Can collective conditionality improve agri-environmental contracts? Insights from experimental economics.

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Abstract

Traditional agri-environmental contracts, action-based voluntary and individual, have not succeeded in meeting the environmental targets set in the European Common Agricultural Policy, despite the large amounts dedicated to their implementation. One of the main reasons for this unsatisfying outcome is the limited and scattered adoption of contracts and the existence of threshold environmental effects. We use a threshold public good experiment to test an agri-environmental contract with a collective conditionality, a new form of contract in which farmers are paid only if the environment production threshold is collectively attained, a sort of collective result-based contract. Our experimental results show that conditional agri-environmental contracts are more efficient than the traditional ones and improve the environmental outcome. We also highlight that early stages of implementation of such mechanism is fundamental for its success and that risk aversion can limit its effectiveness, suggesting the importance of accompanying its introduction with facilitation activities. We conclude that this new form of contracts should be considered in the design of future agri-environmental policies.

Code JEL: Q58, C90

Keywords: agri-environmental contracts, public goods, threshold effects, experimental economics.

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1 Introduction

The growing consensus on the adverse effects of agricultural intensification on the environment in Europe has led to the introduction of a diversity of policy instruments. Among the most important ones are agri-environmental schemes (AES), which are based on voluntary contracts signed with individual farmers, in which they commit to adopt or maintain pro-environmental practices 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).

Several explanations are advanced to explain this unsatisfying outcome. One of them is that most contracts are action-based, land managers are paid based on the pro-environmental actions they undertake (reduction of input use, land set-aside) whatever the ultimate environmental outcome. This system may be particularly problematic in situations with environmental threshold effects, i.e. when the production of environmental benefits does not increase linearly with environmental efforts but presents discontinuities (Perrings and Pearce, 1994; Muradian, 2001). 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. If the sum of pro-environmental efforts is not sufficient, the environment does not improve and public funds are spent without any tangible benefit (Dupraz *et al.*, 2007).

In order to overcome the limitations of action-based agri-environmental contracts, authors have proposed the use of result-oriented contracts. The main principle is that land managers are paid not to perform specific management actions but rather to achieve set environmental outcomes (Burton and Schwarz, 2013). In addition, incentives can be set in a way to provide ecosystem services efficiently (Zabel and Roe, 2009). Result–oriented schemes studied in the literature consider however that environmental results are achieved at the individual farm level, but in the case of environmental threshold, obtaining a tangible environmental outcome requires a collective efforts and targets therefore must be collectively achieved. In this article, we intend to test, in a lab experiment, contracts in which individual payments are conditioned to the collective attainment of the threshold of environmental production. In this mechanism, amounts paid depend on individual efforts as in action-based contracts, but payments are only triggered if the environmental threshold is collectively attained. The main aim of this article is to analyze whether these agri-environmental contracts with collective conditionality, can be more effective in terms of environmental outcomes and more efficient in terms of public spending compared to the existing contracts.

In result-oriented schemes, the risk of not obtaining an environmental outcome, due to bad management practices or natural hazard, is shifted from the regulator to land managers (Derissen and Quaas, 2013). We do not consider this exogenous risk here. In contracts, with collective conditionality, the idea is rather to transfer the risk of a lack of coordination. In this article, the issue at stake is therefore to measure whether the deterrent effect on potential participants of a no-payment outcome (if the threshold is not attained) is stronger or weaker than the incentive to coordinate at the threshold level. Aversion to risk and beliefs on the behavior of others will therefore be key factors to consider in the success of such mechanism.

In this paper, we draw an analogy between agri-environmental contracts and an incentive system subsidizing voluntary contributions to a threshold public good. To our knowledge, only Le Coent et al (2014) analyze the effect of subsidies on the production of threshold public goods. First, we show how the decontextualized lab experiment conducted in Le Coent et al (2014) has been designed to fit the issues of agri-environmental contracts: the traditional action-based agri-environmental contract is represented in the experiment by an unconditional subsidy to individual contribution to the public good (US) and our contract with collective conditionality corresponds to the conditional subsidy scheme (CS) paid only to contributors if the threshold of the public good is reached by the group. Second, we strengthen the analysis of the experimental results presented in the previous article. Indeed, Le Coent et al (2014) underline the performance of the conditional subsidy scheme, but conclude that the results are however quite variable across groups and depend very much on group behavior. Therefore, we propose to investigate new variables such as risk aversion and expectations about the behavior of other members of the group to understand why some groups manage to cooperate above the threshold, while others fail despite the incentive of a subsidy scheme.

This paper is organized as follows. A review on agri-environmental contracts with collective conditionality is presented in section 2. Section 3 describes the experimental design. Section 4 analyses the experimental results and section 5 concludes, drawing recommendations on the design of agri-environmental schemes.

