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CEE-M

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Abstract

One of the factors that discourages farmers from enrolling in agro-environmental schemes (AES) is the uncertainty of the costs and benefits associated with the adoption of the new practices. In this study, we distinguish between the "internal uncertainty" that is related to the characteristics of the farmer and his/her parcels and "external uncertainty", which is related to the occurrence of external events. We propose three innovations to better account for uncertainty in AES design and test their attractiveness through a choice experiment. We find that proposing contracts that allow suspending the conditions of the contract for one year enhances participation.

Keywords: Agri-environmental Measures; Uncertainty; Flexibility; Choice Experiment; Herbicides; Cover Crops; Winegrowing

JEL codes: Q12 Micro Analysis of Farm Firms, Farm Households, and Farm Input Markets; Q18 Agricultural Policy, Food Policy; D8 Information, Knowledge, and Uncertainty;

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Abbreviations

AES: Agri-Environmental Schemes

ASC: Alternative Specific Constant

CE: Choice Experiment

WTA: Willingness To Accept

1 Introduction

Reduced greenhouse gas emissions, a decrease in pesticide and fertilizer use, and biodiversity conservation pose colossal challenges for today's agriculture. Policymakers often attempt to trigger the adoption of new sustainable practices through voluntary contracts called agri-environmental schemes (AES). Regrettably, evidence collected both in Europe (Hanley et al., 1999; Cullen et al., 2018) and the US (Yang et al., 2005) suggests that farmers are reluctant to participate in these programs. As recently highlighted by Chèze et al. (2020) and Lefebvre et al. (2020), one of the factors that discourages farmers from enrolling in AES is the uncertainty of the costs and benefits associated with the adoption of the new practices.[1] In this paper, we distinguish between what we call "internal uncertainty", which is related to the characteristics of the farmer and his or her parcels, and "external uncertainty", which is related to the occurrence of external events (e.g., random shocks such as weather shocks).[2]

Even if some general benchmarks exist, future costs and benefits of new practices are imperfectly known because they depend on the farmers' ability to acquire new skills and adapt the new practices to the local context ("internal uncertainty"). When making the decision to enroll in AES, the farmer possesses incomplete information regarding future costs and benefits, and additional information is only revealed after enrollment. Furthermore, as shown by the literature on option values (Hanemann, 1989; Dixit and Pindyck, 1994), uncertainty is even more problematic when the decision to enroll in the program is irreversible. In the case of AES, irreversibility comes from several sources. First, AES contracts under the CAP are generally five-years long and it is costly to break them (the farmer has to reimburse all payments received from year one). Second, adopting a new practice can entail investment in machinery and changes in the cropping system that would

1. The literature in economics usually divides uncertainty into "risks", for which probabilities of the events are known, and "Knightian uncertainty", also called ambiguity. Ambiguity characterizes situation in which probabilities of the events are unknown to the decision makers (Ellsberg, 1961). In this paper, we use the general term "uncertainty" as it encompasses both types and in practice exact probabilities are not known.

2. Several classifications already exist in the literature. Lefebvre et al. (2020) for instance consider the distinction between foreground and background risk. The background risk can be defined as the uncertainty that cannot be avoided by the agents or insured (Eeckhoudt et al., 1996; Guiso and Paiella, 2008) and the foreground risk refers to the risks that are specifically linked to the AES commitment. In this paper we needed to distinguish between two kinds of uncertainty to which the farmer is exposed when committing to an AES. The same problem arose when looking at the concepts of inherent risks defined as "*the component of environmental uncertainty which derives from the stochastic nature of an ecosystem's behavior*" (Torres et al., 2017) or non-embedded risks defined as the risks beyond the control of the farmers (Dorward, 1999; Ridier et al., 2016). In both concepts, the risk is defined as a part of uncertainty that cannot be reduced or controlled for. For this reason, we choose to offer a new distinction between internal and external uncertainty.

make it costly to go back to former practices. Given the uncertainty associated with an irreversible commitment, farmers are expected to demand for a compensation not only for the foregone income due to a change in practices but also for an uncertainty premium related to the lack of information regarding the future costs and benefits associated with enrollment.

Moreover, the adoption of environmentally-friendly practices can increase exposure to weather shocks and increase yield variability as shown in the case of organic farming (Knapp and van der Heijden, 2018). To take another example, reduced herbicide use increases the risk of weeds competing with the grapevines for water in the case of droughts (Winter et al., 2018). Risk-averse farmers would thus likely enroll only if AES payments covered, not only the foregone income due to the change in practices, but also a risk premium to compensate for the "external uncertainty" linked to future weather shocks.

The appropriate management tool to help farmers cope with uncertainty differs according to the type of uncertainty present. In the case of internal uncertainty, the farmer is missing some relevant information to choose between enrolling and not enrolling. After a few years of enrollment, part of missing information is revealed as the farmer experiments the new practice. The lack of information and the irreversibility of the contract over the five years are crucial elements of uncertainty that affect a farmer's decision of whether or not to enroll in AES. On the other hand, the farmer's external uncertainty is not lessened after enrollment since the probability of weather shocks remains the same but the farmer may suffer larger losses if a shock occurs. In that case, the farmer needs risk management tools to deal with such random shocks. We propose three innovations to deal with these two sources of uncertainty.

First, we propose including an opt-out option in the contract after three years to deal with internal uncertainty. Indeed, this uncertainty will be significantly reduced after a few years of enrollment as the farmer acquires the relevant information regarding the costs and benefits of the implementation of the new practices on his own parcels using his own skills. In the presence of an opt-out option, the irreversibility of the commitment only concerns the first three years of the contract. In other words, we propose a five-year contract with a three-year break clause. Therefore, the farmer is free to end the contract after three years if he observes that the actual costs and benefits make the practices unprofitable. If the practices prove beneficial, the farmer can then choose to continue the contract for another two years.

Second, we propose introducing the possibility for the farmer to suspend the conditions of the contract for one year (of his choice) out of five and still receive the payment for the full five years. We call this option the "wild-card" option in our survey. We hypothesize that this option provides the farmer a risk-management tool if an exogenous random shock, such as a drought, occurs. Indeed, the farmer can freely choose one year out of five, during which he would rather not fulfill the AES stipulations. Thus, the "wild-card" option should decrease the premium associated with uncertainty. In our setting, the farmer still receives the payment if he uses the "wild-card" year for two reasons. First, for local stakeholders, suspending the payments seemed administratively tricky. Second, stable payments can decrease absolute risk aversion and encourage more risk taking in the adoption of new practices. For these reasons, we propose a contract with five years of payments for only four years of actual commitment.

