Voluntary versus involuntary adhesion to a self-governing irrigation system. A field experiment.[1]

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May, 2009

Abstract

Many countries concerned by water scarcity are reforming their nationalized management of irrigation systems to set up self-governing ones. This evolution raises an implementation issue, about the way to provide these collective goods. In this investigation, we conduct a field experiment to compare the provision of a collective good when farmers are forced to adhere to the case where they are free to adhere. In the former case, subjects are providing a pure public good whereas in the latter they are providing a club good. We show that voluntary adhesion improves the cooperative behavior with subjects from low performing irrigation system and with independent farmers. However, voluntary adhesion does not improve the cooperative behaviour with subjects from highly performing irrigation system.

JEL : C93; D71; D60 ; H41; O13; Q18;

Keywords: Public goods, Club goods, exclusion, step-level public good, provision, farmers, irrigation system, field experiment

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[1] This work is financed by *Water **S**avings in **IR**rigation Systems in **MA**ghreb* (SIRMA) project. http://www.eau-sirma.net. Thanks for Marc Willinger (University of Montpellier, France) and Mohamed Salah Bachta (INA Tunis, Tunisia) for their advices and discussions at different stages of this investigation.

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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 top down approach: the ex-centralized state imposes a reform whereby agents are induced to set up an association to self-govern their activities. In this research, we investigate the possible consequences of such voluntary agreements among agents on their willingness to cooperate. More precisely, creating an association governing an irrigation system is a problem of provision of a collective good. Currently the state is implementing a top down policy; it forces the adhesion of farmers to the provision of the collective good. The collective good provided is therefore a public good. In contrast, when individuals are free to choose whether to adhere or not to the creation of the irrigators' association, the context is one of providing a club good. In this work, we aim to examine whether allowing farmers for the possibility of rejection of such process affects the cooperative behaviour. In order to examine this alternative policy, we set up an artefactual field experiment (Harrison and List, 2004) with Tunisian farmers. Tunisia is a country that strongly relies on top down policy to conduct its decentralization reforms and in particular the creation of self-governing irrigation system. On 2007, more than 67% of the irrigation systems were transformed to self-governing ones.

Previous investigations in the provision of collective goods have focused on pure public goods. However, we do know a little about the cooperative behavior in public goods with exclusion. Recently, several investigations started to consider the more realistic case of

impure public goods[3]. In this research, we focus on another possibility of exclusion by means of club goods. Club goods are characterized by voluntarism. “First, privately owned and operated clubs must be voluntary; members choose to belong because they anticipate a net benefit.” (Sandler and Tschirhart, 1997). Voluntary adhesion to a club good can be framed as a public good with an individual option to exit. A seminal experiment[4] 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.

The field experiment that we set up compares each time two situations: the provision of a public good to the provision of a club good. Both collective goods involve a step-level mechanism[5]. The Farmers need to reach a threshold level of contribution in order to provide their association. In both treatments, the Nash prediction is to reach exactly the threshold. Therefore, 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

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[3] For example, a voting procedure (Gary and Chun-Lei, 2006; Margreiter, 2004), an endogenous threshold (Kocher *et al.*, 2005), granting power to a leader to exclude (Levati et al., 2007), a serial cost share mechanism (Gailmard and Palfrey, 2005), excluding the lowest contributors (Croson *et al.*, 2005), or exclusion by the experimenter himself (Gunnthorsdottir *et al.*, 2000).

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

[5] 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.

voluntary adhesion only cheap riding is possible. We show in this investigation that despite the tiny difference in the theoretical predictions, the cooperative behaviour is modified.

