Designing agri-environmental contracts: can collective conditionality improve participation?

Philippe Le Coent [a]*, Raphaële Préget [b], Sophie Thoyer [c]

[a] Université Montpellier 1, UMR 5474 LAMETA, F-34000 Montpellier, France

[b] INRA, UMR 1135 LAMETA, F-34000 Montpellier, France

[c] Montpellier SupAgro, UMR 1135 LAMETA, F-34000 Montpellier, France

* Corresponding author: Email: philippe.le-coent@supagro.inra.fr, Address: UMR LAMETA Bâtiment 26, 2 Place Pierre Viala, 34060 Montpellier Cedex 1, France.

Abstract

Drawing an analogy between agri-environmental contracts and incentive mechanisms to improve the voluntary contribution to threshold public goods, we design a lab experiment to determine the effectiveness and the efficiency of two types of incentive mechanisms: contracts with individual payments proportional to individual environmental efforts (similar to existing agri-environmental schemes) and contracts with the same individual payments but conditioned to the attainment of a collective threshold of environmental efforts. Our experimental results show that subsidy schemes are not only effective but also efficient to improve public good production. In addition, introducing a conditional payment improves the efficiency of the mechanism and in some cases improves its effectiveness, despite identical game-theoretic predictions. Potential reasons for the deviation between predictions and observed results are therefore analyzed. We focus on the effects of beliefs on others' contributions and risk aversion. These results suggest that the introduction of a collective conditionality should be considered in the design of agri-environmental schemes for the 2013 CAP reform.

Keywords: agri-environmental contracts, public goods, threshold effects, experiments, behavior

1 Introduction

The growing consensus on the adverse effects of agricultural intensification on the environment has led to the introduction of pro-environmental measures in the Common Agricultural Policy (CAP). For example, the implementation by member states of agri-environmental schemes (AES) is mandatory since the Agenda 2000 CAP reform. AES in Europe are voluntary contracts signed with individual farmers, in which they commit to adopt or maintain agricultural practices which have a positive effect on the environment, in return for a compensatory payment. Evaluations of these programmes reveal that adoption rates remain relatively low and that environmental impacts are weak (Oréade Brèche, 2005; Barbut and Baschet, 2005; Cour des Comptes Européenne, 2011; Uthes and Matzdorf, 2013).

One of the explanations of these disappointing outcomes is to be found in environmental threshold effects: the production of environmental benefits does not always increase linearly with environmental efforts but rather presents discontinuities (Perrings and Pearce, 1994; Muradian, 2001). If the sum of pro-environmental efforts are not sufficient, the environment does not improve and money is spent without any tangible benefit (Dupraz *et al.*, 2007). For example, risks of eutrophication of water bodies are reduced only if the water concentration of phosphorus and nitrogen falls below a certain threshold. Efforts in terms of agricultural practices reducing fertilizer leakage must be provided at a sufficient level at the scale of the watershed to attain this threshold. Individual agri-environmental contracts as they are currently designed, cannot guarantee such results as there is no specific incentive to induce a minimum level of participation.

The collective dimension aiming at improving joint participation can be introduced in agri-environmental contracts in different ways. For example, contracts can be struck with farmers groups instead of individual farmers to handle agri-environmental issues. This is the case of Dutch environmental cooperatives (Francks, 2011) and is also the foundation of the GIEE (*Groupe d'intérêt économique et environnemental*) initiative launched by the French Ministry of agriculture for the future agricultural law. Another solution is to maintain individual agri-environmental contracts but to condition payments (or part of the payments) to the attainment of a predefined participation threshold. This threshold can be the enrollment of a minimum number of farmers or of a minimum surface of land. Are such "conditional" agri-environmental contracts more effective in reaching the environmental target than existing individual contracts and can they reduce public spending? This will depend very much on farmers' participation choices: even if the levels of monetary incentives provided by the two types of contracts are exactly equivalent, social preferences and psychological reasons such as reciprocity, imitation, and aversion to inequality also determine actions (Shogren and Taylor, 2008). These deviations from the rational choice theory, often called behavioral biases, may interact positively or negatively with the efficiency and effectiveness of policy instruments. Conditional incentives increase interactions between farmers' decisions and can therefore induce behavioural changes that can contribute to improve the effectiveness of agri-environmental schemes. In this paper, we draw an analogy between such contracts and incentive mechanisms to improve the voluntary contribution to threshold public goods (also called provision point public goods). We design a lab experiment to compare the effectiveness and the efficiency of two types of contracts subsidizing the provision of such public goods: contracts with individual payments paid proportionally to the voluntary contribution of each agent to the public good (unconditional subsidy) and contracts conditioning payments to individuals to the collective attainment of the public good threshold (conditional subsidy).

This paper is organized as follows. Section 2 analyses theoretical and empirical results on subsidy schemes with collective conditionality and discusses the main results of the existing experimental economics literature on the voluntary contribution to provision-point public goods. Section 3 describes the experimental design. Section 4 exposes the theoretical predictions and our conjectures. Section 5 analyses the experimental results and section 6 concludes, drawing recommendations on the design of agri-environmental schemes that could be promoted in the wake of the 2013 CAP reform.

2 Incentives with collective conditionality

These mechanisms include a collective conditionality to release incentive payments. Payments are made only if the overall participation to the scheme reaches a given level. However, participation decisions are taken at the individual level and payments are made at the individual level. In this section, we first describe existing agri-environmental contracts with collective conditionality (2.1). Next, we draw an analogy with provision-point public goods on which our experimental work is based (2.2) and we analyze the effect of subsidies on the production of a public good (2.3).

2.1 Agri-environmental contracts with collective conditionality

Dupraz et al (2007) study optimal agri-environmental contracts in a principal-agent setting in the presence of threshold environmental effects. One of their conclusions is that a collective conditionality used to trigger payments to farmers (*i.e.* a minimum threshold of contracted acreage) avoids welfare losses because subsidies are spent only when environmental results are obtained.

This approach has been implemented in various contexts. In the Ille-et-Vilaine Province, France, the local administration has promoted the use of grass strips along river banks to improve water quality. A first experience of individual AES-like contracts had led to a very scattered and ineffective adoption of this practice. Public authorities therefore imposed a minimum enrollment threshold of 60% of the targeted streams' riverbanks to initiate payments to farmers. A similar system is implemented in the State of Oregon, United States, in the framework of the Conservation Reserve Enhancement Program (CREP). This programme, aims at establishing riparian vegetation on agricultural land along streams to improve water quality and protect wildlife habitat. In the main measure, landowners who enroll agriculture riverbank land for a period of 10 to 15 years receive a base annual payment equivalent to the land rental value. In order to encourage the conservation of contiguous portions of the streams and improve the overall environmental impact of the measure, landowners are offered a Cumulative Impact Incentive Bonus (CIIB) equivalent to 4 years of annual rental rate if they (individually or collectively) enroll over 50% of the stream bank in a 5-mile segment (ODA, 2005).

The potential impact of a bonus with collective conditionality was also tested in a choice modeling carried out in the Languedoc Roussillon region, France on the reduction of herbicide use in vine growing (Kuhfuss *et al.*, to be published). In this choice experiment, farmers' Willingness To Receive (WTR) to reduce their herbicide use is elicited based on their choices among different hypothetical contracts. One of the contract attributes is an additional bonus provided at the end of the 5-year contract if 50% of the area of the targeted territory is ultimately enrolled. Interestingly, the analysis of farmers' choices demonstrated that farmers display a higher probability to enroll and have a lower WTR (lower than the individual payment minus the expected additional bonus) than when the bonus is not included in the contract design. This result seems to indicate a consistent preference for subsidy schemes that include a collective conditionality.

2.2 Analogy with provision-point public goods (PPM) and related literature

Individual choices regarding the environment can be modeled by voluntary contributions to a public good. Indeed, individuals adopting pro-environmental behavior generally bear private costs whereas the environmental improvement benefits everyone. The adoption of pro-environmental agricultural practices by farmers presents the same incentive structure. For example, limiting the use of chemical inputs often entails additional costs to farmers (*i.e.* mechanical weeding instead of herbicides) and often reduced yields. Positive changes produced thanks to these efforts, such as improvement of water and air quality, benefit everyone, including other farmers who maintain their intensive use of pesticide. Moreover, in most cases, agri-environmental payments only partially compensate the costs incurred by farmers when enrolling into the scheme. Although the European Regulation on Rural Development advocates that such agri-environmental payments cover all additional costs and revenue losses, several reasons exists why in fact farmers might be underpaid or overpaid: information asymmetries on true compliance costs, ignorance of administrative costs as well as learning costs and the specific design of AES, based on uniform payments and not tailored to each farmer's characteristics. A national survey (Michaud et al, 2013) conducted in France with enrolled and non-enrolled farmers indicates that insufficient payments are one of the major obstacles to their participation to territorialized agri-environmental measures and that their main motivation to enroll is their contribution to the environment.