Third, we propose including the opportunity for farmers to share their experience in peer-groups. Peer-sharing can theoretically reduce the premium associated with both sources of uncertainty. It favors the diffusion of knowledge and skills to cope with the terms of the AES. It also provides information about how to cope with a random shock in order to improve the crop resilience.

These three innovations are tested on winegrowers in the South of France though a choice experiment (CE). The contracts proposed were designed with local stakeholders in order to address real-life conditions and the potential interest of farmers, and thus decrease the hypothetical bias inherent to choice experiments. Targeted practices are the reduction of herbicide use, to improve water quality, and the adoption of cover crops, which helps prevent soil erosion. Both practices also have positive effects on biodiversity conservation.

Our results on a sample of 172 farmers suggest that among the three innovations tested only the wild-card option significantly increases AES attractiveness. The amount that farmers are willing to forgo for an AES including the wild-card are superior to 20% of the total amounts of the payments. This suggests that the attractiveness of this innovation is not only related to the savings of extra costs that would be supported by the farmers to meet the conditions of a standard 5-years AES. We attribute this result to the fact that this option allows winegrowers to better deal with random shocks such as droughts. Section 2 reviews the literature regarding AES and uncertainty and innovations that have already been tested using CE. Section 3 introduces our methodology. Section 4 presents our results and Section 5 concludes.

2 Literature

2.1 AES and uncertainty

The literature on agri-environmental schemes has considered risk and uncertainty issues related to the implementation of conservation practices.[3] A large part of the literature, dominant in 2000's, considers the issue of risk with respect to asymmetric information (moral hazard and adverse selection), compliance and monitoring (Choe and Fraser, 1999; Ozanne et al., 2001; Fraser, 2002, 2004; Ozanne and White, 2007, 2008; Yano and Blandford, 2009, 2011). Other articles tend to show that AES have been used as a risk management tool by risk-averse farmers when uncertain production (e.g. price volatility) is managed though subsidized production with lower but risk-free revenues (Vollenweider et al., 2011; Lastra-Bravo et al., 2015; Arata et al., 2017).

Finally, some articles deal with the impact of risks associated with AES on the adoption of AES itself. Our article fits into this strand of the literature. Mante and Gerowitt (2009) collect data and seek to analyze participation of 865 arable farmers in an AES for field margins in Germany. They find that the risk of weed spreading is a major fear for farmers. Thus, the conditions of field margin implementation and management in AES contracts constitute strong determinants of participation. Wossink and Van Wenum (2003) conduct a contingent valuation on the adoption of a field margin conservation program via reduced chemical spraying and fertilizing on a sample of 250 arable farmers in the Netherlands and show that the perceived risk of field margins causing more weed problems on the farm decrease both participation and the intensity of participation. As shown by Doerschner and Musshoff (2013) in a simulation exercise, risks associated with AES practices should be taken into account in the design of AES.

2.2 Innovation design in AES to cope with uncertainties

The literature on attractiveness of AES and policy innovations mainly relies on choice experiments (Mamine et al., 2020). A few studies focus on offering greater flexibility in AES contracts,

3. There is a literature on the adoption of a variety of environmentally-friendly practices and the role of risk and risk attitudes. However we focus here on AES as a policy tool and not on individual practices.

either by proposing shorter contracts or by offering opt-out options. Seven studies suggest that the duration of the contract negatively impacts the attractiveness of agri-environmental contracts. In Denmark, Christensen et al. (2011) found that, in the context of pesticide-free buffer zones, farmers needed to be paid 128 € more per ha per year to accept a five-year contract rather than a one-year contract. Their study also reveals a strong preference for the option to break the contract (137 € per ha per year). A recent paper regarding a contract for carbon sequestration offered to US farmers finds similar results (Gramig and Widmar, 2018). Results regarding the length of the contract or opt-out options have also been highlighted in the context of biofuel production (Krah et al., 2018) and of forest management, which often involves longer contracts of 10 to 20 years (Klosowski et al., 2001; Horne, 2006; Broch and Vedel, 2010, 2012). In a way our study combines both shorter contracts and the opt-out option, by providing the possibility of renewing the contract for two years at the end of the first three years.

To our knowledge, only one study has explored how the possibility of suspending the contract for one year can impact the attractiveness of AES. In a choice experiment dedicated to the analysis of the preferences of Australian pastoralists for biodiversity contracts, Greiner (2015) introduced the possibility for the farmer to negotiate a one-year suspension but only under exceptional circumstances. Her result suggests a strong preference of the farmers for this option. Our study differs from Greiner (2015), as the possibility of suspending the contract does not depend on exceptional circumstances and does not imply the suspension of the payment.

A number of recent papers have provided evidence that extension policies that seek to promote new technologies in developing countries could be improved by leveraging the power of peer influence, since farmers share personal information and feedback with each other (Beaman and Dillon, 2018; BenYishay and Mobarak, 2019; Nakano et al., 2018). Surprisingly, while many choice experiments have tested how the provision of technical assistance by extension services could improve enrollment in AES (Mamine et al., 2020), to our knowledge, none of them have proposed combining technical assistance with peer-sharing.[4] Among others, Espinosa-Goded et al. (2010), Christensen et al. (2011) or Blazy et al. (2021) found that farmers agree to be paid less if free technical assistance is provided by extension services. Kuhfuss et al. (2016), in a study also targeting winegrowers

4. Several experimental networks in Europe propose combining peer sharing and technical assistance to help selected farmers to adopt green practices: DEPHY in France, LEAK in the UK, PESTIRED in Switzerland and GROEN in the Netherlands. Although it includes the same component, our policy innovation differs as we propose forming groups of farmers that can benefit from a few days of technical assistance a year, while in the aforementioned networks, the extension service worker can dedicate half his annual working time to working with the selected farms.

in the South of France, did not find a significant impact of technical assistance provision on the enrollment in an AES dedicated to pesticide reduction. However, our study differs from Kuhfuss et al. (2016) as we propose a new form of technical assistance based on peer-learning.

3 Survey framework

In this study, we test the attractiveness of innovative AES design to cope with uncertainties. We test the potential of these innovations in the context of a contract for herbicide use reduction and cover cropping in the French Mediterranean area. More specifically, we focus on the Languedoc-Roussillon wine growing region where about half of the cropland is dedicated to vineyards.