Our experiment shows that voluntary adhesion in the provision of a collective good improves the cooperative behaviour of farmers by increasing the level of group contributions and success of provision of the collective good. Our experiment also shows that the provision of the club good is sensitive to the sample type of farmers participating whereas the provision of the public good is not affected. The following section of this chapter defines voluntary adhesion and presents the theoretical predictions of the game. 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 Voluntary vs. Involuntary adhesion in the provision of a collective good:

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, $\frac{\partial U}{\partial xi}>0$, $\frac{\partial U}{\partial gi}>0$ and $\frac{\partial^2 U}{\partial^2 xi}=0$, $\frac{\partial^2 U}{\partial^2 gi}=0$. 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 $\sum_{i=1}^{n} g_i < \mathrm{T}$ 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[6] 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 $g_{-i} = 0$.

$$U^{II} = -\alpha + \beta \quad \text{if } \sum_1^n g_i = T \text{ and } g_i > 0 \qquad (1)$$

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

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

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 experiment consists of two treatments: a baseline treatment and a treatment with voluntary adhesion. The baseline treatment is a linear public good game with a threshold. 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. Below the threshold, individual contributions are lost. If group contributions are above the threshold, each member of the group enjoys the total amount of the collective good provided. 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. Non-contributors are excluded from the consumption of the collective good. Table 1 summarizes the parameters of the experiment.

Table 1

Experimental parameter

Treatment	Threshold	Required contributors to reach threshold	Number of observation	Group	Endowment
Baseline	30	2	6	4	20
Voluntary adhesion	30	2	6	4	20

Leaving the lab and going to the wild can entail an important loss of control. (Harrison, 2005; Ortmann, 2005). The pre-existing ties between farmers can be of particular damage. Indeed, a cooperation experiment is naturally sensitive to relation between subjects. In addition, previous lab investigations already showed such impact (Van Dijk *et al.*, 2002) (Van Dijk and Van Winden, 1997) and some field investigation pointed it out (Cardenas and Carpenter, 2008). In the case of irrigation systems involve tight relations between farmers, our subjects. Therefore, the issue of the experiment can be affected by this variable. Considering ties between subjects as a treatment variable can also be motivated by the policy itself of creating self-governing irrigation system. Indeed, creating a self-governing irrigation system involves groups of individuals who already interact with one another, and not isolated individuals. Therefore, the pre-existing network of interactions among farmers may affect the final success of the policy. Thus, we aimed in our work to investigate the existence of a relation between voluntary adhesion and social ties.

The field experiment was performed in the region of Kairouan located in east central of Tunisia. It is a representative area of the semi arid water problems in Tunisia (Faysse, 2001). Irrigation systems constitute an old tradition in the region that goes back to the ninth century (Perennes, 1993). 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 irrigation systems of the area 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.

Then, we set up a sample of subjects made of farmers selected from different irrigation systems; Sample 1 is made up of participants who belong to a high performing irrigation system (hereafter denoted the H-sample), sample 2 involves participants who belong to a low performing irrigation system (hereafter denoted the L-sample). The irrigation systems were selected thanks to the help of experts from the region and of self administrated surveys. We referred to the Institutional Analysis Development (IAD) of Ostrom et al. (2004) and Tang's (1992) study in order to define a cooperative collective action in an irrigation system. The IAD framework is based on the idea that the success of a collective action depends on the simultaneous resolution of problems in multiple action arenas (The maintenance of the irrigation system, the regular respect of the operational rules, The adequacy of water supply for irrigators). Indicators of each action arena were therefore discussed with different experts to select the different irrigation systems. Several stays were achieved in the area before the experiment in order to address the recruitment issue. We did not "helicopter" our experiment to the field as it is often criticized.

In addition to farmers from irrigation system, we also selected a random sample of independents farmers from the same area, i.e. farmers that do not belong to an irrigation system (hereafter denoted the I-sample). In contrast to the other subjects of the field experiment, they are not involved in the provision of a collective good (neither in the consumption of a common pool resource). Their only pre-existing interaction comes from the fact that they live in the same area. They can do not know each other's. Social ties among subjects in this treatment are "closer" to students recruited in the lab from a same university. This treatment provides a control for the higher level of interaction existing between farmers of the irrigation systems. Table 2 summarizes the design of the treatments.

