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To cite this version:

Laure Kuhfuss, Raphaële Préget, Sophie Thoyer, Nick Hanley. Nudging farmers to sign agri-environmental contracts: the effects of a collective bonus. 2015. hal-01148581

HAL Id: hal-01148581

https://hal.science/hal-01148581v1

Preprint submitted on 19 Nov 2015

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Paper 2015-06

NUDGING FARMERS TO SIGN AGRI-ENVIRONMENTAL CONTRACTS: THE EFFECTS OF A COLLECTIVE BONUS

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February 2015

Nudging farmers to sign agri-environmental contracts: the effects of a collective bonus

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Abstract

Using a choice experiment, this paper shows that the introduction of a conditional collective bonus in an agri-environmental scheme (AES) can improve farmers' participation and increase land enrolment for lower overall budgetary costs. This monetary bonus is paid per hectare of enrolled land in addition to the usual agri-environmental payment if a given threshold is reached in terms of farmers' participation in the region or catchment of interest. Using a choice experiment, we estimate the preferences of wine growers in the South of France for such a bonus. We show that it contributes to increased expectations of farmers on others' participation, therefore changing the pro-environmental social norm and initiating group dynamics towards the adoption of less pesticide-intensive farming practices over time.

Keywords: payment for environmental services, choice experiment, collective incentive, agri-environmental schemes, social norm, behaviour

JEL Codes: Q15, Q18, Q25, Q28, Q53

1. Introduction

Agri-environmental measures were introduced in the Common Agricultural Policy (CAP) in 1992 to reduce the negative impact of agriculture on the environment. They are individual contracts signed with farmers who volunteer to implement environmentally-enhanced management practices in return for an annual payment. This payment is calculated so as to compensate average compliance costs and foregone farming revenue associated with the adoption of less-intensive farming techniques. Over the 2007-2013 financial period, total payments made by the European Union for agri-environmental schemes (AES)[1] amounted to 22.7 billion Euros, and were supplemented by Member states by an equivalent amount.

However, the low participation of farmers and the insufficient farming area enrolled in agri-environmental measures (especially those which demand greater environmental efforts) are a concern for decision-makers and are pointed out by expert reports and research articles to explain the disappointing environmental outcomes of AES (Hanley *et al.*, 1999; Yang *et al.*, 2005; ECA, 2011). They highlight also that the effectiveness of AES is often jeopardized by environmental threshold effects which make changes of farming practices ineffective unless they are adopted at a sufficient scale, in terms of environmental efforts and area concerned. It is therefore crucial to ensure that the participation rate enables us to reach the threshold. Otherwise, the environmental gains from the spending of public money are much reduced (Dupraz *et al.*, 2009).

Agri-environmental schemes in European Member states are regularly revised and adjusted in order to improve their cost-efficiency. The French rural development program for the 2007-2013 period has imposed a better targeting on vulnerable areas and has designed contracts proposing two different levels of environmental practices – an entry-level and a more demanding contract – matched by different levels of financial compensation – in order to better take account of the heterogeneity of farmers' preferences and constraints (Kuhfuss *et al.,* 2012). Despite these adjustments, the participation rate to agri-environmental schemes had remained low at the time of the Mid-Term review.[2] In a context of tight public money, policy-makers are reluctant to propose an upward adjustment of contract payments as a way to attract more farmers into AES. The context of the CAP reform for the 2014-2020 period is offering an opportunity to rethink the design of AES in order to improve the rate of participation and to increase the total area enrolled in AES, without increasing the cost of AES for the taxpayer.

Among the possible solutions, the French Ministry of Agriculture is interested in contracts with a collective dimension that would encourage the participation of a large number of farmers in target areas. It is in line with the European Commission's proposal to promote and contribute financially to the development of cooperative actions by farmers in order to facilitate the transition towards more sustainable farming systems and agricultural practices. The collective contract option has already been explored and tested in some countries. The most well-known examples are the environmental cooperatives in the Netherlands (Franks, 2011; Amblard, 2012) in which members

[1] Financial plan of EARDF axis 2 measure 214 (agri-environment)

[2] An analysis implemented by the Rural development Observatory (ODR, INRA) on the basis of data supplied by the Agence de Services et de Paiement shows that on average 21% of the targeted areas were enrolled in the MAEt scheme in 2012 in France, with a variation ranging from 2% in Nord pas de Calais, a highly field-crop productive region, to 69% in Franche-Comté, a bovine breeding region with a high percentage of grass areas and forests. In Languedoc-Roussillon, the region of our case-study, the participation rate reached 16% in 2012. Data are available at: esrcarto.supagro.inra.fr.

agree jointly to sign a contract and decide together how to share environmental efforts and contract payments. Other types of contracts condition payments to a minimum participation rate (Le Coent *et al.,* 2014).

In this paper, we assess the potential of contracts that reward individual participation, but which also offer a bonus payment to each enrolled farmer when a target pre-defined in terms of total participation is reached at the regional or catchment scale. Our goal is to evaluate, from an empirical viewpoint using a stated preference approach, whether this type of contract can effectively improve the dynamics of engagement and increase the cost-effectiveness of an AES. The principle of such type of payment has already been proposed but with a different focus. It usually addresses the specific issue of spatial coordination of enrolled plots of land. When fragmented land needs to be reunited under a coherent habitat protection policy for example (USDA, 1998), the "agglomeration bonus" pays an extra bonus for every plot a landowner enrols that borders another enrolled plot. The efficiency properties of a contract proposing an agglomeration bonus have been assessed through lab experiments (Parkhurst *et al.,* 2002; Banerjee *et al.,* 2009, 2014). Our focus here is different since we are interested in the way such a conditional bonus can boost participation where a trigger point for the bonus is set.

This choice of contract is motivated by two observations. The first one is that farmers are often reluctant to make a collective commitment that makes them too dependent on others' decisions. They usually prefer individual contracts. The second, which is not contradictory with the first observation, is that the dynamics of contracts may be subject to a phenomenon similar to the diffusion of innovations (Rogers, 1983), farmers committing more easily if they are assured that their neighbours or peers do the same. This effect is documented in a number of case studies (Chen *et al.,* 2009; Beharry-Borg *et al.*, 2012). But it is difficult to measure and predict.

