment of the M-sample + T-sample. (c) : Dummy taking value 1 for Tunis. (d) : Dummy taking value 1 for voluntary adhesion treatment; Regressions are corrected for heteroskedasticity and autocorrelation.

4 Conclusion

The aim of this experiment is to test the provision of a club good with respect to the origin of subjects. The experiment shows few differences between the baseline and the voluntary adhesion treatment. It reveals among the Tunisian students a higher success of provision, an increase of group contributions and an improvement of welfare in the voluntary adhesion treatment. We also find that the number of contributors in a group significantly increases in the voluntary adhesion treatment. This is consistent with the theoretical predictions. Also, the experiment shows that voluntary adhesion raises the level of convergence of group contributions. However, adding voluntary adhesion makes group contributions converge to an amount slightly lower (Montpellier) or higher (Tunis) to the threshold. Besides, cheap riding is not affected; there is not a better coordination among subjects of the voluntary adhesion treatment to reach the provision point. Finally, voluntary adhesion does not decrease group contributions variance.

The comparison of the cooperative behaviour of subjects in Tunis and in Montpellier reveals some subtle differences. Groups contributed significantly the same amount of tokens and subjects earned the same gains in Montpellier and in Tunis. However, two main differences are observed: Firstly, there is a higher number of contributors among the T-sample in comparison to the M-sample (especially in the baseline). In Montpellier, on average 2.91 subjects per group provide the public good. In the T-sample, there are on average 3.43 subjects per group that contribute to the provision of the public good. Secondly, there is less intra-temporal variance among group contributions in the T-sample. A possible explanation to this decrease of group's contributions variance could be the consequence of the increase of the number of contributors among the T-sample.

The finality of the experiment is to control the existence of differences due to the origin of the subjects before conducting a field experiment. The experiment with Tunisian students did not reveal dramatic change, only subtle differences. Therefore, the findings with farmers can safely be related to the farmer's characteristic and not to the Tunisian origin.

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Appendix

Appendix 4.1.

Percentage of Nash equilibria

Appendix 4.2.

Results from panel data regression explaining group contributions convergence to the threshold (M-sample)

Appendix 4.3.

Results from panel data regression explaining asymptotic group contributions (M-sample)

Appendix 4.4.

Number of contributors per group (M-sample)

Appendix 4.5.

Results of panel data regressions explaining group contributions and welfare in the pooled sample (M-sample + T-sample) [(a)]

Appendix 4.6.

The instructions (Baseline, medium threshold)

Appendix 4.1.: Percentage of Nash equilibria

Groups in the voluntary adhesion treatment have contributed significantly less than the Nash prediction in the baseline treatment ($t = -2.43$; $p<0.01$) and significantly more than 30 tokens in the voluntary adhesion treatment. ($t=5.32$; $p<0.01$). Obviously, individual contribution is less than the symmetrical prediction in the baseline ($t=-2.56$; $p<0.01$) and significantly higher in the voluntary adhesion treatment ($t = 5.18$; $p<0.01$). In Montpellier, the Nash equilibrium is predictive for the voluntary adhesion treatment and individual contributions are symmetrical but not for the baseline treatment.

	Percentage of Nash equilibria	
	Baseline	Voluntary adhesion
Montpellier	1.9%	4.8%
Tunis	2.0%	2.6%

Percentage of Nash equilibria = Number of Nash equilibria / Number of times group contribution reach at least the threshold

Appendix 4.2.: Results from panel data regression explaining group contributions convergence to the threshold (M-sample) [(a)]

Regressors	***Baseline***	***Voluntary adhesion***
Intercept	234.73 (***)	281.37 (*)
	(1.95)	(2.97)
Period	--	-46.49 (*)
		(-2.86)
Period_squarre	1.62 (**)	2.19 (*)
	(2.11)	(3.68)
Log likelihood	-1024	-713
Number of observation	150	125
Number of groups	6	5
Time periods	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

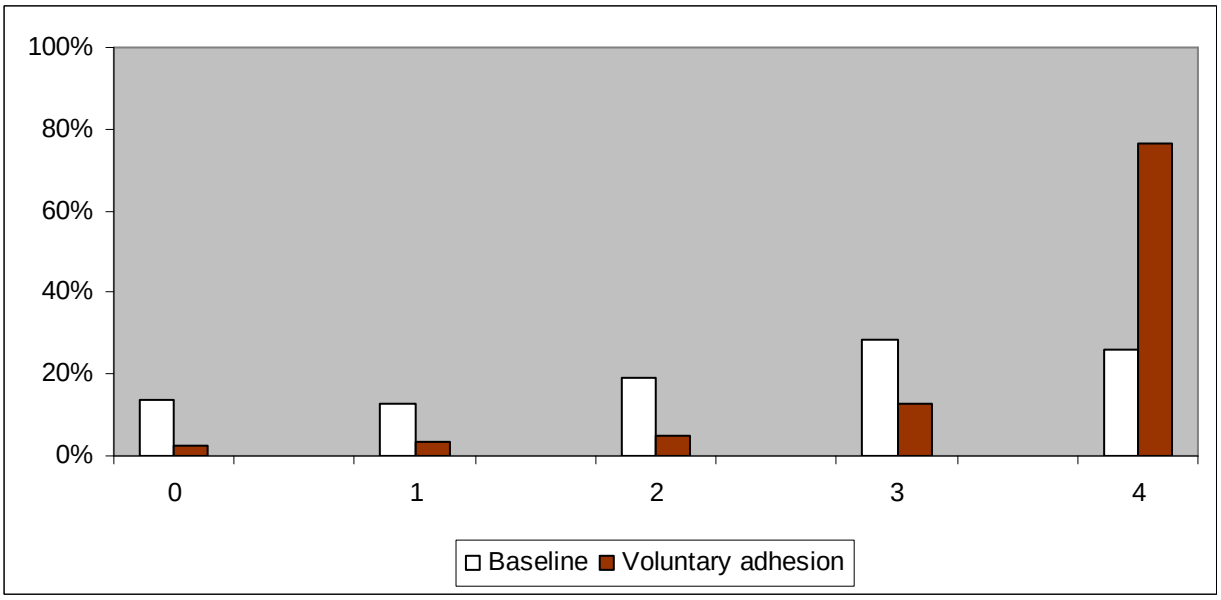
Appendix 4.3.: Results from panel data regression explaining asymptotic group contributions (M-sample) [(a) (b)]

Regressor	**Baseline**	**Voluntary adhesion**
Intercept	22.00 (*)	30.15 (*)
	(2.07)	(21.39)
Period_inver	13.01(**)	23.09 (*)
	(7.45)	(3.89)
Log likelihood	-564	-491
Number of observation	150	125
Number of groups	6	5
Time periods	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) : $G_{it}=G_{\infty}+G_{0*}\left(\frac{1}{t}\right)+u_i+\varepsilon_{it}$ with $\varepsilon_{it}=\rho\varepsilon_{it-1}+v_{it}$ where i=1,2,..,6 and t=1,2,..,25; Regressions are corrected for heteroskedasticity and autocorrelation.

Appendix 4.4.: Percentage of contributors per group (M-sample)



Appendix 4.5.: Results of panel data regressions explaining group contributions and welfare [(a)]

We conduct an analysis to compare group contributions between the baseline and the voluntary adhesion treatment within the pooled sample (T-sample + M-sample). A U test shows that group contributions is significantly equal between the baseline of the M-sample Montpellier and the T-sample (U=-1.68; p=0.09) and also between the voluntary adhesion treatment of Montpellier and Tunis (U= -1.43; p=0.15).

The table below reports the result of the regression explaining group contributions by the location of the experiment, treatment and time. It confirms that there is no difference between the level of group contributions in Tunis and Montpellier. The table of the appendix 4.5 also reports the result of the same regression but with the dependent variable welfare. The regressor *Location* is still not significant. Therefore, we can conclude that there is no impact of the subject's origin on the level of welfare.

Results from panel data regressions explaining group contributions and welfare in the pooled sample (M-sample + T-sample)

Regressors	**Group contributions**	**Welfare**
Intercept	33.21 (*)	24.12
	(19.48)	(47.92)
Location[(b)]	--	--
Period	-0.60 (*)	-0.20
	(-8.04)	(-7.73)
Treatment[(c)]	6.65 (*)	3.16 (*)
	(-6.85)	(7.80)
Log likelihood	-2118	-7876
Number of observation	575	2300
Number of panels	23[(d)]	92[(e)]
Time periods	25	25

(*): Significant at 1% level; (**): significant at 5% level; (***) : significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) : Dummy taking value 1 for Tunis (c) : Dummy taking value 1 for the voluntary adhesion treatment (d) : number of groups (e) : number of subjects; Regressions are corrected for heteroskedasti

Appendix 4.3.: The instructions (Baseline, medium threshold)

INSTRUCTIONS

Bienvenue

L'expérience à laquelle vous allez participer est destinée à l'étude des décisions. Vous allez être confrontés à une décision de répartition de jetons entre deux comptes : un compte individuel et un compte collectif. Les instructions sont simples. Si vous les suivez scrupuleusement et que vous prenez de bonnes décisions de placement, vous pourrez gagner une somme d'argent non négligeable. Toutes vos réponses seront traitées de façon anonyme et seront recueillies au travers d'un réseau informatique. Vous indiquerez vos choix à l'ordinateur devant lequel vous êtes assis et celui-ci vous communiquera vos gains réalisés au fur et à mesure du déroulement de l'expérience.

La somme totale d'argent gagnée pendant l'expérience vous sera versée, en liquide, à la fin de celle-ci.

CADRE GENERAL DE L'EXPERIENCE

16 personnes participent à cette expérience. **Vous êtes membre d'un groupe constitué de 4 personnes choisies au hasard parmi les 16 personnes présentes dans la salle. La composition de votre groupe restera la même tout au long de l'expérience.** Vous ne pouvez pas connaître l'identité des personnes faisant partie de votre groupe parmi celles présentes dans la salle.

Les gains que vous réaliserez dépendront à la fois des décisions que vous prendrez et des décisions prises par les 3 autres membres qui composent votre groupe. Chaque décision de placement que vous prendrez se traduira par un gain en points plus ou moins important. Ce gain en points sera converti, à la fin de l'expérience, en Euros. La procédure de conversion des points en euros est détaillée à la fin des instructions.

La suite des instructions va vous permettre de comprendre de quelle manière vos gains sont calculés.

LES TYPES DE PLACEMENT

L'expérience comporte **25 périodes**. Au début de chaque période, chaque membre de votre groupe est doté d'un budget de 20 jetons. A chaque période vous, ainsi que les 3 autres membres de votre groupe, serez amenés à répartir votre budget entre 2 types de comptes possibles: votre compte individuel et votre compte collectif.

1- Règles du compte individuel :

Chaque jeton que vous placez dans votre compte individuel vous rapporte 1 point. De même, si un membre de votre groupe place un jeton dans son compte individuel, il lui rapportera 1 point.

Les gains des autres membres du groupe ne sont pas affectés par le nombre de jetons que vous décidez de placer dans votre compte individuel. De même votre gain n'est pas affecté par le nombre de jetons placés par les autres membres du groupe dans leur propre compte individuel. Illustrons cela au moyen de 3 exemples:

5- Quelles que soient les décisions de placement des autres membres du groupe, si vous placez 5 jetons dans votre compte individuel, votre gain résultant de cette décision sera de 5 points. Les gains des autres membres du groupe ne seront pas affectés par votre décision.

6- Supposons que l'un des membres du groupe décide de placer 10 jetons dans son compte individuel, quelle que soit votre décision de placement, son gain résultant de cette décision sera de 10 points; votre gain ne sera pas affecté par cette décision.

3- Votre budget = 20 jetons

Votre placement individuel = 6 jetons

Votre compte individuel vous rapporte = $1 \times 6 = 6$ points

Au gain de votre placement individuel s'ajoute le gain résultant du placement collectif. La manière dont est déterminé le gain du placement collectif fait l'objet de la suite des instructions.

2- Règles du compte collectif :

Il existe un seul compte collectif pour tout le groupe. Le gain que vous réalisez dépend du nombre total de jetons que vous et les autres membres du groupe placent dans ce compte. Plus le groupe place de jetons dans le compte collectif, plus les gains réalisés par chacun seront importants (*Cf.* page annexe : Tableau des gains). En effet, chaque jeton placé dans le compte collectif rapporte 0,5 points à chaque membre du groupe.

Cependant, vous toucherez un gain du compte collectif si le placement collectif total du groupe est supérieur ou égal à 30 jetons. Dans ce cas, chaque joueur du groupe, ayant placé ou pas des jetons dans le compte collectif, touche un gain. Dans le cas où le placement collectif des 4 joueurs du groupe est inférieur à 30 jetons, le compte collectif rapporte à chaque joueur 0 point.

Par conséquent, pour que le compte collectif rapporte des gains il faut être au moins deux à y placer des jetons (votre budget est de 20 jetons < 30). Si vous êtes le seul à placer dans le compte collectif, vous ne pouvez pas réaliser un gain et ce même lorsque vous placiez dans le compte collectif la totalité de votre budget.

Illustrons les règles du placement collectif au moyen de trois exemples:

Exemple 1 : Calcul de vos gains lorsque le seuil de 30 jetons est atteint

Votre budget étant de 20 jetons, vous décidez de placer 12 jetons dans votre compte individuel et 8 jetons dans le compte collectif. Supposons que les trois autres joueurs de votre groupe choisissent de placer en totalité 25 jetons dans le compte collectif.

Votre compte individuel vous rapporte = $1 \times 12 = 12$ points

Le compte collectif vous rapporte = $0,5 \times (8+25) = 16,5$ points

De même, le gain du compte collectif pour chacun des autres membres de votre groupe est égal à 16,5 points.

Votre gain total de la période = 12 + 16,5 = 28,5 points.

Exemple 2 : Calcul de vos gains lorsque le seuil de 30 jetons n'est pas atteint

Votre budget étant de 20 jetons, vous décidez de placer 10 jetons dans votre compte individuel et 10 jetons dans votre compte collectif. Supposons que les trois autres joueurs de votre groupe choisissent de placer en totalité 8 jetons dans le compte collectif.

Votre compte individuel vous rapporte = $10 \times 1 = 10$ points

Le compte collectif vous rapporte = $0{,}5 \times (8+10) = 0$ point car le placement collectif total, 18 jetons, est inférieur à 30 (vos 10 jetons plus les 8 jetons des trois autres joueurs).

De même, le gain du compte collectif pour chacun des autres membres de votre groupe est égal à 0 point.

Votre gain total de la période = 10 points.

Exemple 3 : Calcul de vos gains lorsque le seuil de 30 jetons est atteint et vous avez placé 0 jeton dans le compte collectif :

Votre budget étant de 20 jetons, vous décidez de placer 20 jetons dans votre compte individuel et 0 jeton dans votre compte collectif. Supposons que les trois autres joueurs de votre groupe choisissent de placer en totalité 30 jetons dans le compte collectif.

Votre compte individuel vous rapporte = $1 \times 20 = 20$ points

Le compte collectif vous rapporte = $0{,}5 \times (0 + 30) = 15$ points

De même, le gain pour chacun des autres membres de votre groupe est égal à 15 points.

Votre gain total de la période = 20 + 15 = 35 points.

En résumé, à chaque période, chaque membre de votre groupe (vous inclus) dispose de deux sources de gain: le gain du compte individuel et le gain du compte collectif.

LE DEROULEMENT DE L'EXPRIENCE

A chaque période, vous devrez prendre deux décisions de placements ; plus précisément vous devrez répartir entièrement votre budget de 20 jetons entre votre compte individuel et votre compte collectif. Vous êtes libre quant au choix de cette répartition et vous pouvez, par exemple, décider de placer la totalité des 20 jetons dans votre compte individuel ou vice-versa (placer l'ensemble des 20 jetons dans le compte collectif).

L'ordinateur, à chaque période, vous demandera d'indiquer le nombre de jetons que vous souhaitiez placer dans chacun des comptes. Vous devez placer à chaque période la totalité de votre budget. En d'autres termes, la somme des jetons placés dans le compte individuel et les jetons placés dans le compte collectif doit être égale à votre budget. Notez, que vous n'avez pas la possibilité de reporter une partie ou la totalité de votre budget d'une période à l'autre.

Tous les membres de votre groupe (vous y compris) prendront leur décision de placement simultanément. Dès que tous les membres de votre groupe auront pris leur décision, l'ordinateur calculera votre gain pour la période en cours. L'ordinateur vous communiquera le nombre de points que vous avez obtenus pour chacun des deux placements à la période en cours. **Il vous communiquera également le placement collectif total de votre groupe et ce que vous ayez placé dans le compte collectif ou pas**. Un historique de vos décisions apparaîtra sur votre écran à la fin de chaque période. La période suivante pourra alors démarrer. A chaque nouvelle période vous connaîtrez votre gain cumulé sur l'ensemble des périodes précédentes.

Lorsque la 25ème période sera achevée, l'ordinateur vous communiquera le montant total de vos gains en points réalisés au cours des 25 périodes. Le facteur de conversion est de 0.40 Euro pour 20 points.

Exemple :

Si votre gain cumulé à la fin de l'expérience est de 800 points, votre paiement sera de 16 € en liquide :

Taux de conversion : 20 points = 0.40 Euro

Questionnaire

Encerclez la bonne réponse.

1 - Vous êtes dans un groupe de :

* 2 joueurs + vous * 4 joueurs + vous * 3 joueurs + vous

2- L'expérience

* Dure 25 périodes * Dure 15 périodes

3 - Est-ce que le gain issu de votre compte privé dépend des autres joueurs ?

* Oui, il dépend * Non il ne dépend pas

4 – Si votre placement collectif est nul, pouvez-vous bénéficier des gains du compte collectif ?

* Oui, je peux * Non, je ne peux pas

5- Si le placement collectif total de votre groupe est égal à 20 jetons, pouvez-vous bénéficer des gains du compte collectif si vous avez placé 5 jetons dans le compte collectif ?

* Oui, je bénéficie * Non, je ne bénéficie pas

6- Supposons que vous avez placé 4 jetons dans votre compte collectif. Supposons que le placement collectif total de votre groupe s'élève à 35 jetons. Calculez votre gain <u>total</u> de la période.

35 points - 19 points – 33,5 points

7- Vous décidez de placer tout votre budget dans le compte collectif. Le placement collectif total de votre groupe s'élève à 29 jetons. Calculez votre gain total de la période.

20 points – 0 points – 14.5 points

8- Vous décidez de ne pas placer de jetons dans le compte collectif. Le placement collectif total de votre groupe s'élève à 60 jetons. Calculez votre gain total de la période.

50 points – 20 points – 60 points

Poste N°……

Joueur N°……

Fiche de renseignement

* Date de naissance : 19…

* Sexe : Masculin / féminin

* Etat civil : célibataire / marié

* Année d'étude : Bac + ….

* Formation : Economie et Gestion / autre (ex : biologie, agronomie) .

