# Innovative contract solutions for the Agri-Environmental-Climate Public Goods provision: Which features meet the farmers' approval? Insights from Emilia-Romagna (Italy)

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## Abstract

The agroecological transition promoted worldwide is supported by the European Union Common Agricultural Policy towards different strategies and policy tools. The agri-environmental schemes, offering farmers the possibility to adopt environment-friendly practices (thus mitigating negative externalities/providing positive ones) represent a straightforward example. However, there is dissatisfaction about their effectiveness and efficiency, while their improvement is envisaged through a flexible mix of new instruments: novel contract solutions fostering result-based payments, collective implementation, involving value chains and land tenure systems coupled to environmental conditionality. This

paper investigates how farmers from Emilia-Romagna (Italy) perceive these innovative contract solutions as "easy to understand", "applicable", "economic beneficial", and their willingness to enroll. The applied ordered logistic regression models include socio-demographic characteristics, structural features of the holdings, and the farmers' preference(s) for 13 individual contract features. Farmers' perceptions are driven by the previous experience acquired from similar measures, key socio-demographic characteristics/holding structural features, and peculiar contractual elements.

# 1. Introduction

An agroecological transition[1] is being promoted worldwide through the UN 2030 Agenda for Sustainable Development (United Nations, 2015) and in particular in the European Union (EU) through its Common Agricultural Policy (CAP) and the European Green Deal (Baldock and Buckwell, 2021; European Commission, 2019).

Among the CAP strategies and policy tools, the most popular instrument is the eco-conditionality embedded in the indirect subsidies (Mamine et al., 2020) which makes the payment conditional on the uptake of a set of actions considered appropriate for reducing negative externalities or improving positive ones (Hanley et al., 2012; White and Hanley, 2016). Complementary to that, the agri-environmental schemes (AESs) funded by the CAP are based on payments to farmers for the uptake of environment-friendly practices and the provision of ecosystem services that go beyond conditionality. AESs are a compulsory element of the EU Member States rural development plans (RDP) design but are voluntary for farmers. Their relevance lies in the mandatory share of funds allocated to co-financing: 30% of CAP Pillar II (supposed to grow in the future).

A large body of literature considers AESs, assessing their agri-environmental-climate effects (see Hasler et al., 2022 and the references therein), analyzing their cost-effectiveness and efficiency (Ansell et al., 2016; Bartolini et al., 2021; Blazy et al., 2021; Drechsler et al., 2017; Pacini et al., 2015), estimating the effects on the agricultural holdings structure and productive choices (Arata and Sckokai, 2016; Bertoni et al., 2020; Chabé-Ferret and Subervie, 2013; D'Alberto et al., 2018; Mennig and Sauer, 2020), and detecting

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[1] Agroecological transition corresponds to a systemic transformation generated by the ecologisation of agriculture and food. It concerns multiple actors among farmers, supply chains, natural resource managers, policymakers, etc. and it is characterized by the fact that a deliberate political intention is willing to bring such a transformation to move towards a more sustainable agricultural and food system (Magrini et al., 2019).

the factors that influence farmers' uptake decision and behavior (Brown et al., 2021; Drechsler, 2021; Gailhard et al., 2015; Raina et al., 2021; Vergamini et al., 2020).

Despite this abundant literature and the knowledge on AESs, there is dissatisfaction about their effectiveness and efficiency in delivering agri-environmental-climate public goods (AECPGs[2]) and in terms of achievements longevity (Biffi et al., 2021; Bullock et al., 2021). Nowadays, AESs are largely dominated by action-based approaches addressing individual farmers, while their improvement is envisaged through a flexible mix of new instruments (Herzon et al., 2018; Olivieri et al., 2021), such as contract solutions fostering result-based payment schemes or collective implementation, and solutions involving value chains and/or implementing new forms of land tenure systems coupled to environmental conditionality. These novel approaches are expected to provide AECPGs in a more efficient and effective way, being compliant with what is envisaged by the Farm to Fork strategy and the EU Biodiversity Strategy for 2030. The former is at the heart of the European Green Deal that aims at making Europe the first climate-neutral continent by 2050. It plans to reduce the environmental and climate footprint of the EU food system by addressing comprehensive challenges in terms of sustainability towards a transition that ensures that the whole food chain has a neutral or positive environmental impact (European Commission, 2020a). The latter strongly supports such a transition by acknowledging that it cannot be successfully achieved without restoring the endangered ecosystems, "bringing nature back to agricultural land" (European Commission, 2020b). Both initiatives strongly support and incentivize the transition to fully sustainable practices.

To the best of our knowledge, some of these new incentive approaches have been mainly investigated individually, like the result-based payments – the most studied

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[2] These are non-rival, non-excludable goods provided by agriculture and forestry with direct implications in terms of (potential) positive externalities for both climate and environment (e.g., carbon sequestration, air and water quality and quantity, soil restoration/maintenance, etc.) (Cooper et al., 2009).

instrument so far – (Birge et al., 2017; Russi et al., 2016; Sidemo-Holm et al., 2018; Šumrada et al., 2022, 2021; Zabel, 2019) and the collective approaches (El Mokaddem et al., 2016; Narloch et al., 2017; Westerink et al., 2017), while land tenure contracts with environmental clauses and the initiatives along the value chain were seldom addressed by the literature.

This paper investigates four novel contract solutions for the AECPGs provision: result-based (RB), collective (Co), value chain (VC), and land tenure (LT) contracts. These contract types are analyzed in terms of farmers' acceptability and willingness to uptake, by assessing:

1) The farmers' perception of the easiness of understanding related to the innovative contract solution.