Table 2

Experimental design

	H-sample [(a)]	**L-sample** [(b)]	**I-sample** [(c)]
Baseline	24 farmers *Mlelsa* [(d)]	24 farmers *Bou Ali* [(d)]	24 farmers
Voluntary adhesion	24 farmers *Karma I* [(d)]	24 farmers *El Borj* [(d)]	24 farmers

(a) High performing irrigation system ; (b) Low performing irrigation system ; (c) Independent farmers ; (d) : Name of the irrigation system ;

The only condition imposed in the recruitment of farmers is the obligation to be literate (at least writing and reading numbers). 144 farmers participated in the experiment. Table 3 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. 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 and two indoors (in an elementary school). 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. 10 assistants 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.

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. The time needed for the instructions was about 15-20 minutes but reached 45 minutes in one experiment. 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, 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. These examples are: 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". 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 and to identify participants. Once earnings of each group were calculated, assistants were asked to mix the group's spreadsheets with other groups before getting them back to subjects. Indeed, it is possible that some subjects could guess the composition of their group by carefully following the returning of the spreadsheet of a unique assistant. This design allows maintaining the anonymity of the experiment. The first three periods were considered as training periods (however farmers were also paid for them). To help the understanding of the game spreadsheet, 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 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 final payment represented merely the 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[7] (on average 6.46€). The remuneration was sufficient to provide strong incentives to recruit subjects. One of the sessions was organized the same day than the weekly market and farmers preferred nonetheless to participate to the experiment. The final payment was achieved in an isolated

[7] Note that previous works showed that the variation of stakes need to be important in order to affect dramatically cooperative behaviour. (Cameron, 1999; Kocher *et al.*, 2005)

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.

Table 3

Characteristic of the subjects

		Number of farmers[(a)]	Total area [(b)]	Average area per farmer[(c)] (Ha)	Average education (years)	Average age (years)	Farming unique income	Marital Status	Sex	Ownig 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) per irrigation system ; (b) of the irrigation system ; (c) Average area per farmer in the irrigation system (ha)

4 Results

The presentation of results is structured as follow: first, we examine the results of the voluntary adhesion treatments in comparison to the baseline treatments within the three samples separately. Then, we address the provision of the public good and the club good with respect to the sample of farmers. We present at the beginning of the subsection 4.1. and 4.2. the statistical analysis to support our results.

4.1 Voluntary adhesion improves the cooperative behavior with subjects from independent and low performing irrigation system but not with subjects from highly performing irrigation system

In this subsection, we compare the voluntary adhesion treatment to the baseline treatment in each sample of farmers. We show that voluntary adhesion improves the cooperative behaviour in the I-sample and the L-sample. However, there is no or little effect on the cooperative behaviour in the H-sample. Finally, we show that our findings are consistent with the theoretical predictions since we observe an increase of the number of contributors in the voluntary adhesion treatment in all the samples of farmers. Hereafter, we present our evidences.

Result 1: Voluntary adhesion increases the level of group contributions, success of provision and welfare.

To compare the cooperative behaviour of subjects in the baseline treatment and the voluntary adhesion, we focus on three indicators: group contributions to the collective account, the success of provision, i.e. whether a group succeed or not to reach the threshold and welfare measured by final earnings of the subject. Table 4 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.

Table 4 shows that voluntary adhesion increase group contributions, success of provision and welfare. We perform the following analysis. First, we compare the baseline treatment and the voluntary adhesion treatment using non-parametric tests: a two-sided Wilcoxon-

Mann-Whitney test[8] 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[9] data regression with random effects[10].The dependent variable is *group contribution*, *success of provision* and *welfare*. Recall that *group contributions* is 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. When the dependent variable is *success of provision*, a binary variable taking value 1 when the threshold is met, we run a logit regression on panel data. The regressors are for each regression 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 [11]. Results are reported in table 5. We conclude for a significant statistical effect when both the non-parametric tests and the panel data regression agree. The rejection threshold of the null hypothesis is at 5%.

Our test analysis shows that voluntary adhesion increases individual contribution (U=-4.91; p<0.01), group contributions (U=-2.48; p=0.01) and welfare (U=-6.65 ; p<0.01) in the L-sample and respectively in the I-sample (U= -2.57, p=0.01), (U= -4.52; p<0.01) and (U=-3.08; p<0.01).