* Vous avez déjà participé à une expérience en économie expérimentale : oui / non

Feuille de commentaires

Veuillez préciser vos remarques sur le déroulement de l'expérience ainsi que la stratégie que vous avez suivi(e).

Chapter 5: Voluntary versus involuntary adhesion to a self-governing irrigation system. A field experiment.[51]

1 Introduction

Many developing countries are following World Bank recommendations (Gleick, 2000) and are committed to a process of irrigation systems decentralization. Whether it constitutes an adequate solution or not (Bardhan, 2002), the evolution from a centralized towards a decentralized system raises an implementation issue. A possible way to conduct such transition is to rely on a voluntary approach: the ex-centralized states impose a top-down reform, whereby agents are induced to set up an association to self-govern. In this research, we investigate the possible consequences of such voluntary agreements among agents on their willingness to cooperate.

By implementing a voluntarily policy, the state is imposing a collective good: a group of agents is forced to cooperate in order to provide its own self-governing irrigation system. It is a public good. In contrast, when individuals are free to choose whether to adhere or not to an

[51] This work is financed by *Water **S**avings in **IR**rigation Systems in **MA**ghreb* (SIRMA) project.

association, the context is one of providing a club good. Previous findings in the lab showed that voluntary adhesion improves cooperative behaviour by increasing contributions, compared to involuntary adhesion[52]. To what extent do these findings carry over to the field? In particular, are they consistent with the behaviour of farmers involved in irrigation systems? Firstly, the policy issue addressed above deals with a non-standard pool (Harrison and List, 2004). Several studies also pointed out the particular behaviour of farmers in developing countries (for a survey see Cardenas et al. (2008)). Secondly, the decentralization of an irrigation system involves groups of individuals who already interact with one another, and not isolated individuals. In the lab experiments, participants are randomly selected among a large pool of students, who have no –or little- interaction outside the experimental context. At the opposite, farmers belonging to an irrigation system often know each other and have close relations. Therefore, the pre-existing network of interactions among farmers, is a relevant factor for collective action, and may lead influence the cooperation in an experiment for the provision of a collective good (public or club good).

Being aware of these influences, we set up a field experiment in which the participants are farmers from irrigation system. We selected three samples of farmers according to their pre-existing interaction; Sample 1 is made up of participants who belong to a high performing irrigation system, sample 2 involves participants who belong to a low performing irrigation system. Finally, sample 3 is a *control sample*, composed of independent farmers, who are not in an irrigation system. The performance of the irrigation system is defined according to the Institutional Analysis and Development framework (IAD)(Cárdenas and Ostrom, 2004; Tang, 1992). The experiment conducted with farmers is a replication of the experiment in the lab; We compare two situations: the provision of a public good to the provision of a club good. Both collective goods involve a step-level mechanism[53]. Few theoretical differences exist between these two games. In the case of involuntary adhesion, the free riding strategy and cheap riding are allowed whereas with voluntary adhesion only cheap riding is possible. The Nash prediction in both treatments is to reach exactly the threshold and players do not

[52] Cf. Chapter 2 and Chapter 4

[53] The step-level mechanism has been employed in different previous field experiment. However, they either aimed to mimic field conditions of fundraising (Chen *et al.*, 2006; Rondeau *et al.*, 2005; Rondeau *et al.*, 1999; Rose *et al.*, 2002), or to examine selfish subject's behaviour (Cadsby and Maynes, 1998a; Cadsby and Maynes, 1998b), or to address contingent valuation (Poe *et al.*, 2002). In the three cases, it is without interest to our work.

contribute over the threshold since the marginal return of the collective good is lower than the marginal return of the private good.

The sampling and the recruitment issue were carefully addressed in this field experiment. Several stays were achieved in the area before the experiment. We did not "helicopter" our experiment to the field as it is often criticized. Interviews and surveys were conducted beforehand. Advice and assistance by experts from the administration of the irrigation systems were very helpful to build our sample. The aim of this combination between the field study to the experiment tool is the increase of the control. This is in line with the synergy that natural occurring data and experiments can provide (List and Levitt, 2005) and the need for more control in field settings (Harrison, 2005; Ortmann, 2005). Our field experiment can be classified as an artefactual experiment (Harrison and List, 2004). However, it is not the aim of this experiment to link subject's behaviour to an economic outcome (Cardenas and Carpenter, 2005); The success in the provision of the club good does not determine the performance of the association. It is rather the relation between the sample of farmers selected and the provision of the club that we investigate.

The experiment was conducted during summer 2008 in centre Est. of Tunisia. It is a country engaged in the creation of self-governing irrigation system. The results of the field experiment show that voluntary adhesion is not critical in the provision of a collective good, except for the low performing irrigation system where it improves success of provision and welfare. Farmers are highly cooperative and their collective contributions are sustained over time. The sample type of farmers does not affect the provision of the public good, but the provision of the club good is sensitive to the sample. The results are consistent with the theoretical predictions: there are more contributors in the voluntary adhesion treatment than in the baseline treatment.

The following section of this chapter will explain the choice of the irrigation systems. Section III describes the design of the experiment. In Section IV, we report the results of the field experiment. Section V is a conclusion.

2 Choice of the irrigation system

The field experiment was performed in the region of Kairouan located in east central of Tunisia (see map in the Appendix 5.1.2). Irrigation systems constitute an old tradition in the

region that goes back to the ninth century (Perennes, 1993). Kairouan is a representative area of the semi arid water problems in Tunisia (Faysse, 2001).

We selected a highly homogenous area inside a unique administrative zone in Kairouan in order to maximize the control on the effect of the irrigation system. First, our pool of irrigation systems is located within the same climatic area. They undergo similar risks and share the same uncertainty with respect to farming choices. Second, the 14 irrigation systems of the area selected corresponds to small communities with similar parcel sizes: an average surface of 2.52 ha by farmer and an average number of 56 farmers per plot. Third, irrigation systems are settled on the same groundwater, with a pumping to the same depth. There is no heterogeneity in the access to the water resource. Fourth, irrigation systems use the same technology of farming, characterized by family work and a low degree of mechanization. Finally, they favour production of similar crops: grains during winter and horticultural products in summer.

This area selected in the district of Kairouan includes 14 irrigation systems. Our aim is to elaborate a typology in order to select two extreme cases: a high performing irrigation system and a low performing one. For this purpose, we will refer to the Institutional Analysis Development (IAD) of Ostrom et al. (2004) (Cárdenas and Ostrom, 2004). This framework has been applied by Tang (1992) to the irrigation systems in order to evaluate the performance of their collective action. It is based on the intuition that the success of a collective action depends on the simultaneous resolution of problems in multiple action arenas. Measuring the outcomes of these arenas is a way to approach the performance of the irrigation system. These outcomes are:

1) *The maintenance of the irrigation system:* At the end of a period, is the resource well maintained?
2) *The regular respect of the operational rules:* Do most irrigators follow the appropriation rules of the resource in years of no extreme shortage?
3) *The adequacy of water supply for irrigators:* At the end of a period, does the available resource allow to meet the water requirements of the crops?

> *"…Because each of these three outcomes is affected by the extent to which farmers succeed in solving various provision and appropriation problems, they can potentially be used, in combination with one another, to measure the performance of an irrigation system." (Tang, 1992)*

Data collection

We referred to experts in order to elaborate the typology of the irrigation systems. Three experts were requested for this task: the head of Kairouan region's water resources, the head of Kairouan region's irrigation system and the head of our study's area irrigation system. We use the Delphi method to select the irrigation system. This approach is relevant to elaborate the typology since there is small number of irrigation systems and a small number of farmers per irrigation system in the area. Each administrator knows the details of each irrigation system. The iteration of the Delphi method was conducted as follows: first we developed an indicator of the outcomes of irrigation systems. It is a rough indicator but sufficiently discriminating for the needs of our work. All the indicators were inspired from the work of Tang (1992). Second, the classification was presented to the experts. The discussion with them allowed us filling the information gaps that were not captured by the indicator. Each irrigation system was finally rated low, medium or high with respect to the outcome. Third, we crossed the results between the experts. If a consensus was obtained, the classification was validated. If not, a second round was performed. The modified classification was submitted again to validation, and so on. Results are reported in Table 37. Here after the presentation of the outcomes of Tang (1992) and the indicator that we elaborated to discuss the classification with the three experts.

Data for the calculation of the indicators of the outcome is a combination of data collected through self-administrated surveys conducted in the irrigation system and the database of the administration. 7 irrigations irrigation systems selected with the help of the experts were surveyed. We checked whether there are differences/mistakes between the administration's database and the irrigation system records. The observations range from 2003 to 2007. We could not go back further since records were not available in many cases. We also conducted interviews with the *Water Master* of these irrigation systems. The water master is an

employee recruited by farmers in order to organize the administrative activities system (accounting, secretarial work, etc).

- **Maintenance outcome**

This first outcome reflects the action arena of the maintenance activity. At the end of a period, is the resource well maintained? To answer this question we calculated a maintenance ratio. Each irrigation system has to invest each year the equivalent of 0.1% of the initial investment for the well, 0.5% for the irrigation system, 2.5% for the equipment[54] in order to maintain the irrigation system (*Cf.* Appendix 5.1.3.). This is the maintenance responsibility of the self-organized irrigation system. Equation 1 gives the calculation of the maintenance ratio of the irrigation system achieved for each year. Data for the calculation of this maintenance ratio was obtained directly from the irrigation systems.

$$\textit{Maintenance ratio} = \Sigma\ \textit{Expenses for maintenance} / \Sigma\ \textit{duty of maintenance.} \qquad (1)$$

We established a classification of the 14 irrigation systems according to their maintenance ratio from the lowest ratio to the highest (*Cf.* Appendix 5.1.4). At this stage, the classification was proposed to the three experts to discuss the relevance of the standings by taking into account mainly the age of the irrigation system, the water master's care for maintenance and the number of the system failures. The results obtained from this classification, after iteration between the three experts, are reported in Table 37. There is an important difference between the standing of the maintenance ratio and Table 37. Despite the fact that most of the irrigation systems show a low maintenance ratio – and thus they have not, theoretically, accomplished their duty - the experts considered that it is due in 10 out of 14 cases to the recent rehabilitation of the system by the state administration. They argue that farmers of the irrigation system preferred to invest the budget[55] allowed to maintenance into other activities of the irrigation system. On the whole the experts agreed that the irrigation systems have a high level of maintenance.

[54] Source: Ministry of agriculture

[55] Private companies paid by farmers perform maintenance activity. Therefore, there is little collective action around such activity.

- **Conformance Rule outcome**

Do most irrigators follow the appropriation rules of the resource in years of no extreme shortage? We focus on the peak period (beginning of the summer, in our case) to examine the conformance rule of the water allocation within the irrigation system. We assumed that the causes[56] of failure to comply with water rules are an indicator of the conformance of the rule outcome. In our interviews with the water master, the social position of the farmer, the position in the irrigation system (beginning or end of the pipe) and the water rotation were identified as the main causes of the disputes among farmers. In Appendix 5.1.5. we report the rating of these three issues by the water master. The results reported in Table 37 are close to the data collected. Three types of irrigation systems emerge from this analysis: systems involving high compliance with the allocation rules, systems with medium compliance, and system with no compliance.

- **Water supply adequacy outcome**

At the end of a period, was the available water sufficient for meeting the water requirements of the crops? To answer the question, we calculated for each irrigation system, the intensification ratio, defined as total irrigated surface divided by the surface of the irrigation system area (Equation 2). Both areas are measured in hectares. (*Cf.* Appendix *5*.1.6.)

Intensification ratio = total irrigated surface / area of the irrigation system *(2)*

An intensification ratio lower than 100% means that the farmer has not cultivated his entire parcel, more than 100% means that he cultivated more than one crop on the same parcel. A high ratio reflects the capacity of the irrigation system to support the needs of the farmer's crop. We then cross the rate of intensification to the volume of available water for each irrigation system. (*Cf.* Appendix 5.1.7.). Next, just as we did with the maintenance outcome, we establish a classification of the irrigation system ranging from the highest intensification ratio and lowest water consumption to the lowest intensification ratio and highest water consumption (*Cf.* Appendix 5.1.8.). The classification is discussed with the experts in order to validate the standing. Our indicator reflects the opinion of the experts only for the low

[56] Initially, our aim was to consider the number of conflicts within the irrigation system as the indicator of the outcome. However, we were not able to gather such a data. We therefore considered in place the causes of the conflicts.

performing irrigation system. The high intensification ratio of some irrigation systems is in reality due to a privileged access to water of some farmers that distorts the indicator.

Selection of Irrigation system

Tang (1992) elaborated a pattern of outcome. He showed that the three outcomes are nested and that there is an upgrading difficulty in their achievement: maintenance - the easiest activity to perform- followed by conformance rule and finally the water supply adequacy- the most difficult to achieve-.

> " Problems in irrigation systems are arranged cumulatively along a continuum of increasing severity. If a more severe problem is present the less severe ones are usually also present but not vice versa. In other words, problems in irrigation systems usually appear in a specific sequence: first, the water supply is scarce or poorly matched to the standing crops: then more and more irrigators fail to follow allocation and maintenance rules; and finally the maintenance of the appropriation resource begins to deteriorate." (Tang, 1992)

We relied on this statement to construct our irrigation system typology. Therefore, the irrigation systems were classified with respect to the expert's ratings of the water supply adequacy outcome (the hardest outcome to achieve). Table 37 summarizes our typology. The irrigation systems in green are those who get high scores for water supply adequacy. The irrigation systems in orange are those who obtained lowest scores for this outcome. We considered irrigation systems that get high scores in every outcome "high performing irrigation system". In contrast, those who get low scores in every outcome are the "low performing irrigation system".

A good level of maintenance characterizes the irrigation system of *Mlelsa, Sidi Ali Ben Selem II* and *Karma I*, the high performing ones. Farmers respect their turn in irrigation and the volume of water meets the needs of farmers thanks to the planning of crops. High reputation leaders in the group guaranty an equitable distribution of benefits and costs among the users. In contrast, the irrigation systems of *Ajifar*, *Mojehidine, Henchir el Borj* and *H*enchir *Bou Ali* fail to assure sufficient water supply, often have conflicts in water allocation, and sometimes have a low level of maintenance.

Physical attributes and community attributes of the irrigation system

Physical and community attributes shape the context of the evolution of the irrigation systems. While they do not determine directly the performance of outcomes, they might foster or constrain the performance. In the case of our field study, they are more likely to enhance it.

- **Physical attributes**

Physical attributes that affect the action arenas of the irrigation system are the **access to an alternative source of water for irrigation,** the **total irrigated area from the resource and the number of irrigators** (Tang, 1992) **.** For the first attribute- the possibility of access to another appropriation resource-, all the irrigation systems studied are located over groundwater reservoir. Therefore, farmers have the option to build their own well as a substitute to the collective water supply system. However, the construction of a well inside the irrigation system is prohibited. In practice, even if it is possible to build the well, few farmers do it since it needs extra effort and water from the irrigation system is still costless. In our case, there are no wells in the irrigation system selected for the experiment. Therefore, the dependence on the irrigation system resource is quite high. This situation can create positive incentives by stimulating farmers to find a solution. (Tang,1992). For the two other attributes – total irrigated area and the number of irrigators-, the chosen irrigation systems are small – an average of 134 ha each- with few irrigators –56 farmers on average-. The irrigating systems are simple since they have only one water resource and one principal canal. Complex systems would involve multiple resources and several main canals. We are thus in a physical context that favours cooperation (Tang,1992). Nonetheless, the size of the resource and the number of contributors do not constitute a crucial constraint for the success of the collective action. We are in a physical context that may be either enhancing cooperation or neutral but in all cases, does not constrain cooperation.

- **Community attributes**

We distinguish three community issues (Tang, 1992). The first attribute is **social and cultural divisions.** If a community is divided by a racial or a clan problem that limits communication, the costs of organizing the collective action will be higher. In the region of Kairouan there are three historical clans. They are not in conflict but there is naturally a higher solidarity between the members of a same clan than members of different clans. We asked for each irrigation system which one of them was present. Results are reported in Table 37. It does not show a correlation between the presence of the clans and the performance of the irrigation system.

The second and the third attributes are **the distribution of wealth among the irrigators** and **the dependence of the farmer's income on the water resource.** Both attributes address income issue: The first one the disparity of income among the irrigators and the second the dependence of the farmer's income on the water resource. The idea is that a higher dependence stimulates a higher implication in collective actions. It can affect conformance on water allocation rules and maintenance effort. Mixed evidences support a direct link between the income and the collective action. Nonetheless, high variance income in groups is likely to entail more constraints to the collective action than low variance. We could not access accurate data for these two issues. However, there is a consensus between our experts that we should evaluate income variability as low or moderate and consider agriculture as their unique source of income. We were able to verify this last hypothesis in our field experiment: more than 2/3 of the farmers have agriculture as their only source of income. Thus, as for the physical attributes, the community attributes in the case of our irrigation system constitute does not constrain conditions for cooperation.

Discussion

The aim of the typology that we built is to differentiate between the type of collective actions of the irrigation systems. We selected a highly homogenous area inside the region of Kairouan in order to minimize other contextual factors. For example, limiting our selection to irrigation systems with the same pumping depth permitted us to rule out the heterogeneity of access to the groundwater. We referred to experts for selecting our irrigation system. Since performance in a collective action is an abstract concept, we relied on outcomes of the IAD to guide the choice of experts. IAD helped to defined an narrow the issues on which experts could give their opinion. We develop an indicator for each performance outcome, inspired by Tang (1992). These indicators are based on data collected directly from the irrigation system thanks to interviews and self-administrated surveys. The fact that they were roughly defined was actually an advantage for setting the discussions with the experts. They could reconsider our indicator's standing by taking into account their accumulated experience with these irrigation systems. Therefore, we think that a more precise investigation of the irrigation system would not yield a different result. The reason is that we designed our methodology not for investigating the performance of the collective action as such, but to select among the performing irrigation systems.