2 Agri-environmental contracts with collective conditionality

Although agri-environmental contracts with collective conditionality are relatively rare, there are few theoretical and empirical articles in the literature that deal with similar mechanisms.
Dupraz et al (2007) study the optimization of agro-environmental contracts in the presence of threshold environmental effects. The authors first develop a theoretical approach based on a principal-agent model in a context of information asymmetry on farmers' willingness to receive to adopt pro-environmental practices. One of the conclusions is that the establishment of a collective conditionality to trigger payments to farmers, a minimum threshold of contracted acreage, avoids welfare losses because subsidies are spent when environmental results are obtained. This approach has been implemented in the Ille-et-Vilaine Province, France, where the local administration promoted the use of grass strips along river banks to improve water quality. A first experience of individual AES-like contracts led to a very scattered and ineffective adoption of this practice. Public authorities therefore determined that a minimum threshold of 60% of the riverbanks of the targeted streams had to be reached to initiate payments to farmers. Interviews with managers of this programme revealed that this threshold was reached for some of the targeted streams. However, this was mainly obtained thanks to the facilitation and advocacy work of technicians on the ground that convinced farmers to enroll. Indeed, the measure was not financially attractive for farmers as only a small portion of the plots (about 20 meters along the river) was eligible for compensation payments.

A similar system is implemented in Oregon 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 this programme, landowners receive a Cumulative Impact Incentive Bonus (CIIB) equivalent to 4 years of annual rental rate if they (individually or collectively) enroll over 50% of the streambank in a 5-mile segment (ODA, 2005). This collective conditionality was created to encourage the conservation of continuous riverbank in view of having a more significant impact on water quality and ecosystems. In this case, the conditionality applies only to a bonus payment and not to the whole subsidy, as in the Ille-et-Vilaine case.

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.*, 2014). In this choice experiment, farmers' Willingness To Receive (WTR) to reduce their herbicide use, i.e. the amount of subsidy they would require to change this practice, is determined based on their choices among different contracts. For example, one of the possible contract characteristic is to receive an additional bonus provided at the end of the 5-year contract only if 50% of the surface of the targeted territory is ultimately enrolled. Interestingly, the analysis of farmers' choices demonstrated that farmers, if proposed this collectively conditioned bonus, have 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 could therefore mean that higher level of enrollment could be obtained with the same level of public expenditure, if this type of measure would be implemented.

Although out of the scope of this study, the ambient tax scheme proposed by Segerson (1988) is also a (negative) incentive mechanism with collective conditionality. This mechanism was developed specifically to manage problems of uncertainty on the relationship between individual emissions and ambient pollution, which is the general case for non-point source agricultural pollution. Direct regulation could be used if it was economically feasible to monitor the practices of all polluters or if individual emissions could be inferred from measures on the environment. However the relationship between emissions and pollution is often stochastic and it is not feasible to determine the level of individual emissions out of measures of ambient pollution, since ambient pollution levels depend on the behavior of all. The incentive scheme proposed is a tax/subsidy scheme that is not based on individual abatement efforts but rather directly on ambient pollution levels. This mechanism is similar to a collective incentive mechanism for which the conditionality of the tax/subsidy is directly based on the level of an environmental indicator.

In this study, we will focus on agri-environmental contract for which the payment is integrally conditioned to the attainment of the threshold of production of the environmental good. We consider here that the regulator and the participants of the programme have a perfect knowledge on the link between efforts and environmental outcome. Although this is a simplification, our interest was to focus on the strategic risk that exist between farmers and if the mechanism we propose could solve it.

3 Experimental design and procedure

Experimental economics is increasingly being used to assist decision makers in policy design. As mentioned by Vernon Smith, the laboratory can be considered a "wind-tunnel" to test new policy instruments. We follow this approach to test agri-environmental contracts with collective conditionality. Farmers' choice to adopt pro-environmental practices can be modeled by voluntary contributions to a public good. Indeed, farmers adopting these practices generally bear private costs whereas the environmental improvement benefits everyone. If we consider situations in which the environmental production presents thresholds, our problem is better captured by a threshold public good. This experimental setting is our new type of as agri-environmental contract.

3.1 Treatments

The game underlying the experiment is a threshold public good game. The benchmark treatment is the threshold public good game with no subsidy called the *Provision Point Mechanism* (PPM) and the two treatments of interest in this paper are:

- **US**, a treatment with an *Unconditional Subsidy* paid to all contributors proportionally to their contribution whatever the outcome in terms of public good production, and
- **CS**, a treatment with a *Conditional Subsidy* scheme paid only if the threshold is reached by the group.

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 the threshold necessary to ensure an environmental improvement.

Table I: Transposition of the context into the laboratory

Context	**Transposition in the laboratory**
Threshold environmental public good such as water quality or biodiversity conservation	Threshold public good
Farmers	Participants in the experiment (students)
Cost related to the adoption of pro-environmental agricultural practices	Contribution to the public good
Traditional agri-environmental contract: payment to each farmer per ha enrolled whatever the environmental outcome and the decision of others	Subsidy proportional to individual contribution: unconditional subsidy scheme (US). In our case, we consider that the subsidy covers only partially the cost of implementation of AES.
Agri-environmental contract with collective conditionality: payment to each farmer per ha enrolled provided the sum of ha enrolled by all farmers is greater than the required threshold to ensure an environmental outcome.	Subsidy proportional to the contribution triggered if the threshold of the public good is collectively attained: conditional subsidy scheme (CS)

This experiment is run with groups of 4 subjects that represent a community of famers in a given territory. Each subject i is endowed with 20 tokens, and must decide how many (C_i) to contribute to a public account which benefit to all members of the group only if the threshold is reached. In the three treatments, the threshold is set at an intermediate level of 40 tokens which represents 50% of the total endowment of the group (4×20). In addition, 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). The value of marginal per capita return (MPCR) from investing in the public good when the threshold is reached is set at 0.3 which is a value quite low compared to most experiments in the literature, but this choice is intended to reflect the low individual benefit perceived by the farmers from the public good in our applied context.