2) The farmers' perception of the contract's applicability in the farm.

3) The farmers' perception of the economic benefit deriving from the contract.

4) The farmers' willingness to enroll.

The preferences concerning these points are explained using the socio-demographic characteristics of the farmers/land managers and the structural features of the agricultural holdings. The paper also focuses on the assessment of the influence that 13 individual features that define the contract solutions can play in determining the farmers' preferences. Data are collected by means of an online survey carried out within the EU CONSOLE Project[3] among the farmers of Emilia-Romagna (Italy).

The novelty of the paper lies in 1) the investigation of farmers' perceptions of four new, incentive contract types that combine a flexible mix of new instruments; 2) the inclusion in the modeling exercise (in addition to the socio-demographic characteristics of the farmer as well as the structural features of the agricultural holding) of the information about the

farmers' preferences for several individual features characterizing these instruments; 3) the application of ordered logistic regression that, to the best of our knowledge, has never been applied to analyze farmers' preferences for AECPGs contracts.[4] Ordered logistic regression models are rather solid (Agresti, 2019, 2010), but the so-called partial proportional odds/non-parallel lines modelling approach has only recently attained a cohesive formalization (Williams, 2006; Yee, 2010). The main, recent innovation consisted in their expansion for allowing the relaxation of its key assumption, the "proportionality of the odds" (Williams, 2016). The latter states that a respondent operates a proportional shift when evaluating his/her preferences for the levels depicted by the categorical outcome variable. In other words, the assumption states that the "distance" in terms of individual's preferences between a lower level of the categorical outcome variable and a higher one, is proportional for all the levels of such a variable. It has been demonstrated that violations of this assumption frequently occur in practice and they have been nimbly disregarded (Brant, 1990; Long and Freese, 2014; Xu et al., 2022), hence leading to biased and mis-interpretable results (Agresti, 2010). This is not the case of the present work. Indeed, we test the proportionality of the odds and relax the assumption when needed. This relaxation allows for avoiding biased estimates by properly depicting the shift of individual's preferences among the different levels of the categorical outcome variable, applying the partial proportional odds model when there is no proportionality of the odds about the levels of preference.

The results hint at the influence that previous experience (acquired from very similar measures), key socio-demographic characteristics, and structural features of the holding play in driving the farmers' perceptions of the easiness of understanding, applicability, and economic benefit of the contract solutions, as well as their willingness to enroll. In addition,

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[4] A similar application (logit modelling), but targeting AESs is offered by Gailhard and Bojnec (2015).

the above-mentioned perceptions can be influenced by peculiar contractual elements, not only those straightforwardly linked to the identification of the contract type.

The paper is structured as follows: section 2 presents the research framework, the case study, the data at hand, and the statistical method. Section 3 presents the results, while in section 4 we discuss them. Finally, section 5 hosts the conclusions.

## 2. Data and methods

### 2.1 Case study

The Emilia-Romagna region is located in North-eastern Italy. The southern part is hilly and includes the mountainous areas of the Apennines, while the southern part of the Po River plain dominates the northern portion of the territory. The plains are characterized by intensive agriculture and arable crops, the hills by vineyards and orchards, and the mountains mainly by grasslands, arable crops, and woods. The plain area is highly urbanized, while the mountainous areas are marginalized and characterized by land abandonment.

Data on Emilia-Romagna citizens were collected online, using Qualtrics, from May to July 2021 with a questionnaire promoted on the institutional website of the Emilia-Romagna region dedicated to Agriculture (Regione Emilia-Romagna, 2022a) and on the corresponding official Facebook page (Regione Emilia-Romagna, 2022b), allowing respondents to freely access the Qualtrics link. 559 questionnaires were initiated, of which 305 completely answered questionnaires (55%) are used for the present analysis. Table 1 depicts the main descriptive statistics of the sample.

*Table 1. Descriptive statistics of the sample*

| Explanatory variable | Nr. of observations | Percent | Q1, Median, **Mean**, Q3 (Standard Deviation) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| Gender | | | |
| | male | 264 | 86.56 % |
| | female | 41 | 13.44 % |
| Age | | | |
| | 18-30 | 29 | 9.51 % |
| | 31-40 | 42 | 13.77 % |
| | 41-50 | 67 | 21.97 % |
| | 51-60 | 104 | 34.10 % |
| | 61-70 | 41 | 13.44 % |
| | >71 | 22 | 7.21 % |
| Educational level | | | |
| | primary | 74 | 24.26 % |
| | secondary | 156 | 51.15 % |
| | university or higher | 75 | 24.59 % |
| – BA's, MA's, Ph.D. or equivalent | | | |
| Membership | | | |
| | none | 149 | 48.85 % |
| | farmers union | 108 | 35.41 % |
| nature conservation/ | | | |
| environmental organization | | 48 | 15.74 % |
| Proportion of holding sales – to | | | |
| processor | | | |
| | 0 % | 213 | 69.84 % |
| | 1-30 % | 38 | 12.46 % |
| | 31-60 % | 14 | 4.59 % |
| | 61-100 % | 40 | 13.11 % |
| Proportion of holding sales – to | | | |
| private wholesaler/retailer | | | |
| | 0 % | 139 | 45.57 % |
| | 1-30 % | 58 | 19.02 % |
| | 31-60 % | 25 | 8.20 % |