Table 37 : Characteristics of the irrigation systems

	Outcomes			Physical attribute			Community attribute
	Water adequacy	Rule conformance	Maintenance	Alternative access to water source	System Size (Ha)	Number of appropriators	Number of clans per irrigation system
MLELSA	High	High	High	Yes	134	61	1
BEN SALEM 2	High	High	High	Yes	202	47	3
KARMA 1	High	High	High	Yes	90	56	2
KARMA 2	Medium	High	High	Yes	80	42	2
HENCHIRJEFNA	Medium	High	High	Yes	430	205	2
SIDI BEN SALM 1	Medium	High	High	Yes	125	51	3
BEN SALEM 3	Medium	High	High	Yes	165	47	1
CHEBIKA OUEST	Medium	Medium	High	Yes	195	67	3
DRAA AFFEN	Medium	Medium	High	Yes	70	25	1
CHEBIKA EAST	Medium	Medium	Low	Yes	156	61	2
OUSSIF	Medium	Medium	Low	Yes	32	20	1
AJIFAR	Low	Medium	High	Yes	39	13	1
MJABRA	Low	High	High	Yes	139	30	3
MOJHEDINE	Low	Low	High	Yes	74	63	4 (*)
HENCHIR EL BORJ	Low	Low	Low	Yes	84	59	1
HENCHIR BOU ALI	Low	Low	Low	Yes	126	49	2

(*) Includes farmers from outside the region of Kairaoun

3 Experimental design

The field experiment performed with farmers is a replication of lab experiments carried out with subjects in Tunis[57] (T-sample) and in Montpellier[58] (M-sample). It is a provision point mechanism with no money back guarantee. Each subject was endowed with *20* tokens that he had to invest between two accounts: a private account that yields a private marginal return $\alpha = 1$ and a collective account that yields a return $\beta = 0.5$ if the group contribution reaches 30 tokens. Below the threshold, contributions are lost. In the baseline treatment, the public good is available for all the subjects whether they contributed or not. In the test treatment, we introduce voluntary adhesion. The subject has to contribute a strictly positive amount in order to benefit from the club good.

The baseline and the voluntary adhesion treatment were tested with farmers from a high performing irrigation system[59] (H-sample) and a low performing[60] one (L-sample) (*Cf. 2.1.Choice of the irrigation system*). We chose to conduct the baseline and the voluntary adhesion treatment within two different irrigation systems, for three reasons. First, there is a practical reason due to the relatively small size of the irrigation system : nearly 60% of the population can participate in only one treatment *e.g.* the baseline treatment with the L-sample. Second, to avoid information dissemination among participants. Each experiment represents a curious event inside the irrigation system, which becomes quickly popular soon after the end of a session. Consequently, many farmers -who were not involved in the experiment- were aware of the experimental details and the possible earnings. Third, we wanted to avoid time consistency problems (Zelenski *et al.*, 2003). The experiment is very sensitive to social ties. By scheduling several sessions within the same pool we would have exacerbated the sample-selection bias in later sessions: there was a high probability that groups of relatives would have managed to attend the experiment together. Thus, two irrigation systems among the high performing ones were selected, one for the baseline treatment and the other one for the

[57] Hereafter we denote students in Tunis the T-sample.

[58] Hereafter we denote students in Montpellier the M-sample.

[59] Hereafter we denote farmers in the High performing irrigation system the H-sample.

[60] Hereafter we denote farmers in the Low performing irrigation system the L-sample.

voluntary adhesion treatment. Similarly, two irrigation systems among the low performing ones were selected, each one assigned to one treatment.

One can argue that there is less control on the farmer's recruitment inside the irrigation system. We bear in mind that the average population of an irrigation system is 56 farmers. 24 participated in each of the selected ones, which correspond to an average of 42.2% of their population. We assumed that is sufficient to capture the initial situation of the group. We also bear in mind that our aim is to capture two different initial situations: (i) groups low performing, (ii) groups highly performing.

In addition to the treatment within the irrigation system, we also performed two treatments with independent farmers. Independent farmers[61] (I-sample) do not belong to an irrigation system. In contrast to the other subjects of the field experiment, they are not involved in the provision of a collective good. This treatment with independent farmers provides a control for the higher level of interaction existing between farmers of the irrigation systems. Independent farmers were randomly recruited from the same area of the irrigation systems. Table 38 summarizes the design of the treatments[62].

Table 38

Experimental design

	M-sample [(a)]	**T-sample [(b)]**	**H-sample [(c)]**	**L-sample [(d)]**	**I-sample [(e)]**
Baseline	24 students	24 students	24 farmers [(f)] *Mlelsa* [(g)]	24 farmers [(f)] *Bou Ali* [(g)]	24 farmers [(f)]
Voluntary adhesion	20 Students	24 students	24 farmers [(f)] *Karma I* [(g)]	24 farmers [(f)] *El Borj* [(g)]	24 farmers [(f)]

(a) Students in Montpellier ; (b) Students in Tunis ; (c) High performing irrigation system ; (d) Low performing irrigation system ; (e) Independent farmers ; (f) F-sample ; (g) : Name of the irrigation system ;

[61] Hereafter we denote independent farmers the I-sample.

[62] Hereafter we denote treatments with farmers the F-sample.

Upon attending the experiment, farmers were recruited thanks to the water master of the irrigation system and to some responsible administrators. They were contacted a week before the experiment. The only condition that imposed in the recruitment of the farmers was the obligation to be literate[63]. 144 farmers[64] participated in the experiment. Table 39 displays the characteristics of the subjects. They are essentially men (96.52%) aged 41 years on average (Standard deviation of 14 years). Most of them are married 75.6% with a low level of education (6 years[65] with a standard deviation of 3 years). The majority of them own their parcel (88.1%) and agriculture is their unique income (75.5%). The average area of the farm of the subjects is 2.77 ha : 2.28 ha for farmers in the irrigation system, and 3.77 ha for independent farmers.

Each experiment took place in a different location. Therefore, a new experimental setting had to be set up on each occasion. Three experiments were conducted outdoor (Figure 13) and two indoors[66]. The experiments were organized either early in the morning (7 a.m.) or late in the afternoon (6 p.m.) in order to avoid heat and to not disturb farmer's productive activities. The materiel necessary for the experiment was brought each time by a truck. It took between 30 to 50 minutes to prepare the experimental setting. 10 assistants[67] were recruited from the region of Kairouan for the needs of the experiment. They were trained ahead of time to be familiar with the protocol. 4 of them were assigned to the task 'data collection' and the other 6 were assigned to the task 'input the data' in a laptop. Each of these assistant handled a laptop on which they had to input the data on spreadsheet for the group they were responsible.

[63] Farmers had to know at least writing and reading numbers.

[64] No correlation was observed between the demographic variables and the contribution behaviour, except for the ownership of the farm. See Section 4.1.

[65] It can imply 6 years at the same level or finishing elementary school.

[66] 2 treatments were conducted in an elementary school and 1 in a big house in construction.

[67] 9 students + 1 Math teacher of a high school.

Figure 13: Outdoor experiment

Before starting the explanation of the instructions, we checked that each farmer could hear the speech and see clearly the board. If not, they were invited to move for the duration of the explanation. In outdoor experiments, up to 6 farmers were moved. The time needed for the instructions was about 15-20 minutes but reached 45 minutes in one experiment. To shorten the duration of the experiment and to adapt to the low educational level of the farmers, a short version of the instruction was elaborated. Only loud oral explanation was used. The usual private reading of the instructions and the comprehension questionnaire exercise were suppressed since they were too time-consuming.

The instructions were translated in an “elaborated” dialect; the use of the formal Arabic language would require more efforts from the farmer than the daily dialect language. Thus, we used a mix between Tunisian dialect and formal Arabic language. Careful attention was paid to choose the appropriate words. Before the field experiment, the text translated for the oral speech was checked with different farmers and people from the region of Kairouan for

the ambiguous terms. The oral explanation includes the guarantee of the anonymity of participant's identity[68], the group formation (the partner design), the rules of investment in the private and the collective account and the payment rules. After each stage we asked for questions and answered them loudly. Three examples of computation (the same found in the instructions for the students) corresponding to the three main issues in the game were given and explained on the white board in both the baseline and the voluntary adhesion treatment: success in the provision of the public good with a strictly positive contribution, failure in the provision of the public good with a strictly positive contribution and success in the provision of the public good with no contribution of the farmer.

The experiment was conducted by "paper and pencil"[69]. Subjects were randomly assigned to groups of 4 in a partner design. A system of badges was used to maintain the anonymity of the experiment. Before the beginning of the experiment, groups were constituted in a manner that keeps members of the same group distant[70] (Figure 14). Once the subject arrived and chose his place, he was automatically assigned to a group. Only the experimenter knew the composition of the groups. At the end of each period, 4 assistants collected the answer spreadsheets from the subjects randomly. The answer spreadsheets were then distributed to the 6 assistants responsible of the calculation of the earnings (each of these 6 assistants was responsible for one of the 6 groups). Once the earnings were calculated[71], the 4 assistants get back the spreadsheets sorted by group. At this stage, if the assistants return the spreadsheet, it is possible that some subjects could guess the composition of their group by carefully following the returning of the spreadsheet of their unique assistant. To avoid any possibility of identification, the spreadsheets were mixed between the 4 assistants before returning them to the subjects. By mixing the spreadsheets, subjects could not watch the 4 assistants at the same time and identify the other members of their group. This design allowed the anonymity of the experiment to be guaranteed. It also permitted to accelerate the returning of the results to the subjects. Subjects were assigned to a number whose distribution inside the "room" was

[68] The anonymity of the identity of the experiment was highly appreciated by farmers. Before the beginning of the experiment, many farmers wonder about the aim of the utilization of the data.

[69] See the spreadsheet of the game Appendix 5.2.1.

[70] The chairs were spaced by at least 1 meter in the indoor experiments and up to 2 meters in the outdoor ones.

[71] On average, it takes 2 minutes per assistant to calculate the earnings.

perfectly known to the assistants. Therefore, even if the spreadsheets were mixed, the assistants were able to locate quickly each subject.

Figure 14

Anonymity design

The emplacement of the subjects The composition of the 6 groups

The first three periods were considered as training periods (however farmers were also paid for them). To help the understanding of the game sheet, results given to farmers *i.e.* group contributions, earnings of each account and total earning of the period were written in a different colour. We controlled the understanding[72] of the game by checking during these three periods, individually, the comprehension of each farmer and answering loudly additional questions. The most frequent question was: “Can I repeat the same strategy?” .

The same conversion rule was applied to the earnings of farmers in Kairouan and with students in Tunis. The opportunity cost of one hour and a half is higher for farmers than for students –since farmers are professional- but we assumed that the difference of the standard of life between the city –a capital- and a rural area represented an acceptable compensation to maintain the same level of conversion with farmers. The final payment represented merely the

[72] We observe more free riders in the public good treatments than in the club goods treatments in all the treatments (*Cf.* Result 4.2.4.). It is a sign that farmers did understand the game since it is consistent with the theoretical prediction.

energy consumption of one day of irrigation or slightly more than the minimum daily wage of a worker in a rural area for two hours [73] (on average 6.46€[74]). The remuneration was sufficient to provide strong incentives. One of the sessions was organized the same day than the weekly market and farmers preferred nonetheless to participate in the experiment. The final payment was achieved in an isolated place (*e.g.* another classroom in the school) in order to avoid crowding around the experimenter and to guarantee anonymity till the end of the experiment.[75]

Constraints of the field experiment

Three main constraints faced the achievement of the field experiment. The first that we faced was institutional. In order to conduct the experiment, authorization from the different administrations[76] in charge of was required. Unfortunately, the administration of the irrigation system was reluctant to allow the work for several reasons:

- They did not perceive the interest of running such type of experiment. They are more used to the role-playing methods with contextual issues[77]. The abstract decontextualized experiment appeared strange to the administrators.
- They were already very busy.
- It was a "threat" to their work. Farmers frequently prefer not to attend the meetings of the administration since they live far away and they usually do not have a vehicle. For instance, coming to our experiment required 30-45 minutes of walk for many subjects. Therefore, the success of grouping 144 farmers in 5 days challenges somewhat the

[73] We maintained a similar level of remuneration between the M-sample, the T-sample and the F-sample in order to maximize the control on our experiment. Note that previous works showed that the variation of stakes doest not significantly affect the level of cooperation (Cameron, 1999; Kocher *et al.*, 2005)

[74] Show up = 2.75€ ; Average earnings of the experiment = 3.71 €

[75] In the two first treatments, the payment took place in the same place of the experiment. It entailed too much crowding.

[76] Ministry of the agriculture (irrigation system and water resources departments) and ministry of the interior.

[77] During a meeting with the administration, an expert of role-playing method working with farmers of the irrigation systems was present. A debate on the relevance of each method occurred. The expert of role-playing – a sociologist - was contracted by the administration to perform games with farmers. The private expert felt that his work was in rivalry with our research. The incident did not facilitate our institutional approval.

work of the administrators. In our case, it was the monetary incentive that brought the farmers. There is no such incentive to go to a meeting of the administration.

In addition to the agricultural ministry's support, an authorization from the ministry of interior was required. The law obliges to inform the domestic bureau of the area for organizing a meeting of people within a public area. This was not a critical constraint but it made the institutional approval longer.

The second main constraint to the field experiment was the logistic[78] issue. All the equipment had to be found in the rural area of the field experiment including the laptops. The help of the assistants *i.e.* students of Kairouan's region, was a key issue. Also, the equipment had to be stored in a safe place after each session. It had to be brought to the remote location of the experiment. A truck was hired for that purpose. Finding electricity in the outdoor sessions was not easy. Prior visits had to be done to check whether the location was suitable or not. In addition to the logistic issue, the experimenter had to manage 10 assistants during 2 weeks. The experimenter had to keep them serious and motivated: wake up the day of the experiment at 6 a.m., take care of the laptops, do not make mistakes in the calculation of the earnings etc. Furthermore, some assistants expressed a disagreement with their wage: Before the field experiment, an agreement was concluded to pay a flat wage for each session, equal to 5.5€. This wage represents the average earning of the experiment with students in Tunis. All assistants were fully satisfied since this corresponds to the daily wage of a rural worker, which they could earn in about two hours only! However, the second day of the experiment, the assistants claimed a higher pay. They argued that the subjects were better paid than them, and were disappointed for that reason. Finally the oral contract was renegotiated, since the experimenter could convince them that they were fairly well paid.

The last issue that matters was the recruitment of the subjects. Leaders of the irrigation system played a crucial role in the success of the recruitment. They informed farmers and were very efficient in mobilizing and informing potential participants. The head of local administration[79] also knows the key persons to contact in order to inform as many farmers as possible of the event of an experiment. The previous visits to the field facilitated the contact with the leaders

[78] 2 cars, 30 chairs, 6 tables, 6 laptops, 1 white board, 45 m of wires, 24 badges, 24 calculators, 24 workbooks, 30 pencils.

[79] It is important to note that the role of the administrative responsible has to be limited to the recruitment. His eventual presence the day of the experiment can modify the behaviour of the farmers.

and the administration. In addition to the recruiters, an important show up fee (equal to the expected earnings of the experiment) was announced. The earnings of the experiment appeared to be risky to the farmers – since it depends on the performance of the subjects-. Besides, as many farmers come from remote places, it was totally deserved as compensation. The procedure of the recruitment started one week before the experiment[80]. We insisted several times that local head of the administration and leaders of the irrigation system would make sure that subjects will be present on the day of the experiment.

It is clear that the monetary incentive brought subjects to our experiment. However, it was not a sufficient condition. Only announcing to the farmers that an experiment will be performed with a remunerated participation was not enough. The support of an official institution - the head of local administration in our case- was important. It added the required credibility to our work. It was important for farmers to know that they attended a place where a research project supported by the administration was carried, not just an independent work performed by a PhD student! Moreover, they felt more involved since they became valued by participating in a research project that looks after their concerns. They become more motivated and therefore more likely to participate in the experiment.

To conclude, assembling the farmers was not an easy task. The experimenter had to rely on other people in order to recruit. Despite all the efforts that an experimenter could make, chance played also its role. In standard lab experiments, one usually sends e-mails (or phones) to a sample of subjects belonging to a pool of volunteers. Subjects have to confirm (e.g. through a website) their attendance and usually a larger number of subjects than required are invited to prevent defection. The day of the experiment, the experimenter has simply to wait for the subjects. In the field, there is no dataset of farmers phone numbers, promises replace confirmation and extra subjects[81] are just more farmers contacted. The day of the experiment, the experimenter cannot only hope that participants will come to the right place at the right time, if ever they decide finally to attend!

[80] For the independent farmers (the I-sample), subjects were contacted two weeks before the experiment.

[81] In only one experiment, 2 extra subjects have assisted. In the other experiments, the experimenter had to wait till the 24 farmers were reached.

Table 39

Characteristic of the subjects

		Number of farmers in the irrigation system	Total Area of the irrigation system	Average area per farmer participating (Ha)	Average years of education per farmer	Average age (years)	Farming is their only income	Marital Status	Sex	Owning their farm
H-sample	Baseline *(Mlelsa)*	61	134	2.55 (2.19)[(a)]	7	48	62.5%	87.5 %	91.6%	95.8 %
	Voluntary adhesion *(Karma I)*	56	90	1.66 (1.60)[(a)]	6	41	73.9%	83.3 %	100 %	50 %
L-sample	Baseline *(Bou Ali)*	49	126	2.56 (2.57)[(a)]	6	35	79.1%	41.6 %	87.5%	100 %
	Voluntary adhesion (*El Borj)*	59	84	2.36 (1.42)[(a)]	7	37	79.1%	62.5 %	100 %	87.5%
I-sample	Baseline	--	--	4.36	6	48	83.3%	83.3 %	100 %	95.8 %
	Voluntary adhesion	--	--	2.98	4	52	75.0%	95.8 %	100 %	100 %

(a) Average area per farmer in the irrigation system (ha)

4 Results

The presentation of results is structured as follow: we begin by checking the existence of a relation between contribution and demographic variables. Then, we examine the results of the voluntary adhesion treatments in comparison to the baseline treatments within the three samples separately. In the subsection 3.2, we address the provision of the public good and the club good with respect to the sample of farmers. In the last section, we discuss farmer's cooperative behaviour in comparison to the results of the lab. At the beginning of the subsection 4.2., 4.3. and 4.4. we present how do we proceed to support our results.

4.1 Demographic variables

We aim to check the existence of a relation between the demographic variables and the behaviour of the subjects in order to be sure that our observations are only related to the experimental design. We conduct two types of tests depending on the qualitative or quantitative type of the demographic variable. A Spearman correlation coefficient is calculated for quantitative variables (*age*, *years of school* and *farm size).* A U test is conducted for the qualitative variable (*sex*, *marital status*, owning or lending the farm, existing or not of another income resource). First, we perform these tests on the pool of samples (baseline + voluntary adhesion), then inside each treatment. Table 40 reports the results. It shows an independency or weak correlation between contribution and *age*, *years of education*, the *farm size* and *sex*. However, mixed evidences are observed for the marital status (significant in the baseline treatment and not significant in the voluntary adhesion treatment) and a significant positive effect on cooperation for the ownership of the farm and the multiple source of income. Thus, farmers that own their farm and farmers that have another income than agriculture seem to be, according to the test, more cooperative.