This article examines the preferences of winegrowers in the French region of Languedoc-Roussillon for innovative herbicide-reduction contracts combining an individual payment and a conditional final bonus, paid to each participating wine-grower proportionally to his enrolled land, provided that a given threshold is attained in terms of total area enrolled in the scheme at the local level. In a more general setting, the contribution of this paper is to test a contract design that could reduce the risk of under-contribution to a local public good (improved environmental quality) by introducing a club good with threshold: in contracts offering a conditional bonus, each enrolled farmer increases the likelihood that payments of all other participating farmers increase. His participation in the AES can therefore be compared to a contribution to a club good with a contribution threshold.

To measure the interest and farmers' preferences for contracts combining individual and collective incentives, we use a choice modelling method. This method has been used in several recent studies to better understand the impact of various contract designs on adoption rates (for example, Espinosa-Goded *et al.,* 2010; Christensen *et al.,* 2011; Broch and Vedel 2011; Broch *et al.,* 2013). The original contribution of our paper to this method is the introduction of two monetary attributes in the choice sets submitted to respondents, namely the standard monetary attribute that measures the willingness to accept of farmers for different attributes of the agri-environmental contract and the conditional final bonus.

The results of our choice modelling survey, based on responses from 317 wine-growers in Languedoc-Roussillon concerning hypothetical herbicide-reduction measures, show that wine growers have a strong preference for a contract with a conditional bonus, especially when they are more confident that the participation target that triggers the bonus payment can be reached in their area. Moreover, when offered a contract with such a conditional bonus, respondents reduce their willingness to accept by an amount which is much greater than the expected bonus payment. This difference captures the monetary value attributed by farmers to a contract that promotes collective commitment compared to a strictly individual contract. In addition, the analysis of the acreage enrolled by the respondents when they choose a contract shows that the conditional bonus encourages farmers to enrol a larger proportion of their vineyard. Consequently to these three findings, the conditional bonus can be a way to increase the total area enrolled for a lower budgetary outlay. It thus opens opportunities to develop more cost-effective AES.

The paper is organized as follows. Section 2 develops the behavioural factors that can explain the farmers' preferences for contracts with conditional bonus. Section 3 presents the estimation method and data. Section 4 contains the results and discussions. Section 5 concludes.

2. Adoption of agri-environmental measures and collective dynamics

There is a growing theoretical and empirical economic literature on the reasons why farmers choose whether or not to sign an agri-environmental contract (Vanslembrouck *et al.,* 2002; Peerlings and Polman, 2009; Christensen *et al.,* 2011; Ma *et al.,* 2012). This literature shows that farmers' decisions to join an AES are driven both by technical constraints and expected profit but it also highlights the role that behavioural factors can play in farmers' motivations.

In a standard economic analysis, it is assumed that the farmer makes his decision based on the trade-off between the utility of contract payment and the expected disutility of the environmental effort he has to provide. Empirical studies show that his willingness to accept (WTA) when joining an AES depends on the level of restrictions imposed by the agri-environmental contract on farming practices, on his socio-economic characteristics which are correlated to his preferences, but it also depends on specific attributes of the contract such as the contract duration, the flexibility permitted by the menu of authorized management practices, and the perceived transaction costs associated with administration and control (Falconer and Saunders, 2002; Ducos *et al.*, 2009; Ruto and Garrod, 2009). Based on these findings, recommendations are made to improve the design of contracts and to adjust them better to farmers' preferences and constraints in order to boost participation. An under-explored area of contract innovation is the collective dimension of contracts. Designing a specific incentive to encourage a group of farmers to enrol in an agri-environmental scheme can engender positive dynamics of change, by accelerating the contract adoption rate in a given area.

There are several reasons why greater participation in an AES can engender in turn more willingness to participate by those who had decided not to enrol in the first place. The first reason lies in the public good dimension of the benefits: in the case of water contamination by herbicides, which is our case study, each farmer's efforts to reduce pollution contribute to water quality improvement which is a public good shared by all consumers in the same catchment area. It can

even be considered a public good with threshold: if the pesticide concentration exceeds a maximum value set by health authorities, then abstracted water must undergo costly treatments which are paid for by water users through higher water prices. Therefore total efforts to reduce pesticide use must be sufficient to ensure that the threshold is not exceeded. If this is not the case, then all efforts are, to a degree, wasted (Ferraro, 2008).

The second reason is linked to the cost of herbicide use abatement. Indeed, the individual costs borne by farmers to reduce their pollution can also depend on the global participation rate in the AES. Are there cost synergies in herbicide use abatement? The agriculture literature on this point is unclear. On the one hand, if many farmers in the catchment reduce their use of herbicide, we can expect that weeds will prosper and the cost of weed control will increase accordingly. On the other hand, if a group of neighbouring farmers chooses to adopt similar no-herbicide technologies to control weeds, it is likely that they will share experience, and so benefit from mutual learning, and could choose to buy costly equipment together. This could clearly contribute to reduce the unit costs of abatement (Waterfield and Zilberman, 2012).

The third reason relates to behavioural factors. Literature in social psychology and behavioural economics shows that our utility level does not depend exclusively on our absolute level of consumption or wealth but also on how we compare ourselves relative to others and how we perceive our position or rank in the social group to which we belong (Bernheim, 1994; Thaler and Sustein, 2008). The choice of an individual can be guided by his desire to get the same benefits as other members of the group or behave like them. In particular, it has been demonstrated that some individuals value conforming to a social norm. Social norms are usually sustained by feelings attached to the reputation and self-esteem generated by conforming to a common rule or behaviour, or the shame and guilt of not conforming. It plays a powerful role in decisions: individual behaviour can be influenced by the behaviour of other members in the community and, conversely, a change in aggregate behaviour can induce a change in individual's behaviour (Dietz, 2002; Pretty, 2003; Brekke *et al.*, 2003; Czajkowski *et al.*, 2014). Regarding farmers specifically, Chen *et al.* (2009) have studied the effect of different factors on people's intentions of re-enrolling in a specific payment for environmental services scheme in China. They find empirically with a choice modelling approach that, in addition to conservation payments and program duration, the main driver of re-enrolment is the information that the neighbourhood is also intending to re-enrol. In other words, an already high level of participation can positively influence the choice of other farmers to participate.