| | | | |
|---|---|---|---|
| | 61-100 % | 83 | 27.21 % |
| Proportion of holding sales – to cooperatives | | | |
| | 0 % | 193 | 63.28 % |
| | 1-30 % | 21 | 6.89 % |
| | 31-60 % | 21 | 6.89 % |
| | 61-100 % | 70 | 22.95 % |
| Proportion of holding sales – direct to final consumer | | | |
| | 0 % | 228 | 74.75 % |
| | 1-30 % | 37 | 12.13 % |
| | 31-60 % | 15 | 4.92 % |
| | 61-100 % | 25 | 8.20 % |
| Specialization | | | |
| | arable | 136 | 44.59 % |
| | horticulture | 15 | 4.92 % |
| | permanent | 84 | 27.54 % |
| | livestock | 32 | 10.49 % |
| | mixed | 38 | 12.46 % |
| Organic production | | | |
| | no | 232 | 76.07 % |
| | yes | 73 | 23.93 % |
| Utilized Agricultural Area owned – in hectares | | | 5.5, 18, **62.41**, 40 (191.57) |
| Utilized Agricultural Area rented in – in hectares | | | 0, 9, **49.67**, 45 (188.81) |
| Direct CAP payments | | | |
| | no | 60 | 19.67 % |
| | yes | 245 | 80.33 % |
| RDP payments – Euro | | | |
| | no | 115 | 62.30 % |

| | | | |
|---|---|---|---|
| | yes | 190 | 37.70 % |
| Previous experience | | | |
| | no | 205 | 67.21 % |
| | yes | 100 | 32.79 % |

**Note:** Q1 = 1st quartile; Q3 = 3rd quartile.

## 2.2 Questionnaire overview

The survey questionnaire (D'Alberto et al., 2022) is based on two parts: the first collects the socio-demographic characteristics of the respondent and the main characteristics of the agricultural holding he/she manages/owns; the second focuses on the contract solutions. First, we investigated the respondent's preference(s) for 13 individual features that potentially define a generic environmental programme/contract. Secondly, information on the respondent's preference about the four contract solutions (RB, Co, VC, LT) was collected, specified in terms of "understandability", "applicability" in the farm, and "economic benefit". Finally, the respondent was asked about his/her willingness to enroll.

Table 2 depicts the 13 individual contract features with their definitions, built on the findings from the scientific literature review on the subject (Eichhorn et al., 2020) in combination with the insights gathered from the discussion of such findings among (and with) the European stakeholders (Viaggi et al., 2020b).[5] These features were selected since they potentially characterize, in general, an agri-environmental programme/contract and, at the same time, for being specifically distinctive of one (or more) incentive contract solution. For example, "the payment gets higher, the better your environmental results are" specifically fits to result-based contract solution. However, this contractual element can be part of a collective-based incentive or a solution involving the value chain. Therefore, the

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[5] The literature review found and analyzed 58 existing case studies within and outside the EU. A survey among project partners and stakeholders and a workshop addressing 105 stakeholders from 11 EU Member States and the United Kingdom were held for discussing, selecting, and debating the most promising examples.

features are not explicitly linked to a contract type, while each of them can regard a specific aspect of the contract. Finally, as per the stakeholders' suggestions and insights, the 13 features help in framing the general idea of the innovative contract solutions in the most understandable way for the EU farmers/land managers, disregarding their experience(s) with the CAP agri-environmental-climate measures (AECMs).

*Table 2. Individual contract features*

| Contract feature | Definition |
| --- | --- |
| Self-chosen measures | In the contract, you are free to decide about the management practices to achieve the specified environmental result(s). |
| Better results, higher payment | The payment gets higher, the better your environmental results are. |
| Collective agreement | You can collectively agree on environmental targets and measures at landscape-level together with other land managers/forests owners. |
| Common payment | You and other land managers (farmers/forests owners) receive a common payment. You jointly agree on the distribution of the payment. |
| Labelled product | You sell your holding's products labelled as environmentally friendly (e.g., animal welfare products, climate friendly products) when following management measures as prescribed in a processor or retailer contract. |
| Paid by customers | The contract is not paid by public money, instead the compensation that you get for environmentally friendly production is paid by buyers of your products. |
| Reduced land rent | You can lease land with a reduced rent, if you agree to follow environmental management clauses as specified in the lease contract. |
| Self-monitoring | You can do the monitoring of the environmental results yourself (e.g., count specific plants). |
| Control by authority | The results that you achieve are regularly controlled by the competent authority coming onto your farm, e.g., once per year. |
| Free training or advice | You are offered free training and advice that enables you to reach the environmental targets. |

| | |
|---|---|
| Sales guarantee | You get a sales guarantee from a processor or retailer in return for implementing environmental measures. |
| Annual compensation | You get environmental compensation payment on an annual basis. |
| Periodical payment | You get half of the environmental payment at the beginning of, e.g., the five-year contract, and half at the end of it. |

The features in Table 2 were presented to the respondent as general attributes of a hypothetical agri-environmental contract/programme. Before describing RB, Co, VC, and LT contract solutions in detail, the respondent was asked: *"How much would the following characteristics of agri-environmental contracts increase or decrease your willingness to enroll to an environmental contract or programme?"*. The possible answers (Likert scale) were: 1 = "Decreases my willingness considerably", 2 = "Somewhat decreases my willingness", 3 = "No effect on my willingness", 4 = "Somewhat increases my willingness", 5 = "Increases my willingness considerably".

Table 3 depicts the descriptions of the four contract solutions offered to the respondent (Viaggi et al., 2020a, 2020b).