Table 40

Results of tests between contribution and demographic variables

	Contribution		
	Pool	Baseline	Voluntary adhesion
Age [(a)]	-0.0226	-0.0616	0.0226
Years of school [(a)]	0.0105	0.0302	0.0102
Farm size [(a)]	0.0818	0.0815	0.1066
Farm ownership [(b)]	U= -4.00 ; p=0,00	U= -2.84 ; U=0,00	U= -4.75 ; U=0.00
Income source [(b)]	U=-1.82 ; p= 0,06	U=-4.58 ; p =0,00	U=2.27 ; p=0.02
Sex [(b)]	U= 0.42 ; p=0.67	U=1.21 ; p=0.22	-- [(c)]
Marital status [(b)]	U= -1.98 ; p=0.04	U= -3.31 ; p<0.01	U= 1.45 ; p=0.14

(a) : Spearman correlation coefficient ; (b) : Wilcoxon-Mann-Whitney test - The null hypothesis tests the absence of an effect.; (c) not enough observations

We develop the analysis with a panel data regression explaining individual contribution – the dependent variable - by the demographic variables and a dummy treatment. Results are reported in Table 41. All coefficients of the regressors are non significant, except for the *farm size* and the *farm ownership*. Thus, for the three variables singled out by the statistical test only one -*farm ownership*- is significant. The remaining two variables -*Marital status* and the *income* source- are not significant. We thus ruled out their effect on collective contribution. The regression also points out a stronger effect of the *farm size* on cooperation than the Spearman correlation (0.08). Mixed confirmations are observed for this variable. Owning a farm is the only strong effect observed. We assumed that it is not enough to consider the existence of a demographic variables effect in our treatments.

Table 41

Results from panel data regression explaining individual contribution in the pooled sample (H-sample + L-sample + I-sample) [(a)]

Regressors	**Contribution**
Intercept	--
Age	--
Years of school	--
Farm size	0.21(*)
	(3.69)
Farm ownership	1.26(*)
	(2.98)
Income source	--
Sex	--
Marital status	--
Period	--
Dummy_treatment (supressed) [(b)]	
Log likelihood	-8970
Number of observation	3050
Number of groups	122
Periods	25

(*): significant at 1% level; (**) : significant at 5% level ; (***) : significant at 10% level ; -- non significant

(a) : T-statistics are in parentheses (b) Dummy variable for each treatment suppressed for ease of presentation ; Regressions are corrected for heteroskedasticity and autocorrelation.

4.2 Provision of club goods with farmers

In this subsection, we compare the voluntary adhesion treatment to the baseline treatment in each sample of farmers. Our results show that there is no differences between the voluntary adhesion treatment and the baseline in the H-sample with respect to the group contributions, success of provision and welfare (Result *H-sample*). In result *L-sample*, we show that the welfare and the success of provision increase in the voluntary adhesion treatment. Also, we show that group contributions sustain longer in time in the L-sample and the I-sample (Result I-sample). Finally, in the *result H-sample+L-sample+I-sample*, we show that the number of contributors is higher in the voluntary adhesion treatment than the baseline within the three samples of farmers. Hereafter, we present our evidences.

We take as a reference our findings with the T-sample to interpret the field experiment observations. This is motivated by the subtle differences observed between the M-sample and the T-sample[82]. On the whole, similar results were obtained between the T-sample and the M-sample. Nonetheless the variance of group contributions is lower among the T-sample, there are more contributors (especially in the baseline treatment) and voluntary adhesion does not decrease the cheap riding. Therefore, in order to not exacerbate these differences in our comparison to the lab i.e. the student's pool and to not overwhelm with negative results that have been already proven to not resist subject's origin comparison, we choose to interpret our field experiment's observations only to the T-sample. This involves that we only expect in our field experiment (i) an increase of group contributions, success of provision and welfare (ii) a rise in the level of asymptotic group contributions and (iii) an increase in the number of contributors. However, we do not consider in our analysis that voluntary adhesion decreases group contributions variance and cheap riding.

We perform the following analysis for the four results exposed below. First, we compare the baseline treatment and the voluntary adhesion treatment using non-parametric tests: a two-sided Wilcoxon-Mann-Whitney test[83] or a two-sided χ^2 test depending on the variable (qualitative or quantitative). Then, we control for the differences between the two treatments

[82] Cf. Chapter 3

[83] We denote the Wilcoxon-Mann-Whitney test U test in the rest of the paper.

with a GLS panel[84] data regression with random effects[85]. The dependent variable is defined specifically for each analysis. When it is a binary variable, *e.g.* success of provision, we run a logit regression on panel data. Unless reported otherwise, the regressors are a dummy treatment taking value 1 for the voluntary adhesion (0 for the baseline) and a time variable. They are denoted *Voluntary adhesion* and *Period.* We correct for heteroskedasticity and auto-correlation each time it was detected [86]. We conclude for a significant statistical effect when both the non-parametric tests and the panel data regression agree. We discuss the robustness of the results if mixed evidences are reported. The rejection threshold of the null hypothesis is at 5%.

In addition to this scheme of analysis, we estimate the asymptotic group contributions within each sample of farmers by carrying out the following regression (Camera *et al.*, 2003) (Equation 3) :

$$G_{jt} = G_{\infty} + G_0 \frac{1}{t} + u_j + \varepsilon_{jt} \qquad (3)$$

where $j = 1, 2, .., 6$ and $t = 1, 2, .., 25$

[84] We check the presence of unobserved individual heterogeneity with a Breusch and Pagan LM test before each panel data regression. The tests confirm the significant presence of individual effects and thus the relevance of the data as a panel structure.

[85] The Random effects were preferred over fixed effects since they allow for regressors that do not vary over time (dummy variable) and the GLS estimator corrects for multiple observations from a single group of subjects. Also, random effects were appropriate since they assume that subjects are drawn from a large population. In the case of a field experiment with farmers it is a relevant hypothesis. (Greene, 2003)

[86] For all regressions we check for the existence of auto-correlation and heteroskedasticity : If only heteroskedasticity was detected (White test) we correct by running FGLS with a variance covariance matrix of the errors allowing for heteroskedasticity. If only intra-individual autocorrelation (Breusch and Pagan LM test) or inter-individual autocorrelation was detected (Wooldridge test) or both simultaneously, we correct by a GLS random effects regression with a Durban-Watson coefficient. Finally, if both heteroskedasticity and any form of auto-correlation was detected, we correct by running a FGLS with a modified matrix of covariance of the errors allowing for autocorrelation and heteroskedasticity. See (Baltagi, 1995) for a discussion of hetroskedasticity and autocorrelation under panel data.

j stands for groups of subjects, *t* for time u_j for the group effect and ε_{jt} for the error term. We explain group contributions G_{jt} – the dependent variable- by an inverse function of time *1/t* - the regressors-. As *t* becomes large, *1/t* gets negligible. Thus, the intercept, $G\infty$ represents the asymptotic group contributions. At the opposite, $G\infty + G_0$ represents the initial group contributions.

Table 42 summarizes our findings. It reports for each treatment - the baseline and the voluntary adhesion treatment – and for each sample – H-sample L-sample I-sample- the average individual contribution, the average group contributions, the success rate of provision and the average earning of the subjects. We have also reported in Table 42 previous results of the treatments with the T-sample and the M-sample and the Pareto dominant Nash prediction.

H-sample: Voluntary adhesion does not increase group contributions, success of provision and welfare. Also, groups of both treatments converge to a similar level of contributions.

Visual inspection of the average group contributions shows few differences between the baseline treatment and the voluntary adhesion treatment (Figure 15). In the last periods (19-25) average group contributions in the baseline treatment exceeds even the group contributions of the voluntary adhesion treatment. We first compare group contributions, success of provision and welfare by non-parametric statistical test. Recall that group contributions are the sum of contributions of the 4 subjects of the group and welfare is measured by subject's aggregate earning from the private account and the collective account.[87] The success of provision is a binary variable taking value 1 when the threshold is met. The U test and the Chi2 test reveal no significant differences between the baseline and the voluntary adhesion treatment.

Then we run a panel data regression explaining *Group contributions* and *welfare* by a treatment dummy denoted *voluntary adhesion.* Appendix 5.2.7. reports the results of the regression. *Voluntary adhesion* is not significant in any of the three treatments confirming the findings of the non-parametric test. Thus, subjects in both treatments contribute the same amount per group, meet the same number of time the threshold and earn the same monetary payments. Finally, Appendix 5.2.8. reports the result of the asymptotic group contributions.

[87] We will consider this measure of the welfare for the rest of the paper.

Both groups of subjects converge to a higher level of group contributions than the Nash equilibrium. However, both treatments converge to a similar level of group contributions (the baseline treatment even converges 1 token higher than the voluntary adhesion treatment). Clearly, the voluntary adhesion treatment did not affect behaviour of farmers in the H-sample.

Table 42

Descriptive statistics

	Average individual contribution (SD)		**Average group contributions (SD)**		**Success rate of provision [(c)]**		**Welfare [(d)] (SD)**	
	Baseline	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*	*Baseline*	*Voluntary adhesion*
M-sample	6.44 (6.67)	7.83 (5.89)	25.79 (17.88)	31.35 (14.26)	39.7%	67.7%	558.48 (80.60)	626.4 (101.09)
T-sample	6.86 (6.04)	8.66 (5.51)	27.42 (12.97)	34.66 (10.72)	45.3%	69.3%	546.5 (93.01)	623.12 (91.63)
H-sample	9.08 (5.65)	9.05 (5.46)	36.35 (11.16)	36.21 (8.88)	71.3%	79.3%	645.41 (76.03)	659.41 (81.91)
L-sample	9.48 (5.68)	11.08 (5.23)	37.92 (12.04)	44.35 (11.16)	73.3%	90.6%	656.5 (129.42)	745.95 (92.48)
I- sample	9.2 (5.64)	10.03 (5.58)	36.80 (10.96)	40.15 (10.70)	74.0%	82.6%	656.25 (101.90)	696.22 (80.68)
Nash prediction [(a)]	7.5[(b)]	7.5[(b)]	30	30	--	--	--	--

(a) Pareto-dominant Nash equilibrium ; (b) The symmetrical Pareto-dominant Nash equilibrium

(c) Success rate of provision= Number of times groups reach the threshold / Number of periods

(d) Welfare = Total points accumulated at the end of the experiment. (1 token in the private account = 1 point ; 1 token in the collective account = 0.5 point)

L-sample: Voluntary adhesion increases the welfare and weakly the success of provision. It raises the level of convergence of group contributions.

Figure 16 depicts the evolution of the average group contributions in the baseline and the voluntary adhesion treatment. Clearly, average group contributions reach higher level of group contributions than the voluntary adhesion treatment. We perform the same previous analysis to examine this graphical observation. A U test shows an increase in individual contribution (U=-4.91; p<0.01), group contributions (U=-2.48; p=0.01) and welfare (U=-6.65 ; p<0.01). A χ^2 test shows also an increase in the success of provision (χ^2=15.26; p<0.01). Table 43 reports the result of the regression. Welfare increases significantly confirming the U test results. However, the success of provision and group contributions are not significantly affected by voluntary adhesion. Mixed support is thus observed for these variables. The increase of the success of provision is significant at the 1% level in the statistical test but the effect is not strong enough to be captured by the regression (significant only at 7%). We recall that the success rate reached 90.6% in this voluntary adhesion treatment. It is the highest rate ever reached in our experiment (including the experiments with MBG with voluntary adhesion Cf. Chapter 3). It is difficult to increase significantly the success rate of a baseline treatment that reaches 73%. Moreover, if welfare increases significantly then it is probably due to a higher success rate. Besides, the Figure 16 clearly suggests a higher level of group contributions than the baseline treatment. Hence, we have considered that voluntary adhesion treatment does increase the success of provision but weakly. For group contributions, the regression rejects the existence of a significant change. It therefore contradicts the U test result. We thus conclude that there is no significant change. Finally, Table 44 reports that voluntary adhesion treatment raises asymptotic group contributions by 8.75 tokens. Clearly, there is a significant higher level of convergence in the voluntary adhesion treatment than in the baseline treatment.

Table 43

Results from panel data regressions explaining group contributions, success of provision and welfare (L-sample) [(a)]

Regressors	**Group contributions**	**Success of provision [(b)]**	**Welfare**
Intercept	34.39	--	25.74(*)
	(10.16)		(48.92)
Voluntary adhesion [(c)]	--	0.91 (***)	3.44 (*)
		(1.80)	(7.71)
Period	0.27 (*)	0.02 (*)	0.10(*)
	(3.78)	(1.78)	(3.46)
Log lieklihood	9.8%[(d)]	-116	- 4159
Number of observation	300	300	300
Number of groups	12	12	12
Time periods	25	25	25

(*): Significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses ; (b) :Logit regression ; (c) : dummy variable taking value 1 for the voluntary adhesion treatment and 0 for the baseline treatment ; (d) : R2 overall ; Regressions are corrected for heteroskedasticity and autocorrelation.

Table 44

Results from panel data regression explaining asymptotic group contributions (L-sample) [(a) (b)]

Regressors	**Baseline**	**Voluntary adhesion**
Intercept	37.50 (*)	46.25 (*)
	(13.87)	(47.35)
Period_inver	--	-13.50 (*)
		(-3.50)
Log likelihood	-574	-561
Number of observation	150	150
Number of groups	6	6
Time periods	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) : $G_{it}=G_{\infty}+G_{0*}\left(\frac{1}{t}\right)+u_i+\varepsilon_{it}$ with $\varepsilon_{it}=\rho\varepsilon_{it-1}+v_{it}$ where i=1,2,..,6 and t=1,2,..,25 ; Regressions are corrected for heteroskedasticity and autocorrelation.

I-sample: Voluntary adhesion raises the level of convergence of group contributions.

Figure 17 displays the average group contributions for both treatments with the I-sample. Visual inspection shows no differences. However, the non-parametric tests reveal a significant increase in individual contribution (U= -2.57, p=0.01), group contributions (U= -4.52; p<0.01) and welfare (U=-3.08; p<0.01) except for the success of provision. (χ^2 =15.26; p=0.06). Appendix 5.2.9. reports the results of the panel data regressions. It reveals that *voluntary adhesion* is not significant in explaining *Group contributions, success of provision* and *welfare*. Therefore, when non-parametric statistical tests show significant increase for

group contributions and welfare, the regressions analysis brings little support. We conclude that these mixed evidences are not sufficient to support the existence of a significant difference between the baseline and the voluntary adhesion treatment. Finally, Table 45 reports the analysis of the asymptotic group contributions. It shows that both treatments converge to a significantly higher level than the Nash equilibrium. It reveals also an increase of 4.49 tokens between the asymptotic group contributions in the voluntary adhesion and in the baseline treatment that does not vary over time.

Table 45

Results from panel data regression explaining asymptotic group contributions (I-sample)[(a) (b)]

Regressors	**Baseline**	**Voluntary adhesion**
Intercept	36.24 (*)	40.73 (*)
	(33.36)	(39.95)
Period_inver	--	--
Log likelihood	-562	- 568
Number of observation	150	150
Number of groups	6	6
Time periods	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) : $G_{it}=G_{\infty}+G_{0^*}\left(\frac{1}{t}\right)+u_i+\varepsilon_{it}$ with $\varepsilon_{it}=\rho\varepsilon_{it-1}+v_{it}$ where i=1,2,..,6 et t=1,2,..,25 ; Regressions are corrected for heteroskedasticity and autocorrelation.

Figure 15: Average group contributions (H-sample).

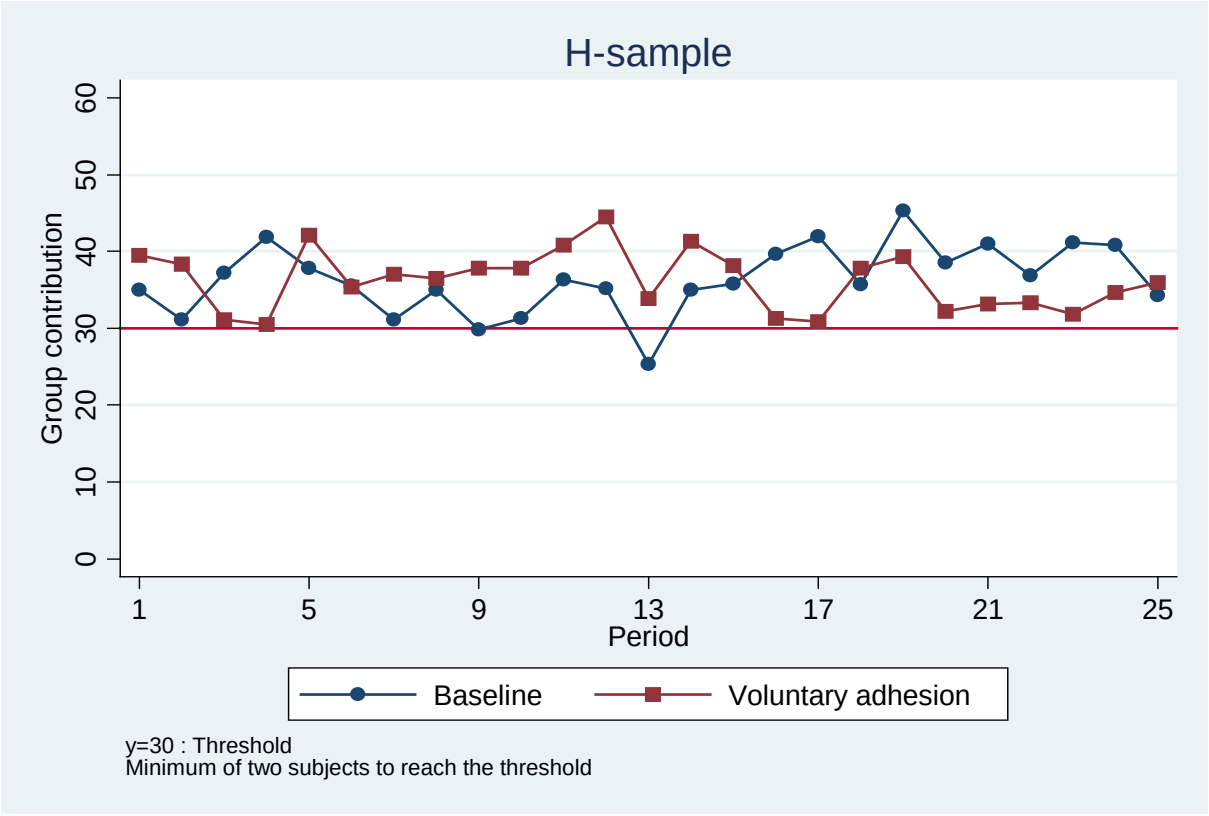


Figure 16: Average group contributions (L-sample)