In this paper, we therefore deliberately focus on agricultural practices that generate a positive welfare to enrolled and non-enrolled farmers when a given threshold of environmental effort is reached and for which payments are insufficient to cover all costs. This setting can be adequately captured by a public good game with a provision-point mechanism.

In public good experiments with threshold or provision point, that we will further call Provision Point Mechanisms (PPM) experiments, the principle is that the public good is produced only if a condition on minimum contributions is met. The introduction of a threshold changes significantly the theoretical prediction of the outcome of a linear public good experiment. Similarly to the Chicken game, the provision point generates the existence of a multiplicity of non-cooperative equilibria and participants need to coordinate to select one (Ledyard, 1995).

Results presented in Isaac et al. (1989) and confirmed in most experiments show that simply introducing a threshold can raise contributions compared to a standard Voluntary Contribution Mechanism (Suleiman and Rapoport, 1992; Dawes and Orbell, 1986; Rondeau *et al.*, 2005). However, the threshold is not attained in all cases. Many factors and mechanisms that could improve this outcome are therefore investigated in the literature.

In a meta-analysis on PPM, Croson and Marks (2000) develop the Step Return (SR) indicator, expressed as:

$$\text{SR}= \frac{\text{aggregate group payoff from the public good}}{\text{total contribution threshold}} = \frac{N\times\beta\times T}{T} = N\beta$$

With N the number of players, β the return rate to public good contribution and T the threshold. The SR can be interpreted as the ratio of an individual's value of the public good to his share of the cost. This criterion is particularly useful to compare results of various experiments as experimental conditions vary greatly from one experiment to another. The SR varies from 1.2 to 9.53 across the results considered in the meta-analysis. A regression on the rate of successful provision across experiments confirms the significant positive influence of the SR level. Another reason advanced for the failure to reach the threshold in PPM experiments is the risk for subjects to waste their contribution if the public good is not ultimately produced. Various authors have therefore tested a Money Back Guarantee. In this system, if the threshold is not reached, contributors get a full refund. Most authors have demonstrated the positive effect of this system on the level of contribution (Rapoport and Eshed-Levy, 1989; Isaac *et al.*, 1989; Cadsby and Maynes, 1999).

In addition, participants in a PPM experiment face the risk that if contributions exceed the threshold, and if the public good stays constant beyond the threshold, part of their investment may be lost. To address this issue, various rebate rules have been tested to deal with excess contributions. Marks and Croson (1998) test two rebate rules: proportional rebate policy where excess contributions are rebated proportionally to an individual’s contribution, and a utilization rebate policy where excess contributions provide some continuous public good. Interestingly, the second system is the only one that has a significant positive effect on average contributions.

2.3 The effect of subsidies on public good production

The social dilemma in public good games has raised questions about the potential role of public interventions to reach a Pareto optimum. Warr (1982) demonstrated that when voluntary contributions are all strictly positive, implementing a tax mechanism to finance public good with public money has neutral results on the production of the public good. Contributors who pay taxes raised for this purpose are not subject to budget illusion and therefore reduce exactly by a dollar-for-a-dollar their contributions to the public good.

Andreoni and Bergstrom (1996) challenge this result and propose a mechanism that allows an increase of the equilibrium supply of a public good, even in the absence of budget illusion: taxes are used to provide subsidies to contributors rather instead of financing directly the production of the public good. In their model, in order to neutralize government taxes used to fund this subsidy scheme, contributors need information about the level of others' contributions, which they rarely have. This result seems to confirm the potential positive incentive that can be played by agri-environmental payments to increase the adoption of pro-environmental practices. However, the effect of subsidies on threshold public goods has not been previously studied. The experiment we propose in the next section will therefore bring a novel contribution in this area of research.

3 Experimental design

The proposed experimental design has been elaborated with the objective to determine the effect of an incentive mechanism with collective conditionality in the context of agri-environmental schemes. Many choices in the protocol have therefore been made in view of mimicking the conditions under which farmers are offered the choice to adopt or not an agricultural practice that contributes to the production of an environmental public good such as water quality or biodiversity. We first describe the three treatments in our experiment (3.1) and then detail the protocol (3.2).

3.1 Treatments

In our experiment, three treatments are tested: the classical provision point mechanism (PPM) which is our baseline; the unconditional subsidy scheme (US); and the conditional subsidy scheme (CS). In our applied context (table 1), the PPM represents the situation without AES, the US represents the actual AES in which farmers receive individually a subsidy for each hectare they enroll and the CS represents the subsidy scheme that we want to test, a subsidy by ha enrolled that is paid to each enrolled farmer provided that the sum of agricultural land enrolled exceeds a given threshold.

Context	**Transposition in the laboratory**
Environmental public good such as water quality	Threshold public good
Farmers	Participants in the experiment (students)
Cost related to the adoption of pro-environmental agricultural practices	Contribution to the public good : number of tokens placed in the public account

AES payment paid to each farmer per ha enrolled	Subsidy proportional to individual contribution : unconditional subsidy scheme (US)
"Conditional incentive mechanism" : AES payment paid to each farmer per ha enrolled provided the sum of ha enrolled by all farmers is greater than a given level in the targeted zone .	Subsidy proportional to the contribution triggered if a threshold of collective contribution is attained : conditional subsidy scheme (CS)

Table 1: AES context and transposition in the laboratory

The PPM treatment is very similar to the one used by Bchir and Willinger (2009). Subjects start each period with an initial endowment E (E=20 tokens) and are assigned to a group of N subjects (N=4). In each period, subject i is requested to allocate his tokens between a private account and the common account of the group. The amount placed by the subject i in the common account is noted C_i. At the end of each round, tokens placed in the private account have a private return α_i (in our experiment $\alpha_i = 1 \; \forall i \in \{1 \ldots N\}$). If the total amount of tokens placed in the common account ($\sum_{i=1}^{N} C_i$) is above the threshold T for the provision of the public good, each subject of the group receives the benefits of the common account $\beta \sum_{i=1}^{N} C_i$ (with 1/N<β<1). In this experiment, we consider that the public good keeps increasing beyond the provision point which is similar to the public good production function in Isaac et al. (1989). This methodological choice is motivated by the AES context in which additional environmental efforts beyond the threshold improve the environment further.

Therefore in the PPM, if $\sum_{i=1}^{N} C_i < T$ the payoff of subject i is:

$$G_i(C_i, C_j) = E - C_i$$

If $\sum_{i=1}^{N} C_i \geq T$ the payoff of subject i is:

$$G_i(C_i, C_j) = E - C_i + \beta \sum_{i=1}^{N} C_i = E + (\beta - 1)\, C_i + \beta \sum_{j \neq i} C_j$$

The US is similar to the PPM except that when subjects contribute C_i, they receive an individual subsidy that is a proportion γ (0< γ<1) of their individual contribution. In order to ensure that the benefits generated by 1 token placed in the public account are superior to the costs of the subsidy for the regulator, γ should also be inferior to Nβ.

Therefore, if $\sum_{i=1}^{N} C_i < T$ the payoff of subject i is:

$$G_i(C_i, C_j) = E - C_i + \gamma C_i = E - (1 - \gamma) C_i$$

If $\sum_{i=1}^{N} C_i \geq T$, the payoff of subject i is:

$$G_i(C_i, C_j) = E - C_i + \gamma C_i + \beta \sum_{i=1}^{N} C_i = E + (\beta + \gamma - 1)\, C_i + \beta \sum_{j \neq i} C_j$$

with $\beta + \gamma < 1$.

Finally, in the CS, the individual subsidy remains proportional to the contribution but is paid only if aggregate contributions reach the threshold.