3.1 Weed management and cover crops

Historically, weeds have been an issue in agriculture because they exert pressure on resources (water, nitrogen, light) and produce a lot of seeds that perpetuate their growth. Weeds can potentially cause severe crop yield losses when not sufficiently controlled (Oerke, 2006; Storkey and Cussans, 2007; Tesic et al., 2007). Yet recent studies show that management options exist and that the impact of weeds on yields can be quite negligible, which sheds light on the advantages of cover cropping and has begun to bring into question the use of herbicides (Gaba et al., 2020, 2016; Petit et al., 2015). Weeds provide habitat and resources: pollen for pollinators, seeds for birds and insects, and leaves for herbivores. Hence, it is important to reconsider how weeds are managed, not by systematically eliminating them, but rather by managing them to maintain both yields and biodiversity. In their meta-analysis, Winter et al. (2018) even show that, in comparison to intensive vegetation management (soil tillage, herbicide use), extensive vegetation management (vegetation cover, organic cropping system...) can favor various ecosystem services such as carbon sequestration, pest control and soil fertility.

Cover cropping can be spontaneous or crops can be sown. The cover can be permanent or temporary, in the row (the strip under the vine) and/or in the inter-row (the alleys) of the vineyard plot. Natural grass is usually preferred to sown crops since it is comparatively cheaper and easier to implement. Yet some plant species can have a positive impact on vines (better nitrogen fixation, lower water demand, pest repellent), which could motivate farmers to switch to sown crops. However, sowing crops is new to most winegrowers and the choice of seeds can be complex. The issue of cover crop destruction, using tillage or herbicides, and the date and extent of destruction also involve complex choices that impact ecosystem services production and yields (Tesic et al., 2007; Winter et al., 2018). Winegrowers need to experiment with different strategies for adapting and taking full advantage of their cover crops.

In order to avoid water competition in arid conditions, bare soil is the most common option in the vineyards of our study area (Celette and Gary, 2013). To be more specific, as shown by Fernández-Mena et al. (2021), for the area of our case study, most farmers keep a cover during the winter season but destroy it after the grapevine bud busrt in March. However, over the long-run, cover cropping could improve soil quality and prevent soil erosion in a region marked by floods and droughts fueled by climate change. Therefore, the challenges for local stakeholders are to increase the number of inter-rows covered, delay the destruction of the cover until grapevine flowering in May, and avoid herbicide use.

3.2 Focus groups

We conducted six focus groups with local stakeholders, including winegrowers, extension services staffs, farmer associations, and farm-union bodies. The objective was, first, to identify the constraints associated with herbicide use reduction and cover cropping, and second, to discuss how innovative AES design could improve the adoption of these practices.

Farmers and other stakeholders specifically emphasized that herbicide reduction and cover cropping may cause substantial yield losses through water stress, especially as droughts become more frequent with climate change. The "wild-card" option, that is, the possibility to suspend the commitments one year out of five, emerged as a relevant solution to overcome this constraint.

In relation with cover-cropping, winegrowers emphasized a need to experiment with different strategies for adapting and taking full advantage of their cover crops. They stressed that the impact on yields of cover cropping is uncertain and that, if the cover is not adapted to local conditions, it can induce considerable reductions in yields. Experimentation was described as requiring flexibility and learning opportunities. Winegrowers would need to learn more about new practices and would prefer enrolling over shorter period in order to acquire the relevant information. This was the basis for the inclusion of an opt-out option in our survey.

Some farmers also mentioned the importance of feedback from peers and suggested the development of peer-learning goups. In contrast, other farmers considered peer groups as a time-consuming constraint. For this reason, we test in our survey how an innovative form of technical assistance based on peer-learning can impact the acceptability of AES.

3.3 Attribute levels

In order to analyze the potential of our innovation for AES's attractiveness, we use a choice experiment (CE) survey. A CE is a stated-preference method used to assess individual *ex ante* preferences in hypothetical situations (Louviere, 2001). In particular, this method allows researchers to quantify preferences for different attributes of a good and is widely used to study farmer preferences regarding the contractual elements of AES (see Villanueva et al. 2017, Latacz-Lohmann and Breustedt 2019 and Mamine et al. 2020 for reviews).

In CE, farmers are given a series of choice cards, on each of which they are asked to choose between various alternatives, usually two different hypothetical contracts and the status quo (i.e., their current situation). Each hypothetical contract is a package of attributes (e.g. contract payment, technical constraints, etc.) and each attribute offers different levels which vary between alternatives. The analysis of the contract choices provides information on how the relative levels of the attributes influence these choices, and the payments associated with the contracts allow us to estimate the willingness to accept (WTA) for each level of the attributes.

The attributes and their levels (Table 1) were adjusted in focus groups and through a pilot study.[5] Some characteristics are common to all of the proposed contracts: farmers have to use cover crops at the headlands (field boundaries) throughout the year and in every inter-row during winter time (from harvest until grapevine bud burst) on the enrolled acreage. These prerequisites were identified as acceptable by all the winegrowers present at the focus groups. The hypothetical contracts vary according to five attributes. Two attributes relate to the three AES innovations designed to manage uncertainty; two attributes concern the stringency of farming practices (herbicide use and cover crops); and one attribute outlines the payment levels.

The first attribute of interest for this study is *commitment flexibility* with three levels. Proposed contracts can last five years (no flexibility), or three years with an optional contract extension of

5. As explained above, we conducted six focus groups with local stakeholders including winegrowers, extension services staffs, farmer associations, and farm-union bodies. We also conduct five face to face pilot surveys with winegrowers.

two years, or five years with a "wild card" of one year, meaning that farmers are paid five years but are allowed not to fulfill the terms of the chosen contract during one year (of their choice). We expect both flexibility levels to increase the attractiveness of the contracts as they decrease the premium linked to uncertainty related to AES enrollment. The opt-out option allows the farmer to gather information before making a longer term commitment, and thus helps to buffer internal uncertainty. The "wild card" option provides a risk-management tool if a random shock should occur, and thus helps to mitigate external uncertainty.

Our second attribute of interest is the *peer-learning group*. Our hypothetical contracts can provide farmers with peer interaction and free collective technical assistance. Specifically, farmers have the possibility to share their experience within a group of four to eight winegrowers supported by a facilitator and, once a year, by an expert (in agronomy, in communication etc, depending on the group's needs). A peer learning group can theoretically help farmers to deal with both sources of uncertainty.

The other attributes include the *inter-row cover* which is the minimum number of inter-rows covered from grapevine bud burst until flowering on the enrolled acreage. Proposed contracts can require farmers to use cover crops on at least one of every three inter-rows, one of every two inter-rows, every inter-row, or none of the inter-rows (i.e., destroying the soil cover at the bud burst). We expect additional inter-row cover requirements to decrease farmers' willingness to participate in contracts.