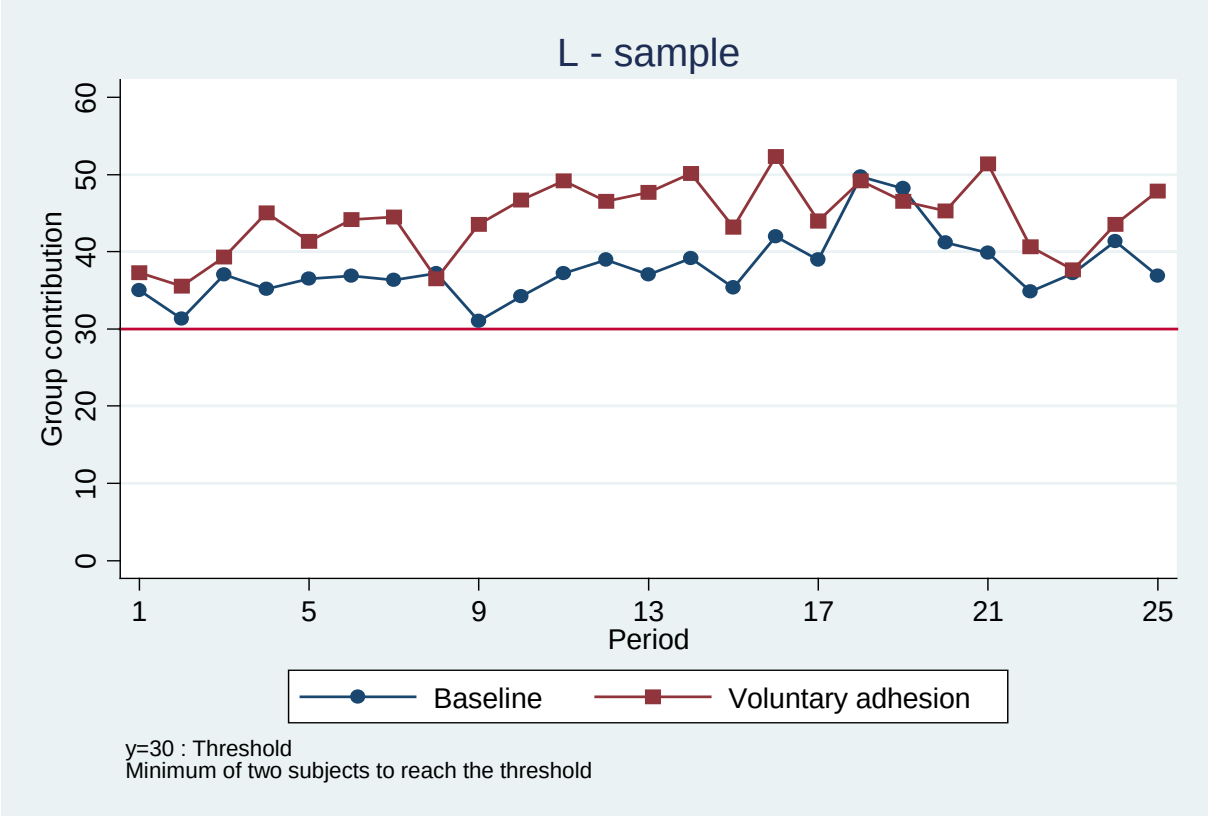
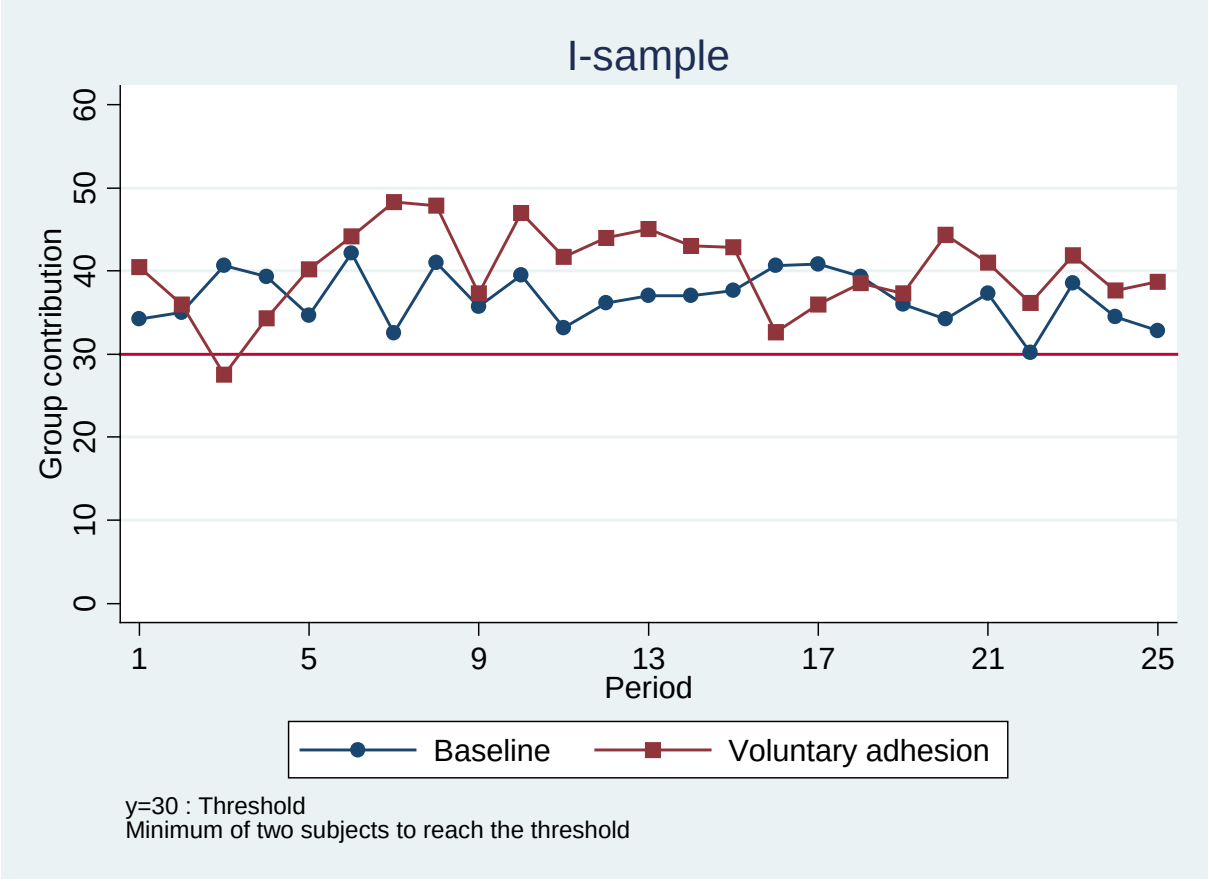


Figure 17: Average group contributions (I-sample)



H-sample + L-sample + I-sample: Voluntary adhesion treatments increase the number of contributors.

One main result of the voluntary adhesion treatment is the increase of the number of contributors. We report in Table 46 the average number of contributors per group in all the treatments. It indicates a higher average number of contributors among farmer in the voluntary adhesion treatments. However, it also outlines an important increase of the number of contributors in the baseline treatments. Thus, do our previous findings in the lab still available with farmers?

Table 46

Average number of contributors per group

	M-sample	T-sample	H-sample	L-sample	I-sample	Group size
Baseline (SD)	2.46 (1.38)	3.06 (1.13)	3.78 (0.41)	3.79 (0.43)	3.69 (0.50)	4
Voluntary adhesion (SD)	3.35 (1.20)	3.79 (0.42)	3.90 (0.31)	3.96 (0.19)	3.93 (0.25)	4

(SD): Standard deviation between brackets

To address the differences between the baseline and the voluntary adhesion treatments we first run a Chi2 test. It reveals the existence of a significant increase within the three samples of farmers: H-sample (U= -3.03 ; p<0.01) L-sample(U= -4.14 ; p<0.01) and I-sample (U= -5.01 ; p<0.01). Then, we perform a panel data regression explaining the number of contributors per group for each sample of farmers by a treatment dummy, *voluntary adhesion*, over time. Table 47 reports the results of the regression. It shows that the dummy variable is significant and positive. The increase of the number of contributors is thus significant. The regression reveals also that the regressor *period* is not significant in the three cases. Hence, it indicates that the increase of the number of contributors is stable over time. This finding is the unique[88] effect of voluntary adhesion that we observe in all the treatments: in the lab at

[88] Previous findings with the M-sample showed a decrease of cheap riding. It suggested that voluntary adhesion favourite a better coordination among subjects –Individually each subject contribute less tokens but collectively a higher group contributions is reached since more individuals contribute collectively –. We did not confirm this result with Tunisian students. Nonetheless, we have conducted the analysis with farmers. We run a U test to compare the individual contribution to the contribution level of only real contributing periods (we drop observation where there is 0 tokens contributed). It shows that there is no difference for the H-sample (U=1.02; p=0.30) and the I-sample (U=-0.82; p 0.40). For the L-sample, it even increases (U=-3.84; p<0.01). The previous finding with the T-sample – absence of cheap riding - is thus confirmed with farmers.

Montpellier, with students in Tunis and in Kairouan with farmers –including the H-sample where group contributions, success of provision and welfare remain unchanged between treatments-.

Table 47

Results from panel data regressions explaining the number of contributors per group for each sample [(a)]

Regressors	**H-sample**	**L-sample**	**I-sample**
Intercept	3.81 (*)	3.86 (*)	3.74 (*)
	(2.57)	(121.18)	(77.31)
Voluntary adhesion [(b)]	0.12 (*)	0.12 (*)	0.18 (*)
	(3.13)	(3.98)	(4.45)
Period	--	--	--
Log likelihood	0.45	37	- 99
Number of observation	300	300	300
Number of groups	12	12	12
Time periods	25	25	25

(*): Significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) dummy variable taking value 1 for the voluntary adhesion treatment and 0 for the baseline treatment ; Regressions are corrected for heteroskedasticity and autocorrelation.

4.3 Sample of farmers and the provision of collective goods

In our field experiment, we deal with three samples. We wonder in this subsection whether we observe differences in the provision of the club good and the public good with respect to the sample of farmers. In other terms, do the three samples providing club goods (respectively public goods) obtain the same results? *Result 1* shows that there is no difference between the

three samples providing public goods (group contributions, success of provision and welfare are similar). However, samples providing club goods differ in the level of group contributions provided (see *Result 2*). Hereafter we present our evidences.

We conduct the following analysis: we first compare, by non-parametric tests, individual contribution, group contributions, success of provision and welfare between the samples. Each sample is compared to the 2 other ones. 12 tests per treatment are therefore performed. Then, we support our result by a panel data regression with sample dummies (3 dummies) and time as regressors. We choose to interpret our results with respect to the I-sample.

Result 1: The provision of the public good is not related to the sample of farmers : Group contributions, success of provision and welfare are significantly equal between the H-sample, the L-sample and the I-sample.

Appendix 5.2.10 reports the results of the statistical tests comparing individual contribution, group contributions, success of provision and welfare between the three samples of farmers. All the 12 statistical tests are non-significant. Clearly, there is no difference between the three groups of farmers in the provision of the public good.

We develop our analysis by examining the relation of group contributions, success of provision and welfare – the dependant variables of three regressions – to the samples of farmers (*High performing, Low performing* and *Period* are the regressors). Table 48 reports the results. The coefficients of the dummy variables – *High performing* and *Low performing* - are not significant confirming thus the results of the statistical test. Therefore, despite all the differences that can exist between the three samples of farmers we obtain the same findings for the provision of threshold public good game. Moreover, this result brings additional evidence that the effects observed in the voluntary adhesion in comparison the baseline treatments (*Cf. 3.1 Voluntary adhesion and farmers*) are due to the voluntary adhesion variable.

Table 48

Results from panel data regression explaining group contributions, success of provision and welfare in the baseline treatment of the pooled sample (H-sample + L-sample + I-sample) [(a)]

Regressors	Baseline treatment		
	Group contributions	**Success of provision**	**Welfare**
Intercept	34.93 (*)	0.95	25.52
	(12.52)	(2.11)	(13.28)
High Performing [(b)]	--	--	--
Low Performing [(c)]	--	--	--
Period	0.14(**)	0.01	--
	(2.23)	(1.09)	
Log likelihood	1.0%[(d)]	-249	0.0%[(e)]
Number of observation	450	450	450
Number of groups	18	18	18
Periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) Dummy for H-sample; (c) Dummy for L-sample; (d) : R2 overall ; The dummy variable of the I-sample is dropped ; Regressions are corrected for heteroskedasticity and autocorrelation.

Result 2: The provision of club goods depends on the sample of farmers participating; Group contributions are highest among the L-sample, then the I-sample and lastly the H-sample.

The same analysis performed with the baseline treatment is conducted with the voluntary adhesion treatment. Table 49 reports the results of the U test and χ^2 tests. It shows that in contrast to the baseline, results of the provision of the club good depend on the sample of farmers participating. All the statistical tests are significant. (except for the success of provision between the H-sample and the I-sample). We conduct the same previous panel regression. Table 50 reports the results. It shows that in the case of the H-sample, group contributions decreases within the H-sample – in comparison to the I-sample- whereas it increases within the L-sample. For the success of provision and welfare, the coefficients of the dummies variables are not significant. Thus, the statistical test suggests the existence of differences between the samples of farmers in the voluntary adhesion treatments whereas the regression supports the significant change only for group contributions. We observe therefore mixed evidences. Nonetheless, the existence of such discussion, in comparison to the provision of public good, supports a higher sensitivity to the sample of farmers participating in the provision of club goods than in the provision of public goods.

Table 49

Results from non-parametric tests comparing individual contribution, group contributions, success of provision and welfare between H-sample, L-sample and I-sample in the voluntary adhesion treatment.

	Individual contribution	Group contributions	Success of provision	Welfare
H-sample / L-sample	U=0.63 ; p<0.01	U= 6.41; p<0.01	χ^2= 7.55; p<0.01	U= 7.20; p<0.01
H-sample / I-sample	U= 3.04 ; p<0.01	U= 3.37; p<0.01	χ^2= 0.54; p= 0.46	U= 3.08; p<0.01
L-sample / I-sample	U= -3.29 ; p<0.01	U= -3.13; p<0.01	χ^2= 4.15 p= 0,04	U= -4.15; p<0.01

Table 50

Results from panel data regression explaining group contributions, success of provision and welfare in voluntary adhesion treatment of the pooled sample (H-sample + L-sample + I-sample) [(a)]

Regressors	Voluntary adhesion treatment		
	Group contributions	**Success**	**Welfare**
Intercept	39.79 (*)	1,71	28.18
	(27.89)	(3.98)	(16.70)
High Performing [(b)]	-3.32 (**)	--	--
	(-2.52)		
Low Performing [(c)]	3.57 (**)	--	--
	(2.40)		
Period	--	--	--
Log likelihood	-1639	-188	8.4%[(d)]
Number of observation	450	450	450
Number of groups	18	18	18
Periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) Dummy for H-sample ; (c) Dummy for L-sample ; (d) : R2overall ; The dummy variable of the I-sample is dropped ; Regressions are corrected for heteroskedasticity and autocorrelation.

4.4 The cooperative behaviour of farmers

In this subsection we show that farmer's cooperative behaviour is strongly different from students. We show in *Result 1* that farmers contribute significantly more than subjects from Tunis. In *result 2,* we point out the high level of performance in the baseline treatment of farmers. In *result 3,* we show that group contributions of the baseline and the voluntary

adhesion treatment sustain longer in time than group contribution of students. Hereafter we present our evidences.

We assume the existence of a significant difference whenever both subjects of the baseline treatment and the voluntary adhesion treatment of the field experiment show different contribution behaviour than subjects of the lab[89]. Therefore, we run a panel data with a dummy variable, *dummy_farmer,* taking value 1 for farmers and 0 for the T-sample. More precisely, the dummy takes value 1 for all the three samples of farmers – H-sample, L-sample and I-sample- and whether it is the baseline or the voluntary adhesion treatment. Similarly, it takes value 0 with the T-sample for both treatments. If the *dummy_farmer* is not significant no differences is pointed out between the T-sample and the F-sample. On the opposite, if a significant change is revealed (an increase or decrease of contributions), we conclude for the existence of a different behaviour.

Result 1: Farmers contribute strongly more to the collective account

We report in Table 51 the percentage of the endowment contributed to the collective account by subjects from the M-sample, the T-sample and the F-sample. It shows a range of contributions from the third of an endowment 34.6% – in the M-sample - to almost the half of the endowment 48.2% – with farmers-. Table 51 also indicates an average increase of 10% of the contributions in the F-sample in comparison to the T-sample. To examine the significance of our observation we run a panel data regression. We choose the individual contribution (the dependent variable) as an indicator of the cooperative behaviour. The regressors are *dummy_farmer* and *period*. We then perform the regression on the pooled subjects, that is we mix subjects from the baseline + subjects from the voluntary adhesion treatment. Next, separately, we run another regression separately in the baseline and in the voluntary adhesion treatment.

[89] We recall that we compare only to the Tunisian students (*Cf. 3.1.Voluntary adhesion and farmers*)

Table 51

Percentage of the endowment contributed to the collective account

	Sample	Percentage of the endowment collectively contributed
Montpellier	Students	34.6%
Tunis	Students	38.8%
Kairouan	Farmers	48.2%

Table 52 reports the output of the regression. *Dummy_farmer* is significant and positive within the pooled subjects (+2.90 tokens), the baseline's subject (+4.16 tokens) and the voluntary adhesion subjects (+1.76 tokens). Furthermore, the intercept represents the amount of tokens contributed by the T-sample. Adding the *Dummy_farmer* to the intercept reflects the average contribution in the F-sample. It is around 10 tokens (9.65 tokens in the baseline and 10.25 tokens in the voluntary adhesion treatment). Thus, the results of the panel data regression confirm the observation of Table 52 observation: farmers not only contribute more but also contribute almost the half of their endowment. Their cooperative behaviour is strongly higher than the one of the T-sample.

Table 52

Results from panel data regression explaining individual contribution in the pooled sample (T-sample + M-sample + F-sample) [(a)]

Regressors	**Pool[(b)]**	**Baseline treatment**	**Voluntary adhesion**
Intercept	7.02 (*)	5.49 (*)	8.49 (*)
	(13.57)	(16.29)	(23.57)
Dummy_farmers[(c)]	2.90 (*)	4.16(*)	1.76 (*)
	(29.78)	(13.77)	(5.64)
Period	--	--	--
Log likelihood	-14454	- 7215	-7222
Number of observations	4800	2400	2400
Number of groups	192	96	96
Time periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) T-statistics are in parentheses (b) Voluntary adhesion + Baseline ; (c) Dummy taking value 1 for farmers ; Regressions are corrected for heteroskedasticity and autocorrelation.

Result 2: The farmer's baseline treatment reaches a high level of group contributions and success of provision in comparison to student's baseline. It is significantly equal to the voluntary adhesion treatment of students.

Table 42 shows that farmers contribute and success more in providing the public good in comparison with the students in Tunis. More specifically, it shows an important improvement of the baseline treatment of the farmers. On average the success of provision in the baseline treatment of the F-sample increases by 28.7% in comparison to the the baseline treatment of

the T-sample, group contributions rise by 10.5 tokens and the number of contributors by more than 0.73 unit (*Cf.* Table 46). Hereafter, we aim to show statistically this improvement of the baseline treatment of the farmers. A simple way to measure the relative importance of this change is to compare the results from the baseline of the F-sample to the results of the voluntary adhesion treatment of the T-sample. That is to compare the public good of the farmers to the club good of the students. We focus in our comparison on group contributions, success of provision and the number of contributors [90].