Thus, an action, information or an incentive that changes the perception or expectation that an individual has on the general behaviour (or social norm) can induce them to change their decisions (Benabou and Tirole, 2012; Collier *et al.*, 2010). This result can be used to "nudge" behaviour by adapting policy design (Collier *et al.*, 2010; Duflo *et al.*, 2011; World Bank, 2015), supercharging the effects of economic incentives (Videras *et al.*, 2012; Croson and Treich, 2013). Our "nudge" relies on the conditional bonus paid to each farmer who has signed a contract, in addition to the contract payment, provided that 50% of farming land in the area of interest is enrolled in the AES.

Of course, at first sight, the introduction of such a bonus in a contract is expected to boost the rate of enrolment by offering an additional incentive to contractors. But it is expected to have

more subtle positive indirect effects: with such contracts, would-be contractors should be more confident that others will join as well and that the overall participation rate will be high (Francks, 2011). It can thus trigger a greater desire to participate, associated with the three reasons exposed above, even for a lower individual payment. It is also a way to signal that the "social norm" is to participate to the AES rather than not. Farmers who prefer to behave like the rest of the social group might be induced to participate for a lower payment. If their WTA is reduced by an amount that is greater than the expected bonus payment, then both participation rate and enrolled area can be increased without increasing public spending.

3. Estimation method and data

3.1. Choice experiment method

In order to analyse the impact of the bonus on farmers' participation and acreage enrolment we use a choice experiment survey. In this stated preference survey, farmers are confronted with a succession of choice cards, in each of which they are asked to choose between two different alternative agri-environmental contracts and a status quo option, specifically, the possibility to keep their present practices. The contracts are described in terms of attributes, each alternative presenting different level of these attributes. If the respondent chooses one of the alternative contracts on a choice card, rather than the status quo option, he is then asked how much of the acreage of his farm he would be willing to enrol in this contract. This two steps procedure is very close to the process of choices a farmer is confronted to in 'real life' situation.

The analysis of the contracts chosen by the farmers provides information on how the relative levels of the attributes influence these choices. The idea here is to also analyse whether the levels of the attributes do also have an influence on the acreage that farmers wish to enrol.

3.2. Modelling the decision over how much land to enrol.

First step: the choice of a contract

Farmers' decisions to choose a contract is guided by the relative level of utility he can gain by choosing one contract (identified by its *k* attributes) compared to the alternative contracts available and the *status quo* (no participation in the AES). Each farmer makes *T* successive choices during the survey. According to Lancaster's theory (1966), this utility is a linear function of the contract's attributes. Following the random utility theory, we assume that the utility of farmer *n* when choosing alternative *i* in a choice card C_t $(t = 1, \dots, T)$ (U_{int}, unobserved) consists of an observable deterministic element V_{int} and a random part ε_{int}:

$$U_{int} = V_{int}(X_{int}) + \varepsilon_{int}$$

Where V_{int} depends on the attributes of contract *i* faced by *n*, X_{int}.

Individual *n* will choose alternative *i* in choice card C_t if this alternative procures him the highest level of utility of all *J* alternatives present in this choice card. If A_{int} is a dummy variable that takes the value 1 if alternative *i* is chosen by farmer *n* in choice card C_t, then:

$$A_{int} = \begin{cases} 1 \text{ if } U_{int} > U_{jnt}, \forall j \in C_t,\ j \neq i \\ 0 \text{ if} U_{int} \leq U_{jnt}, \forall j \in C_t,\ j \neq i \end{cases}$$

with the assumption that the unobservable error terms ε_{int} are independently and identically distributed (IID) among the alternatives and across the population and follow a Gumbel distribution, then, following expression of the Conditional Logit model, the probability that farmer *n* chooses alternative *i* in the choice card C_t is:

$$P(A_{int} = 1) = \frac{exp(X_{it}{}'\beta)}{\sum_{j \in C_t} X_{jt}{}'\beta}$$

with β the vector of *k* preference parameters, representing the average 'weight' of each attribute of the contract on farmers' preferences.

The use of Conditional Logit model supposes that Irrelevant Alternatives are Independent (hypothesis of IIA), which is a strong assumption. The mixed logit model relaxes this assumption. Using this specification, the parameters β_{kn} are specific to each individual and randomly distributed across the population, with a density function $f(\beta_k)$. Then, conditional on vector β_n the probability that farmer *n* chooses alternative *i* in choice card C_t is:

$$P(A_{int} = 1|\beta_n) = \frac{exp(X_{it}{}'\beta_n)}{\sum_{j \in C_t} X_{jt}{}'\beta_n}$$

The probability of observing the sequence of *T* choices by individual *n* is:

$$P(A_{in1} = 1, \dots, A_{inT} = 1) = \int \prod_{t=1}^{T} \left(\frac{exp(X_{it}{}'\beta)}{\sum_{j \in C_t} X_{jt}{}'\beta} \right) f(\beta) d\beta$$

where $f(\beta)$ can be specified to be normal or lognormal: $\beta \sim N(b, \sigma)$ or $\ln \beta \sim N(b, \sigma)$. The parameters *b* and *σ* are respectively the mean and the covariance of these distributions and are to be estimated by simulation (Train 2009).