Therefore, if $\sum_{i=1}^{N} C_i < T$ the payoff of subject i is the same as in the PPM treatment:

$$G_i(C_i, C_j) = E - C_i$$

If $\sum_{i=1}^{N} C_i \geq T$, the payoff of subject i is the same as in the US treatment:

$$G_i(C_i, C_j) = E - C_i + \gamma C_i + \beta \sum_{i=1}^{N} C_i = E + (\beta + \gamma - 1)\, C_i + \beta \sum_{j \neq i} C_j$$

In the three treatments, the threshold T is set at an intermediate level of 40 tokens that represents 50% of the endowment since N = 4 and E = 20. The value of β is set at 0.3, a relatively low level. The SR is therefore at 1.2 in the baseline treatment, which is among the lowest levels listed by Croson and Marks (2000). This parameter choice is made in view of reflecting a relatively low perception by farmers of benefits brought by environment-friendly agricultural practices, such as water quality. The subsidy rate γ is set at 0.3, the same level as β. This relatively modest subsidy level, as compared to subsidy rates in AES, is chosen to make sure that allocating money to the public account is not too attractive. The mechanism therefore hopefully generates a diversity of behavior and leaves space for the effect of the allocation mechanism (US or CS).

Group earnings as a function of aggregate contributions in the three mechanisms are represented in Figure 1.

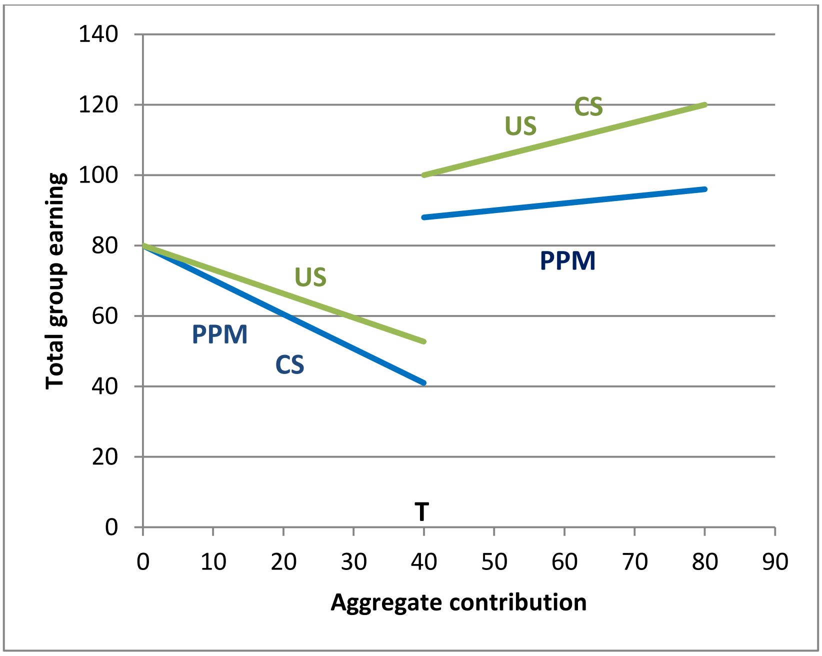

Figure 1: Total earning of groups as a function of aggregate contribution

These schemes differ from other mechanisms tested in PPM experiments, although they present similarities. The US is equivalent to a partial money back guarantee but only when the threshold of contributions is not reached. The US and CS could also be considered as forms of rebate rules however subjects do not receive a proportion of their excess contributions beyond the threshold, as in rebates, but rather a proportion of their whole contribution to the public good.

3.2 Protocol

This experiment is run in a "between-within" setting in order to determine the effect of each treatment and also to investigate the impact of the transition from one treatment to another. Nevertheless not all possible treatment combinations were tested. The treatment sequence and the number of groups that participated in each sequence are presented in Table 2.

	Sequence 1	**Sequence 2**	**Number of subjects**	**Number of groups**
Session A	PPM	US	40	10
Session B	PPM	CS	40	10
Session C	US	CS	28	7
Session D	CS	US	32	8

Table 2: Treatments tested in each session of the experiment

During each session, participants are told that there will be 2 sequences in the experiment. However, in order to avoid wealth effects, participants are informed that only one sequence will be randomly chosen at the end of the experiment in order to determine their final earning and payment. Earnings in the game are expressed in points. At the end of the game, the accumulated sum of points is converted at a pre-announced exchange rate of one point equals 0.06 €. The experiment lasted a maximum of 2 hours and the average earning was 16.21 € with a standard deviation of 3.13€. Subjects received an addition show-up fee of 2€ if they were students in the university site where the experiment was carried out and of 6€ otherwise.

At the beginning of the experiment, subjects are randomly affected to a group of 4 subjects, which remains the same during the two sequences. This "partner" (Andreoni, 1988) setting is preferred because it represents more faithfully the decision environment of farmers in stable interaction with their neighbors. During each sequence, the PPM, US or CS treatments are played repeatedly for 10 periods. The experiment is conducted in a complete information setting as defined by Bagnoli and Lipman (1989): the number of participants, the level of the provision point, the vector of endowments, and the vector of valuations for the public good. In addition, each subject receives at the end of each period a feedback on the aggregate contribution of their group and on his individual payoff.

Subjects were invited through the recruitment software for experimental economics ORSEE (Greiner, 2004). Experiments were conducted between June 21st and November 5th, 2013. 92% of the subjects were students from the University of Montpellier with only 14% studying Economy. 28% had already participated in an economic experiment but we made sure that none had participated in a public good experiment before. We did not pay any particular attention to gender in the recruitment; 53% of the subjects were women.

We hypothesized that risk aversion and beliefs about others' contributions influence the effect of the different treatments. We therefore elicited these two characteristics. Risk aversion was elicited through a simple series of lotteries implemented at the beginning of the experiment that provided information on subjects' sensitivity to exogenous risk. In 10 different games, subjects were requested to choose between a safe option with a gain of 20.5 points (lottery A) and an uncertain option in which they had a probability to earn 40 points and a probability to earn 1 point (lottery B). In game 1, the probability to earn 40 units was 10% and this probability increased by 10% in each following game. Subjects' aversion to risk was characterized by their "switching point", *i.e.* the first game for which they chose the uncertain option. To determine subjects' earning, one of the games was randomly chosen and then the outcome of the game was determined using a random system. Subjects were informed that they would know their earnings only at the end of the experiment. We also considered that understanding beliefs is important to interpret behaviour. However, the elicitation of beliefs with financial incentives can interact with contribution decisions in public good experiment (Gächter and Renner, 2010). We therefore used a protocol similar to Fischbacher and Gächter (2010) that limits this bias. At each period, before subjects announced their contribution to the public good, they were asked to give their estimation of the contribution of the 3 other members of their group. If their estimation was accurate, they earned 5 points; if it was 1 token away from the actual contribution of others, they earned 4 points; if it was 2 tokens away, they earned 3 points; if it was more than 2 tokens away, they had no earning.

4 Theoretical predictions and conjectures

4.1 Game theory predictions

In the PPM game when β>1/N, there is a multiplicity of equilibria: all the combinations of contributions such as $\sum_{i=1}^{N} C_i = T$; and the strong free-riding equilibrium $C_i = 0, \forall i$.

The level of asymmetry between contributions in the group is however bounded. In fact, if subject i considers that others contribute a total of contribution T-C. He will have an interest to contribute C, if the payoff that he gets is his maximum payoff. The maximum payoff a player can get if the threshold is not reached is E. If he contributes C, he will be better-off than if he contributes nothing in situations where:

$E < E - C + \beta \sum_{i=1}^{N} C_i$ which is equal to $E - C + \beta T$ if he contributes exactly C.

This means that $C < \beta T = 12$ with the parameters of the PPM chosen in our experiment. There are 165 equilibria[1] that respect this conditionality, among which none tolerates a free-riding behavior by one of the subjects.

These equilibria Pareto-dominate the strong free riding equilibrium but cannot be Pareto-ranked. The Pareto optimum of our version of the PPM would be that all players contribute

[1] For contributions allowing only integer numbers

their full endowment to the public good. Therefore our PPM game still represents a social dilemma.

Theoretical predictions for the US and the CS treatments are the same as for PPM if the level of subsidy γ is inferior to (1-β), i.e. a multiplicity of equilibria for which $\sum_{i=1}^{N} C_i = T$ and a strong free riding equilibrium. There are however a higher number of equilibria. In fact, if subject i considers that others contribute T-C in total, he will contribute C if the payoff that he gets is his maximum payoff among the options he has. The maximum payoff he can get, if the threshold is not reached, is E. He will therefore be better off if he contributes nothing than if he contributes exactly C if:

$E < E + (1-\gamma)C + \beta \sum_{i=1}^{N} C_i$ which is equal to $E + (1-\gamma)C + \beta T$ if he contributes exactly C *i.e.* if $C < \frac{\beta T}{1-\gamma} = 17$ with the parameters chosen in this experiment. There are 3551 equilibria that respect this condition. Interestingly, 312 equilibria tolerate a contribution of 0 by one of the participants.