Starting by the success of provision, a Chi2 test does not reject the existence of differences between the two treatments (χ^2=0.70; p=0.40). We also run the following regression. We explain the success of provision by the *dummy_farmer* taking value 1 for the baseline of the F-sample and 0 for the voluntary adhesion treatment of T-sample. Table 53 reports the results. *dummy_farmer* is non-significant. It confirms the non-parametric test result. We perform the same analysis with group contributions and the number of contributors (Table 53). We find the same result for group contributions. There is no significant change between the baseline of the F-sample and the Voluntary adhesion of the T-sample. However, the increase of the number of contributors in the baseline does not equal the increase of the number of contributors in the voluntary adhesion treatment. The number of contributors in the club good of the T-sample is still higher than the number of contributors in the public good of the F-sample. This is another confirmation of the robustness of the conjecture that the voluntary adhesion treatment increases the number of contributors. (*Cf. Result* 4.2.4.)

[90] In addition to this comparison between the baseline of the F-sample to the voluntary adhesion of the T-sample, we also compared directly the baseline of the F-sample to the baseline of the T-sample. The results are reported in the Appendix 5.2.11. It shows a higher level of group contributions, success of provision and welfare among farmers.

Table 53

Results from panel data regression explaining success of provision, group contributions and number of contributors per group in the baseline treatment of the F-sample and the voluntary adhesion treatment of the T-sample[(a)]

Regressors	**Success of provision [(b)]**	**Group contributions**	**Number of contributors**
Intercept	0.83 (**)	34.06 (*)	3.89(*)
	(2.09)	(20.50)	(108.90)
Dummy_farmers[(c)]	--	2.49(***)	-0.11(*)
		(1.72)	(-3.60)
Period	--	--	--
Log likelihood	-342	-2252	-249
Number of observation	600	600	600
Number of groups	24	24	24
Periods	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses ; (b) : logit regression on panel data with odds ratio (c) Dummy taking value 1 for the farmers of the baseline treatment and 0 for the students of the voluntary adhesion treatment in Tunis ; Regressions are corrected for heteroskedasticity and autocorrelation.

Result 3: Group contributions in farmer's treatment sustain over time.

The usual pattern that we observe in a Voluntary Contribution Mechanism (VCM) is a decay of group contributions over time. However, Figure 18 depicts a sustaining in the group contributions of the F-sample while the traditional decrease in the group contributions of the M-sample and the T-sample. In order to address this issue, we run a threshold convergence

analysis (Marks and Croson, 1998). We calculate the squared distance of the threshold of each group for each period. It is the dependent variable. The regressors are *Period* and *Period_squared*. A negative significant coefficient of the regressor *Period* means the existence of a convergence to the threshold while a significant positive sign means a divergence of the threshold. Finally, a significant coefficient of *Period_squared* means that the convergence/divergence is non linear. Table 54 reports the results. It shows significant positive coefficients for the regressors of the farmer's treatment whereas negative coefficients for the treatments with students. We report in the Table 54 the results of the regression on the pooled subjects of the baseline + the voluntary adhesion treatment for the ease of the presentation. A more precise analysis with a regression on each specific treatment does not report different conclusion. It reveals that group contributions may not diverge significantly from the threshold (the coefficient of the regressor *Period* is positive but not significant) in two cases: the voluntary adhesion treatment with high performing farmers and the baseline treatment with the low performing farmers. Note that in these two cases, the asymptotic convergence level is higher than the threshold, 37 tokens and 33 tokens respectively.

Table 54

Results from panel data regression explaining threshold convergence for each sample. [(a)]

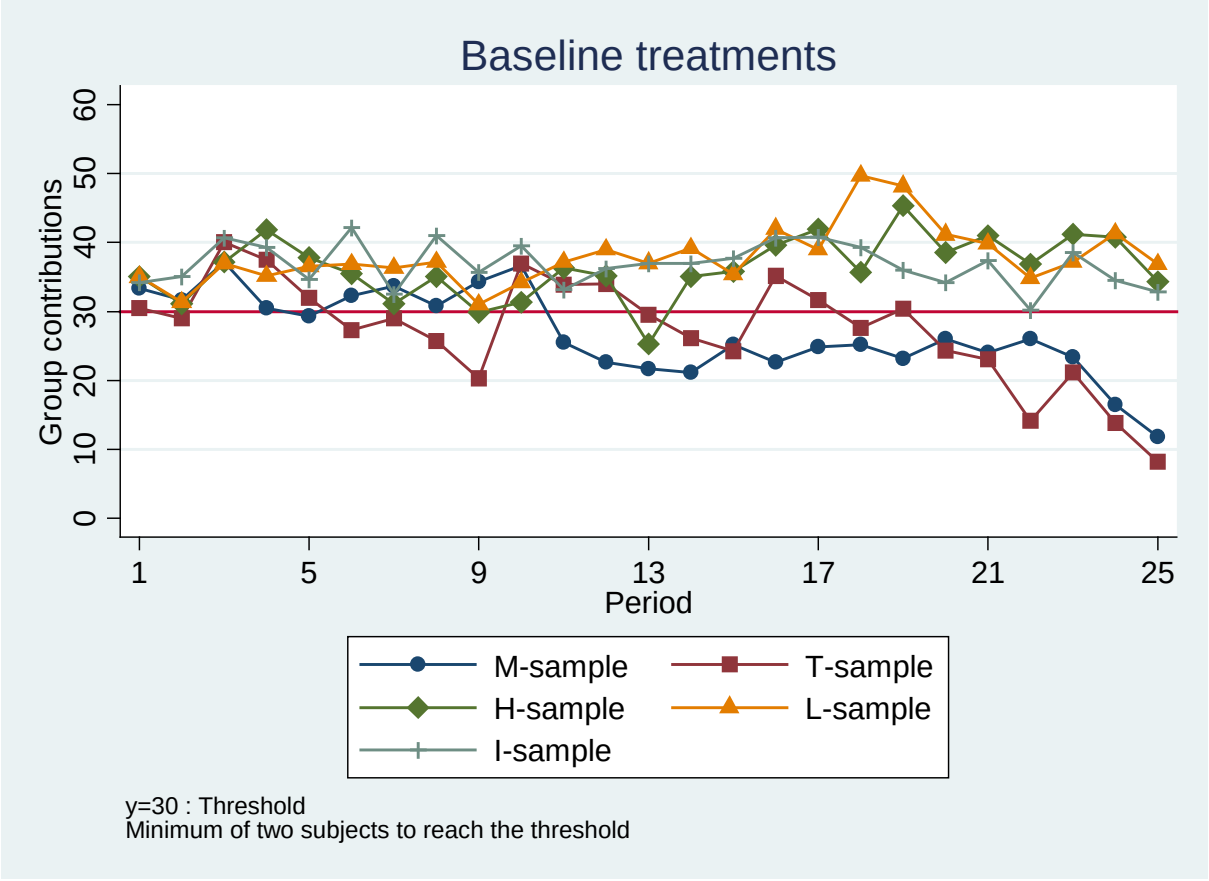
Regressors	**M-sample**	**T-sample**	**H-sample**	**L-sample**	**I-sample**
Intercept	216.34(*)	120.44 (*)	58.55 (***)	79.8(***)	86.60(*)
	(3.04)	(5.03)	(1.79)	(1.61)	(2.42)
Period	-30.05(*)	-7.94 (***)	15.33 (*)	20.97(*)	13.89(**)
	(-2.44)	(-1.87)	(2.64)	(2.38)	(2.20)
Period_squared	1.73 (*)	0.56 (*)	-0.57(*)	-0.63(**)	-0.52(**)
	(3.82)	(3.54)	(-2.67)	(-1.93)	(-2.21)
Log likelihood	-2345	-1909	-1952	-2114	-2014
Number of observation	275	300	300	300	300
Number of groups	11	12	12	12	12
Time periods	25	25	25	25	25

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) T-statistics are in parentheses ; Regressions are corrected for heteroskedasticity and autocorrelation.

Figure 18

Average group contributions in the baseline treatment. (M-sample + T-sample + F-sample)



Conclusion

Many countries concerned by water scarcity (*e.g.* Tunisia) are reforming their nationalized management of irrigation systems to set up self-governing systems. This evolution raises an implementation issue, about the way to achieve such an evolution. A possible policy to implement the transition is to rely on a voluntary approach whereby the ex-centralized state forces agents to participate in the provision of the collective good. In this case, the latter becomes a pure public good. An alternative policy is to give the agents the choice to accept – or to reject - the adhesion to the provision of the collective good. In this case, the latter has the properties of a club good. We investigate in this work the possible consequences on agent's cooperative behaviour of a policy of voluntary adhesion. More precisely, we address whether the pre-existing network of interactions among farmers affects the provision of the club good.

For that purpose, we conducted an artefactual field experiment (Harrison and List, 2004) with different samples of farmers. We found that voluntary adhesion increases the number of contributors in all the treatments. This is consistent with the theoretical predictions. We also observe that voluntary adhesion increases the success of provision and welfare in the L-sample. We finally observe that it raises the convergence level of group contributions with the L-sample and the I-sample. However, in comparison to similar experiments conducted in the lab, voluntary adhesion is less effective in the field. There is no significant increase of group contributions and most effects of voluntary adhesion are observed within one sample of farmers out of three. The reason seems related to the high success rate for farmers in the baseline treatment (70%), which is larger than the success rate obtained with student subjects under voluntary adhesion (see Chapter 2), and larger than the success rate obtained in our experiment with Money Back Guarantee (see Chapter 3).

Why do farmers cooperate so strongly? A possible explanation is that our subjects are used to provide collective goods (public or club). Farmers of an irrigation system already experienced the advantages and disadvantages of cooperation and of provision of collective goods (e.g. association). In contrast, students may be less used to these situations. Another possible explanation that appeared to us relevant is the existence of a sharp contrast in the behaviour between rural *vs.* urban areas. The comparison of cooperative behaviour between students in Montpellier and in Tunis did not reveal any strong difference. However, within the same country we do observe differences in the cooperative behaviour between pools of subjects. An extension of this study including a field experiment with farmers in France would be inetresting to compare the high level of the cooperative behaviour observed with farmers. Nonetheless, this field experiment with Tunisian farmers offers the possibility of comparison with previous field experiments dealing with cooperation issue[91]. Our result are consistent with earlier findings: We observe a high cooperative behaviour that sustain in time with a contribution close to the half of the endowment in the Voluntary Contribution Mechanism(Cardenas and Carpenter, 2008). Carpenter et al. (2007) found this result in a public good experiment with social disapproval in urban slums in southeast Asia. Carpenter

[91] A higher cooperative behaviour is also observed when we allow for sanctions but we do not address this issue in our work. (Barr, 2003) (Carpenter, 2007) (Heldt, 2005). (Visser and Burns, 2005). Also for experiments with communication that permits a sustainable extraction from common pool resources (Cardenas *et al.*, 2002).

and Seki (2005) with a close design found the same result with fisherman in Japan , just as Gächter et al. (2004) in a one shot public good game with urban and rural subjects in Russia. Field experiments are still at their beginning and stylised facts are rare. However, our finding of high cooperative behaviour of farmers seems to be robust since it was observed in several highly different contexts.

Finally, our experiment reveals little correlation between cooperation and demographic variables. Again there is no proved relation in the literature to which we could compare our findings. Moreover, mixed results are observed. On the one hand, Gächter et al. (2004) found no significant relation between contributions and demographic variables except age (young subjects appear to be more selfish). List (2004) observed the same finding. Henrich et al (2001) also found that demographic variables do not explain behaviour in a remote field experiment with primitive populations. On the other hand, Carpenter et al (2007) found that men do contribute more than women, that schooling teach free riding (positive correlation between years of education and less contribution) and that age is not significant for explaining the level of contributions. Further experiments are needed to infer relevant information from this issue.

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Appendix

4.1. The choice of the irrigation system

Appendix 5.1.1.: Flyer of Kairouan (SIRMA)

Appendix 5.1.2.: Location of the field experiment.

Appendix 5.1.3.: Maintenance outcome: duty of maintenance expenses

Appendix 5.1.4.: Maintenance outcome: ratio of maintenance (Classified outcomes)

Appendix 5.1.5.: Rule conformance outcome: Origin of conflicts in the irrigation system

Appendix 5.1.6.: Water supply adequacy outcome: intensification rate

Appendix 5.1.7.: Water supply adequacy outcome: average pumped water

Appendix 5.1.8.: Water supply adequacy outcome: average pumped water crossed with average intensification rate (m3 per ha)

4.2. Experimental result

Appendix 5.1.1.: Flyer of the field experiment (SIRMA)

Appendix 5.2.2: The spreadsheet of the game

Appendix 5.2.3.: Percentage of Nash equilibria

Appendix 5.2.4.: Group contributions (H-sample)

Appendix 5.2.5.: Group contributions (L-sample)

Appendix 5.2.6.: Group contributions (I-sample)

Appendix 5.2.7.: Results of panel data regressions explaining group contributions, success of provision and welfare (H-sample)

Appendix 5.2.8.: Results from panel data regression of the asymptotic group contributions (H-sample)

Appendix 5.2.9.: Results of panel data regressions explaining group contributions, success and welfare (I-sample)

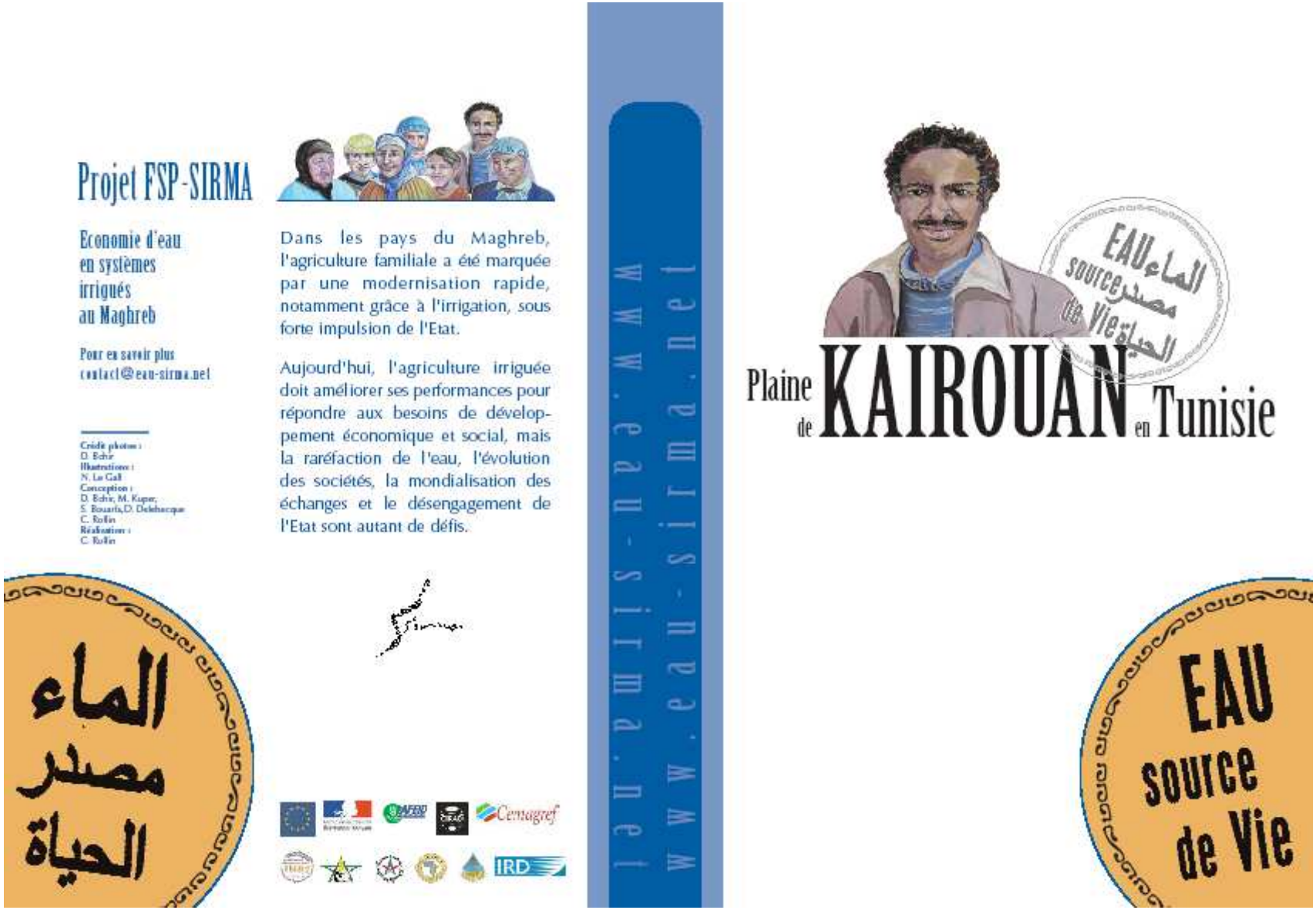
Appendix 5.2.10.: Results from non-parametric tests comparing individual contribution, group contributions success of provision and welfare between H-sample, L-sample and I-sample in the baseline treatment.

Appendix 5.2.11.: Results from panel data regression explaining group contributions, success of provision and welfare in the baseline treatment of the M-sample, T-sample and the F-sample.