Second step: the choice of acreage

Once the respondent has chosen one of the alternative contracts in a choice card *t*, he is asked which acreage of his farm he would enrol in such a contract. Then, the acreage y_{int} enrolled by farmer *n* in contract *i* is only observed for selected (non-status-quo) alternatives, *i.e.* if $A_{int} = 1$, and can be expressed as:

$$y_{int} = Z_{int}\alpha + u_{int}$$

The acreage enrolled, y_{int}, depends on the characteristics of the alternative contract A_{int}, and on the individual characteristics of farmer *n* and his farm, all included in vector Z_{int}. y_{int} also depends on unobservable factors, u_{int}. The regression function on the sub-sample of selected alternatives is:

$$E(y_{int}|A_{int} = 1) = Z_{int}\alpha + E(u_{int}|A_{int} = 1)$$

with $E(u_{int}|A_{int} = 1) = 0$ if ε_{int} and u_{int} are independent. It is possible that the unobserved factors affecting farmers' choice of a contract, ε_{in}, are correlated with the unobserved factors that will influence his choice of acreage, u_{int}. Then, $E(u_{int}|A_{int} = 1) \neq 0$ and this selection

bias needs to be corrected. We use two different methods: first we use a fixed effect specification for the regression model and then we use a two-step procedure.

The random term in equation can be considered as being composed of two parts:

$$u_{int} = \theta_{in} + e_{int}$$

θ_{in} contains the individual time-invariant unobserved factors of farmer's acreage choice, while e_{int} reflects the remaining source of variation in acreage enrolment. A fixed effect specification of the regression eliminates θ_{in} from the equation, which can be re-written as:

$$\ddot{y}_{int} = \ddot{Z}_{int}\alpha + \ddot{e}_{int}$$

with $\ddot{y}_{int}$, $\ddot{Z}_{int}$ and $\ddot{e}_{int}$the time-demeaned variables ($\ddot{y}_{int} = y_{int} - \bar{y}_{in}$).

Under the assumption that $E(\ddot{e}_{int}|A_{int} = 1) = 0$, α can be estimated consistently using OLS on this last equation.

Another way of dealing with this bias is to use a two-step procedure as this problem is very close to the selection bias addressed by Heckman's procedure (Heckman, 1979). This procedure has been implemented to correct for selection bias in the analysis of factors influencing farmers' participation and choice of acreage based on real participation data in AES (Chang and Boisvert, 2009, Giovanopoulou *et al.,* 2011). However, we need to account for the specificities of our data, where the first step (selection) is a choice between many alternatives that cannot be modelled with a probit but requires the use of a conditional logit model or a mixed logit.

Söderbeg and Barton (2014) use Lee's correction method (1983) to account for selection bias in a contingent valuation study. This method has been compared to two other methods by Bourguignon *et al.* (2007) to address the issue of selection bias correction based on multinomial logit models. Depending on the method, the selection bias is corrected through the introduction of different additional terms in the regression, that are functions of the predicted probabilities of choice of each alternative, $P(A_{int} = 1) = P_{it}$, estimated in a first step through a multinomial logit model. The authors show through Monte Carlo simulations that an extension of Dubin and McFadden (1984)'s specification performs better. The first step of this procedure, the MNL, relies on the same assumption as mixed logit, that ε_{in} are independent and identically Gumbel distributed. They show that under this assumption, the parameters α_{in} from the outcome equation (acreage enrolled in our case) can be estimated by least squares on the basis of:

$$y_{in} = W_{in}\alpha + \sigma\frac{\sqrt{6}}{\pi}\left[\sum_{j\neq i} r_j\left(\frac{P_j ln(P_j)}{1-P_j}\right) - r_i ln(P_i)\right] + w_{in}$$

where σ is the standard deviation u_{in}, r_i (respectively r_j) is a correlation coefficient between u_{in} and ε_{in} and finally w_{in} is a residual, mean-independent from the regressors. As Z_{in}, W_{in} includes the characteristics of the alternative contract A_{in}, and the individual characteristics of farmer *n* and his farm. The difference between these two vectors is that at least one of the variables included in X_{in} in the selection equation (choice of a contract) is not included in W_{in}.

In our case farmers choose between alternatives A_1, A_2 and A_3 in each choice card, A_3 being the *status quo*. Let us define, A_1 as the chosen alternative and m_1, m_2, m_3, μ_1, μ_2 and μ_3 as:

$m_1 = -ln(P_1)$, $m_2 = P_2 \frac{ln(P_2)}{1-P_2}$, $m_3 = P_3 \frac{ln(P_3)}{1-P_3}$, $\mu_1 = \sigma \frac{\sqrt{6}}{\pi} r_1$, $\mu_2 = \sigma \frac{\sqrt{6}}{\pi} r_2$ and $\mu_3 = \sigma \frac{\sqrt{6}}{\pi} r_3$

With $A_{1t}=1$ the regression equation becomes:

$$y_{1n} = Z_{1n}\alpha + m_1\mu_1 + m_2\mu_2 + m_3\mu_3 + w_{in}$$

By including m_1, m_2 and m_3 in the regression, consistent estimators of α, μ_1, μ_2 and μ_3 can be obtained by least squares.

To summarise the second procedure, we first estimate $\beta_n$with a mixed logit, estimate the predicted probabilities $P(A_{in} = 1)$, then, we use these probabilities to control for selection bias in the acreage regression and obtain estimates for α.

3.3. Data

Our evaluation is conducted in the Languedoc-Roussillon region, located in the South East of France, where nearly two thirds of the agricultural area is dedicated to vineyards. The widespread use of chemical herbicides to control weeds has contributed to the contamination of groundwater and streams. French authorities have identified 38 watersheds in Languedoc-Roussillon which may represent a sanitary risk for drinking water and for which policy solutions must be found to reduce agricultural diffuse pollution. The main policy option is to induce farmers to switch to more environmentally-friendly weed control techniques such as mechanical weeding or controlled grass cover. France is thus re-examining the design of its AES in order to enrol larger vineyard areas in low-herbicide practices.