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

[9] 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.

[10] 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)

[11] 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 4

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*
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)

Similarly the χ^2 test shows also an increase in the success of provision in the L-sample (χ^2=15.26; p<0.01) and in the I-sample (13.276; p<0.01). These findings are confirmed with panel data regression. Group contributions increase in the voluntary adhesion by 7.43 tokens in the L-sample and 4.11 tokens in the I-sample in comparison to the baseline treatment.

Note that table 5 also shows a high cooperative level of farmers. In comparison to step level experiments in the lab, farmers reach a higher level of success of provision. They score success percentage similar to the experiments with Money Back Guarantee incentive. In addition, subjects contribute almost half of their endowment (48.2%) to the collective in the three samples. Stylised facts are still rare in field experiments but this is consistent with previous field experiments with farmers from highly different context (Cardenas and Carpenter, 2008).

Table 5: Results from panel data regression explaining group contributions, success of provision and welfare by treatment in the L-sample and the I-sample[(a)]

Regressors	Group contributions		Success of provision [(c)]		Welfare	
	L-sample	**I-sample**	**L-sample**	**I-sample**	**L-sample**	**I-sample**
Intercept	33.52 (***)	36.68 (***)	--	--	26.09 (***)	26.56 (***)
	(25.20)	(26.66)			(53.97)	(50.07)
Voluntary adhesion [(b)]	7.43 (***)	4.11 (***)	5.02(***)	1.71 (**)	2.73 (***)	1.59 (***)
	(6.42)	(3.46)	(3.47)	(2.46)	(6.64)	(3.48)
Period	0.23 (***)	--	1.04	--	0.08 (***)	--
	(2.96)		(3.67)		(3.08)	
Log likelihood	-1137	-1131	-467	- 610	-4103	-4230
Number of observation	1200	1200	1200	1200	1200	1200
Number of subjects	48	48	48	48	48	48
Time periods	25	25	25	25	25	25

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

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

<u>Result 2:</u> Voluntary adhesion raises the level of convergence of group contributions in the L-sample and the I-sample.

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 2). 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.

We report in table 6 asymptotic group contributions within the I-sample and the L-sample.

$$G_{jt} = G_{\infty} + G_0 \frac{1}{t} + u_j + \varepsilon_{jt} \quad \text{where } j = 1, 2,.., 6 \text{ and } t = 1, 2,.., 25 \qquad (2)$$

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. *j* stands for groups of subjects, *t* for time u_j for the group effect and ε_{jt} for the error term. Thus, the intercept, $G\infty$ represents the asymptotic group contributions. At the opposite, $G\infty + G_0$ represents the initial group contributions.

The difference between the $G\infty$ in the voluntary adhesion treatment and the baseline is equal to 8.75 tokens in the L-sample, and to 4.49 tokens in the I-sample. Thus, the analysis of the convergence of group contributions supports the findings of results 2 Group contributions in the voluntary adhesion are significantly higher than in the baseline treatment and this difference is not affected over time. We observe also that there is no treatment where group contributions converge to the Nash equilibrium; the lowest level of convergence (the baseline treatment of the I-sample) is 36 tokens whereas the Nash equilibrium is 30 tokens. In other terms, the level of convergence is significantly higher than the threshold. This is another observation of the highly cooperative behaviour of farmers.

Table 6 Results from panel data regression explaining asymptotic group contributions [(a) (b)]

Regressors	L-sample		I-sample	
	Baseline	**Voluntary adhesion**	**Baseline**	**Voluntary adhesion**
Intercept	37.50 (*)	46.25 (*)	36.24 (*)	40.73 (*)
	(13.87)	(47.35)	(33.36)	(39.95)
Period_inver	--	-13.50 (*)	--	--
		(-3.50)		
Log likelihood	-574	-561	-562	- 568
Number of observation	150	150	150	150
Number of groups	6	6	6	6
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) : $G_{it}=G_{\infty}+G_{0*}\left(\frac{1}{t}\right)+u_i+\varepsilon_{it}$ 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.