5.1. The choice of the irrigation system

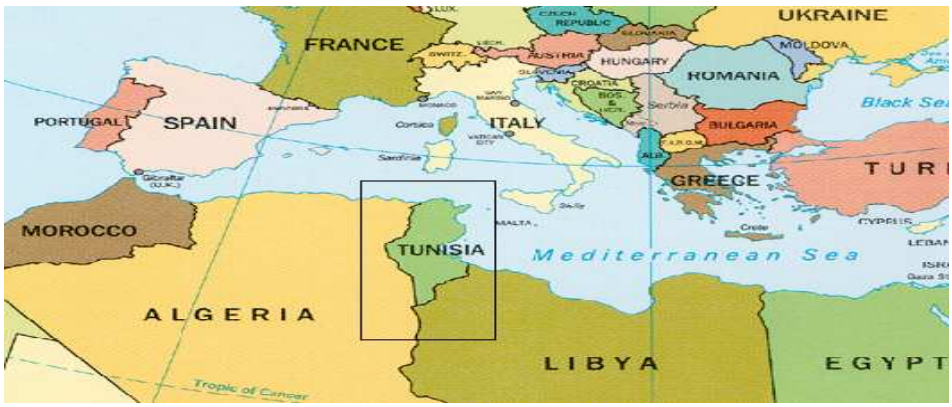
Irrigation canal

Appendix 5.1.1. : Flyer of Kairouan (SIRMA)

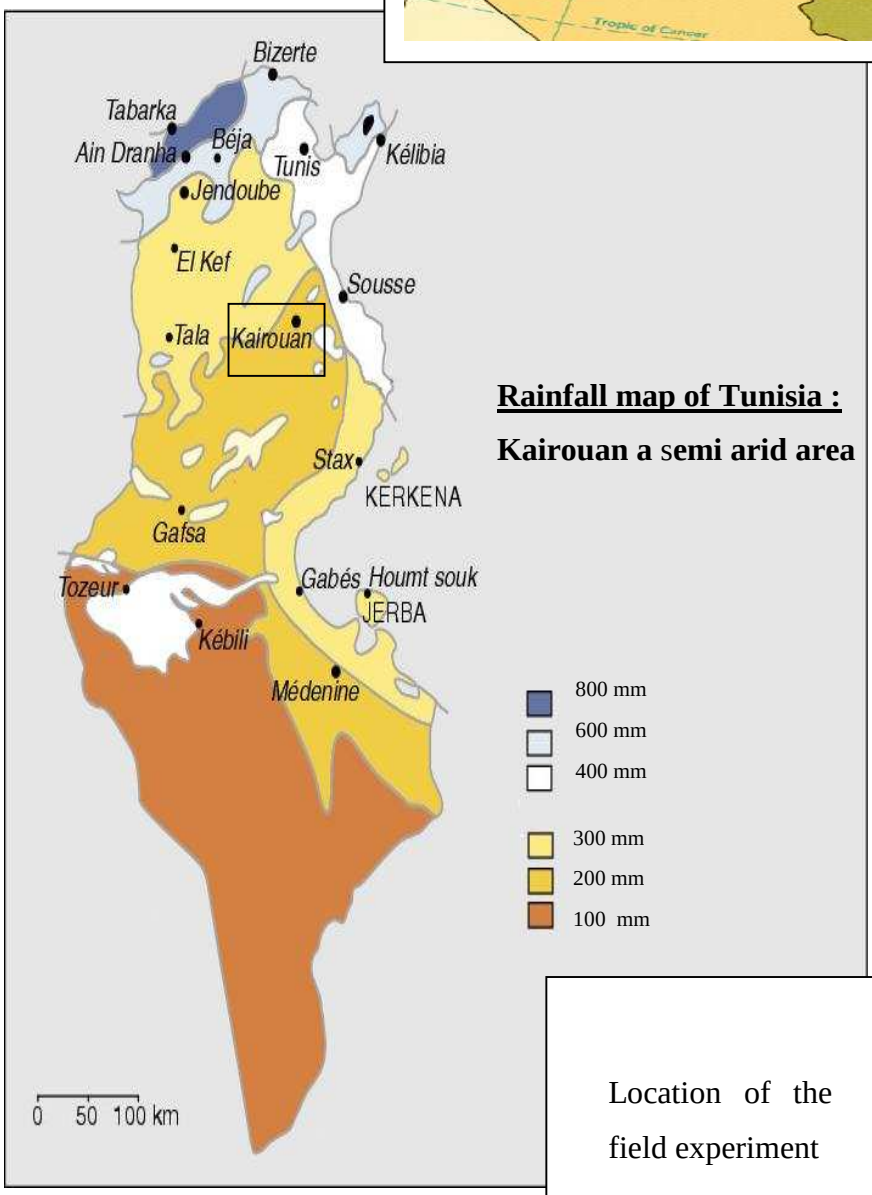


Appendix 5.1.2. : Location of the field experiment

Tunisia : a Mediterranean country



Source : Mediterranean Atlas (2000)



Rainfall map of Tunisia :

Kairouan a semi arid area

Source : Tarhouni et al. (2007)

District of Kairouan

Location of the field experiment

Source : Ministère de l'éducation et de la formation (2007)

Appendix 5.1.3 :

Maintenance outcome: maintenance responsibility

	Initial well Investment (TD)	Initial civil Engineering investment (TD)	Initial Equipement Investment (TD)	Maintenance responsibility (well) (TD)	Maintenance responsibility (civil engineering) (TD)	Maintenance responsibility (Equipement) (TD)	Total Maintenance responsibility (TD)
MLELSA	36000	354254	95000	36	1771	2375	4 182
Ouled Nasser	100000	616635	60000	100	3083	1500	4 683
BEN SALEM 3	69000	355000	72000	69	1775	1800	3 644
HENCHIRJEFNA	300000	434019	149918	300	2170	3747	6 218
BEN SALEM 2	93000	405878	45121	93	2029	1128	3 250
KARMA 1	75000	220934	165465	75	1104	4136	5 316
KARMA 2	69000	224090	165412	69	1120	4135	5 324
CHEBIKA EAST	210000	719079	175253	210	3595	4381	8 186
CHEBIKA OUEST	62000	231000	20000	62	1155	500	1 717
AJIFAR	110000	179364	64370	110	896	1609	2 616
MJABRA	84000	161000	140000	84	805	3500	4 389
OUSSIF	144000	183442	81880	144	917	2047	3 108
HENCHIR EL BORJ	89000	172000	30000	89	860	750	1 699
HENCHIR BOU ALI	92000	12300	20000	92	61	500	653
DRAA AFFEN	85000	227704	80881	85	1138	2022	3 245
Sidi ali Ben selm I	69000	373678	175146	69	1868	4378	6 316
Mojehdine	50000	150000	30000	50	750	750	1 550

TD : Tunisian Dinar

Source : our data + Ministry of agriculture

Appendix 5.1.4.

Maintenance outcome: maintenance ration(Classified irrigation system)

	2003	2004	2005	2006	2007	Average expense per year for maintenance	Total maintenance responsibility	Maintenance ratio
BEN SALEM 3	1506	367	2437	***	9846	3539	3644	97.1%
CHEBIKA OUEST	3017	904	810	***	1700	1608	1717	93.6%
SIDI BEN SALM 1	1538	1450	230	***	1655	4873	6316	77.2%
BEN SALEM 2	***	1612	1431	4949	1303	2323	3250	71.5%
HENCHIRJEFNA	2135	1361	3590	917	12642	4129	6218	66 .4%
MLELSA	1079	959	2784	***	***	1607	4182	38 .4%
DRAA AFFEN	641	1231	2000	1086	***	1239	3245	38.2%
KARMA 2	***	267	***	***	3016	1642	5324	30.8%
AJIFAR	***	104	126	1398	***	543	2616	20.7%
Ouled Nasser	125	239	542	1158	1500	891	4683	19.0%
HENCHIR BOU ALI	85	***	***	149	***	117	653	17.9%
OUSSIF	***	***	***	783	259	521	3108	16.8%
MJABRA	596	482	***	1446	413	734	4389	16.7%
KARMA 1	***	479	145	1148	1620	848	5316	15.9%
MOJHEDINE	68	180	300	***	211	190	1550	12.2%
HENCHIR EL BORJ	73	34	82	150	165	101	1699	5.9%
CHEBIKA EAST	547	***	137	152	185	255	8186	3.1%

Source : our data + Ministry of agriculture

Appendix 5.1.5.

Origin of conflicts in the irrigation system

	Existence of privileged Farmers in access to water due to social position	Existence of privileged farmers due to the position in the irrigation system	Respect of the water rotation
MLELSA	No	No	Yes
BEN SALEM 2	No	No	Yes
KARMA 1	No	No	Yes
KARMA 2	Yes	No	Yes
HENCHIRJEFNA	Yes	Yes	Yes
SIDI BEN SALM 1	Yes	No	Yes
BEN SALEM 3	Yes	No	Yes
CHEBIKA OUEST	Yes	No	Yes
DRAA AFFEN	Yes	No	No
CHEBIKA EAST	Yes	Yes	Yes
OUSSIF	Yes	No	No
AJIFAR	Yes	Yes	Yes
MJABRA	No	No	Yes
MOJHEDINE	Yes	Yes	No
HENCHIR EL BORJ	Yes	Yes	No
HENCHIR BOU ALI	Yes	Yes	No

Source : Our data : Inteviews with irrigated water master

Appendix 5.1.6

Water supply adequacy : Intensification ratio

Intensification ratio

	2003	2004	2005	2006	Average (2003-2006)
MLELSA	113%	63%	109%	115%	100%
BEN SALEM 3	105%	128%	104%	97%	109%
HENCHIRJEFNA	79%	62%	105%	83%	82%
BEN SALEM 2	80%	115%	104%	94%	98%
KARMA 1	120%	141%	126%	110%	124%
KARMA 2	88%	121%	136%	120%	116%
CHEBIKA EAST	99%	110%	93%	103%	101%
CHEBIKA OUEST	69%	116%	115%	116%	104%
AJIFAR	92%	67%	100%	62%	80%
MJABRA	56%	25%	40%	32%	38%
OUSSIF	97%	106%	113%	153%	117%
HENCHIR EL BORJ	95%	76%	48%	79%	75%
HENCHIR BOU ALI	91%	67%	48%	25%	58%
DRAA AFFEN	116%	144%	100%	86%	111%
SIDI BEN SALM 1	97%	95%	106%	100%	99%
Ouled nasr	132%	119%	120%	124%	124%
MOJHEDINE					

Source : our data + Ministry of agriculture

Appendix 5.1.7.

Water supply adequacy: average pumped water

	Water pumped (m3)							
	2003	**2004**	**2005**	**2006**	**2007**	**Average per year**	**Area (ha)**	**Average (m3 perha)**
MLELSA	381668	389460	388034	47430	451299	331578	134	2474,5
BEN SALEM 3	306972	338233	406339	342191	357569	350260	165	2122,8
HENCHIRJEFNA	595457	896418	839457	292299	934693	711664	430	1655
BEN SALEM 2	345508	445747	461068	216924	402703	374390	202	1853,4
KARMA 1	80854	126355	206601	****	250373	166045	90	1845
KARMA 2	62532	71654	103770	15474	158310	82348	80	1029,4
CHEBIKA EAST	93988	178342	187698	146744	105318	142418	156	912,9
CHEBIKA OUEST	178342	250844	247896	222743	54742	190913	195	979
AJIFAR	54742	67608	21550	55660	75491	55010	39	1410,5
MJABRA	131220	79299	****	****	****	105259	139	757,3
OUSSIF	39518	103984	19080	118462	206954	97599	32	3050
HENCHIR EL BORJ	53655	90486	42104	1147	112485	59975	126	476
HENCHIR BOU ALI	72390	****	67608	46986	111014	74499	126	591,3
DRAA AFFEN	229968	219809	****	****	104892	184889	70	2641,3
SIDI BEN SALM 1	197715	374520	231636	6384	236218	209294	125	1674,4
Ouled nasr	100751	109200	144881	364480	108817	165625	74	2238,2
MOJHEDINE	101850	61000	****	****	265260	142703	81	1761,8

Source : our data + Ministry of agriculture

Appendix 5.1.8.

Water supply adequacy : average pumped water crossed with average intensification ratio m3/ha (2003_2007)

	Average rate of intensification 2003_2007	Average water pumped m3/ha
KARMA 1	124%	1845
Ouled nasr	124%	2238
OUSSIF	117%	3050
KARMA 2	116%	1029
DRAA AFFEN	111%	2641
BEN SALEM 3	109%	2123
CHEBIKA OUEST	104%	979
CHEBIKA EAST	101%	913
MLELSA	100%	2474
SIDI BEN SALM 1	99%	1674
BEN SALEM 2	98%	1853
HENCHIRJEFNA	82%	1655
AJIFAR	80%	1411
HENCHIR EL BORJ	75%	476
HENCHIR BOU ALI	58%	591
MJABRA	38%	757
MOJHEDINE		1762

5.2. Experimental Results

Preparation of the experimental setting “input data”

<u>Appendix 5.2.1. :</u> Flyer of the field experiment

Appendix 5.2.2.:

The spreadsheet of the game

اللاعب رقم ...

الدورة	الحساب الخاص	حساب المجموعة	الإستثمار الجملي في حساب المجموعة	الربح من الحساب الخاص	الربح من حساب المجموعة	الربح الجملي للدورة
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
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15						
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17						
18						
19						
20						
21						
22						
23						
24						
25						

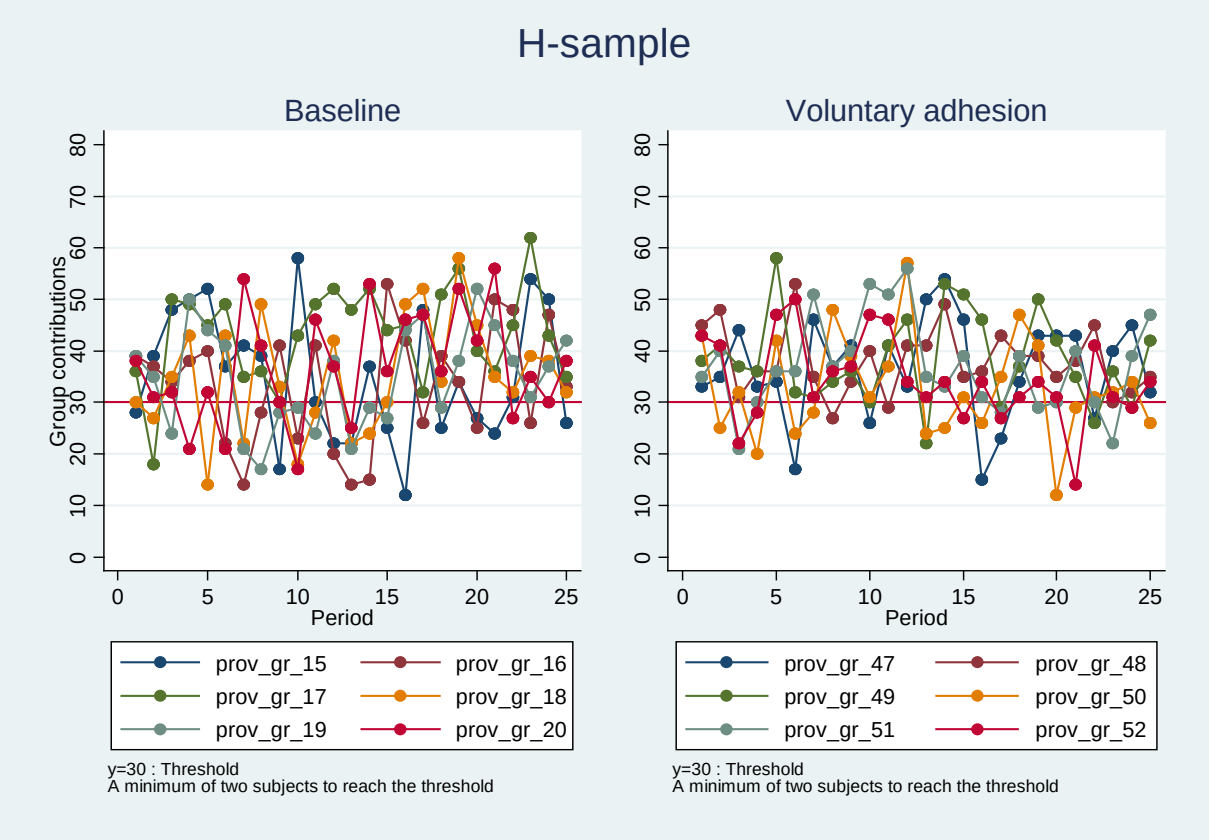
Appendix 5.2.3. :

Percentage of Nash equilibria

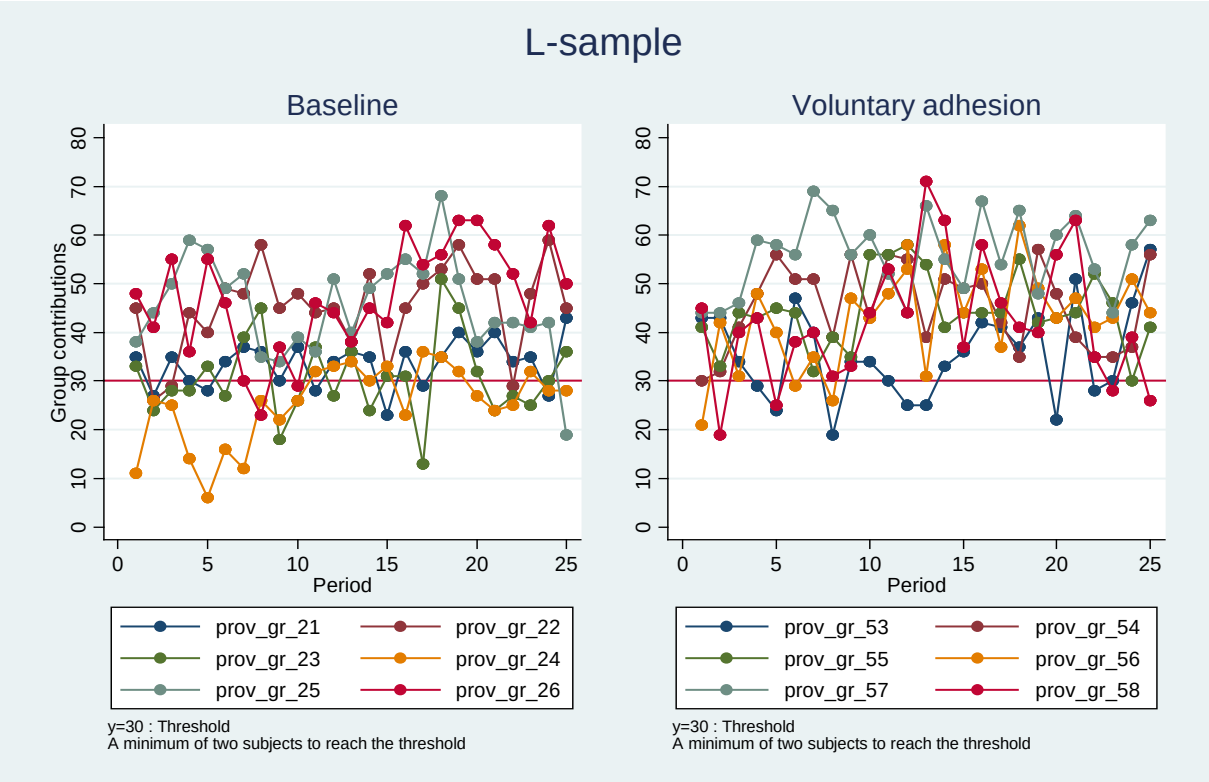
	Baseline	Voluntary adhesion
M-sample	5.0%	7.5%
T-sample	4.4%	3.8%
H-sample	5.6%	4.2%
L-sample	4.5%	2.9%
I- sample	1.8%	3.22%

Percentage of Nash equilibria = Number of Nash equilibria / Number of times group contributions reach at least the threshold

Appendix 5.2.4.
Group contributions (H-sample)