As mentioned before, the data were collected through a choice experiment survey in which farmers were invited to select their best option between two different contracts and a 'status quo' alternative (Figure 1). If they chose one of the two contracts proposed, they were then asked how much land (in ha) they would be prepared to enrol in the selected contract. In our survey setting, the conditional bonus is paid at the end of the five-year contracting period. This choice was made for two reasons: first, it can be difficult to reach the target area (50% of the farming area in the zone of interest) in only one year and, second, because it gives enough time for diffusion and social norm effects. In particular, enrolling farmers can encourage fellow farmers to participate in order to increase the likelihood of reaching the target.

The attributes of the contract and their levels (Table 1) were chosen with the technical help of the four local farm union-run bodies called Chambres Départementales d'Agriculture. The questionnaire was discussed with two focus groups made of winegrowers and was then partially redesigned. A pilot survey was conducted with 31 face to face interviews with winegrowers.

Table 1: Attributes and attribute levels chosen for the choice experiment

Attribute	Description	Levels
Herbicides used on the farm during the contract	Global reduction of herbicide use on the enrolled area (in proportion of present use)	Quantitative variable : -30% ; -60% ; -100%
Localized use of herbicides	Supplementary localized use of herbicides beyond the committed reduction	Dummy variable : Allowed (reference) ; Forbidden
Collective and final conditional bonus	150€/ha after five years, provided that, at the end of the 5 years, 50% of the area of interest is engaged in a process of herbicide use reduction	Dummy variable : Final bonus (150€/ha equivalent to 30 €/ha/year) ; No bonus (ref.)
Administrative and technical assistance	Free administrative and technical assistance included in the contract and provided by a local technician	Dummy variable : Yes ; No (ref.)
Individual annual payment per enrolled hectare	Payment received each year by the winegrower per enrolled hectare	Quantitative variable : 90€/ha ; 170€/ha ; 250€/ha ; 330€/ha ; 410€/ha ; 500€/ha

Two attributes concern herbicide use in the engaged plots: the first one is the overall reduction in herbicide use as a proportion of present use, and the second one introduces flexibility in the contract by allowing or not the possibility to spread locally herbicides above the contractual limit defined by the first attribute, as long as this doesn't represent more than 10% of the engaged area. This practice is common among vine growers and facilitates the control of residual weeds. If this practice were to be forbidden in the contract it would likely decrease farmers' willingness to participate in the AES. Administrative burden is frequently mentioned as an important obstacle to farmers' participation in AESs, therefore, the introduction of free administrative and technical assistance – the fourth attribute- should facilitate farmers' participation. The payment attribute is an annual and per hectare individual payment. The amounts vary between 90 and 500 €/ha/year. The present scheme for herbicide use reduction in the region proposes payments that vary from 141 €/ha for a reduction in herbicide use by 40% of the regional standard to 350 €/ha for a conversion to organic vine growing.

Finally, the main attribute of interest is the bonus. This additional payment is conditional on an overall participation rate of 50% of the local vineyard and would be paid to each participating farmer at the end of the 5 year contract. It is meant to favour higher participation rates by providing an additional incentive.

A full factorial design (all possible combinations of attribute levels) would have represented 20,592 choice cards. Thus an efficient design was selected (by an initial estimation of parameters from the responses obtained in the pilot survey) composed of 3 blocks of 6 choice cards. An example of choice card is presented in Figure 1.

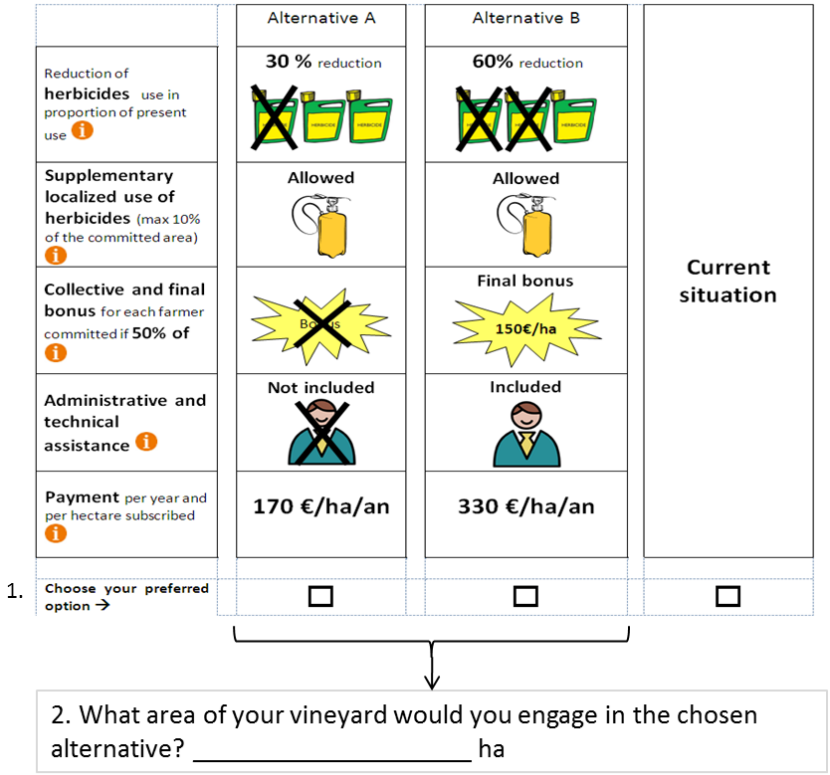

Figure 1: Example of choice card

The data were collected using an online, e-mail distributed survey sent to 3100 winegrowers in Languedoc-Roussillon with the help of the Chambres Départementales d'Agriculture of the four wine making Departments of the region (Aude, Gard, Hérault and Pyrénées-Orientales). 317 farmers answered the survey (a response rate of 10.2%), each answering to 6 successive choice cards. They also answered questions on their present herbicide use practices and on their socio-economic characteristics. Follow-up questions included a specific question on the attainability of the threshold. It was phrased as follows: "Do you believe that the 50% threshold of AES-enrolled land in your area can be reached?" It was used in our analysis as a proxy of farmers' beliefs that the bonus will be paid. 69% of our sample believed that this threshold can be reached.