In US and CS treatments too, there is no equilibrium in which all subjects would contribute their full endowment. In fact, when the threshold is reached, we can consider that additional contributions are made in the framework of a classical voluntary contribution mechanism. There is therefore an incentive to free ride and to stick to the level of the threshold.

4.2 Strategic behavior and behavioral biases

Standard game-theoretic predictions are identical for the two incentive mechanisms. The explanation of potential differences of subjects' behavior when confronted to these treatments therefore requires the mobilization of other theories. It is shown that behavioral biases or behavioral failures (Shogren and Taylor, 2008) explain many of the deviations from game-theoretic predictions of voluntary contributions in public good games. We review in turn the role of assurance problem and reciprocity behavior in predictions concerning contributions in PPM.

The assurance problem: since the PPM is a coordination game, there is scope for the assurance problem as described by Sen (1967) and Runge (1984). Each player has a strategic uncertainty on the contributions of the other group members. Below a certain value of beliefs about others' contributions, there is no interest to contribute to the public good because the probability that the threshold will be reached is too low. When this value is reached, it is optimal to contribute to reach the threshold. However, when beliefs about average contributions of others increase, this model predicts that optimal contribution should decrease, considering that the public good will be produced by others and it is possible to free-ride on others. The assurance problem can be worsened by fear of getting the sucker's payoff, *i.e.* getting a low payoff while making an effort (Ahn et al, 2001; Bougherara et al, 2009). Beliefs and risk aversion may therefore affect cooperation by reducing the individual subjective probability that others' will contribute at a sufficient level. Runge (1984) argues that the purpose of political and economic institutions, dealing with public goods, is the coordination of these expectations. Institutions should therefore provide assurance regarding the behavior of others, and thereby help to mitigate the assurance problem. A subsidy scheme can help to increase confidence that the threshold will be met. Our expectation is that both subsidy schemes can raise peoples' beliefs about others' contribution and therefore facilitates coordination, despite the fact that there are more equilibria than in the classical PPM. Similar to the positive effect of a money back guarantee on the production of threshold public goods (Rapoport and Eshed-Levy, 1989; Isaac *et al.*, 1989; Cadsby and Maynes, 1999) the unconditional subsidy mechanism guarantees a partial subsidy (that could be considered as a partial refund) to subjects even if the threshold of the public good is not reached. This mechanism therefore reduces cooperators' losses when the threshold is not attained and alleviates the suckers' payoff. The conditional subsidy scheme, by making the reward conditional on the attainment of the threshold, can contribute further to strengthen beliefs that other players will provide a sufficient contribution to trigger the subsidy.

Reciprocity: Fehr and Gächter (2000) consider that reciprocity means that in response to friendly action, people are frequently much nicer and much more cooperative than predicted by the self-interest model "even if it yields neither present nor future rewards". The same type of behavior occurs in response to unfriendly action, with the presence of "positive reciprocity" and "negative reciprocity". This attitude is considered different from kind actions in repeated interactions that are motivated by future material gains. It is also different from altruism that is considered a form of unconditional kindness. This notion of reciprocity is however very close to the notion of fairness. Fehr and Gächter (2000) insist on the fact that institutional environments, such as subsidy schemes, determine whether the reciprocal or the selfish types of subjects are pivotal. Considering that opting for AES is not always the most profitable option for a farmer, it is therefore fundamental to take into account the potential impact of reciprocity in the design of agro-environmental contracts. The result of Kuhfuss et al. (To be published), that farmers' WTR in the form of individual subsidies would be lower if proposed a bonus with collective conditionality, can be interpreted by the tendency of farmers to value the fact that environmental efforts are shared by all (or at least by a minimum number of people). In other words, they are willing to make more efforts for the same reward if they are not alone to make such effort. The positive effect of the conditional subsidy on contributions could be reinforced if this type of behavior prevails.

4.3 Conjectures

Based on this literature review, we make conjectures about the possible effects of the US and the CS. We focus on relative effectiveness and efficiency of subsidy schemes as compared to the classical PPM. We understand by effectiveness, the effect of the introduction of this incentive on the production of the threshold public good (Conjectures 1 and 2). The efficiency is characterized by the cost effectiveness of public funds used in the form of subsidies[2] to produce the public good (Conjecture 3). In our experiment, the welfare (W) is measured by the difference between the sum of individual payoffs (excluding payoffs from belief and risk elicitation) and the sum of costs for the regulator.

[2] We consider here that the transaction costs linked to subsidy implementation are null.

W = ∑ payoffs of the 4 members of the group - ∑ costs for the regulator

= ∑ benefits of private accounts + ∑ benefits of the common account + ∑ subsidies - ∑ subsidies

= ∑ benefits of private accounts + ∑ benefits of the common account

Conjecture 1*: Treatments with subsidy (US and CS) lead to a more frequent attainment of the threshold and to higher contributions than the PPM treatment because of a higher step return.*

The SR in the PPM treatment of our experiment equals 1.2, while the SR in the subsidy treatments (US and CS) equals 1.5. Considering that the SR is a good predictor for successful provision in PPM experiments (Croson and Marks, 2000; Cadsby *et al.*, 2007), we expect that this will lead to a more frequent successful provision of the public good and higher contributions.

Conjecture 2*: With the conditional subsidy (CS), contributions are higher and the public good is more frequently produced than with the unconditional subsidy (US*

In the US treatment, we may expect that unconditional subsidies encourage contributions even if there is a risk that the threshold is not reached since subjects know that they will receive at least the subsidy (partial money back guaranteed or insurance effect). In the CS treatment, the fact that the subsidy is conditional may have two opposed impacts. On the one hand, the conditionality increases the risk of contributing, leading most pessimist or risk averse subjects to not contribute at all. On the other hand, the conditionality increases the incentive to reach the threshold which may also lead to higher contributions and to a higher frequency of success. Therefore, we expect a higher variability between groups in the CS treatment. We however hypothesize that positive factors prevail on negative ones, leading to higher effectiveness of the CS treatment.

Conjecture 3*: CS has a better efficiency than US which has a better efficiency than PPM.*

Given conjecture 1 and conjecture 2 and since subsidies are spent by the regulator only if the public good is produced in CS, CS should be more efficient than US. Besides, we conjecture that US and CS have a higher efficiency than PPM: the value of public good produced under subsidy schemes exceeds the cost of subsidies.

Finally, we propose two conjectures for the analysis of data at the individual level. Conjecture 4 relies on beliefs about others' contributions. Conjecture 5 is about the impact of subject risk aversion across treatments.

Conjecture 4*: Subsidy schemes have a positive impact on beliefs about others' contributions, particularly in the first period.*

Beliefs about others' contributions are an important key to understand subjects' decision process. We hypothesized that beliefs are strongly influenced by subsidy mechanisms in the first period but are subsequently largely conditioned by the experience of cooperation in the previous period.

Conjecture 5*: The negative impact of risk aversion on contributions is less pronounced in the US treatment compared to PPM and CS.*

We anticipate that risk aversion impact is more pronounced in CS and PPM than in US, due to the assurance effect played by the unconditional subsidy. Said differently, we expect that risk averse subjects contribute more in the US treatment than in the other two treatments.

5 Experimental results

We first present experimental results at the group level, distinguishing the effectiveness of subsidy schemes based on group contributions (5.1) and their efficiency analyzing the welfare (5.2). Next, we investigate individual behavior (5.3) through individual data on contributions: we focus on subjects' beliefs about the contribution of the other group members and subjects' risk aversions.

5.1 Effectiveness of subsidy schemes

We first carry out a between-session analysis of the first sequence of all sessions. This type of data is privileged because it is not influenced by a potential order effect, i.e. the influence of a previous treatment on results.

Our first indicator of effectiveness is the impact of treatments on the attainment of the threshold of the public good. As expected in conjecture 1, the public good threshold is reached significantly more often in the treatments with subsidies than in the PPM treatment without subsidy according to the Khi square test (3).

Treatment	Number of groups	Frequency of success	Frequency of failure	Pairwise Khi2 test	
				PPM	US
PPM	20	38%	62%		
US	7	63%	37%	***	
CS	8	59%	41%	***	NS

Table 3: Frequency of success and failure of production of the public good of the different treatments tested (***significant at α=1%, NS: not significant)

Descriptive statistics on group contributions (Table 4) and the graphical representation of average group contributions during the first 10 periods of all sessions (Figure 2) show a rather clear difference between the subsidy treatments and the PPM but it is not confirmed by the Mann-Whitney test. Figure 2 also shows the decay of contributions, classically observed in public good experiment. Figure 3 shows group contributions for the various treatments throughout periods.