<u>Result 3</u>: Voluntary adhesion does not affect the cooperative behavior with subjects highly performing irrigation system.

Visual inspection of the average group contributions shows few differences between the baseline treatment and the voluntary adhesion treatment (Figure 1). In the last periods (19-25) average group contributions in the baseline treatment exceeds even the group contributions of the voluntary adhesion treatment. We perform the following analysis to address this visual inspection. We first compare group contributions, success of provision and welfare by non-parametric statistical test. 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 1 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 2 reports the result of the asymptotic group contributions. Both groups of subjects converge to a higher level of group contributions than the Nash equilibrium. Both treatments converge to a similar level of group contributions but to a slightly higher level (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.

<u>Result 4:</u> Voluntary adhesion increases the number of contributors for all the treatments.

The model predicts that introducing the possibility of adhesion will increase the number of contributors. In Table 7 we report for each treatment the average number of contributors per group. It indicates a higher average number of contributors in the voluntary adhesion treatments than in the baseline treatment and a lower standard deviation. We first run a Chi2

test to examine these differences. The increase is statistically significant for the three samples: 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 8 reports the results of the regression. It also shows that there is a significant positive variation of the number of contributors between the voluntary adhesion treatment and the baseline. The regression reveals also that the regressor *period* is not significant in the three treatments. This increase of the number of contributors is therefore stable over time. This finding is consistent with theoretical predictions. This is a relevant evidence that the control set up in our design on the field allow to reach a fair level of the internal validity of the experiment (Harrison, 2005).

Table 7

Average number of contributors per group

	H-sample	**L-sample**	**I-sample**	**Group size**
Baseline (SD)	3.78 (0.41)	3.79 (0.43)	3.69 (0.50)	4
Voluntary adhesion (SD)	3.90 (0.31)	3.96 (0.19)	3.93 (0.25)	4

(SD): Standard deviation between brackets

In the L-sample and the I-sample there is a higher level of group contribution in the voluntary adhesion treatment than in the baseline treatment. Is that due to the higher number of subjects contributing or to a better coordination among contributors? Similarly, a group contribution in the voluntary adhesion treatment of the H-sample is significantly equal to the group contributions of the baseline. We can expect that subjects contribute individually less but since there are more contributors, they can reach the same level of contributions.

To address this observation, we have compared strictly positive individual contributions in both baseline and voluntary adhesion treatment. The U test 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, individual contributions increase (U=-3.84; p<0.01)[12]. Thus, a higher number of contributors do not decrease the contribution effort. In other words, it does not improve the coordination among subjects. A higher level of contributions is reached thanks to more "contributors contributing".

Table 8

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.

[12] We find the same results with a panel data regression explaining the individual positive contributions with a dummy coding for treatments and time as regressors.

Figure 1: Average group contributions (H-sample).