Therefore in the PPM treatment, subject i's payoff (π_i) is :

$$\pi_i = \begin{cases} 20 - C_i & \text{if } \sum_{i=1}^{4} C_i < 40 \\ 20 - C_i + 0.3 \sum_{i=1}^{4} C_i & \text{if } \sum_{i=1}^{4} C_i \geq 40 \end{cases}$$

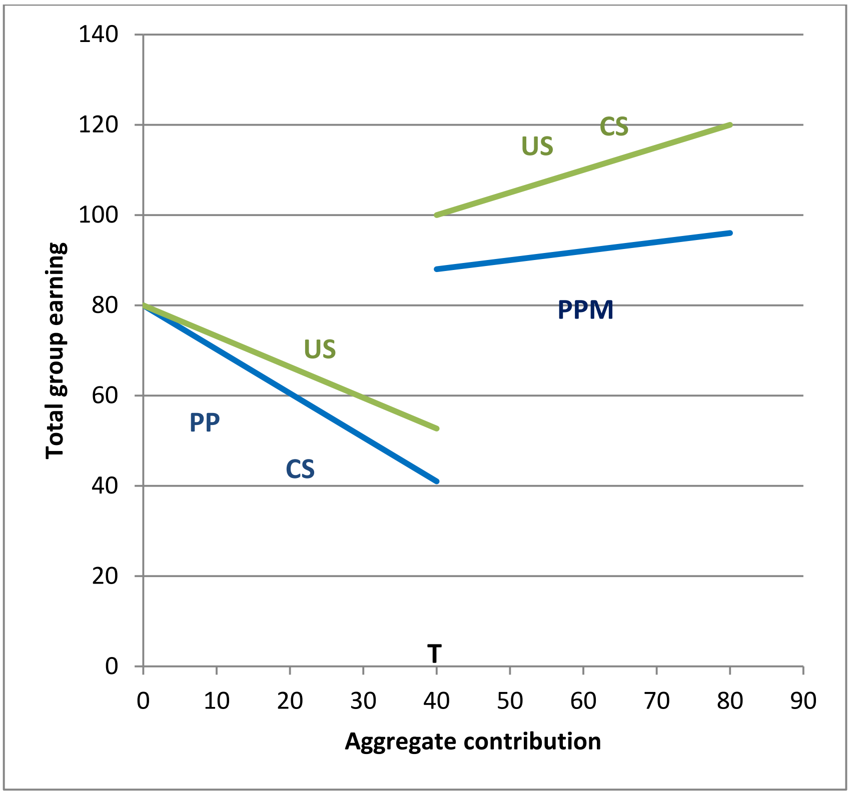
The US is similar to the PPM except that when subjects contribute C_i, they get an individual subsidy that is a proportion (0.3) of their individual contribution. This relatively modest subsidy level is chosen to ensure that allocating money to the public account is not too attractive since we want to ensure that our experimental setting can be likened to the agri-environmental contract case.

Therefore in the US treatment, subject i's payoff is:

$$\pi_i = \begin{cases} 20 - 0.7C_i & \text{if } \sum_{i=1}^{4} C_i < 40 \\ 20 - 0.7C_i + 0.3 \sum_{i=1}^{N} C_i & \text{if } \sum_{i=1}^{4} C_i \geq 40 \end{cases}$$

Finally, in the CS treatment, the individual subsidy remains proportional to the contribution but is paid only if aggregate contributions reach the threshold. Therefore, if the threshold is not reached, subject i's payoff is the same as in the PPM treatment: $20 - C_i$, and if the threshold is reached, subject i's payoff is the same as in the US treatment: $20 - 0.7C_i + 0.3\sum_{i=1}^{N} C_i$. The total group earning according to the group contribution for the three treatments is illustrated in Figure I.

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



3.2 Discussion of the design and theoretical predictions

Results presented in Isaac et al. (1989) and confirmed in most experiments show that introducing a threshold in a standard voluntary contribution mechanism can raise contributions (Suleiman and Rapoport 1992, Dawes and Orbell 1986, and Rondeau, Poe, and Schulze 2005). Actually, there is a multiplicity of non-cooperative equilibria in provision point mechanisms in which the sum of the group members' contributions equals the threshold and participants need to coordinate to select one (Ledyard, 1995). However, the threshold is not attained in all cases. Indeed, not contributing at all, i.e. $C_i = 0, \forall i,$ is still an equilibrium in PPM. Theoretical predictions for the US and the CS treatments are qualitatively the same as for the PPM treatment, i.e. a multiplicity of equilibria for which $\sum_{i=1}^{4} C_i = 40$ and a zero contribution equilibrium. However the number of equilibria at the threshold is much higher.[1]

As in standard public good games, there is still a social dilemma in our three treatments. The equilibria at the threshold level Pareto-dominate the zero contribution equilibrium but are not Pareto optima. The Pareto optimum in the three treatments is that all players contribute their full endowment to the public good.