Treatment	Number of groups	Average	Standard deviation	Minimum	Maximum
PPM	20	27.8	20.3	0	66
US	7	41.8	23.6	0	73
CS	8	38.0	28.0	0	80
Total	35	32.9	23.7	0	80

Table 4: Descriptive statistics of group contributions

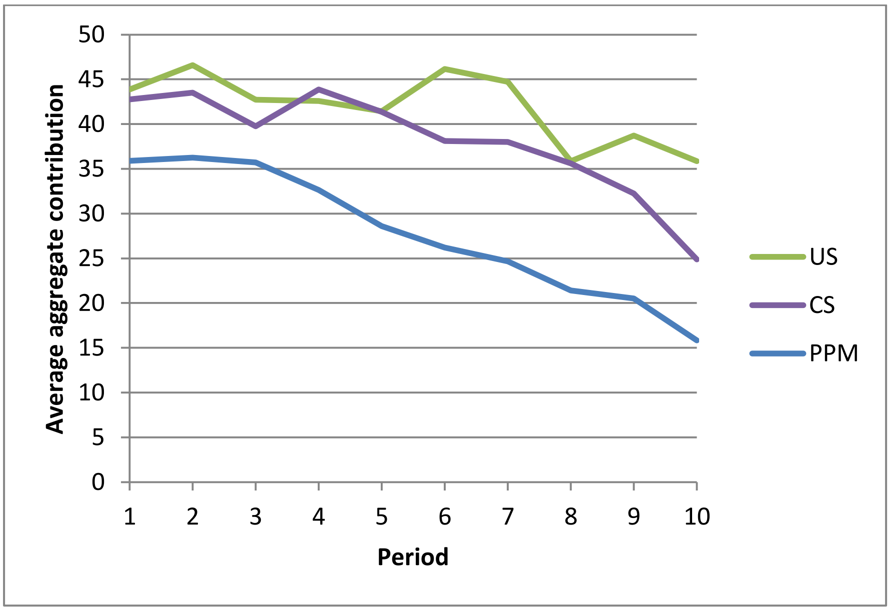

Figure 2: Average aggregate group contributions by period for the three treatments

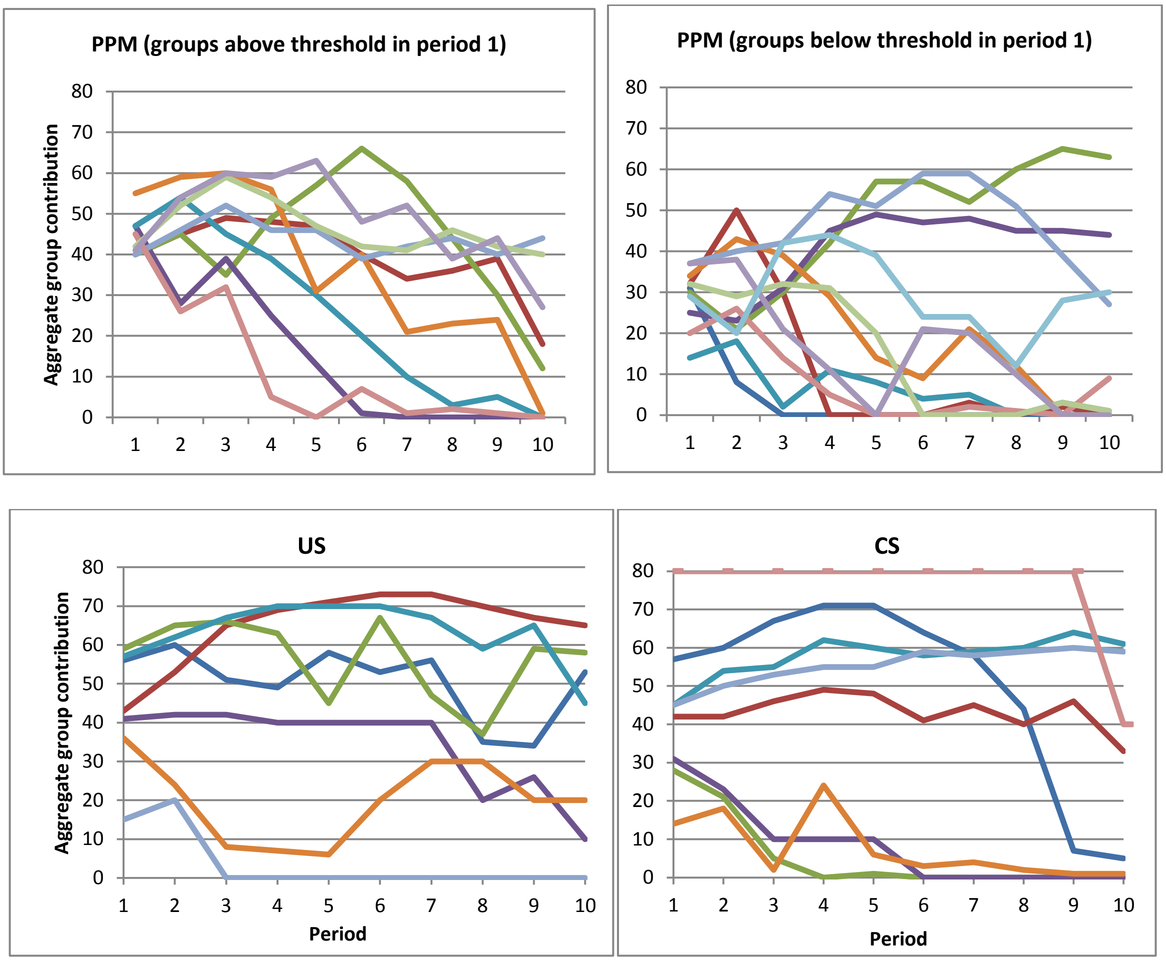

Figure 3: Aggregate group contributions for the different treatments (1 group=1 data serie). For the PPM treatment, two graphs are represented: 1 for groups that contributed more than 40 tokens in the first period and one for groups that contributed less than 40 tokens in the first period.

The graphical analysis of Figure 3 shows intra-treatment heterogeneity of results, responsible for the lack of significance of differences on aggregate contributions. This variability is however of a different nature depending on the treatment.

With the PPM, there is a high intra-group variability with generally more unstable contributions. Aggregate contribution are represented in two different graphs in Figure 3 in order to better highlight this heterogeneity: 1 graph with the groups that contributed more than 40 tokens in the first period and 1 other with the ones that contributed less than 40 tokens in the first period..

In treatments with subsidy (US and CS), intra-group variability is rather low while inter-group variability is high. For the CS, two types of groups clearly emerge: groups that manage to coordinate over the threshold and groups that don't. Put in a simple way, the graphs seem to indicate that if a group manages to coordinate in the first period, its aggregate group contribution remains over the threshold for most of the sequence, until end-game effects start appearing. However, if the group does not manage to coordinate at the threshold in the first period, its contributions rapidly converge at the strong free riding equilibrium. The US presents similar characteristics. However groups that do not coordinate above the threshold do not coordinate as rapidly towards the strong free riding equilibrium. Intermediate levels below the threshold are maintained, probably because losses are limited when the threshold is not reached thanks to the unconditional subsidy mechanism.

The importance of the success of production of the public good in the first period as well as the relatively larger importance of this with the CS as compared to the PPM is confirmed using a panel regression on group contributions (Table 5).

Term	**Estimate**	**Std Error**	**p-value**
Intercept	17.97	8.74	0.04
PPM (ref CS)	16.14	9.74	0.10
US (ref CS)	5.06	13.66	0.37
Period	-2.13	0.23	**0.00**
Success 1st period	51.62	10.93	**0.00**
Success 1st period x PPM	-39.39	12.83	**0.00**
Success 1st period x US	-7.74	16.61	0.64

R^2=0.53. Observations: 315. Prob>Chi2(Wald)=0.000

Table 5: Panel regression with random effects on group contributions to the common account (period 2 to 10)

With subsidy mechanisms, the stability of group contributions above the threshold can probably be explained by the fact that subsidies are a form of individual incentive to keep contributing to the public good. This therefore reduces the incentive to reduce the contribution when the threshold is attained in order to free ride on others, behavior that often leads to cooperation breach.

Compared to theoretical predictions, the strong free riding equilibrium is observed in groups' decisions. However the other set of Nash equilibria at the level of the threshold does not seem to be a good prediction of aggregate subjects' behavior. Indeed, in most cases, groups that manage to coordinate above the threshold at the beginning tend to reach aggregate contributions that remain higher than the threshold throughout the periods.