*Table 3. Contract solutions descriptions*

| Contract solution | Description |
|---|---|
| Result-based | In a result-based contract you receive a **payment only for the delivery of environmental or climate results**. You are **free in your decision about the management practices**, e.g., how to contribute to water protection, landscape improvement, biodiversity or to sequester carbon. Selected indicators and scoring systems to monitor environmental or climate results are often used, and they will be exactly defined in the contract. You have access to free advice or training when you participate in this contract, and you can voluntarily engage in the monitoring activity. |

| | |
|---|---|
| Collective | You become a **member of a group** of land managers (farmers or foresters) who **applies jointly for compensation in order to implement environmental or climate activities**, e.g., water protection, carbon sequestration, biodiversity or landscape improvement. A minimum number of group members (e.g., 5) from your region is required to **collaborate in order to get a payment**. The group members decide about the implementation and locating the measures, and the distribution of the payment. Within the group, peer land managers and advisors share knowledge and support the achievement of the environmental objectives. |
| Value chain | As a producer, you are part of the value chain (producer, processor, retailer, distributor). You engage in a contract where you commit to deliver **environmental or climate benefits connected to the production of selected products**, e.g., by carrying out management measures which contribute to water protection, landscape improvement, biodiversity, or carbon sequestration. Often these products get a special label. You are **paid** for it **by the market**, mainly through a premium price paid by the processor or retailer. |
| Land tenure | You enter into a land-tenure contract where you **commit to give particular attention to environmental aspects beyond legal requirements when producing on the leased land**. The landowner accepts a lower **lease payment** than for comparable land under usual land tenure agreements to compensate your additional efforts. In the contract environmentally friendly management practices on the leased land are prescribed in order to maintain or improve environmental targets, e.g., water protection, landscape and biodiversity improvement or carbon sequestration or alternatively. |

After each short description of the contract, the respondent was asked: *"How do you see this contract type? Do you agree or disagree with the following statements?"*. The three statements were: *"Easy to understand"*, *"Applicable for my farm"*, and *"Potentially economically beneficial for my farm"*. The respondent was asked to express an opinion

where 1 = "Strongly Disagree", 2 = "Disagree", 3 = "Neutral", 4 = "Agree", 5 = "Strongly Agree".

Finally, for each specific contract solution (RB, Co, VC, LT) the respondent was asked: *"How likely is that you would enroll in a –name– contract type in the future?"* (the answers were 1 = "Very Unlikely", 2 = "Unlikely", 3 = "Neutral", 4 = "Likely", 5 = "Very Likely").

Considering the contract features presented in Table 2, Figure 1 depicts the distribution of the scores that have been given by the respondents to the 13 individual contract features.
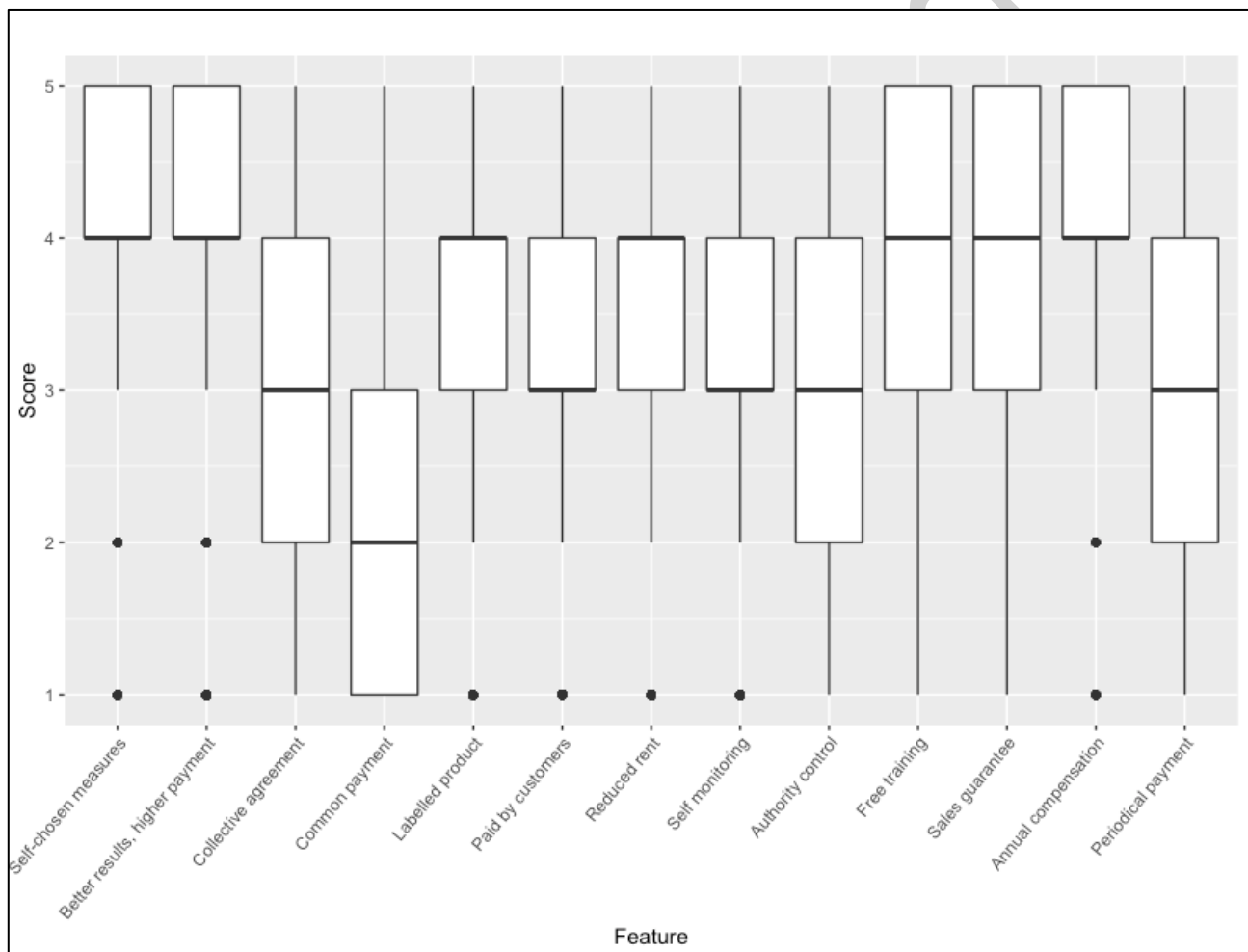