Herbicide use on the enrolled acreage can be allowed, limited or banned. The constraint is partial when herbicide use is limited, allowing farmers to apply herbicides in the row only. Indeed, weed management is especially challenging in the wine row. Alternative practices to herbicides being more costly, we expect that the propensity of farmers to choose a contract will decrease as the constraint on herbicide use increases as in Kuhfuss et al. (2016).

Lastly, our monetary attribute is the annual *payment* per hectare which varies from 100 € to 600 €. The amounts were chosen based on actual AES payments offered for vineyards in the studied region [6] and following the study of Jacquet et al. (2019) on the costs of alternatives to glyphosate. The upper limit of these amounts enables us to assess the willingness to accept (WTA) of the most

6. Eliminate all herbicide use (EU PHYTO_02), 236 € ; eliminate herbicide use in the inter-rows (EU PHYTO_10), 110 € ; and maintain a permanent and sown inter-row cover (EU COUVER11), 110 €.

reluctant farmers. A higher payment is expected to have a positive effect on a farmer's propensity to subscribe to contracts.

Table 1: Attributes and levels presented in hypothetical contracts

Attribute	Description	Levels
Commitment flexibility	Flexibility in contract length and in compliance with terms	5 years 3 years + 2 optional years 5 years incl. 1 "wild-card" year
Inter-row cover	Minimum number of inter-rows covered from grapevine bud burst until grapevine flowering	None 1 every 3 inter-rows 1 every 2 inter-rows All inter-rows
Herbicide use	Constraint on herbicide use	Allowed Allowed in the row only Banned
Peer-learning group	Opportunity to share experiences within a peer group supported by a facilitator and occasionally by technical advisers	Not included Included
Payment	Payment received by the farmer each year per enrolled hectare	100 €, 150 €, 250 €, 350 €, 450 €, 600 €

To understand how the relative levels of the attributes influence the choice of contracts, we combine these levels in alternatives that constitute different contracts and then gather alternatives in pairs to form choice cards (as illustrated in Figure 1). The full factorial design of the CE, namely the number of unique choice cards that can be constructed from the selected number of attributes and levels, includes 186,192 choice cards. Using the Ngene software package (ChoiceMetrics, 2018), we selected an efficient design composed of 12 choice cards split into two blocks of six choice cards (each respondent being randomly assigned to one of the two blocks). [7]

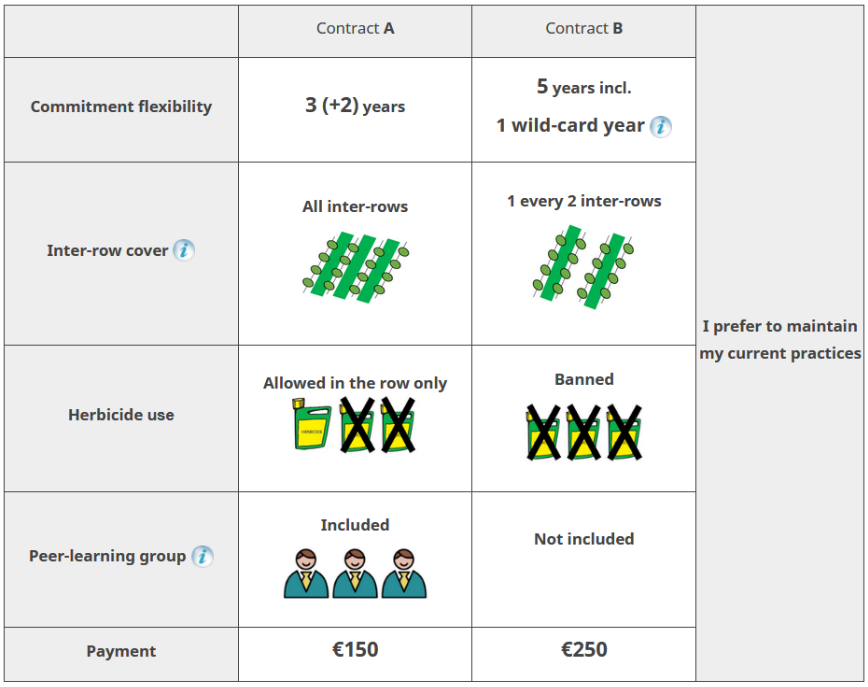
We added a status quo option to each choice card, which states "I prefer to keep my current practices". Note that current agricultural practices may vary from one winegrower to another and,

7. Efficient design has been deduced based upon "priors". The reasonableness of the design priors has been determined using information obtained from previous work, focus groups and pilot interviews. We have selected optimal efficient design by minimizing the D-error, the most commonly used measure of efficiency in experimental design practice.

if farmers choose to keep their current practices then the status quo should be defined according to individual current practices in order to take into account the fact that some farmers have already adopted these practices and are likely to maintain them. However, there is no *a priori* straightforward way to code the status-quo for the attribute regarding commitment flexibility. We chose to code the status-quo as a five year contract in order to capture how our two innovations modify the WTA compared to a standard five-year AES contract, but we test the robustness of our results to alternative coding.

Regarding the level of other attributes, our survey gives us information about herbicide use in the inter-row, but not in the row. Therefore, we assume that among the winegrowers who do not use herbicides in the inter-row, only organic winegrowers do not use herbicides in the row. Similarly, we have relevant information regarding the use of cover crops, but not for the number of inter-rows covered. Since we do not have such a precise level of information about farmers' cover practices, we decided to merge the two intermediate levels (one every three inter-rows and one every two inter-rows) into a single level called partial inter-row cover cropping. Then, from the attribute inter-row cover cropping, we create two variables: "Partial inter-row cover cropping" and "Cover crops on all inter-rows". If the farmer chooses the status-quo and uses cover crops, the variable "Partial inter-row cover cropping" is equal to one and the variable "Cover crops on all inter-rows" is equal to zero.

Figure 1: Example of choice card



3.4 Choice Modelling

The CE approach is in line with Lancaster's theory of consumer choice (Lancaster, 1966) and the econometric modeling is based on the behavioral framework of random utility theory (McFadden, 1974). It is assumed that a farmer chooses a contract if the net utility from that contract is greater than either the other contract or the farmer's current situation. The utility that farmer n obtains from alternative i in choice card t can be written as:

$$U_{nit} = V_{nit} + \varepsilon_{nit} = V(X_{nit}) + \varepsilon_{nit}. \tag{1}$$

where X_{nit} refers to the vector of the levels of the attributes. U_{nit} is composed of both an observed component V_{nit}, the deterministic part of the utility and a random unobserved component ε_{nit}, a stochastic error term.