The results of the within-analysis provide additional insights to differentiate between treatment effects (Table 6).They compare average group contributions as well as rate of success and failure in reaching the threshold.

Session	Sequence	Treatment	Number of groups	Average group contribution	Wilcoxon paired test	Success	Failure	Khi2 test
A	1	PPM	10	26.0	***	33%	67%	***
	2	US	10	41.1		69%	31%	
B	1	PPM	10	29.6	***	42%	58%	***
	2	CS	10	53.7		86%	14%	
C	1	US	7	42.0	NS	63%	37%	NS
	2	CS	7	47.2		75%	25%	
D	1	CS	8	38.0	NS	59%	41%	NS
	2	US	8	44.0		67%	33%	

Table 6: Summary of session by session comparison of treatments using Khi2 and Wilcoxon paired test (**: significant at α=5%***significant at α=1%, NS: not significant)

Results of sessions A and B show that the introduction of a subsidy increases significantly public good provision. The introduction of a subsidy in sequence 2 when there was none in sequence 1 creates a strong incentive to coordinate.

Numerical differences are observed in sessions C and D between US and CS but they are not significant. Conjecture 2 is therefore not confirmed when US and CS treatments are mobilized successively. In other words, in a within setting, CS treatment is as effective as US treatment.

We also carried out a between-session analysis in order to compare the effect of the introduction of the subsidy schemes after a PPM (analysis of sequence 2 of sessions A and B). Group contributions and success rates of the two PPM sequences are not significantly different; we could therefore directly compare US (session A) and CS (session B) (Table 7).

Term	**Estimate**	**Std Error**	**p-value**
Intercept	76.5	5.4	**0.000**
PPM (Ref: CS)	-40.1	3.3	**0.000**
US (Ref: CS)	-9.3	2.9	**0.001**
Period	-1.6	0.3	**0.000**

R^2=0.25. Obs=400. Prob>Chi2(Wald)=0.00

Table 7: Panel regression with random effects on group contributions to the common account with data of session A and B

The results suggest that group contributions are significantly higher when a conditional subsidy is introduced after a PPM than when an unconditional subsidy is introduced. The frequency of success is also significantly superior with the CS treatment (Table 8).

Treatment	**Frequency of success**	**Frequency of failure**	**Pairwise Khi2 test with US**
US	69%	31%	
CS	86%	14%	***

Table 8: Frequency of success and failure of production of the public good of the different treatments tested data of session A and B (***significant at α=1%)

This strong result confirms conjecture 2 and is a strong argument in favour of the use of conditional subsidies.

In summary, these results partially confirm our first two conjectures. Both subsidy schemes do facilitate the attainment of the threshold of public good production but with an important heterogeneity among groups. When the conditional and the unconditional subsidy systems are mobilized successively, the conditional one is as effective as the unconditional one. However, the conditional subsidy has a better effectiveness than the unconditional subsidy when introduced after a sequence without subsidy. These results that cannot be predicted using the standard game theory are further explored in section 5.3

5.2 Efficiency of subsidy schemes

The welfare generated by our three treatments is compared using the between-analysis provided in Table 9.

Treatment	Number of groups	Average welfare	Mann Whitney test PPM	Mann Whitney test US
PPM	20	74.3		
US	7	81.5	**	
CS	8	83.7	**	NS

Table 9: Comparison of average welfare between treatments using the Wilcoxon Mann-Whitney test. (**significant at α=5%, *significant at α=10%, NS: not significant).

In this experiment, both subsidy schemes generate welfare improvement as compared to the classical PPM experiment, which is a significant result in the debate on the usefulness of subsidy schemes. The welfare difference between US and CS is however not significant. These results are confirmed if we undertake a panel regression on group welfare (Table 10).

Term	Estimate	Std Error	p-value
Intercept	82.11	3.32	**0.00**
PPM (Ref: CS)	-9.34	3.58	**0.01**
US (Ref: CS)	-2.17	4.42	0.62
Period	0.29	0.25	0.24

Adj. R^2=0.08. Observations: 350. Prob>Chi2(Wald)=0.02

Table 10: Random effect panel regression on group welfare

Finally, to investigate further the comparison between the two subsidy treatments and the validity of conjecture 3, we use a cost efficiency indicator: the average public good produced by groups in a period, divided by the average subsidy received. For the CS, this rate amounts mathematically to 4 while this rate can deviate from 4 in the US if subsidies are disbursed without production of public good. Results presented in Table 11 show the greater efficiency of the CS as compared to the US. No statistical analysis can however be produced as we have only one value per treatment.

Treatment	Average group public good produced	Average group subsidy	Efficiency (units of PG/Subsidy)
US	43.4	12.6	3.5
CS	41.7	10.4	4.0

Table 11: Comparison of subsidy efficiency between US and CS

5.3 Analysis of individual behavior

Deviations from the predictions of the standard game theory are confirmed with the analysis of group results. With the analysis of individual behavior, we therefore explore individual behavioral mechanisms that may explain these results.

We describe the diversity of individual decisions observed in our experiment using individual data from the first sequence (Table 12).

Treatment	Number of subjects	Average individual contribution	Standard deviation
PPM	80	6.94	6.72
US	28	10.46	7.58
CS	32	9.50	7.90

Table 12: Statistics on individual contributions

Figure 4 represents graphically the diversity of contribution decisions taken by the 100 subjects during the 10 periods of sequence 1 and their frequency.

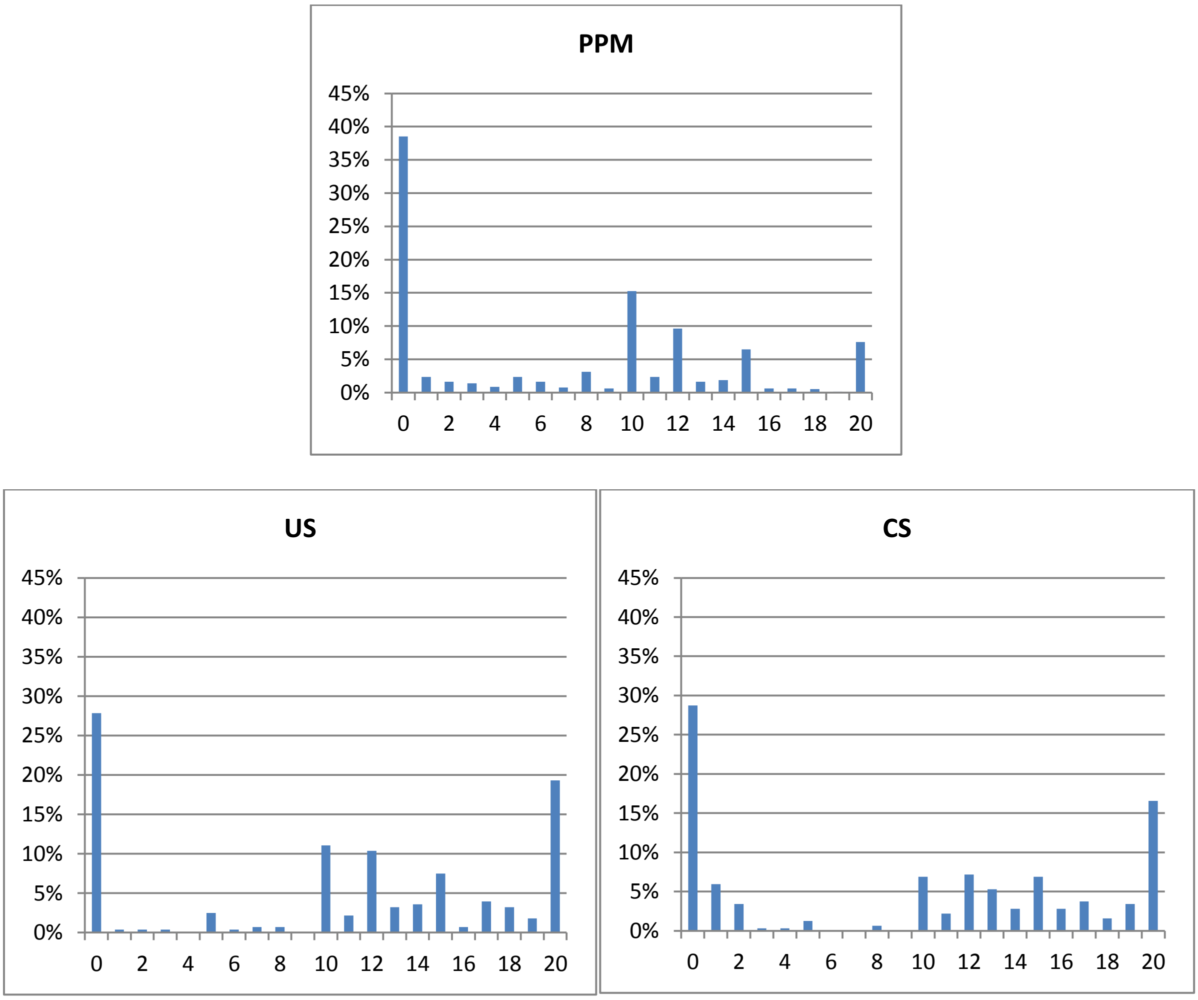

Figure 4: Frequency of contribution decisions (for all possible contribution levels) treatment by treatment.