In addition, failure to reach the threshold leads to net losses in terms of wasted contributions since the public good is not produced whereas contribution costs have been supported. To mitigate this problem, mechanisms such as money back guarantee[2] (Rapoport and Eshed-Levy 1989, and Cadsby and Maynes 1999) and rebate rules[3] (Marks and Croson 1998, and Spencer et al. 2009) are investigated in the literature. The subsidy schemes we test differ from these mechanisms, although they present similarities. When the threshold is not reached, the US is equivalent to a partial money back guarantee system, but in our US treatment, subject's contribution is partially reimbursed in any case, as it is the case in current agri-environmental contracts. In our applied context, a standard money back guarantee mechanism could correspond to an AES which would be implemented only if enough farmers enroll in the scheme so as to be certain to reach the threshold of producing the public good before incurring costs. The US and CS could also be considered as forms of rebate rules. However, subjects receive a proportion of their whole contribution to the public good whereas in classical rebate rules, contributors get only a proportion of their excess contributions beyond the threshold.

When comparing our treatments, note that the step return[4] in the PPM treatment equals 1.2, while it equals 1.5 in the two subsidy treatments (US and CS). Considering that the step return is a good predictor for successful provision in PPM experiments (Croson and Marks 2000, and Cadsby et al. 2007), we expect that this will lead to higher contributions and to more frequent successful provision of the public good.

In the US treatment, we may expect that unconditional subsidies encourage contributions even under the risk that the threshold is not reached since subjects know that they will get 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 limit their contribution. On the other hand, the conditionality increases the incentive to reach the threshold which may lead to higher contributions and to

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[1] Readers interested in theoretical predictions for this experiment can refer to section 3 of Le Coent et al (2014).

[2] A money back guarantee is a system that guarantees the reimbursement of contributions to the public good if the threshold is not reached.

[3] Rebate rules are used to compensate subjects for their excess contributions when aggregate contributions are beyond the threshold

[4] Step return = $\frac{\text{agregate group payoff from the public good}}{\text{total contribution threshold}}$

a higher frequency of success. Therefore, we expect a higher variability between groups in the CS treatment depending on subjects' beliefs on reaching the threshold. However, we hypothesize that the use of the CS scheme will not reduce contributions significantly compared to the US scheme.

Since risk aversion and beliefs about others' contributions may influence the effect of the different treatments, we propose in this paper to elicit these two variables so as to include them in our behavioral analysis.

3.3 Implementation

First, in order to analyze the impact of risk aversion on subjects' contributions in the different treatments, we elicit that variable through a simple series of lotteries implemented at the beginning of the experiment. 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' risk aversion was characterized by their "switching point", *i.e.* the first game for which they chose the uncertain option. Individuals with multiple switching points were considered to have an undetermined risk aversion. To determine subjects' earnings, one of the games was randomly chosen and its outcome was determined using a randomized system. Subjects were informed that they would be told their earnings only at the end of the experiment.

Second, the three treatments are run in a "between-within" setting (see Table II).

Table II: Treatments tested in each session of the experiment

Sessions	**Sequence 1** 10 periods	**Sequence 2** 10 periods	**Number of subjects**	**Number of groups**
A	PPM	US	40	10
B	PPM	CS	40	10
C	US	PPM	40	10
D	CS	PPM	40	10
E	US	CS	28	7
F	CS	US	32	8
Total		**220**		**55**

The groups of 4 subjects remained the same during sequence 1 and sequence 2. The voluntary contribution game was repeated for 10 periods within each sequence. Each subject got a feedback at the end of each period on the aggregate contribution of his group to the public account and on his individual payoff.

To elicit subjects beliefs we used a protocol similar to Fischbacher and Gächter (2010): at each period, before subjects announced their contribution to the public good, each subject was asked to give his estimation of the contribution of the 3 other members of his group. If his estimation was accurate, he earned 5 points; if it was 1 token away from the actual contribution of others, he earned 4 points; if it was 2 tokens away, he earned 3 points; if it was more than 2 tokens away, he earned nothing. These points were added to the points earned in the contribution game. All the periods of a sequence were paid, but only one randomly chosen sequence was paid among the two sequences. Subject knew there would be 3 parts in the experiment (risk elicitation, sequence 1 and sequence 2) but new instructions were given only at the beginning of each part of the experiment.