**Figure 1.** *Distribution of the scores of the 13 individual contract features*

As per Figure 1, there are individual contract features that relevantly influence, in a positive way, the willingness to enroll in a hypothetical agri-environmental contract/programme, e.g.,

"self-chosen measures", "better results, higher payment", and "annual compensation". Namely, respondents stated that each one of these characteristics contribute in increasing considerably their willingness to enroll in an environmental contract/programme. In contrast, a feature like, e.g., "common payment" has a negative influence on the willingness to enroll (i.e., it is expected to somewhat decrease such a willingness).

## 2.3 Methodological approach: proportional odds and partial proportional logit models

The socio-demographic characteristics of the respondents, the characteristics of agricultural holdings, and the scores related to the 13 individual contract features are used as explanatory variables in the models (one for each incentive contract solution) where the ordered response variables are 1) the *easiness of understanding*, 2) the *applicability in the farm*, 3) the *economic benefit,* 4) the *willingness to enroll*.

These outcome variables are ordered categorical variables, based on a Likert scale. They can be treated by the ordered logit model, also called the proportional odds (PO) or parallel lines (PL) model (Mccullagh, 1980; Winship and Mare, 1984). Following the notation of Agresti (2010), let $Y$ be the outcome of interest: an ordinal dependent variable of $M$ categories observed for the $i$-th individual ($i = 1, \dots, N$). The generalized ordered logit model can be written as:

$$P(Y_i > j) = g(X\beta_j) = \frac{\exp{(\alpha_j + X_i\beta_j)}}{1 + \{\exp(\alpha_j + X_i\beta_j)\}}, \qquad 1)$$

where $j = 1, \dots, M - 1$. The probabilities that the outcome variable takes on each of the values $1, \dots, M$ are equal to:

$$P(Y_i = 1) = 1 - g(X_i \beta_1),$$

$$P(Y_i = j) = g(X_i \beta_{j-1}) - g(X_i \beta_j), \text{ with } j = 2, \dots, M - 1 \qquad \text{2)}$$

$$P(Y_i = M) = g(X_i \beta_{M-1}).$$

From this generalized framework, special cases can be derived. For example, when $M = 2$, the model in Equation 1) equals the logistic regression, while, for $M > 2$, it becomes equal to a series of binary logistic regressions, one for each pair of categories of the dependent variable.

The PO/PL model is a further special case that can be written as follows:

$$P(Y_i > j) = g(X\beta) = \frac{\exp(\alpha_j + X_i\beta)}{1 + \{\exp(\alpha_j + X_i\beta)\}}, \qquad \text{3)}$$

where $j = 1, \dots, M - 1$. Such a model presents $\beta$ coefficients that do not vary across the values of $j$, as it is instead in Equation 1). Therefore, this modelling approach requires that only the $\alpha$'s do vary across the $j$ values and, hence, it implies that the $M - 1$ regression lines are parallel. This is the key underlying assumption of the PO/PL model, usually called "proportionality of the odds". It states that the relationship between each pair of outcome levels is the same. Namely, the shift in individual's preferences from one level of the categorical variable to the higher/lower one is proportional for all the levels of such a variable. It is well-acknowledged that this cannot *always* occur in practice. The method has been largely applied by several disciplines in different fields (Agresti, 2019), but violations of this fundamental assumption which can frequently occur in practice have been nimbly disregarded (Brant, 1990; Long and Freese, 2014; Xu et al., 2022) leading to biased and mis-interpretable results (Agresti, 2010). Furthermore, this assumption has been discovered to be overly restrictive (Williams, 2016).

In fact, the PO/PL model offers two main pros: 1) it can lead to highly interpretable results (Williams, 2016); 2) it benefits from computational efficiency (Agresti, 2010). Although being very sensitive to violations of the proportionality of the odds, by relaxing the assumption, the aforementioned pros can still be of interest in choosing to apply such a modelling strategy. A successful solution for relaxing the assumption is offered by the partial proportional logit model (PPO) or non-parallel lines model (NPL) (Mccullagh and Nelder, 1989; Peterson and Harrell, 1990). This alternative modelling strategy has recently gained attention due to the developments proposed by Williams (2006) and Yee (2010), being a great alternative to the generalized ordered logit model (Williams, 2016).

Relaxing the proportionality of the odds can lead to one or more $\beta$'s differing across the values of $j$, while some other coefficients can still be equal. For the sake of clarity, let $X_1, X_2, X_3$ be three explanatory variables. The model in Equation 3) can be re-written as:

$$P(Y_i > j) = g(X\beta) = \frac{\exp(\alpha_j + X_{1i}\beta_1 + X_{2i}\beta_2 + X_{3i}\beta_{3j})}{1 + \{\exp(\alpha_j + X_{1i}\beta_1 + X_{2i}\beta_2 + X_{3i}\beta_{3j})\}}, \qquad 4)$$

where $j = 1, \dots, M - 1$. In the model of Equation 4) the $\beta$'s for $X_1, X_2$ are the same for all the values of $j$, while the coefficient for $X_3$ can differ.