Not contributing at all to the public good is by far the most frequent contribution decision taken by subjects. This confirms the importance of the strong free riding equilibrium whatever the treatment. On the other hand, the positive contributions are mostly found above 10 with another peak at 20 whereas contributions below 10 remain rare. The difference between the PPM and the subsidy treatments essentially lies in the frequency of contributions above 10, which is much higher in US and CS treatments (49% for the PPM, 67% for the US and 59% for the CS). It is surprising that we do not observe a much higher frequency at 10. Indeed, contributing 10 (half of each dotation) seems *a priori* the easiest and the fairest decision to coordinate with the other members of the group for a threshold level of 40. Therefore group contributions frequently go much beyond the level of the threshold and remain so for several periods (Figure 3).

In order to verify conjecture 4, we investigate the effect of beliefs about others' contribution on subjects' behavior and analyze the process of beliefs formation. First, we undertake a panel regression, in which belief is used as an exogenous variable (Table 13).

Term	Estimate	Std Error	p-value
Intercept	3.94	1.08	**0.00**
PPM	-1.26	0.94	0.18
US	0.59	1.31	0.65
Belief	0.22	0.01	**0.00**
Period	-0.20	0.53	**0.00**

R^2=0.55. Observations: 1400. Prob>Chi2(Wald)=0.00

Table 13: Panel regression with random effects on individual contributions to the common account (Reference is the CS for the treatment effects, errors are clustered at the group level).

Consistent with other research results (eg. Croson, 2007; Fischbacher et al., 2001), beliefs on others' contribution come out as a very significant variable to explain individual contribution decisions. On average, when a subject believes that the three other members of his group will contribute one more unit, he increases his contribution by 0.22 units. This result is consistent with the conclusion that many people are "imperfect conditional cooperators" (Fischbacher and Gächter, 2010). Indeed, perfect reciprocity would entail that subjects would increase their contributions by 0.33 units in our experiment setting.

Runge (1984) insists on the role of policies and institutions to improve coordination through their impact on expectations. We therefore investigate the impact of the various treatments we have tested on beliefs about others' contribution. However, according to a panel regression on beliefs, treatments do not have a significant impact.[3]

Figure 3 shows that the first period has a fundamental role, especially for the subsidy treatments, on subsequent subjects' coordination. We therefore analyze the impact of treatments on beliefs in the first period (Table 14).

Treatment	Number of subjects	Average belief	Standard Deviation	PPM	US
PPM	80	29.6	16.3		
US	28	32.6	11.3	NS	
CS	32	34.3	14.8	*	NS

Table 14: Comparison of beliefs about others' contribution between treatments in the first period using the t- test (NS: not significant; *significant at 10%)

This analysis confirms conjecture 4 that there are significant differences of beliefs between treatments (Mann-Whitney U test) in the first period of the experiment. Subjects believe that contributions will be higher in the CS treatment than in the PPM treatment. The positive impact of the CS on contributions to the public good therefore starts by a positive impact on beliefs in the first period of the experiment. Variability of beliefs between subjects within treatment is however high especially for the PPM and CS treatment. This variability is probably one of the important sources of contribution difference among groups in the first period. We can conclude at this point that treatments influence belief mainly in the first period.

[3] A table result of the panel regression is available upon request.

To test the second part of conjecture 4 that beliefs are strongly influenced by subjects' experience of cooperation in the previous period, we carry out a panel analysis on beliefs in which we introduce the lagged contribution of others (one period-lag) (Table 15).

Term	Estimate	Std Error	Z	p-value
Intercept	4.78	1.91	2.50	**0.01**
PPM	1.05	1.39	0.76	0.44
US	-0.06	2.09	0.09	0.98
Contribution of others in P-1	0.93	0.03	30.83	**0.00**
Period	-0.30	0.18	-1.70	**0.09**

R^2=0.76. Observations: 1260.

Table 15: Panel regression with random effects on beliefs about others' contributions to the common account (Reference is the CS for the treatment effects, period 1 excluded).

After the first period, many subjects seem to follow a strategy close to the tit-for-tat strategy, *i.e.* their contribution is directly determined by results of the previous group interaction.

This analysis is consistent with the results of group contributions with subsidy treatments described in section 5.1. Groups that manage to coordinate in the first period generally maintain cooperation over the sequence, except sometimes at the end, while groups that do not manage to coordinate rapidly converge to the free riding equilibrium. In order to better predict the effects of subsidy mechanisms, it is therefore important to understand factors that may influence beliefs and behavior in the first period. Subsidies seem to have a positive effect on beliefs in the first period but with an important variability. We therefore examine the role of risk aversion.

Subjects' aversion to risk was summarized in an indicator which is the rank of the switching point[4] (see section 3.2). The risk aversion indicator is spread from 1 to 11 with an average of 6.84 and a standard deviation of 1.91.

In a panel regression on individual contribution, the risk-aversion variable does not come out as a significant driver of contributions. We however considered that the effect of risk aversion could mainly intervene in the first period of the experiment as subsequently, the history of group coordination has more influence. An OLS regression on individual contributions in the first period, confirms the significant negative effect of risk aversion on individual contributions (Table 16).

[4] Considering, that some individuals switched several times (only 6 subjects did so out of 100 subjects), we considered that switching was definitive as long as subjects maintained the choice of lottery B in two consecutive games.

Term	Estimate	Std Error	t	p-value
Intercept	15.24	2.26	6.71	**0.00**
PPM	-2.13	1.28	-1.66	**0.10**
US	0.21	1.57	0.13	0.90
Aversion to risk	-0.63	0.28	-2.28	**0.02**

R^2=0.06. Observations: 140. Prob>F=0.04

Table 16: OLS regression on individual contribution to the common account in period 1 (Reference is the CS for the treatment effects)

The hypothesis that risk-aversion affects more contributions in the PPM and CS than in the US is also confirmed by the correlation rate between contribution and risk aversion and the correlation rate between beliefs and risk aversion calculated treatment by treatment in the first period (Table 17).

Treatment	Correlation rate between risk aversion and contribution in the first period	Correlation rate between risk aversion and beliefs in the first period
PPM	-0.21	-0.22
US	0.00	0.32
CS	-0.29	-0.22

Table 17: Correlation between 1) risk aversion and contributions and 2) risk aversion and beliefs about others' contributions in the first period of the experiment according to the treatment (Number of observation 140)

The variability of subjects' aversion to risk may therefore explain the stronger heterogeneity of contributions in the conditional subsidy scheme. Despite higher average expectations on others' contribution in the CS treatment, variability in subjects' risk aversion leads the more risk averse subject to contribute zero to the public good (Conjecture 5). Groups with this type of subjects therefore do not manage to coordinate above the threshold. This is confirmed by the correlation between groups' contributions in the first period and the average level of risk aversion in the groups (Table 18).

Treatment	Correlation rate between average group risk aversion and group contribution in the first period
PPM	-0.41
US	0.21
CS	-0.55

Table 18: Correlation between risk aversion and contributions in the first period of the experiment according to the treatment (Number of observation 35)

Subsequently, subjects are strongly influenced by the lack of coordination in the first period and do not manage to coordinate except in a new sequence.

6 Conclusion

Agri-environmental schemes are criticized because of their limited impact and their low cost-efficiency. One of the reasons for this disappointing outcome is that contracts are signed with individual farmers without taking into account threshold environmental effects and the need to coordinate environmental efforts at a pertinent scale. To achieve better results, the design of agri-environmental contracts therefore needs to evolve in order to facilitate coordination of agricultural practice changes among farmers.