The probability that a farmer will make a particular choice is assumed to increase as the utility of that choice increases. The probability that farmer n will choose alternative i over J alternatives j contained on choice card t can therefore be expressed as:

$$P_{nit} = \frac{exp(\beta_n X_{nit})}{\sum_j^J exp(\beta_n X_{njt})} \tag{2}$$

β_n is a vector of preference parameters, representing the average "weight" of each attribute level of the contract on farmers' preferences. We estimate coefficients β_n using mixed-logit models which allow parameters to vary randomly across individuals, providing a continuous distribution of preferences (Boxall and Adamowicz, 2002). Thus, the model allows for the fact that different individuals may have different preferences. We also provide results using conditional logit model as a benchmark.

We include in X_{nit} an Alternative Specific Constant (ASC) equals to one for the status quo alternative of not entering into any of the proposed contracts. X_{nit} also includes a continuous variable for the amount of payments received for each alternative. For the other attributes, we include one dummy variable for each level of the attribute described in Table 1 except one. This excluded level per attribute represents the reference level for each attribute.

The average marginal WTA for each attribute level can be obtained is given by:

$$WTA_x = \frac{-\beta_x}{\beta_{payment}}, \tag{3}$$

where β_x and $\beta_{payment}$ are respectively the estimated coefficients associated with attribute level x and the monetary attribute. WTA_x is the average annual payment per ha required by the farmer to accept the change implied by an increase by one unit of the attribute level x compared to the reference level of the attribute.

4 Results

4.1 Descriptive statistics

We conducted an online survey that was sent out by our field partners to winegrowers in Languedoc-Roussillon in the spring of 2020. We collected the answers of 172 farmers (a response rate of about 10%), each completing six choice cards. Once protest answers have been dropped, we end up with 165 usable responses, equivalent to 2,970 observations (165 farmers x six choice cards x three alternatives).[8] Responses per block of choice cards are relatively balanced (47% for the first block, 53% for the second block). The quality of the data is good: the average reading time for the description of the attributes is more than one and a half minutes and the farmers' reported degree of certainty in their choices is quite high (average rating: 7.6/10).

Descriptive statistics of usable answers are presented in Table 2. Wine growing is the principal activity for about 89% of the sample and the average land size is around 36 ha and an average of 72% in of the farmers own their land. Almost 30% are engaged in organic farming and more than 20% are members of an Economic and Environmental Interest Group (EEIG), a group of farmers working together to adopt environmentally-friendly practices, suggesting self-selection of farmers already engaged in the agri-environmental transition. A high percentage (68%) of the farmers are also past or current participants of AES, reflecting a certain awareness and concern with regard to environmental issues on the part of respondents. It also indicates that most of the farmers in the sample are familiar with the contracts presented in the choice experiment, thus ensuring a good level of confidence concerning the reliability of responses. We expected that more farmers with experience in cover cropping and herbicide use reduction would respond than others. Indeed, 68% of the respondents use cover crops and 60% do not use herbicides in the inter-rows. Among those who use cover crops, about 61% destroy the cover before the grapevine flowering (including a vast majority that destroy the cover around the grapevine bud burst). Note that these percentages are in line with the results by Fernández-Mena et al. (2021) who analyzed the management of cover crops in our study area.

8. Among our 172 respondents, 21 (13%) always choose the status-quo, which may hide protest answers. In order to identify these latter, we ask farmers to explain their choice each time they choose the status-quo. If respondents always choose the status-quo and always explain that it was because they "refuse to be constrained on [their] practices whatever the monetary compensation", they are considered as protest respondents and removed from the sample (7 individuals out of the 172 respondents that is 4% of the sample), while the other explanations include "the constraints on practices are too heavy" and "the payments are too low".

Table 2: Summary statistics: Sample

Variable	Description	Obs.	Mean	Std. Dev.
Farmer-level characteristics				
Gender	1 = male, 0 = female	165	0.83	-
Age				
18-34 years old	1 = yes, 0 = no	165	0.12	-
35-44 years old	1 = yes, 0 = no	165	0.29	-
45-54 years old	1 = yes, 0 = no	165	0.31	-
55-64 years old	1 = yes, 0 = no	165	0.24	-
Over 65 years old	1 = yes, 0 = no	165	0.04	
Education				
No degree	1 = yes, 0 = no	165	0.02	-
Primary level	1 = yes, 0 = no	165	0.01	-
Secondary level	1 = yes, 0 = no	165	0.16	-
Upper secondary level	1 = yes, 0 = no	165	0.26	-
Undergraduate level	1 = yes, 0 = no	165	0.33	-
Graduate level	1 = yes, 0 = no	165	0.22	-
Farm-level characteristics				
Land size (LS)	Hectares	164*	36.37	43.30
Ownership	Share of land	165	71.39	36.23
Agricultural status				
Single household unincorporated farm	1 = yes, 0 = no	165	0.57	-
Jointly run farm	1 = yes, 0 = no	165	0.08	-
Private limited farming company	1 = yes, 0 = no	165	0.19	-
Other	1 = yes, 0 = no	165	0.16	-
Secondary activities				
Cereal crops	1 = yes, 0 = no	165	0.09	-
Vineyards	1 = yes, 0 = no	165	0.09	-
Market garden	1 = yes, 0 = no	165	0.02	-
Arboriculture	1 = yes, 0 = no	165	0.13	-
Livestock	1 = yes, 0 = no	165	0.02	-
No secondary activity	1 = yes, 0 = no	165	0.65	
Vinification				
In cooperative cellar	1 = yes, 0 = no	161	0.66	-
In private cellar	1 = yes, 0 = no	161	0.24	-
Both	1 = yes, 0 = no	161	0.09	-
Production under PDO	1 = yes, 0 = no	165	0.68	-
Organic farming	1 = yes, 0 = no	165	0.29	-
AES	1 = yes, 0 = no	165	0.68	-
EEIG	1 = yes, 0 = no	165	0.21	-
DEPHY	1 = yes, 0 = no	165	0.08	-
Current farming practices				
Inter-row cover cropping	1 = yes, 0 = no	162	0.68	-
Temporary cover	1 = yes, 0 = permanent cover	110	0.62	-
Weeding before June	1 = yes, 0 = no	68	0.99	-
Inter-row herbicides use	1 = yes, 0 = no	162	0.14	-
Technical assistance	1 = yes, 0 = no	162	0.49	-

*We excluded an outlier farmer who reported a land size of 1,650 hectares.