For the sake of simplicity, the unconstrained PPO model proposed by Peterson and Harrell (1990) and further extended by Lall et al. (2002) is adopted here. This model offers a re-parametrization of the model in Equation 4) such that, for each explanatory variable, we have a coefficient $\beta$ and $M - 2 \gamma$ coefficients that indicate a deviation from proportionality.

Therefore, here we consider PO/PL models as the starting point of the analysis, test the proportionality of the odds, and (when needed) eventually relax such an assumption by adopting a properly specified PPO/NPL model.

The choice of which explanatory variables should be included in the model for the outcome variable of interest is based on the following stepwise approach. First, we included

in the PO-defined model all the potential explanatory variables. Second, we checked for convergence of the model, discarding the explanatory variables that forced convergence to fail. Third, we have undergone the assessment of the parallel lines assumption as suggested by Long and Freese (2014) and Williams (2016): if the whole model fails the assumption according to the Brant test, a PPO-defined model is run, by relaxing the assumption of proportionality of the odds for the explanatory variables for which the Brant test is statistically significant. Fourth, we attempted to discard the explanatory variables showing non-statistically significant coefficients but keeping them if their discarding lowered the log-likelihood and the pseudo-$R^2$ of the model, in comparison to the other, newly defined model(s) (i.e., we kept them if the model's goodness of fit decreased).

## 3. Results

In the following, the estimated odds ratios are presented.[6]

The results are depicted according to the prescriptions of Craemer (2009) and Williams (2016): when the explanatory variables included in the model meet the parallel lines assumption, the $\beta$ coefficients are depicted (with the related p-values). In other words, if the coefficients are depicted only for the first category of the ordinal outcome variable (i.e., only in the second column of the tables) this means that the coefficients are the same for all the categories (since the proportionality of the odds does hold), as per the model in Equation 3). When the p-values from the Brant test on proportionality are statistically significant, $\gamma$ coefficients are depicted (with the related p-values), hence identifying the predictors that are not constrained to meet the parallel lines assumption, as per the model in Equation 4). In

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[6] For the sake of brevity, only the statistically significant explanatory variables are depicted. Please, refer to the supplementary material for the integral version of the results on the models' coefficients. Please, note that we present here only the odds ratios of the statistically significant predictors, although the predictors included in the models were all those depicted in the integral version of the tables in the supplementary material.

such cases, the $\gamma$ coefficients are shown for each category of the response variable (i.e., in the other columns of the tables).

### 3.1 Result-based contracts

Table 4 depicts the odds ratio from the models for the RB contract. They are PO/PL models, as per the one depicted in Equation 3).

***Table 4.*** *Odds ratio, result-based contract solution*

| Explanatory variable | VU vs U, N, L, VL[*] | VU, U vs N, L, VL[*] | VU, U, N vs L, VL[*] | VU, U, N, L vs VL[*] |
|---|---|---|---|---|
| | Easiness of understanding | | | |
| Age (18-30) | | | | |
| 31-40 | 0.922 (0.859) | | | |
| 41-50 | [‡] **0.395** (0.030) | | | |
| 51-60 | 0.540 (0.141) | | | |
| 61-70 | 0.620 (0.312) | | | |
| >71 | 0.699 (0.529) | | | |
| Membership (none) | | | | |
| farmers union | 1.361 (0.191) | | | |
| nature conservation/ environmental org. | [‡] **1.995** (0.046) | | | |
| Self-chosen measures | [‡] **1.755** (0.016) | | | |
| | Applicability in the farm | | | |
| Proportion of holding sales – to cooperatives (0%) | | | | |
| 1-30 % | 1.984 (0.116) | | | |
| 31-60 % | 1.616 (0.340) | | | |
| 61-100 % | [‡] **2.266** (0.006) | | | |
| Organic production (no) | | | | |
| yes | [‡] **2.301** (0.002) | | | |

| | | |
|---|---|---|
| Self-chosen measures | ‡ **1.687** (0.038) | |
| Collective agreement | ‡ **1.627** (0.004) | |
| Reduced land rent | ‡ **1.917** (0.006) | |
| Economic benefit | | |
| Better results, higher payment | ‡ **1.731** (0.036) | |
| Willingness to enroll | | |
| Age (18-30) | | |
| | 31-40 | 1.345 (0.598) |
| | 41-50 | 0.909 (0.850) |
| | 51-60 | 0.664 (0.408) |
| | 61-70 | 0.646 (0.428) |
| | >71 | ‡ **0.199** (0.016) |
| Self-monitoring | ‡ **1.659** (0.035) | |
| Free training | ‡ **0.494** (0.029) | |
| Periodical payment | ‡ **1.691** (0.012) | |

**Note:** The reference modality of the explanatory variable is in parentheses. * VU = Very Unlikely, U = Unlikely, N = Neutral, L = Likely, VL = Very Likely; p-values in parentheses; ‡ **in bold** indicates the 0.05 level of statistical significance.

In terms of odds, it is worth noticing that for members of nature conservation/environmental organizations, the odds of being more likely to easily understand the RB contracts are almost 2 times greater. By a unit increase in the scoring of *self-chosen measures*, the odds of being more likely to easily understand the contract is 1.8 times greater.

For the holdings that are largely exposed to cooperatives in terms of sales, the odds of considering "applicable" the RB contract solution is 2.3 times greater. For the holdings producing organic, the odds of being more likely to perceive "applicable" the RB contracts is 2.3 times greater than non-organic holdings. For the higher scoring of *self-chosen*

*measures*, *collective agreement,* and *reduced rent land*, the odds of the perceived applicability in the farm are between 1.6 and 1.9 times greater.