Subjects were invited through the recruitment software for experimental economics ORSEE (Greiner, 2004). Experiments were conducted in 2013 and 2014 at the LEEM (Laboratoire d'Economie Expérimentale de Montpellier). 92% of the subjects were students from the University of Montpellier. 42% had already participated in an economic experiment but we made sure that none had participated in a public good experiment before. The experiment lasted a maximum of 2 hours and the average earning was 15.9€ with a standard deviation of 3.0€. Subjects were given an additional show-up fee of 2€ if they were students from the university site where the experiment was carried out and of 6€ otherwise.

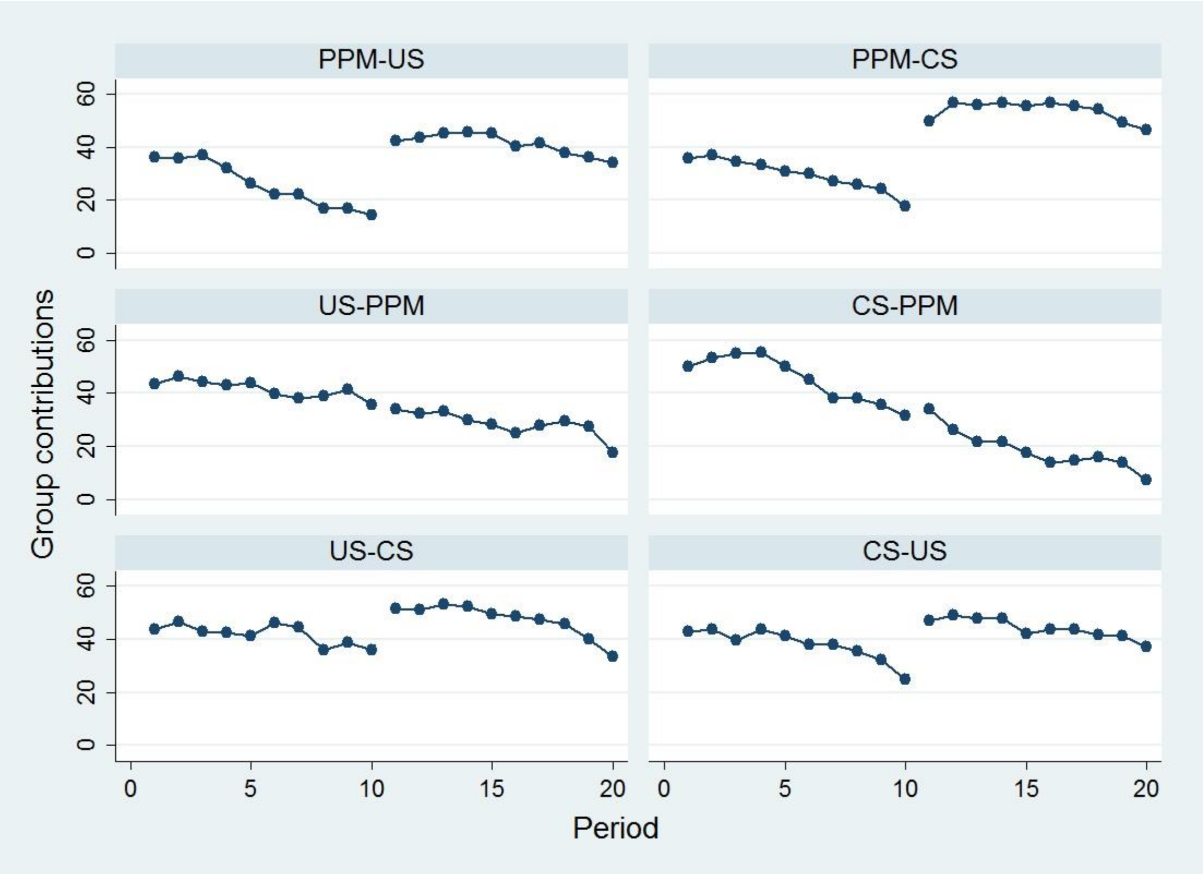
4 Experimental results

First in 4.1, we remind about the main findings of Le Coent et al (2014) on the effectiveness and the efficiency of the two subsidy schemes. Then we deepen the analyze of the experimental results which underline the importance of the results of the first period (4.2) and the impact of subject's risk aversion and beliefs about other members contributions.

4.1 Effectiveness and efficiency of subsidy schemes

We first analyze the effectiveness of the various treatments by examining graphically group contributions in the 6 sessions of the experiment (figure II). As expected, group contributions seem to be higher with subsidy treatments than with the PPM and the level of contribution seem to be quite similar with the two subsidy treatments. We can also observe a decay of contributions over the periods of the experiment, throughout treatments, as generally reported in public good experiments. Finally, subsidy treatments seem to be particularly effective when they are applied in the second sequence of the experiment.

Figure II: Average group contribution by period in the 6 sessions of the experiment



We subsequently analyze statistically these results, using a panel regression on the whole data of the experiment. The effectiveness of the conditional subsidy mechanism is mainly highlighted in the panel regression on group contributions carried with all the data of the experiment (Table III)

Table III: Panel regression with random effects on group contributions with all data pooled (***significant at 1%,**significant at 5%).