Follow-up questions allow us to explain the behavior of the farmers in the choice experiment task (see Table 3). Farmers report that the most important attribute in the contracts, on average, is the payment, followed by the herbicide use, and then the inter-row cover. About a third of our sample considered that commitment flexibility was important or very important in their choices. The greatest declared obstacles to implementing cover crops are first water stress, then yield loss, and lastly investment in machinery.

Table 3: Summary statistics: Follow-up questions

Variable	Unit	Obs.	Mean	Std. Dev.
Strongest barrier to cover cropping (N=151)				
Water stress	1 = yes, 0 = no	151	47.68	-
Nutrient competition	1 = yes, 0 = no	151	7.95	-
Yield loss	1 = yes, 0 = no	151	15.23	-
Unsuitable soil features	1 = yes, 0 = no	151	1.99	-
Unsuitable age of vines	1 = yes, 0 = no	151	1.99	-
Lack of workforce	1 = yes, 0 = no	151	7.28	-
Investment in machinery	1 = yes, 0 = no	151	15.89	-
Lack of information	1 = yes, 0 = no	151	1.99	-
*Confidence in contract choice*s	1 = not sure at all to 10 = very confident	152	7.58	2.05
Influence of attributes on choices				
Commitment flexibility	% considering this attribute as important or very important	151	31.79	-
Cover cropping	% considering this attribute as important or very important	150	54.00	-
Herbicide use	% considering this attribute as important or very important	151	59.60	-
Peer-learning	% considering this attribute as important or very important	151	27.15	-
Payment	% considering this attribute as important or very important	151	61.59	-

4.2 Main results

Table 4 displays the results of our main estimation using two models, a conditional logit in column (1) and a mixed logit in columns (2), (3) and (4), respectively, which display the estimation of coefficients β_n, the associated estimates of standard deviation and the WTA. Results in column (2) of the mixed logit estimation mostly confirm the results of the estimation of the conditional logit model displayed in column (1).

Table 4: Main results

Variables	Conditional logit	Mixed logit		
	Est. param.	Mean	SD	WTA (€)
	(1)	(2)	(3)	(4)
Payments (k €)	1.891***	4.603***		
	(0.434)	(1.027)		
ASC	0.099	-0.094		
	(0.160)	(0.371)		
3 years + 2 optional years	-0.041	-0.066	1.404***	
	(0.107)	(0.241)	(0.371)	
5 years incl. 1 "wild card" year	0.206*	0.524*	1.764***	-113.90
	(0.109)	(0.309)	(0.527)	[- 4.05 ; - 223.73]
Partial inter-row cover cropping	-0.220**	-0.315	1.778***	
	(0.094)	(0.250)	(0.286)	
Cover crops on all inter-rows	-0.475***	-1.389***	3.741***	301.74
	(0.126)	(0.441)	(0.785)	[121.02 ; 482.46]
Herbicides allowed in the row only	0.090	0.297	1.316***	
	(0.092)	(0.214)	(0.339)	
Herbicides banned	-0.362***	-1.497**	5.997***	325.11
	(0.103)	(0.750)	(1.506)	[28.87 ; 621.37]
Peer-learning groups	-0.043	-0.202	1.577***	
	(0.080)	(0.242)	(0.320)	
Observations	2,970	2,970		
Respondents	165	165		

Standard errors in parentheses; 10% confidence interval in brackets.
WTA displayed only for significant variables
*** p<0.01, ** p<0.05, * p<0.1

The coefficient associated with the payment is significant and of the expected sign, which means that an increase in the payment increases the probability that the farmer will enroll in the AES. The coefficient associated with the ASC variable is not significant. The ASC captures the administrative burden of contracting and the costs associated with the attributes common to all contracts and described in the survey i.e. permanent cover at the headlands and full inter-row cover during winter time. These requirements are on average not considered as a constraint by the farmers. This finding may sound surprising but a negligible administrative cost is consistent with the fact that 68% of the sample are past or current beneficiaries of AES payments. Moreover, cover at the headland is not a costly practice and inter-row cover cropping in the winter is fairly widespread among the winegrowers of the region.

Banning herbicides and full inter-row cover cropping decreases the probability of enrollment in a contract in both specifications. According to column (4), farmers demand 325 €/year/ha on average to waive herbicide use. On average, an additional 302 € is required to convince the farmer to implement cover crops on every inter-row during spring time. These last two attributes are associated with additional costs for the farmers, including initial investment in machinery, and additional time and labor. These practices are also associated with the need to acquire new skills, and the risks inherent in delaying the destruction of weeds or the banning of herbicides. It is important to note that these payment amounts are substantially higher than the payments offered in similar AES which compensate farmers 236 € to ban herbicides and 110 € to cover all inter-rows permanently.

The possibility to suspend the conditions of the contract for one year increases the probability of enrollment in the program in both estimations. Farmers on average are willing to forgo 114 €/ha/year to get a five-year contract that includes a "wild-card" year. In such a contract, we could expect farmers to renounce about 20% of the payment (one yearly payment out of five), since they are only constrained for four years of foregone income out of five years of payments. Thus, the estimated WTA associated with the wild-card attribute should be assessed with respect to a 20% decrease in total WTA for the contract. Below a 20% decrease, the willingness to accept does not necessarily correspond to a decrease in the premium associated with uncertainty. Nevertheless, not adopting the practices for one year out of five is only an option, farmers can fulfill the clause of the contract for five years even if they have the option to use their "wild-card". Furthermore, the highest amount paid contract in our choice cards is 600 €/ha/year. For these contracts, a WTA of 114 € corresponds to a 19% decrease in the amount paid. Therefore, for contracts paid less than 600 €/ha/year, decreasing the payments by 114 € corresponds to more than 20%. The average amount proposed by a contract in our choice cards being 320 €, the wild-card option WTA represents 35% of this amount. This finding confirms that including a risk-management tool to account for external uncertainty in the design of AES can increase their attractiveness. This represents a very interesting result given the gap between the estimated WTA for herbicide banning and cover cropping and the common design of current AES.

To better understand this interesting result, we solicited qualitative evidence to explain our results through online surveys administrated during the feedback meeting with local stakeholders.

Among a list of potential explanations, 73% of the local stakeholders believed that the attractiveness of the wild-card option is related to the management of water stress. Other sources of random shocks including unpredictable expenses, such as machine breakdowns, or life events (injuries, disease, etc.) were also mentioned, which confirms that the "wild-card" is understood as a risk-management tool. On the contrary, only 33% believed that the attractiveness is due to savings on the extra costs related to the change in practices that would not be supported during the "wild-card" year. Therefore, we are confident that the attractiveness of the "wild-card" option can be explained by the fact that it would allow farmers to better cope with uncertainty.