For farmers giving higher scores to the possibility that, within the contract, the payment gets higher as much as the achieved environmental results ameliorate, the odds of perceiving as "economic beneficial" the RB contract is 1.7 times greater.

With a unit increase in the scoring of *free training,* the odds of being more likely to enroll in RB contracts decrease, while by a unit increase in the scoring of *self-monitoring* and *periodical payment*, the odds of being willing to enroll in RB contracts are 1.7 times greater.

### 3.2 Collective contracts

Table 5 depicts the odds ratio from the models for the Co contract. The models for the outcome variables *easiness of understanding* and *economic benefit* are PPO/NPL models, as per the one depicted in Equation 4). The other two models for the outcome variables *applicability in the farm* and *willingness to enroll* are PO/PL models, as per the one in Equation 3).

*Table 5.* Odds ratio, collective contract solution

| Explanatory variable | | VU vs U, N, L, VL[*] | VU, U vs N, L, VL[*] | VU, U, N vs L, VL[*] | VU, U, N, L vs VL[*] |
|---|---|---|---|---|---|
| | | Easiness of understanding | | | |
| Direct CAP payments (no) | | | | | |
| | yes | 0.360 (0.050) | 1.749 (0.236) | ‡ **5.436** (0.005) | ‡ **10.134** (0.046) |
| Previous experience (no) | | | | | |
| | yes | ‡ **6.189** (0.000) | | | |
| Collective agreement | | ‡ **2.104** (0.022) | 0.724 (0.236) | 0.705 (0.288) | ‡ **0.441** (0.023) |
| | | Applicability in the farm | | | |
| Age (18-30) | | ‡ **0.388** (0.040) | | | |

|  |  |  |
|---|---|---|
|  | 31-40 |  |
|  | 41-50 | ‡ **0.357** (0.014) |
|  | 51-60 | 0.491 (0.075) |
|  | 61-70 | 0.748 (0.521) |
|  | >71 | ‡ **0.328** (0.037) |
| Utilized Agricultural Area owned – in hectares |  | ‡ **0.827** (0.024) |
| Collective agreement |  | ‡ **1.898** (0.001) |
| Common payment |  | ‡ **1.604** (0.006) |
| Economic benefit | | |
| Annual compensation |  | ‡ **1.476** (0.038) |
| Willingness to enroll | | |
| Age (18-30) |  |  |
|  | 31-40 | 0.448 (0.117) |
|  | 41-50 | ‡ **0.318** (0.016) |
|  | 51-60 | 0.443 (0.075) |
|  | 61-70 | 0.552 (0.251) |
|  | >71 | ‡ **0.181** (0.006) |
| Collective agreement |  | ‡ **1.527** (0.039) |
| Common payment |  | ‡ **1.666** (0.007) |
| Self-monitoring |  | ‡ **1.996** (0.003) |

**Note:** The reference modality of the explanatory variable is in parentheses. * VU = Very Unlikely, U = Unlikely, N = Neutral, L = Likely, VL = Very Likely; p-values in parentheses; ‡ **in bold** indicates the 0.05 level of statistical significance.

The odds ratio of *direct CAP payments* suggests that for the holdings receiving this payment, the odds of being "Likely" or "Very Likely" versus the lower categories of *easiness of understanding*, as well as the odds of being "Very Likely" (versus the lower categories) are, respectively, 5.4 and 10 times greater than that of the holdings not receiving the

payment. Having previously experienced collective-alike measures makes the odds of being more likely to easily understand the Co contract 6.2 times greater. *Collective agreement* produces asymmetric effects on the *easiness of understanding*: by a unit increase in the scoring of such contract feature, the odds of being more likely to consider "easy to understand" the Co contract is greater, when "Very Unlikely" is confronted with the upper categories. Nevertheless, the odds ratio for the highest level of the response variable ("Very Likely" versus the lower categories) decreases.

By a unit increase in the scoring of the *collective agreement*, the odds of being more likely to perceive "applicable in the farm" the Co contract solution is 1.9 times greater. By a unit increase in the scoring of the contract feature *common payment*, the odds of being more likely to consider the Co contract applicable is 1.6 times greater.

For an increase in the scoring of *annual compensation* the odds of perceiving as "economic beneficial" the Co contract solution is 1.5 times greater.

For an increase in the scoring of the predictors *collective agreement*, *common payment*, and *self-monitoring* the odds of being more likely to enroll in Co contracts are between 1.5 and 2 times greater.

### 3.3 Value chain contracts

Table 6 depicts the odds ratio from the models for the VC contract. All models are PO/PL models, as per the one in Equation 3).

*Table 6. Odds ratio, value chain contract solution*

| Explanatory variable | VU vs U, N, L, VL[*] | VU, U vs N, L, VL[*] | VU, U, N vs L, VL[*] | VU, U, N, L vs VL[*] |
|---|---|---|---|---|
| Easiness of understanding | | | | |
| Proportion of holding sales – to private wholesaler/retailer (0%) | | | | |
| 1-30 % | [‡] **0.285** (0.000) | | | |

| | | |
|---|---:|---|
| | 31-60 % | 0.505 (0.150) |
| | 61-100 % | 1.176 (0.659) |
| Proportion of holding's sales – direct to final consumer (0%) | | |
| | 1-30 % | ‡ **2.412** (0.019) |
| | 31-60 % | ‡ **3.602** (0.025) |
| | 61-100 % | 0.528 (0.126) |
| Specialization (arable) | | |
| | horticulture | 1.100 (0.867) |
| | permanent | 1.122 (0.711) |
| | livestock | ‡ **2.773** (0.016) |
| | mixed | 1.108 (0.781) |
| Utilized Agricultural Area rented in – in hectares | | ‡ **1.003** (0.046) |
| Previous experience (no) | | |
| | yes | ‡ **7.963** (0.000) |