Group contribution	Coef.	(Std. Err.)
Intercept	54.7***	(2.7)
PPM (ref CS)	-21.7***	(1.1)
US (ref CS)	-4.1***	(1.2)
Period (1 to 10)	-1.6***	(0.1)
Sequence 2 (ref 1)	1.6**	(0.8)
Nb. of observations	1100	
Nb. Of groups	55	
Wald chi2	593.34	
Prob chi2	0.00	

This panel regression reveals a positive effect of the conditional subsidy as compared to the PPM, as expected, but more interestingly as compared to the unconditional subsidy scheme on group contributions. The conditional subsidy leads to significantly higher group contributions (+ 4.1 tokens on average) than the unconditional subsidy system when all data are pooled together. This result strongly confirms the potential interest of this subsidy scheme for public policies.

Subsequently, we compare the efficiency reached under the three treatments using a between analysis (comparison of sequence 1 of all sessions) provided in Table IV. Net "social gains" are a proxy for efficiency and are measured as the sum of players' payoff minus public spending on subsidies.

Table IV: Comparison of net social gains in the first sequence of all sessions using the Mann-Whitney test. (**significant at 5%, NS: not significant).

Treatment	Number of groups	Net social gains	Mann Whitney test PPM	Mann Whitney test US
PPM	20	74.3		
US	17	80.4	**	
CS	18	82.6	**	NS

Both subsidy schemes generate net social gain improvements as compared to the classical PPM, which is a significant result in the debate on the usefulness of subsidy schemes. However, although we could expect a net advantage of the CS scheme over the US scheme, since the subsidy is paid only when the public good is produced, experimental results are less clear-cut. The net social gains generated by CS are not significantly different from those generated by the US treatment. This might be due to the heterogeneity of group contributions. However, when we pool all data together and carry out a panel regression analysis, we can emphasize that net social gains are superior with the CS scheme than with the US scheme (Table V). This confirms our hypothesis of greater efficiency of the conditional subsidy system as compared to the two other treatments. As observed for group contributions, net social gains are also superior in sequence 2.

Table V: Panel regression with random effects on net social gains with all data pooled together (***significant at 1%,*significant at 10%).

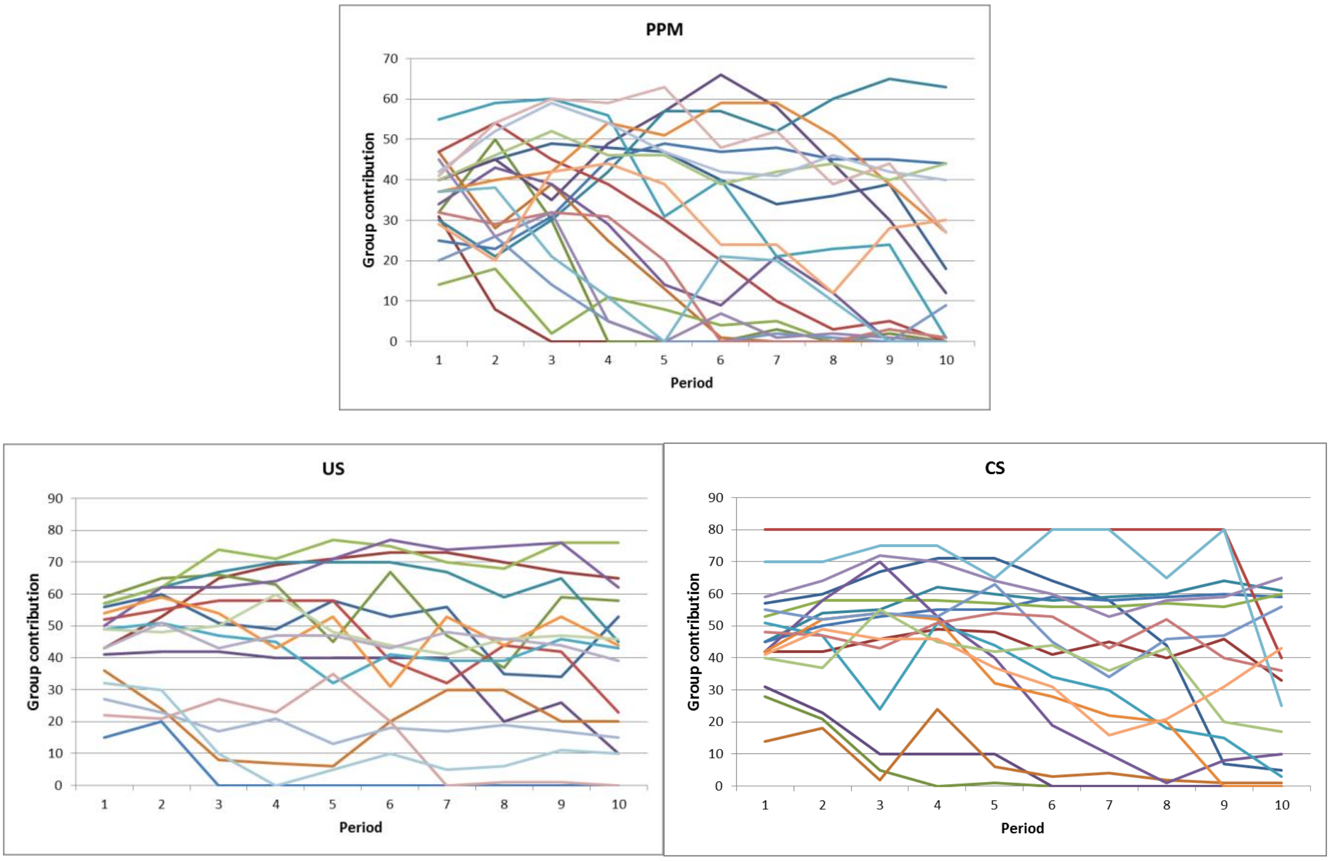
Net social gains	Coef.	(Std. Err.)
Intercept	83.2***	(1.4)
PPM (ref CS)	-8.0***	(1.0)
US (ref CS)	-2.0*	(1.1)
Period (1 to 10)	-0.1	(0.1)
Sequence 2 (ref 1)	4.3***	(0.8)
Nb. of observations	1100	
Nb. Of groups	55	
Wald chi2	99.11	
Prob chi2	0.00	