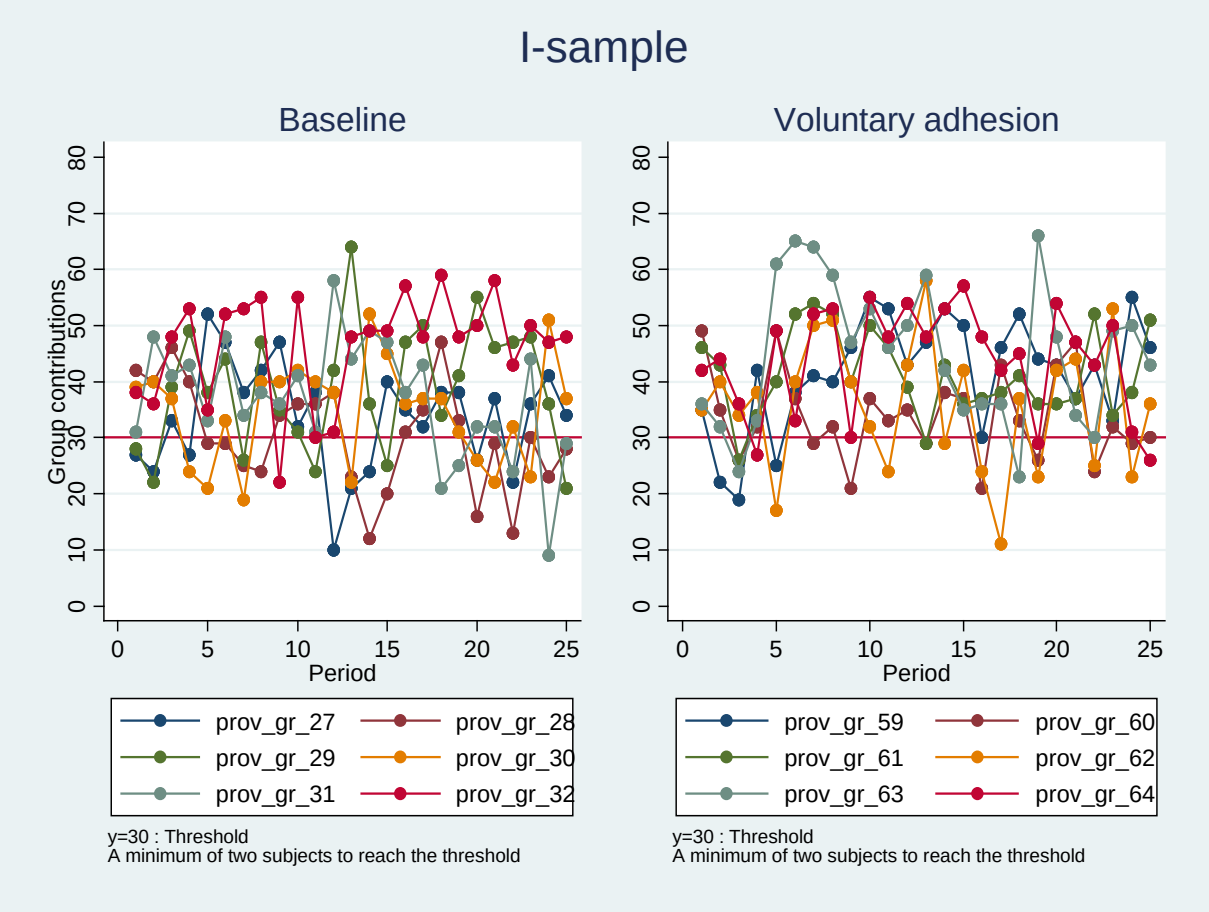


Appendix 5.2.5.
Group contributions (L-sample)



Appendix 5.2.6.

Group contributions (I-sample)



Appendix 5.2.7.

Results from panel data regressions explaining group contributions, success of provision and welfare (H-sample) [(a)]

Regressos	**Group contributions**	**Success of provision** [(b)]	**Welfare**
Intercept	35.04 (*)	0.55 (*)	26.22 (*)
	(23.93)	(2.57)	(46.15)
Voluntary adhesion [(c)]	--	--	--
Period	--	--	--
Log likelihood	-1110	-164	- 4276
Number of observation	300	300	300
Number of groups	12	12	12
Time periods	25	25	25

(*): Significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) : Logit regression ; (c) dummy variable taking value 1 for the voluntary. ; Regressions are corrected for heteroskedasticity and autocorrelation.

Appendix 5.2.8.

Results from panel data regression of the asymptotic group contributions (H-sample) [(a) (b)]

Regressors	**Baseline**	**Voluntary adhesion**
Intercept	36.88 (*)	35.90 (*)
	(32.93)	(37.48)
Period_inver	--	--
Log likelihood	-572	-535
Number of observation	150	150
Number of groups	6	6
Time periods	25	25

(*): significant at 1% level ; (**) : significant at 5% level ; (***) : significant at 10% level; -- non significant

(a) : T-statistics are in parentheses (b) $G_{it}=G_{\infty}+G_{0*}\left(\frac{1}{t}\right)+u_i+\varepsilon_{it}$ where i=1,2,..,6 and t=1,2,..,25. ; Regressions are corrected for heteroskedasticity and autocorrelation.

Appendix 5.2.9.

Results from panel data regressions explaining group contributions, success and welfare (I-sample)[(a)]

Regressors	**Group contributions**	**Success of provision** [(b)]	**Welfare**
Intercept	37.34 (*)	0.75 (*)	26.55 (*)
	(16.22)	(3.28)	(22.27)
Voluntary adhesion [(c)]	--	--	--
Period	--	--	--
Log likelihood	2.4% [(d)]	-152	0.0% [(d)]
Number of observation	300	300	300
Number of groups	12	12	12
Time periods	25	25	25

(*): Significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses ; (b): Logit regression ; (c) : dummy variable taking value 1 for the voluntary adhesion treatment ; (d) : R2 overall ; Regressions are corrected for heteroskedasticity and autocorrelation.

Appendix 5.2.10.

Results from non-parametric tests comparing individual contribution, group contributions success of provision and welfare between H-sample, L-sample and I-sample in the baseline treatment.

	Individual contribution	**Group contributions**	**Success of provision**	**Welfare**
H-sample / L-sample	U= 1.21; p= 0.22	U= 0.94; p= 0.34	χ^2= 0.14; p= 0.69	U= 0.97; p= 0.33
H-sample / I-sample	U= 0.34; p = 0.72	U= 0.29; p= 0.76	χ^2= 0.26; p= 0.60	U= 0.77; p= 0.44
L-sample / I-sample	U= -0.91; p= 0.35	U= -0.62; p= 0.53	χ^2= 0.01; p= 0.89	U= -0.22; p= 0.82

Appendix 5.2.11.

Results from panel data regression explaining group contributions, success of provision and welfare in the baseline treatment of the all the pools of participants [(a)]

Regressors	**Group contributions**	**Success of provision [(c)]**	**Welfare**
Intercept	26.88	--	21.91(*)
	(9.80)		(41.03)
T-sample [(b)]	--	--	--
H-sample[(b)]	10.95(*)	1.46(*)	3.63(*)
	(3.96)	(2.92)	(5.91)
L-sample [(b)]	10.51(*)	1.65(*)	2,49
	(3.59	(3.24)	(3.91)
I-sample [(b)]	11.29(*)	1.60(*)	2.49(*)
	(4.06)	(3.19)	(3.84)
Period	-0.16(**)	-0.02(***)	--
	(-2.06)	(-1.93)	
Log likelihood	-2790	-448	-8377
Number of observation	750	750	
Number of groups	30	30	
Periods	25	25	

(*): significant at 1% level; (**): significant at 5% level; (***): significant at 10% level; -- non significant

(a) : T-statistics are in parentheses ; (b) Dummy variable for the treatments in Montpellier dropped ; (c) Logit regression ; Regressions are corrected for heteroskedasticity and autocorrelation.

Conclusion

The Tunisian state is committed to a decentralization policy of the irrigation system. This evolution from a centralized towards a decentralized system raises an implementation issue. The state is relying on a top down strategy whereby it enhances the creation of self-governing systems. In this investigation, we question the consequences of such approach on the cooperative behavior of farmers. More precisely, we investigated whether cooperative behaviour is affected by voluntarism in the provision of a collective good. This is accomplished by comparing the provision of a public good with the provision of a club good. Several features characterize club goods; in particular we focused on voluntarism and on the critical level of provision. The latter issue was addressed first in our research. We framed a club good as a step level mechanism whereby contributors are required to meet a threshold in order to provide the club. However, in this initial setting subjects had to solve two puzzles simultaneously: reaching a threshold and dealing with an assurance problem. In a later setting, we isolated the specific effect of voluntary adhesion by ruling out the assurance problem. Our third and fourth questions concentrate on the external validity of our lab findings. The experimental methodology is frequently criticized for its lack of external validity[92], especially when field issues motivate it. Specifically, we are dealing with a non-standard pool of subjects- farmers- in a developing country, and, in contrast to the randomly selected subjects in the lab, farmers in the field have close ties and interact frequently with each other. Thus, in our process to getting closer to the field, we first begun to check the robustness of our lab results on a pool of student subjects from Tunisian origin. After that we run an field experiment involving Tunisian farmers of the irrigation systems. The field experiment was designed to identify a possible influence of the relative performance of the irrigation systems on cooperative behavior.

Our findings showed that voluntary adhesion in the provision of a collective good does affect subject's cooperative behavior. The experimental data reveals (i) a significant increase of group contributions, success of provision and welfare (except when the threshold is high) (ii)

[92] For a discussion of the relevance of the external validity of the experimental tool see (Cardenas and Carpenter, 2005; Harrison and List, 2004; Levitt and List, 2008; List, 2007; List and Levitt, 2005)

an increase of the number of contributors. These findings are consistent with the theoretical predictions. Voluntary adhesion also moderates cheap riding by inducing sustained group contribution over time. Our results also show that voluntary adhesion is more effective when money-back is not guaranteed (the assurance problem). When the assurance problem is ruled out, voluntary adhesion no longer increases group contributions, success of provision and welfare. However, the voluntary adhesion mechanism decreases the variance of group contributions (especially for the high threshold). It also moderates cheap riding when the threshold is low. In addition, our experimental findings show that voluntary adhesion generates similar outcomes than the MBG mechanism (for low and medium threshholds).

The investigation of the external validity of our lab results indicates that our results hold with respect to subject's origin. Subtle differences exist but no dramatic change was observed. The experiment with Tunisian students shows a lower variance of group contributions and a higher number of contributors in the baseline treatment in comparison to students in Montpellier. Also, voluntary adhesion no longer moderates cheap riding. In contrast, the field experiment reveals less effective findings in the voluntary adhesion treatments. Success of provision and welfare only increase in one sample of farmers out of three (the low performing irrigation system). Nonetheless, our field experiment revealed that voluntary adhesion increases the number of contributors in all the treatments performed. This is consistent with the theoretical predictions. As a consequence, it is also a relevant indicator of the internal validity of our setting implemented *in-vivo (Harrison, 2005).* In addition, our field experiment revealed that farmers behave more cooperatively than student subjects; we observe a high level of collective contributions, close to half the endowment (only a third of the endowment for students) that sustain over time and a highly effective provision of public good in the baseline treatment.

With regard to theses findings, our investigation of the voluntary adhesion mechanism to the provision of a collective good raises two issues. Firstly, why does voluntary adhesion improve cooperative behavior? A possible explanation of the improved cooperative behavior is the reduction of strategic uncertainty. This is because voluntary adhesion guarantees the achievement of a fraction of the Nash group contribution. When all members of the group (four players in the experiment) decide to adhere to the club a minimum fraction of the target

Nash equilibrium is achieved: 26.6% for the low threshold, 13.3% for the medium threshold and 6.6% for the high threshold. Our conjecture was that the reduction of strategic uncertainty would enhance cooperation. It is also the reason why the most effective results are observed with the low threshold, then with medium and high threshold. In a follow up experiment where voluntary adhesion guaranteed 66.6% of the Nash equilibrium, we found that cooperation is sharply increased. The success rate of provision of the club good raised from 30.0% to 83.0% (high threshold). Hence, the voluntary adhesion mechanism provides strong incentives to avoid coordination failures. However, our previous experiments did not highlight whether a given level of strategic uncertainty within the three levels of thresholds would yield the same results or not. Since increasing the threshold exacerbates the assurance problem and the strategic uncertainty at the same time, we cannot isolate the specific effect of the assurance problem when varying the threshold. One should set up a design whether a same minimum level of contribution proportional to the thresholds is imposed. That is a player has to contribute at least 1 token in the low threshold, 2 tokens in the medium threshold and 4 tokens in the high threshold in order to adhere to the club (26.6% of the provision equilibrium in the three treatments). This setting will allow holding constant the strategic uncertainty and therefore examining the specific effect of different level of threshold i.e. assurance problem.

Secondly, what policy insights our can our field experiment infer? It is worth noting that the creation of self- governing irrigation system is a highly complex issue; Showing that voluntary adhesion improves cooperative behaviour is not enough to tackle the whole problem. Nonetheless, a first policy insight is the sensitivity of voluntary adhesion to the characteristics of the group of farmers involved. In our experiment, we found that the provision of club goods is more effective than public goods when the group of farmers are less cooperative. A second policy insight concerns the high level of cooperation observed (whether it is for the provision of the public good or the club good). This is an encouraging indicator for the ability to cooperate in self-governing irrigation systems as it can be seen as a support for the strategy of creating a self-governing irrigation system. Yet, our field investigation does not inform whether our results hold in the other areas of the country. For instance, the humid north or the desert south can behave differently in comparison with the semi arid center. A further investigation would assure that farmers of the region of Kairouan do not behave specifically to their region, and thus confer a higher robustness to our results.

Finally, in our investigation of voluntary adhesion we assumed that agents value homogenously their club. In reality, agents who intend to adhere to a club have heterogeneous benefits. The provision of the club good has not the same utility for each member. Thus, a possible extension to this work would be to consider a heterogeneous case. Furthermore, adding more realism by relaxing the homogeneity assumption would allow to analyze more deeply the strategic uncertainty. Indeed, high-valuing players are more likely to contribute than low valuing ones[93]. We conjecture that voluntary adhesion in this heterogeneous setting would increase the success of provision. Several step-level experiments use the heterogeneous induced values setting. (Croson *et al.*, 2006; Croson and Marks, 1999; Marks and Croson, 1999; Rondeau *et al.*, 2005; Rondeau *et al.*, 1999; Spencer, 2007) In particular Croson and Marks (1999) found that heterogeneous valuation reduces the variance of group contributions but does no affect the provision of the step-level good. However, these experiments aimed to mimic fundraising conditions (e.g. unknown distribution of heterogeneous valuation in the group) or to address the demand revealing aspect of the step-level mechanism. Besides, it was always combined with Money Back Guarantee mechanism i.e. a setting that modifies the structure of the game. The investigation of the heterogeneous valuation of the club without MBG could indeed bring new insights on the effects of heterogeneity.

Secondly, what are the policy implications of our findings? The creation of self- governing irrigation system is a highly complex issue, of which the success depends on many factors. All things equal, the voluntary adhesion mechanism improves cooperative behaviour, but more interestingly from the policy point of view, is the sensitivity of voluntary adhesion to the characteristics of the group of farmers involved. In our experiment, we found that the provision of club goods is more effective than the provision of public goods when the group of farmers is weakly cooperative. A second policy insight concerns the high level of cooperation observed (whether it is for the provision of the public good or the club good). This is an encouraging indicator for the ability to cooperate in self-governing irrigation systems as it can be seen as a support for the strategy of creating self-governing irrigation systems. Yet, our field investigation does not inform whether our results hold in the other areas of the country. For instance, farmers living in the humid north or the desert south can

[93] See Appendix 6.1. for a possible proposition of a model of heterogeneous valuation.

behave differently in comparison with the semi arid center. A further investigation would assure that farmers' behaviour observed in the region of Kairouan is not specific to this region, but applies to other regions as well, which would strengthen the robustness of our results.

Finally, in our investigation of voluntary adhesion we assumed that agents value homogenously the club good. In reality, agents who intend to adhere to a club have heterogeneous benefits. Since the provision of a club good has not the same utility for each member, a natural extension of this research would be to consider a heterogeneous population. Furthermore, adding more realism by relaxing the homogeneity assumption would allow analyzing more deeply the strategic uncertainty issue. High-valuing players are more likely to contribute than low valuing ones[94]. We conjecture that voluntary adhesion in this heterogeneous setting would increase the success of provision. Several step-level experiments use the heterogeneous induced values setting. (Croson *et al.*, 2006; Croson and Marks, 1999; Marks and Croson, 1999; Rondeau *et al.*, 2005; Rondeau *et al.*, 1999; Spencer, 2007) In particular Croson and Marks (1999) found that heterogeneous valuation reduces the variance of group contributions but does no affect the provision of the step-level good. However, these experiments aimed at mimicking fundraising conditions (e.g. unknown distribution of heterogeneous valuation in the group) or to address the demand revealing aspect of the step-level mechanism. Besides, they considered only the Money Back Guarantee mechanism which rules out the assurance problem that voluntary adhesion affect. The investigation of the heterogeneous valuation of the club without MBG could indeed bring new insights on the effects of heterogeneity.

A second extension of our work is the investigation of cheap riding in the provision of a club good. In our setting, the minimum contribution (1 token) allowed a member to benefit from the club and get the maximum Nash earning (in case the club good was provided). This is "equivalent" to choose the free riding strategy to maximize benefits from public goods. Showing that subjects effectively use a specific cheap riding strategy for the club in comparison to the public good case constitutes another extension to our work (See Appendix

[94] See Appendix for a possible proposition of a model of heterogeneous valuation.

2). A parallel investigation to this Phd research was performed[95] where the same design of the provision of club goods with a refund mechanism was replicated. A stranger design vs. a partner design was used to stress the free riding behavior. The experiment confirmed the existence of a different strategic behavior and also revealed a higher level of contribution among subject's of the stranger design. This result differs from previous experimental findings, for which reason further investigations are required (e.g. experiment with a stranger design but without MBG).

[95] Rouaix, Agathe, 2008. La métamorphose du comportement de passager clandestin sous l'influence de l'exclusion. Une étude expérimentale du comportement de free-rider en bien club avec seuil de fourniture. Master Thesis, Supagro, Montpellier.

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Appendix

Appendix 1 : Heterogenous valuation of the club

We keep the same conditions on variables and for parameters of our experiment. *Ci* is the induced value of the provision of the club good (*Ci>0).* Contributions above the threshold $\lambda(G-T)$ entail similar returns for all players. Only the provision of the club provides different valuations. The prediction of such game differs from the one studied in our work by limiting the number of vectors of equilibria for the low valuing players and increasing it for the high valuing players. The 2 Nash equilibria - reaching the threshold and no contribution- remain.

$$U_i(g_i, G) = \alpha(w - g_i) + \lambda_i C_i + \lambda_i \beta(G - T) \quad \text{if } G = \Sigma_{i=1}^{n} g_i >= T$$
$$U_i(g_i, G) = \alpha(w - g_i) \quad \text{else}$$

$$\text{with } \lambda_i = 1 \text{ if } g_i > 0$$
$$\lambda_i = 0 \text{ if } g_i = 0$$

$$\alpha > \beta \,;\, \alpha < n\beta$$

<u>Appendix 6.2.:</u> Quantiles of individual contribution. Cheap riding in the club.