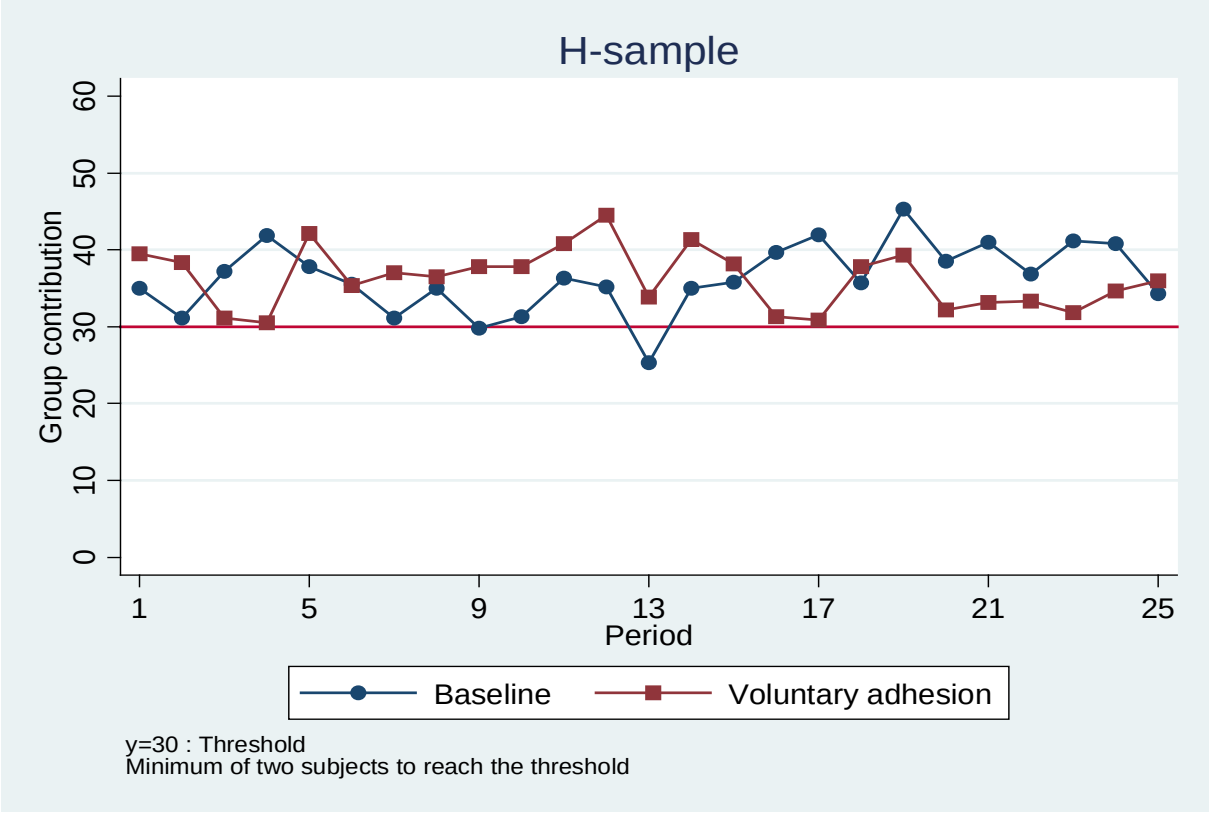


Figure 2: Average group contributions (L-sample)