In contrast, the coefficient for the possibility to enroll for only three years with two optional years is not significant. In the previous sections, we explained why we proposed these two forms of flexibility to deal with two different types of uncertainty. According to our results, winegrowers are mainly interested in the possibility not to meet the contract commitment for one year. This suggests that, in our context and for our respondents, the main source of uncertainty with AES is external, so mostly driven by risk aversion, rather than by the necessity to have better information on implementation costs (internal uncertainty). Other explanations include the fact that farmers seek stable payments (Dessart et al., 2019) when using AES as a risk management tool, and that they have a preference for the 5-year contracts they are used to (Bougherara et al., 2021).

Regarding the possibility to join a group of peers, this form of technical assistance does not impact the probability to enroll in the AES in either specification. Among a list of possible explanations, 83% of the local stakeholders present at the feedback meeting considered that this result was due to the fact that wine-growers are too time-constrained.

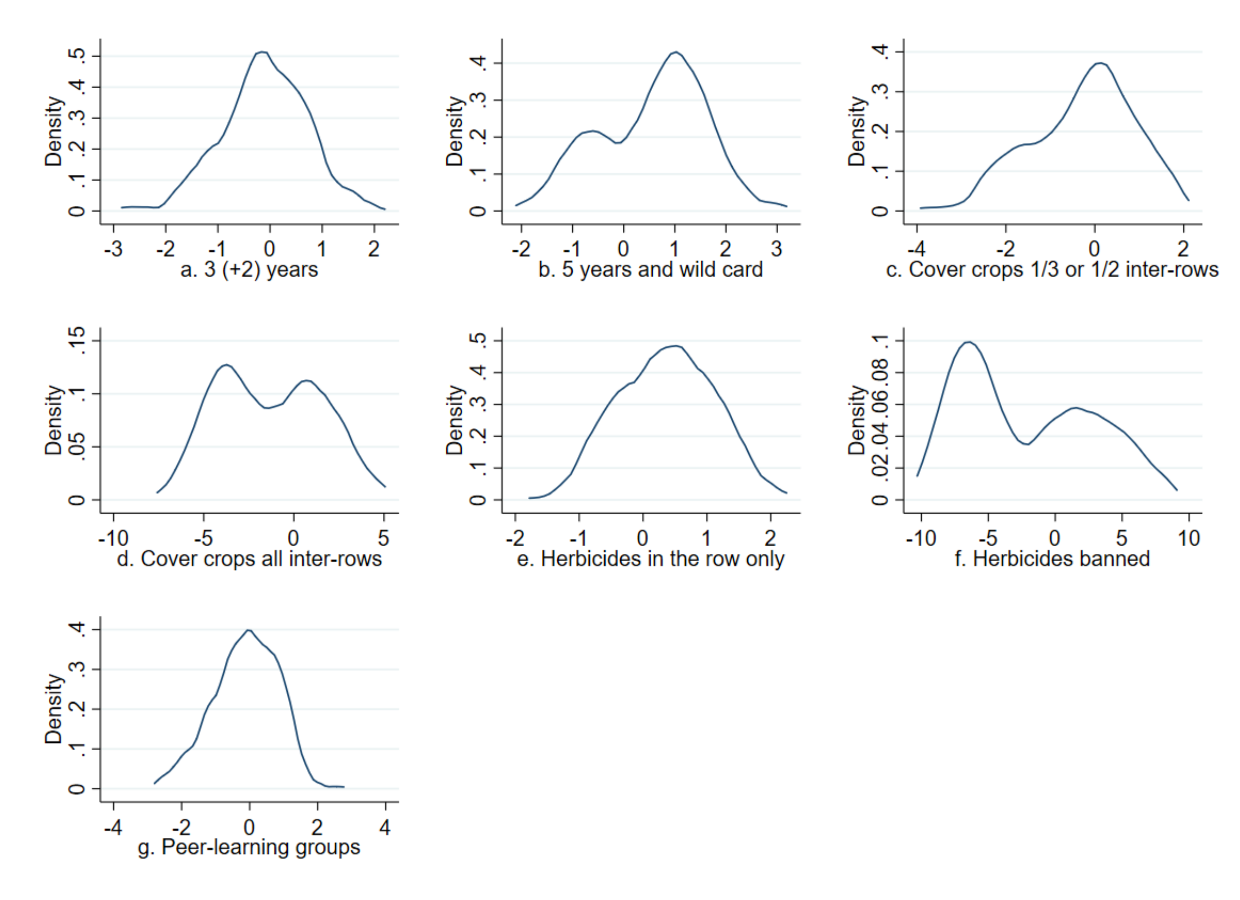
Figure 2 displays interesting results regarding the distribution of the individual coefficients. As a matter of fact, we can see that the distribution of individual coefficients for cover cropping of all inter-row (panel d) and for total ban of herbicides (panel f) is bimodal. This suggests that a share of our sample is indifferent to this type of commitment but that another share, possibly different between the two attributes, is highly sensitive to this type of commitment [9].

Figure 2 also suggests that the "wild-card" option increases the probability of enrollment for a specific share of our sample (panel b). Given these observations, it would be interesting to explore

9. Note that we checked wether or not this result was driven by organic farmers. According to additional analysis not displayed here, organic farmers present a similar pattern of coefficient distribution.

the heterogeneity of our results using sub-samples in order to characterize those specific groups. However, given the size of our sample, explanatory analyses aren't conclusive.

Figure 2: Mixed logit: Individual coefficients. Kernel density estimates



4.3 Robustness tests

4.3.1 Coding the status quo

Section 3.4 stressed that there is no *a priori* obvious or theory-driven way to code the status quo in order to estimate the impact of our two forms of flexibility. We chose to code the status quo as a five-year contract in order to be able to estimate the coefficient associated to the ASC and our two innovations. Table 5 in the Appendix displays the results of our estimation using alternative ways to code the status quo. Columns (1) and (2) display the results when recoding the status quo as the opt-out option. In column (3) and (4), we exclude the ASC but include the three dummies. In this latter option, the status-quo is coded zero for the three dummies.

The coefficients and the WTA concerning the "wild-card" option are stable in both estimations. However, the coefficient is only significant with a p-value equals to 16% if we include the three dummies.

4.3.2 Sample selection

To check whether estimates are robust to specification of the model, we apply several tests including those suggested by Johnston et al. (2017). Robustness checks are presented in Table 6 in the Appendix. If learning is involved in repeated choice tasks, responses to the first question may not provide the best estimates so we exclude responses to the first choice card seen (column 2) by respondents. In column (3), we exclude responses to the last choice card in order to check for a lassitude effect. Next, in column (4), we exclude respondents who indicate they are uncertain about their contract choices (rating strictly less than 5). Finally, we exclude respondents who read the description of attributes in less than thirty seconds. Results are fairly stable, even if the coefficient associated with the wild-card option is significant at only 15%. Note that the decrease in sample size increases the minimum effect size.