The effectiveness and efficiency advantages of the conditional subsidy over the unconditional subsidy and the PPM emphasize the potential interest of agri-environmental contracts with conditional subsidy in situations of environmental threshold. The results of the conditional subsidy system are however quite variable across groups. Therefore the use of this type of mechanisms requires particular attention. In the rest of the article, we therefore investigate why some groups manage to cooperate above the threshold, while others fail despite the incentive of a subsidy scheme. We particularly focus on the analysis of the role of the first period of the experiment and on how behavioral factors, individual risk aversion and expectations about the behavior of other members of the group, may underpin the performance of the conditional subsidy system.

4.2 The crucial role of the first period of the experiment

The graphic representation of the dynamics of group contributions throughout the first sequence of the experiment seems to reveal that the result of the first period is key to explain individual behavior. (Figure III). With the PPM, there is a high intra-group variability with generally more unstable contributions. 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 graph seems 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 zero contribution equilibrium. The US presents similar characteristics, however groups that do not coordinate above the threshold do not coordinate as rapidly towards the zero contribution 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.

Figure III: Aggregate group contributions for the different treatments (1 group=1 data serie) in the first sequence of the experiment



We statistically investigate this intuition with a panel regression on individual contribution (without the first period of the experiment), in which we include the success in the first period (group contribution≥40) and the interaction with treatments, as exogenous variables (table VI).

Table VI: Panel regression with random effects on individual contributions to the public account (errors are clustered at the group level and period 1 excluded). (***significant at 1%,*significant at 10%).

Individual contribution	Coef.	(Std. Err.)
Intercept	8.54***	(1.21)
CS	-4.04***	(1.44)
US	-2.23	(1.45)
Success in first period	3.06*	(1.77)
Success in first period x CS	7.82***	(2.02)
Success in first period x US	7.20***	(2.08)
Period	-0.53***	(0.09)
Nb. of observations	1980	
Nb. Of groups	55	
Wald chi2	553.2	
Prob chi2	0.00	

This regression confirms that the success in the first period has a significant positive effect on subsequent contributions. In addition, the interaction between the subsidy treatments and the first period success are highly significant and positive. This confirms that, with subsidies, if subjects contribute above the threshold in the first period they are likely to keep on doing so in the following periods. On the contrary, if the public good is not produced in the first period, contributions are lower in the conditional subsidy as compared to the PPM (the effect of CS becomes significant and negative) and contributions rapidly converge to the zero-contribution equilibrium. This analysis therefore reveals that one of the advantages of the conditional subsidy is that contributions remain stable if players successfully coordinate at the beginning of the experiment; if not, they rapidly converge to the zero contribution equilibrium. This could explain the advantages of subsidy treatments in term of effectiveness and the efficiency advantage of the conditional subsidy.

This result has implications on the implementation of agri-environmental contracts with collective conditionality. The early stages of the introduction of such a mechanism in a community will require particular attention because a failure of coordination in this phase could have long-term negative effects. The use of this type of contract would therefore require the development of a thorough facilitation process to ensure that coordination above the threshold is reached directly in the early phases of the implementation process. In order to better understand the key aspects on which this facilitation would need to focus, we investigate the behavioral factors that may intervene in the success of coordination in the first stage of implementation of agri-environmental contracts with collective conditionality.

4.3 The role of aversion to risk and beliefs

Since these experiments are coordination games, the *assurance problem,* as described by Sen (1967) and Runge (1984) might arise and explain individual behaviour. 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 expected probability that the threshold will be reached is too low. When this value is reached, it is optimal to contribute to reach the threshold. Runge (1984) argues that the purpose of political and economic institutions, dealing with public goods, is the coordination of expectations and beliefs. Institutions should therefore provide assurance regarding the behavior of others, and thereby help mitigating the assurance problem. Our hypothesis is that subsidy schemes can play that role. Both subsidy schemes can therefore raise peoples' beliefs about others' contribution and facilitate coordination. The conditional subsidy scheme, by strengthening the psychological focus on the threshold, could even play a stronger role on beliefs.