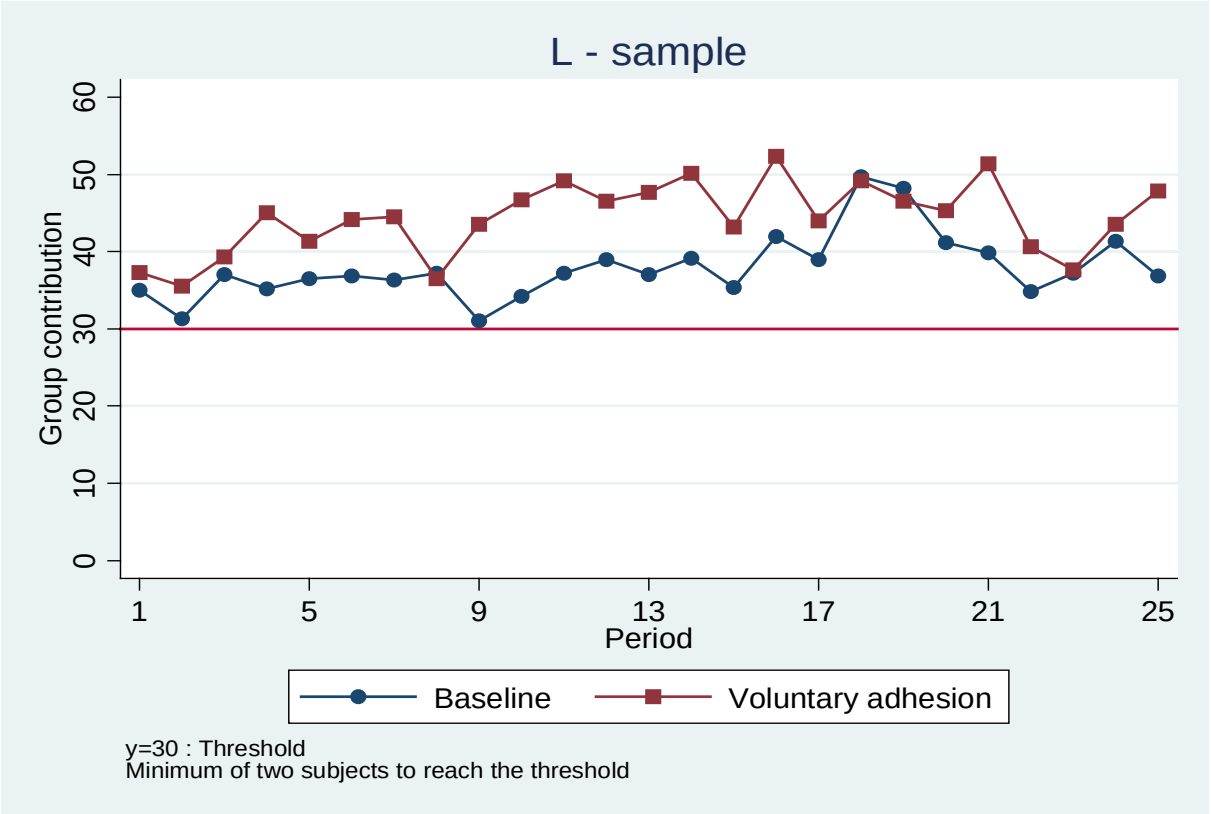
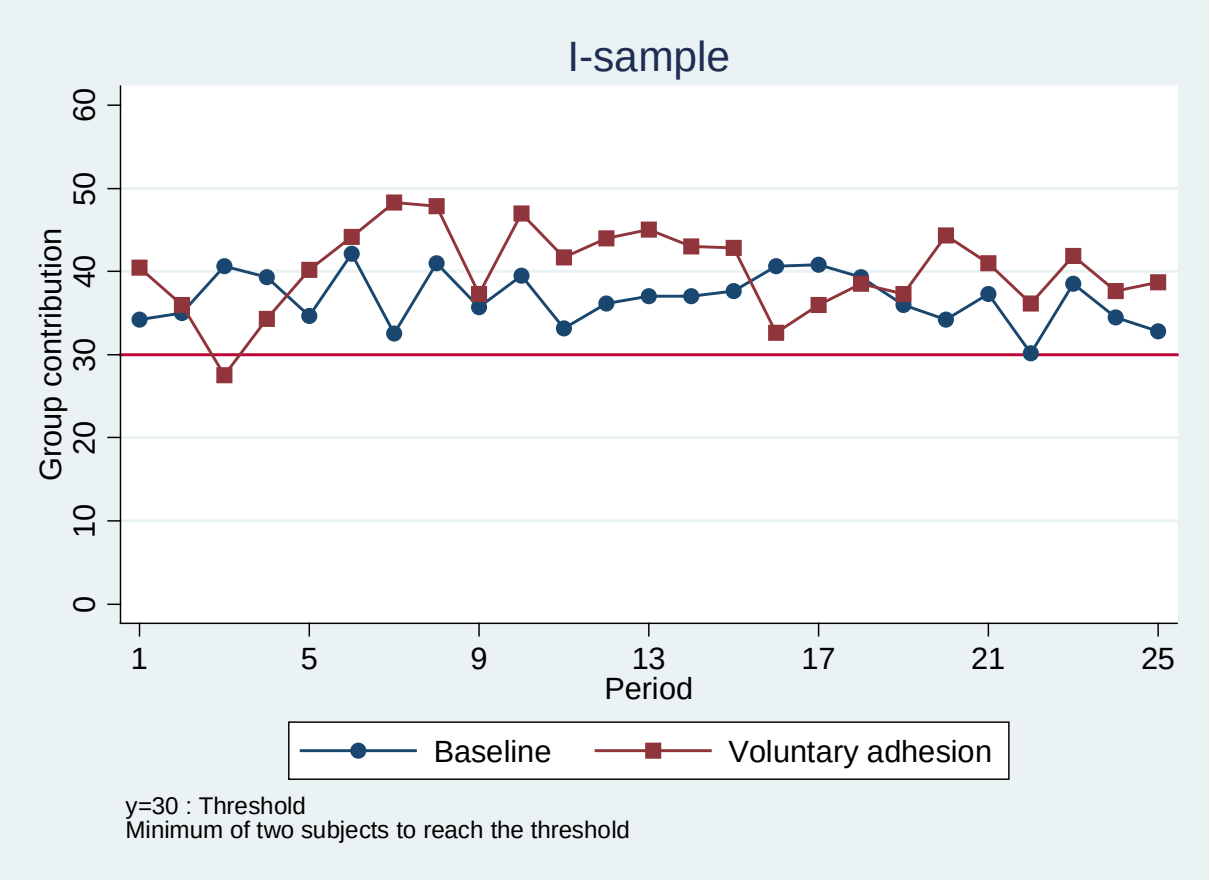