Using an experimental approach based on a threshold public good experiment, we have tested a collective incentive mechanism. In a context-free protocol conducted in a lab with students, we compared the effectiveness and efficiency of a standard provision point mechanism and two subsidy schemes: an unconditional subsidy scheme and a conditional subsidy paid if the public good threshold is met. Both types of subsidies were proportional to the individual contribution to the public good. Results showed that both subsidy mechanisms increase the frequency of production of the public good, increase the stability of group contribution and improve welfare. The conditional subsidy also performs better than the unconditional subsidy when introduced after a treatment without subsidy. Finally, the efficiency of the conditional subsidy is superior, mainly due to the fact that subsidies are not spent when the public good is not produced.

Subsidy effects are however highly variable depending on the group of subjects, suggesting a strong impact of individual preferences. Investigations at the level of individual data showed that individual behavior is strongly affected by beliefs on others' contributions to the public good. Subjects generally respond positively to an increase of their beliefs on others' behavior, coherent with a mixture of reciprocity, reputation building and risk-aversion. The types of subsidy schemes affect contributions through a positive impact on beliefs especially in the first period of the experiments. If subjects manage to cooperate above the threshold at that point, this cooperation remains stable for almost the whole experiment. Nevertheless, groups that do not manage to cooperate above the threshold in the first period rapidly converge to the strong free riding equilibrium.

It would be interesting to test a fourth treatment, closer to the collective bonus proposed by Kuhfuss *et al*. (to be published) which appears easier to implement in the field. This alternative subsidy mechanism would be an incentive mechanism that cumulates an unconditional subsidy and a conditional subsidy. Finally considering that the ultimate goal of this work is to propose new designs of agri-environmental contracts, the next step would be to test collective incentive mechanisms in field experiments with a more contextualized protocol and possibly in real conditions with a natural experiment.

In summary, the experiment demonstrates that subsidy schemes are effective to improve public good production and increase welfare. This conclusion provides a strong justification for the use of even partial subsidies of contribution costs in order to encourage people to contribute to a public good, such as agri-environmental subsidies used in the second pillar of the Common Agriculture Policy. In addition, our experiment shows that introducing a condition on collective contributions improves the efficiency of subsidies and in some cases the effectiveness. In a context of rationalization of public funds, this result advocates for the use of agri-environmental schemes that include a condition on the attainment of certain effort objective, such as a minimum number of ha or of farmers enrolled, when environmental targets present thresholds or discontinuities. This result is timely in a period when the guidelines for new agri-environmental schemes for the period 2014-2020 are being formulated in France and at the regional level.

7 References

Ahn, T., Ostrom, E., Schmidt, D., Shupp, R. and Walker, J., 2001. Cooperation in PD games: Fear, greed, and history of play. *Public Choice*, **106**, p. 137–155.

Andreoni, J., 1988. Why free ride? Strategies and learning in public goods experiments. *Journal of Public Economics*, **37**, p. 291–304.

Andreoni, J. and Bergstrom, T., 1996. Do government subsidies increase the private supply of public goods?. *Public Choice*, **88**, p. 295–308.

Bagnoli, M. and Lipman, B.L., 1989. Provision of Public Goods: Fully Implementing the Core through Private Contributions: *The Review of Economic Studies*, **56**, p. 583–601.

Barbut, L. and Baschet, J., 2005. L'évaluation de la politique de soutien à l'agroenvironnement. *Notes et études economiques*,**22**, p. 32

Bchir, M.A. and Willinger, M., 2012. Does a membership fee foster successful public good provision? An experimental investigation of the provision of a step-level collective good. *Public Choice*, p. 1–15.

Bougherara, D., Costa, S., Grolleau, G. and Ibanez, L., 2009. Dealing with aversion to the sucker's payoff in public goods games. *Economics Bulletin*, **29**, p. 3194–3202.

Cour des Comptes Européenne, 2011. L'aide agroenvironnementale est-elle conçue et gérée de manière satisfaisante?. Rapport spécial n°7. Luxembourg : Cour des comptes européenne, p.75

Croson, R.T, 2007. Theories of Commitment, Altruism and Reciprocity: Evidence From Linear Public Goods Games. *Economic Inquiry*, **45**, p. 199–216.

Croson, R.T. and Marks, M.B., 2000. Step returns in threshold public goods: A meta- and experimental analysis. *Experimental Economics*, **2**, p. 239–259.

Dawes, R. and Orbell, J., 1986. Organizing groups for collective action. *The American Political Science Review*, **80**, p. 1171–1185.

Dupraz, P., Latouche, K. and Turpin, N., 2007. Programmes agri-environnementaux en présence d'effets de seuil. *Cahiers d'Economie et Sociologie Rurales*, **82-83**, p. 5–32.

Fehr, E. and Gächter, S., 2000. Fairness and Retaliation: The Economics of Reciprocity. *Journal of Economic Perspectives*, **14**, p. 159–182.

Fischbacher, U. and Gächter, S., 2010. Social Preferences, Beliefs, and the Dynamics of Free Riding in Public Goods Experiments. *The American Economic Review*, **100**, p. 541–556

Fischbacher, U., Gächter, S. and Fehr, E., 2001. Are people conditionally cooperative? Evidence from a public goods experiment. *Economics Letters*, **71**, p. 397–404.

Franks, J.R., 2011. The collective provision of environmental goods: a discussion of contractual issues. *Journal of Environmental Planning and Management*, **54**, p. 637–660.

Greiner. B., 2004. An Online Recruitment System for Economic Experiments. In: *Forschung und wissenschaftliches Rechnen 2003* (Kurt Kremer, Volker Macho Eds.) p.79-93.

Isaac, R., Schmidtz, D. and Walker, J., 1989. The assurance problem in a laboratory market. *Public Choice*, **62**, p. 217–236.

Kuhfuss, L., Préget, R. and Thoyer, S. Préférences individuelles et incitations collectives : quels contrats agroenvironnementaux pour la réduction des herbicides par les viticulteurs ? *Revue* *d'Etudes en Agriculture et Environnement/Review of Agricultural and Environmental Studies*. (to be published)

Ledyard, J., 1995. Public goods: A survey of experimental research. In: *The handbook of experimental economics* (Kagel, J. and Roth, A., eds.) Princeton University Press, Princeton, NJ.

Marks, M. and Croson, R., 1998. Alternative rebate rules in the provision of a threshold public good: An experimental investigation. *Journal of Public Economics*, **67**, p. 195–220.

Michaud, A., Désolé, M., Kuhfuss, L., Preget, R., Thoyer, S., 2013, Bilan de la mise en œuvre des MAEt en France 2007-2012 – Synthèse des résultats d'une enquête nationale. Ministère de l'Agriculture, 4 p.

Muradian, R., 2001. Ecological thresholds: a survey. *Ecological economics*, **38**, p. 7–24.

Oregon Department of Agriculture, 2005. The Conservation Reserve Enhancement Program. Partnership that benefit Oregon's wtaresheds and agriculture. Tualatin, Oregan, USA. ODA. http://oregon.gov/OWEB

Oréade-Brèche, 2005. Evaluation des mesures agro-environnementales. Rapport final. Auzeville, France : Oréade-Brèche, 233 p.

Perrings, C. and Pearce, D., 1994. Threshold effects and incentives for the conservation of biodiversity. *Environmental & Resource Economics*, **4**, p. 13–28.

Rapoport, A. and Eshed-Levy, D., 1989. Provision of step-level public goods: Effects of greed and fear of being gypped. *Organizational Behavior and Human Decision Processes*, **44**, p. 325–344.

Rondeau, D., Poe, G.L. and Schulze, W.D., 2005. VCM or PPM? A comparison of the performance of two voluntary public goods mechanisms. *Journal of Public Economics*, **89**, p. 1581–1592.

Runge, C., 1984. Institutions and the free rider: The assurance problem in collective action. *The Journal of Politics*, **46**.

Sen, A., 1967. Isolation, assurance and the social rate of discount. *The Quarterly Journal of Economics*, **81**, p. 112–124.

Shogren, J.F. and Taylor, L.O., 2008. On Behavioral-Environmental Economics. *Review of Environmental Economics and Policy*, **2**, p. 26–44.

Sugden, R., 1984. Reciprocity: the supply of public goods through voluntary contributions. *The Economic Journal*, **94**, p. 772–787.

Suleiman, R. and Rapoport, A., 1992. Provision of step-level public goods with continuous contribution. *Journal of Behavioral Decision Making*, **5**, p. 133–153.

Uthes, S. and Matzdorf, B., 2013. Studies on agri-environmental measures: a survey of the literature. *Environmental management*, **51**, p. 251–66.

Warr, P.G., 1982. Pareto optimal redistribution and private charity. *Journal of Public Economics*, **19**, p. 131–138.