5 Conclusion

One of the factors expected to discourage farmers from enrolling in AES is the uncertainty of costs and benefits associated with the adoption of the new practices. This uncertainty can be related to the characteristics of the farmer and his/her parcels (internal uncertainty) or to the occurrence of external events (external uncertainty). In close collaboration with winegrowers and local stakeholders, we defined three innovations to account for these uncertainties in AES contracts and tested them on 172 winegrowers in the South of France using a CE. Environmental practices targeted were the reduction of herbicide use and the practice of cover cropping. The implications of our results are threefold.

First, the formation of peer groups animated by an environmental facilitator in order to share knowledge to both ease practice implementation (internal uncertainty) and share experience in response to weather shocks (external uncertainty) does not significantly improve AES attractiveness, probably due to the time consuming nature of these activities.

Second, the opportunity to commit to a contract for three initial years and then two optional years does not significantly impact the decision to enroll either. This innovation aimed at giving farmers the opportunity to experiment the practice, thus relieving the uncertainty of implementation costs given the farmer's parcel and his own skills (internal uncertainty). This suggests that, in our context and for our respondents, the main source of uncertainty with AES may be external rather than internal. Besides, it might capture a preference for stable payments (Dessart et al., 2019), or a preference for familiarity as farmers are used to 5-year contracts (Bougherara et al., 2021), which outweigh the willingness to have the opportunity to experiment over shorter time periods.

Third, the possibility of not meeting the term of the contract for one year out of five while still receiving the full payment however significantly improves AES attractiveness for farmers. This goes beyond the possibility of having a free lunch one year out of five as farmers on average accept a reduction in payments of more than 20% if the contract includes this option. This "wild-card" option decreases the uncertainty premium in AES contracts. Given the design of this option, our results on other innovations, and the exchanges with local stakeholders, it appears that external uncertainty is the uncertainty most alleviated by the wild-card option.

Obviously, depending on the targeted practices, one has to ensure that the innovation in the AES design proposed is compatible with the environmental aim of the measure. Evaluating the expected environmental impact of an innovation such as the wild-card option is not an easy task. One should consider the increase in the number of farmers enrolling in AES but also the expected weed pressure given the expected weather. Besides, farmers have the opportunity to use the wild-card option but do not need to do so. The actual use of the option after contracting is an open question. The type of AES targeted for including the wild-card option should be carefully considered. Kuhfuss and Subervie (2018), when looking at the impact of various AES to reduce herbicides, showed that less restrictive AES reduce herbicide use only when weed pressure is high, while the more demanding AES decrease herbicide use whatever the year scrutinized. In that context, one must be careful when proposing a wild-card year in the design of an AES. Kuhfuss and Subervie (2018)'s results suggest it may be safer to offer the wild-card option only with demanding AES in order to ensure the measure achieves its environmental goal.

To conclude, given the reluctance of farmers to participate in AES contracts and the uncertainty surrounding costs and benefits in agriculture, especially due to the impact of weather shocks, increasing flexibility in AES design through a wild-card option could benefit both farmers and decision makers. It could help to enroll larger groups of farmers and begin the transition in practices in groups more reluctant than those that usually subscribe to AES.

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Table 5: Recoding the status quo

VARIABLES	(1) Mean	(2) SD	(3) Mean	(4) SD
Payments (K€)	4.851 ***		4.870***	
	(0.992)		(1.668)	
ASC	0.086			
	(0.340)			
5 years	-0.001	1.069***	0.056	-1.356**
	(0.231)	(0.413)	(0.405)	(0.586)
5 years incl. 1 "wild card" year	0.566**	-1.537***	0.544†	1.702**
	(0.274)	(0.481)	(0.396)	(0.702)
3 years + 2 optional years			-0.079	1.382***
			(0.389)	(0.395)
Partial inter-row cover cropping	-0.268	1.638***	-0.231	1.685***
	(0.235)	(0.320)	(0.252)	(0.638)
Cover crops on all inter-rows	-1.324***	3.397***	-1.503***	3.590***
	(0.418)	(0.574)	(0.506)	(0.802)
Herbicides allowed in the row only	0.373*	1.218***	0.356†	1.246**
	(0.220)	(0.309)	(0.248)	(0.544)
Herbicides banned	-2.041**	5.252***	-2.676**	5.468***
	(0.929)	(1.271)	(1.317)	(0.783)
Peer-learning groups	-0.208	1.436***	-0.265	1.445***
	(0.261)	(0.285)	(0.248)	(0.331)
Observations	2,970	2,970	2,970	2,970
Respondents	165	165	165	165

Robust standard errors in parentheses
*** $p<0.01$, ** $p<0.05$, * $p<0.1$, † $p< 0.2$

Table 6: Robustness to sample selection

VARIABLES	(1) Without first card	(2) Without last card	(3) Without uncertain resp.	(4) Without fastest readers
Payment (K€)	5.059***	5.382***	4.960***	5.247***
	(1.185)	(1.289)	(1.146)	(1.196)
ASC	0.053	0.031	-0.173	0.073
	(0.452)	(0.404)	(0.399)	(0.421)
3 years + 2 optional years	0.009	-0.111	-0.183	-0.185
	(0.293)	(0.260)	(0.239)	(0.281)
5 years incl. 1 "wild-card" year	0.492††	0.488††	0.434††	0.546*
	(0.335)	(0.311)	(0.279)	(0.284)
Partial inter-row cover cropping	-0.237	-0.512*	-0.229	-0.275
	(0.281)	(0.282)	(0.260)	(0.331)
Cover crops on all inter-rows	-1.912***	-1.695***	-1.395***	-1.565***
	(0.587)	(0.506)	(0.433)	(0.585)
Herbicides allowed in the row only	0.610**	0.352	0.302	0.458*
	(0.285)	(0.247)	(0.236)	(0.267)
Herbicides banned	-2.135**	-2.185***	-3.161***	-2.501***
	(0.878)	(0.623)	(0.951)	(0.799)
Peer-learning groups	-0.101	-0.136	-0.100	-0.149
	(0.285)	(0.224)	(0.216)	(0.257)
Observations	2,475	2,475	2,826	147
Respondents	165	165	157	

Robust standard errors in parentheses
†† p<0,15, *** p<0.01, ** p<0.05, * p<0.1

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