Our sample is slightly biased because of the use on an on-line survey. Indeed, the comparison of the characteristics of our sample to these of Languedoc-Roussillon winegrowers (data from the French farm census 2010) shows that our sample is representative of the population who has an internet access, but not of the whole population. Women, older (more than 65 years old), lower educated winegrowers and smaller farms belonging to a cooperative winery are under-represented. We will keep in mind this sampling bias during the analysis of the results.

In all, 71 (22%) of the 317 respondents always prefer not to subscribe a contract, i.e. they choose the opt-out option in the 6 choice situations. The systematic choice of the status quo may hide protest responses, even if choice experiment methods are expected to be less prone to this bias than contingent valuation methods (Hanley et al., 2001). In order to identify potential protest respondents, we used a debriefing question. Each time a respondent selected the 'status quo'

option, he was given the opportunity to explain his decision. He could explain his rejection of the two proposed alternatives by ticking one of the following options:

- *The financial compensations are too low (1)*
- *The required level of herbicide reduction is too constraining for my farm (2)*
- *I do not want to be constrained in my farming practices, regardless of the compensation awarded (3)*
- *Other : _____*

Among the 71 farmers who always preferred not to sign a contract, 27 systematically chose the third explanation. We identify these 27 wine growers as protest respondents since they reject the contract whatever the associated financial compensation. When analysing the follow-up questions included in the survey, we noted that those respondents were significantly less convinced by the impact that such agri-environmental contract can have on water quality improvement and on the conversion of farmers to more environmentally-friendly practices (Wilcoxon Mann-Whitney tests). Therefore, as it is commonly done in the literature, we removed those 27 protest respondents from the sample (Adamowicz et al., 1998; Bario and Loureiro, 2010). Thus, the following results are obtained with a reduced sample of 290 respondents.

4. Results

First, we analyse the determinants of farmers' willingness to enrol. Second, we present the results on the decision acreage enrolment when a contract is chosen.

4.1. Analysis of participation

The Conditional Logit model gives a first estimation of the average effects of contract attributes on farmers' choice (β). This first model (see CL in Table 2) only contains the attributes of the contract as a factor of choice. The Hausman test shows that the independence of irrelevant alternatives (IIA) hypothesis is violated in our sample, making conditional logit estimators non valid. Thus, in Table 2, we also present the results of two mixed logit estimations. In both Mixed Logit (ML1 and ML2) we assume a normal distribution of the beta parameters of all the attributes except for the payment attribute, for which a lognormal distribution is specified. The first mixed logit model (ML1) only contains the attributes of the contract as a factor of choice as a comparison with the conditional logit model (CL1). In the second mixed logit model (ML2), we introduce three individual characteristics of the respondents and their farm in interaction with the Alternative Specific Constant (ASC). Farmers' characteristics can thus influence farmers' willingness to adopt an AES, rather than staying at their *status quo*. These individual characteristics need to be introduced in interaction with the ASC as they are invariant through the choices of a respondent. These characteristics are: their present use of herbicides (IFT) and the total area of their vineyard. The third farmers' characteristic included is the confidence that respondents declare to have in the possibility that the threshold can be reached. Indeed, the particularity of the collective bonus is that it is paid only if 50% of the zone of interest is enrolled in the AES. *Threshold Confidence* is coded as a dummy variable: *Threshold Confidence* = 0 if farmers believe that the threshold cannot be reached, *Threshold Confidence* = 1 if farmers believe that this threshold can be reached.

The results of the first model (CL) are significant and match our hypothesis: the more constraining the contracts are, the less attractive they are to farmers. Indeed, winegrowers as a whole are reluctant to reduce their use of herbicides and to be forbidden localized chemical weed control. Introducing a bonus or free technical and administrative assistance in the contract has a positive influence on their probability to participate in the AES. The positive value of the ASC shows that farmers prefer to choose one of the contracts proposed rather than their *status quo* (significant at a 90% confidence level). Finally, as expected, the payment influences positively the probability of choosing the contract.

Results from the first Mixed Logit (ML1) comfort these results and also reveal that preferences for all the attributes, excepted for the bonus, are heterogeneous among the farmers of our sample. This is consistent with previous work (Kuhfuss *et al.,* 2014) analysing preference heterogeneity through a latent class model. Thus, ML2 completes this analysis by showing that trusting that the threshold will be reached is an important driver of contract adoption.

Table 2 Conditional Logit model and Mixed Logit estimations

	Conditional Logit CL		Mixed Logit ML1		Mixed Logit ML2	
	N = 290		N = 290		N = 254	
Depend. Var. : Choice	β	St. error	β	St. error	β	St. error
Mean						
ASC	0.285*	0.158	3.105***	0.364	0.486	0.696
Herbicides reduction	-0.025***	0.002	-0.077***	0.007	-0.070***	0.006
Herbicides : localized use	-0.523***	0.075	-1.172***	0.139	-1.182***	0.143
Bonus	0.444***	0.074	0.648***	0.110	0.555***	0.117
Free assistance	0.174**	0.086	0.521***	0.160	0.436**	0.184
Payment	0.003***	$0.3x10^{-3}$	0.005***	<0.001	-0.005***	0.001
IFT * ASC	-	-	-	-	0.093	0.428
Threshold Confidence * ASC	-	-	-	-	3.597***	0.501
Total vineyard area * ASC	-	-	-	-	-0.004	0.008
Standard Deviation						
ASC	-	-	2.826***	0.286	1.039***	0.358
Herbicides reduction	-	-	0.069***	0.007	0.048***	0.006
Herbicides : localized use	-	-	0.719***	0.220	0.429*	0.243
Bonus	-	-	0.144	0.209	0.329	0.287
Free assistance	-	-	1.106***	0.233	1.751***	0.269
Payment	-	-	0.008***	0.002	0.007***	0.001
IFT * ASC	-	-	-	-	0.997***	0.285
Threshold Confidence * ASC	-	-	-	-	2.321***	0.339
Total vineyard area * ASC	-	-	-	-	0.014**	0.006
Number of observations	*5220*		*5220*		*4572*	
LR chi2	*382.33*		*880.22*		*578.14*	
Prob > chi2	*0.000*		*0.000*		*0.000*	
Pseudo R2	*0.100*		-		-	
Log likelihood	*-1720.42*		*-1280.31*		*-1117.05*	