Figure 3: Average group contributions (I-sample)



4.2 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.

<u>Result 1:</u> 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 3 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 further 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 9 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.

Table 9

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 (*) (12.52)	0.95 (2.11)	25.52 (13.28)
High Performing [(b)]	--	--	--
Low Performing [(c)]	--	--	--
Period	0.14(**) (2.23)	0.01 (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.

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

We conduct the same statistical test analysis and panel regression for the voluntary adhesion treatment. In the Appendix 3, we report 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). Table 10 reports the results of the regression. It shows that group contributions increases from the I-sample to the L-sample by

3.97 tokens and decreases with 3.68 tokens between the H-sample and the I-sample. Same observation is found for the welfare and the success of provision. Hence, the voluntary adhesion treatment is sensitive to the pre-existing social ties.

Table 10

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	40.01 (*) (27.83)	1.71 (3.98)	28.18 (16.70)
High Performing (b)	-3.68 (***) (-2.67)	--	-1.72 (***) (-3.68)
Low Performing (c)	3.97 (***) (2.74)	0.82 (***) (3.03)	2.26 (***) (5.35)
Period	--	--	--
Log likelihood	-1651	-755	-6227
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.

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 with three 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 improves the cooperative behaviour in the Low performing irrigation system and with independent farmers. It increases the group contributions, the success of provision and welfare. We observe also that it raises the convergence level of group contributions. However, our experiment shows that voluntary adhesion does not improve the cooperative behaviour when subjects are recruited from highly performing irrigation systems. Group contributions reach the same level in the baseline and in the voluntary adhesion treatment.

A possible explanation to our results is that voluntary adhesion acts as a guarantee mechanism about others subject's contribution. It reduces the strategic uncertainty on the contribution of players of a same group. In our experiment, it is set as the minimum possible, i.e. 1 token. It is remarkable that with such tiny minimum level of adhesion we can observe different cooperative behaviour. The principle itself of allowing subjects to contribute or on the contrary to auto-exclude themselves has already an effect on the cooperative behaviour[13]. Hence, when subjects in our field experiment are recruited from a highly cooperative group, the guarantee incentive of voluntary adhesion has no longer an effect. On the opposite, when subjects are recruited from a low cooperative group or when subjects have few previous ties, the voluntary adhesion incentive is able to act as a guarantee mechanism.

[13] Cf. Bchir M.A. Willinger Marc. Forthcoming. "Experiments on the provision of club goods".

We observe in this field experiment a specific cooperative behaviour of farmers in comparison to a standard pool of students in the lab. Farmers cooperate strongly. The average success rate of provision observed with farmers (78.55%) for our threshold game without Money Back guarantee mechanism is comparable (even higher) to lab experiments with Money Back Guarantee (for example see Marks and Croson (1998) or Cadsby and Maynes (1999)). We also observe that farmers contribute 48.2% of their endowment to the collective account and group contribution sustain over time (no decay of contribution). Comparing this results to other field experiments dealing with cooperation issue[14] we find that Carpenter et al. (2007) observe similar results in a public good experiment with social disapproval in urban slums in southeast Asia. Carpenter 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

[14] 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).

explaining the level of contributions. Further experiments are needed to infer relevant information from this issue.

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Appendix 1

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 2

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 3

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

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