In order to verify these hypotheses, we compare beliefs on others' contribution in the first period of the first sequence for the three treatments using a t-test. Beliefs on others' contribution are indeed significantly higher with the conditional subsidy than with the two other treatments (Table VII).

Table VII: Comparison of beliefs about others' contribution between treatments in the first period using the t- test (NS: not significant; **significant at 5%; ***significant at 1%)

Treatment	Number of subjects	Average belief	Standard Deviation	PPM	US
PPM	80	29.6	16.3		
US	68	31.5	12.9	NS	
CS	72	36.1	12.8	***	**

This positive effect of the conditional subsidy on the expectation about others' behavior is probably one of the explanations for the positive results of this mechanism. However, given this advantage, it is questionable why the conditional subsidy does not show an even clearer advantage in the rest of the experiment. One explanation could be that, considering that the subsidy is conditioned to the behavior of others, subjects are more cautious when they choose their contribution in the first period. As we mentioned earlier, in this mechanism the exogenous risk of a lack of coordination is shifted from the regulator to the farmer. The assumption is therefore that the more subjects are risk averse the less they will tend to contribute out of fear of losing their contribution. In our applied context, the more farmers are risk averse, the less they will adopt pro-environmental practices, in fear of not reaching the environmental threshold and thus not receiving the conditional payment.

We test this hypothesis using data we elicited on risk aversion[5]. An OLS regression on individual contributions in the first period, confirms the significant negative effect of risk aversion on individual contributions in the first period (Table VIII). However, although we anticipated that risk aversion would have a different impact depending on the treatment, we could not highlight this difference.

[5] Subjects' aversion to risk is characterized by the rank of the switching point (see section 3.3). For individuals that switched several times the risk aversion value was considered missing. The risk aversion indicator is spread from 1 to 11 with an average of 6.96 and a standard deviation of 1.70.

Table VIII: OLS regression on individual contribution to the public account in period 1 (***significant at 1%,*significant at 10%)

Individual contribution	Coef.	(Std. Err.)
Intercept	14.88***	(1.93)
PPM (ref CS)	-2.85***	(1.02)
US (ref CS)	-0.82	(1.06)
Aversion to risk (1 to 11)	-0.44*	(0.25)
Nb. of observations	203	
R^2	0.05	
Prob>F	0.02	

A Mann-Whitney test however reveals that the average risk aversion of groups that fail to reach the threshold is significantly higher than the one of groups that succeed for the CS treatment (table IX)[6].

Table IX: Comparison of average group risk between groups that success or fail to reach the threshold in the first period using a Mann-Whitney test (NS: not significant; ***significant at 1%)

	Average group risk aversion (Number of groups)		
Treatment	**Threshold not reached in the first period**	**Threshold reached in the first period**	**Mann Whitney test**
PPM	6.8 (9)	6.8 (11)	NS
US	7.1 (12)	7.0 (5)	NS
CS	6.9 (15)	8.2 (3)	***

Aversion to risk should therefore be particularly considered in the implementation of contracts with collective conditionality, considering that farmers are generally considered to be particularly risk averse.

5 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 implemented without taking into account threshold environmental effects and the need to coordinate environmental efforts at a pertinent scale. We use a laboratory experiment to test a new form of agri-environmental contracts for which the payment is conditioned to the collective attainment of the environmental threshold. Results show that this mechanism is more efficient and effective than traditional agri-environmental contracts in the presence of environmental threshold.

The result of this mechanism is however variable depending on the group of subjects. Investigations of individual behavior show that contributions are strongly affected by the result of the first period, especially for subsidy treatments. If subjects manage to cooperate above the threshold in the first period,

[6] There is no significant difference of average group risk aversion between treatments.

this cooperation remains stable in the following periods. However, groups that do not manage to cooperate above the threshold in the first period rapidly converge to the zero-contribution equilibrium. Considering the importance of the first period, we subsequently focus our analysis on decisions taken in the first period of the experiment. Both types of agri-environmental contracts, and especially the one with collective conditionality, positively affect contributions through a positive impact on the expectations on others' behavior in the first period. On the other hand, groups with more risk averse subjects tend to fail to coordinate especially when the payment presents a collective conditionality. Facilitation activities would therefore be crucial to strengthen trust and expectations on others' behavior as well as reducing the impact of risk aversion.

In order to strengthen external validity, these results,obtained with students in the laboratory would need to be confirmed using field experiment with farmers. Transposing strictly the experiment to a real context would mean that farmers need to adopt pro-environmental practices and would receive a subsidy only in cases where the environmental threshold is attained. This system may be considered too strict and not easily accepted by farmers. An option would be to require farmers to commit to adopt the pro-environmental practice in anticipation and to open contracts only when the threshold would be reached. This situation would alleviate the risk for farmers not to receive either the contract payment or the benefits of the public good. Another option would be to condition only a proportion of the payment to the attainment of the environmental threshold. This conditional bonus has been already tested in a choice experiment by Kuhfuss et al. (2014) with promising results.

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