Significant levels: * p<0.10, ** p<0.05, *** p<0.01

At this point, our first main result concerning the influence of collective incentives on farmers' preferences is that the introduction of the bonus does have a significant and positive influence on farmers' decision to choose an AE contract. Additionally, farmers who believe that the

threshold can be reached, *i.e.* that more than 50% of the local vineyard will be enrolled in such a contract, are more likely to participate, but the two other individual characteristics have no significant impact on farmers' decision to participate. We believe that this bonus acts like a nudge. That is, by focussing respondents' attention on the fact that others are more likely to participate, the bonus influences farmer's choices. In addition from results in Table 2, the willingness to accept[3] a contract with a final conditional bonus is 138€ less per ha and per year with ML1 (108€ with ML2) than the same contract without bonus, which is much higher than the conditional monetary value of the bonus (30 €/ha/year). Thus, the introduction of a bonus in the AES could not only increase participation, but also reduce the cost of the AES.

We now estimate the impact of this bonus, as well as the impact of the other attributes on the area that farmers are willing to enrol in the AES.

4.2. Analysis of acreage

As seen in the second step of section 3.2, each time the respondent choses one of the two contracts proposed, he had to indicate how much of his farmland (in ha) he would be willing to enrol in the chosen contract. This additional information allows us to analyse the proportion of farmland enrolled for each type of contract. The proportion of farmland enrolled might depend on farm and farmer characteristics, but here we will limit our investigation to the impact of the contract attributes. However we propose different estimation models to account for the specificities of our data.

Among the choices of the 290 farmers, 1022 alternatives other than the status quo were chosen and 971 values of areas were completed by 239 farmers (52 values are missing). On average, these farmers would enrol 79% of their farmland in the chosen contract, with a minimum value of 4.5%. Most of the time (54% of the observations) the whole vineyard would be enrolled when a contract is chosen, but it is also quite frequent that only a part of the vineyard would be enrolled ($0 < y < 1$).

We first assume that the reasons why a farmer might be willing to engage his whole farm area might be different from the reasons why he would enrol only a proportion of his farmland. Thus, we use a One Inflated Beta regression (Cook *et al.,* 2008). Its density function *g* is defined as:

$$g(y;\ \pi, \mu, \varphi) = \begin{cases} (1-\pi) f(y; \mu, \varphi), & if\ y < 1 \\ \pi, & if\ y = 1 \end{cases}$$

where *f* is a Beta distribution with parameters μ (mean) and φ (precision parameter) and π is a parameter that accounts for the probability of observations at one.

[3] The willingness to accept of farmers for each attribute (by comparison with the reference level, see table 1) can be estimated with the Conditional Logit and Mixed Logit estimators by dividing the value of the parameter estimated for the attribute by the value of the parameter for the payment attribute.

Table 3 One Inflated Beta model estimation

Depend. Var. : % of total vineyard area (*y*)		
	Coef.	St. error
Proportion (0 < y < 1) (n=443)		
Herbicides reduction	-0.005***	0.002
Herbicides : localized use	-0.066	0.083
Bonus	0.188*	0.098
Free assistance	-0.019	0.100
Payment (in k€)	0.906***	0.287
Intercept	0.067	0.174
One Inflate (y = 1) (n= 528)		
Herbicides reduction	0.007***	0.003
Herbicides : localized use	-0.285*	0.157
Bonus	0.042	0.134
Free assistance	-0.125	0.166
Payment (in k€)	0.418	0.566
Intercept	-0.194	0.298
Ln_phi Intercept	1.370***	0.126
N	*971*	

Significant levels: * p<0.10, ** p<0.05, *** p<0.01

In contrast to the results of Table 2, where all the attributes of the contract have a significant impact on the probability to enrol, Table 3 shows that not all the attributes have a significant impact on the proportion of the vineyard area enrolled. In particular, the attribute "free assistance" seems to have no significant impact on the acreage decision, but only on whether to enrol or not.

The first part of Table 3 presents the estimations on the 443 observations of partial commitment of farmers' vineyard ($0 < y < 1$). These estimations show that, as we could expect, when the contracts become more restrictive in terms of herbicides use, or when payments are lower, farmers enrol a smaller share of their vineyard. The bonus also tends to increase the proportion of vineyard enrolled (almost significant at the level of 5%, p = 0.054). We can see two explanations to this result: when the bonus is proposed, a larger area enrolled increases the chances that the threshold be reached. The second explanation is that farmers have higher expected revenue and, as seen with the sign of the payment parameter, this has a positive effect on the proportion of vineyard enrolled.

The second part of Table 3 presents the estimations on the 528 observations when farmers declare to be willing to enrol their whole vineyard (y = 1). The results are quite different from those obtained when only a proportion is enrolled. Indeed, here, the more restrictive the herbicides use reduction, the more likely farmers are to sign in their whole vineyard. This surprising result is nevertheless consistent with the fact that completely renouncing the use of herbicides requires an investment in equipment for mechanical weeding that is only worthwhile if used on the whole farm. Furthermore, we can see that if the flexibility to use herbicides in specific problem areas is not offered, farmers are less likely to engage their whole vineyard. This flexibility is therefore important to induce farmers to enrol their whole vineyard area.

Table 4 presents the results obtained with three different estimation models taking into account the potential selection bias in our acreage data (see section 3.2). In model 1, the selection

bias issue is eliminated by estimating a panel model with fixed effects. In model 2 and 3, the estimation relies on a 2-step method. As explained in section 3.2, mixed logit estimators (ML1 Table 2) are used to predict the probabilities for each contract of being selected. These probabilities are then used to control for the selection bias through 3 correction variables (*m1*, *m2*, *m3*, corresponding to the 3 independent alternatives of the choice cards) introduced in the equation of interest (acreage). As in the two parts of the OIB estimation (Table 3), the variable "free assistance" does not have any significant impact on acreage in model 1. This is consistent with the idea that free assistance reduces fixed costs of participation (*e.g.* administrative burden of and learning alternative weeding practices) which do not vary with the acreage enrolled. This result enables us to use this attribute as an instrumental variable in the selection equation and thus to remove it from the equation of interest in model 2 and in model 3. Model 3 takes also into account the panel structure of our data.

Table 4: Estimations accounting for a potential selection bias

Acreage (% of total vineyard)	(1) Panel regression with fixed effects		(2) OLS regression + bias correction		(3) Panel regression with random effects + bias correction	
	α	St. error	α, μ_k	Bootstrap St. error	α, μ_k	Bootstrap St. error
Herbicides reduction	- 0.001***	$0.2x10^{-3}$	- 0.002*	0.001	- 0.001	0.001
Herbicides : localized use	- 0.007	0.009	- 0.096***	0.034	- 0.027	0.019
Bonus	0.006	0.009	0.058**	0.027	0.022**	0.013
Free assistance	$0.3x10^{-3}$	0.011				
Payment	$0.1x10^{-3}$**	$0.03x10^{-3}$	$0.3x10^{-3}$***	$0.1x10^{-3}$	$0.1x10^{-3}$**	$0.1x10^{-3}$
_m1			0.070	0.069	0.051	0.031
_m2			-0.035	0.176	0.028	0.053
_m3			-0.372	0.248	0.021	0.109
_cons	0.795***	0.017	0.501***	0.176	0.751***	0.074
N	971		971		971	

Significant levels: * p<0.10, ** p<0.05, *** p<0.01

The results of Table 4 show that a stronger reduction in herbicides would significantly decrease the proportion of farmland enrolled only in model 1. The lack of robustness of this attribute on the acreage enrolled probably comes from the fact that farmers tend to commit their whole vineyard when the reduction in herbicides is very high and requires large investments (see Table 3). All the model estimations confirm that the payment would have a significant positive effect on the acreage. However, forbidding localized use of herbicide has a negative significant impact on acreage only in model 2. The bonus has a significant positive effect on enrolled acreage (at 5% in model 2 and model 3 but not in model 1). This result is important since not only does the bonus have a significant, positive impact on participation and would thus lead new farmers to enter the AES, but it also encourages participants to increase their commitment in enrolling a larger proportion of their vineyard. These results comfort our intuition/hypothesis that the introduction of a collective performance dimension in AES such as this conditional bonus can efficiently increase the total area enrolled. Finally, we can highlight that the estimated coefficients for the correction parameters are

not significantly different from zero, thus indicating that the selection bias is not a big issue in this data.

5. Conclusion

One of the policy questions addressed in the wake of the recent CAP reform is to find ways of promoting a wider and more effective participation of farmers in agri-environmental schemes without increasing budgetary expenditures. Results obtained in our choice experiment conducted with winegrowers in Languedoc Roussillon show that the introduction of a collective dimension to agri-environmental contracts could effectively enhance such scheme's efficiency in three ways. First, it would enhance farmers' initial participation. Indeed, our conditional bonus attribute is highly significant in explaining the enrolment of respondents into an agri-environmental contract. In addition, the negative willingness to accept for this bonus means that the payment for a contract can be lowered by this amount if a relatively small bonus is included. Therefore, even if a bonus has to be paid to each farmer who has signed a contract (because the threshold has been reached), the cost of the scheme per hectare is reduced. Finally, we have found that the collective bonus does encourage farmers to enrol a larger share of their vineyard in the scheme.

The main contribution here, compared to the analysis conducted in Kuhfuss *et al.* (2014) which focuses on the heterogeneity of the farmers' preferences, is the analysis of the acreage enrolment decision. This new variable leaded us to consider two steps decision econometric models: first the decision to participate or not in AES, and second the choice of the acreage to enrol when a contract is selected. Nevertheless, the acreage data collected in this choice experiment present several specificities. First, we had panel data since each respondent faces 6 choice cards. Second, we had to take into account a potential selection bias since we observe the acreage variable only if a contract is chosen. Third, the selection equation could not rely on a probit model but had to be specified as a conditional or mixed logit model. Indeed, the respondents had first to choose an alternative among two hypothetical contracts and a status quo.

Beyond the impact of the bonus on the participation rate and acreage enrolment, our study contributes to the analysis of farmers' behaviour towards collective dimensions of herbicides reduction contracts for local water quality. Respondents value the inclusion of the collective bonus option in the contract (from 108 to 138€/ha/year) more than its financial magnitude (30€/ha/year). This is consistent with the hypothesis that farmers are more willing to provide environmental efforts when their neighbours also do so. One interpretation is that farmers want to make sure that their efforts do have a significant impact on water quality, an impact that cannot be reached unless most famers also participate. Another interpretation is their willingness to choose the practice which is used by most of their neighbours. This collective bonus appears as a tool that could encourage the emergence of a new social norm influencing winegrowers' behaviour towards pro-environmental practices. It is also encouraging to note that although we thought that a payment threshold of 50% being enrolled of the area was quite challenging, a majority of respondents (69%) believed that this threshold could be reached. Moreover, our mixed logit results show that, in contrast to all the other attributes included in this choice experiment, the preferences for the bonus appear quite homogenous among the farmers of our sample. On the whole, contracts with the conditional bonus incite the winegrowers to enter the AES.

To conclude, we think that the CAP policy might benefit from implementing new contract designs which include collective dimensions.

Acknowledgement: The authors are particularly grateful to Jean-Marc Rousselle (UMR Lameta, INRA Montpellier) who published the online version of the questionnaire. We also would like to thank the « Chambres Départementales d'Agriculture » of the Aude, Gard, Hérault and Pyrénées-Orientales counties. This survey was funded by the ONEMA in the framework of the 2011 call for research projects « Changer les pratiques agricoles pour préserver les services écosystémiques », supporting the implementation of the French National Action plan Ecophyto 2018.

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