Applicability in the farm

| | | |
|---|---:|---|
| Proportion of holding sales – to private wholesaler/retailer (0%) | | |
| | 1-30 % | ‡ **0.462** (0.034) |
| | 31-60 % | 1.034 (0.948) |
| | 61-100 % | 1.023 (0.951) |
| Proportion of holding sales – direct to final consumer (0%) | | |
| | 1-30 % | ‡ **2.326** (0.033) |
| | 31-60 % | 0.699 (0.956) |
| | 61-100 % | 0.636 (0.284) |
| Previous experience (no) | | |
| | yes | ‡ **4.311** (0.001) |
| | | |
| Labelled product | | ‡ **2.318** (0.001) |

| | | |
|---|---|---|
| Control by authority | ‡ **1.538** (0.038) | |

| Economic benefit | | |
|---|---|---|

| Age (18-30) | | |
|---|---|---|
| 31-40 | 0.762 (0.534) | |
| 41-50 | 0.652 (0.285) | |
| 51-60 | ‡ **0.442** (0.032) | |
| 61-70 | 0.551 (0.183) | |
| >71 | 0.766 (0.613) | |

| Willingness to enroll | | |
|---|---|---|

| Specialization (arable) | | |
|---|---|---|
| horticulture | 1.468 (0.660) | |
| permanent | 0.951 (0.893) | |
| livestock | ‡ **3.225** (0.050) | |
| mixed | 0.864 (0.754) | |
| Previous experience (no) | | |
| yes | ‡ **15.748** (0.001) | |
| Paid by customers | ‡ **1.589** (0.043) | |
| Control by authority | ‡ **1.651** (0.033) | |

**Note:** The reference modality of the explanatory variable is in parentheses. * VU = Very Unlikely, U = Unlikely, N = Neutral, L = Likely, VL = Very Likely; p-values in parentheses; ‡ **in bold** indicates the 0.05 level of statistical significance.

For the holdings selling to private direct consumers a share between 1% and 60% of the holding product(s), the odds of being more likely to consider "easily understandable" the VC contracts is 2 up to 3.6 times greater. For livestock holdings, the odds of being more likely to perceive "easy to understand" the VC contract is 2.8 greater than that of permanent-specialized farms. By a unit increase of the hectares of UAA rented-in by the holding, the odds of being more likely to consider "understandable" the VC contract solution increases

very slightly (it is 1.003 times greater). For respondents who experienced similar measures, the odds of being more likely to "easily understand" the VC contract is almost 8 times greater.

Concerning the *applicability in the farm*, the previous experience boosts the odds (for "experienced" respondents the odds ratio is 4.3 times greater).

The (potential) economic benefit of VC contracts is negatively influenced by *age*, while considering the *willingness to enroll*, for livestock holdings the odds of being more likely to enroll is 3.2 times greater than that of farms specialized in permanent crops. In addition, the previous experience relevantly boosts the odds ratio, while for higher scoring of *paid by customers* and *control by authority*, the odds of being more likely to enroll are 1.6 times greater and 1.7 times greater, respectively.

### 3.4 Land tenure contracts

Table 7 depicts the odds ratio from the models for the LT contract. The model for the outcome variable *economic benefit* is a PPO/NPL model – depicted in Equation 4) –, while the others are, all, PO/PL models, as per the one depicted in Equation 3).

*Table 7. Odds ratio, land tenure contract solution*

| Explanatory variable | VU vs U, N, L, VL* | VU, U vs N, L, VL* | VU, U, N vs L, VL* | VU, U, N, L vs VL* |
|---|---|---|---|---|
| | Easiness of understanding | | | |
| Age (18-30) | | | | |
| 31-40 | 0.421 (0.080) | | | |
| 41-50 | ‡ **0.361** (0.026) | | | |
| 51-60 | ‡ **0.383** (0.030) | | | |
| 61-70 | ‡ **0.318** (0.024) | | | |
| >71 | 0.436 (0.156) | | | |
| Previous experience (no) | | | | |
| yes | ‡ **5.754** (0.000) | | | |

| | | | | | |
|---|---|---|---|---|---|
| Self-chosen measures | ‡ **1.833** (0.019) | | | | |
| Sales guarantee | ‡ **0.560** (0.043) | | | | |

| Applicability in the farm | | | | | |
|---|---|---|---|---|---|
| Age (18-30) | | | | | |
| 31-40 | -0.493 (0.113) | | | | |
| 41-50 | -0.505 (0.085) | | | | |
| 51-60 | -0.572 (0.136) | | | | |
| 61-70 | ‡ **0.381** (0.027) | | | | |
| >71 | ‡ **0.359** (0.041) | | | | |
| Control by authority | ‡ **1.357** (0.047) | | | | |

| Economic benefit | | | | |
|---|---|---|---|---|
| Proportion of holding sales – direct to final consumer (0%) | | | | |
| 1-30 % | 1.561 (0.235) | | | |
| 31-60 % | ‡ **3.459** (0.040) | | | |
| 61-100 % | 0.907 (0.818) | | | |
| Self-chosen measures | 2.701 (0.053) | ‡ **0.357** (0.019) | 0.533 (0.224) | 0.397 (0.105) |
| Reduced land rent | ‡ **1.924** (0.004) | | | |
| Control by authority | ‡ **1.616** (0.013) | | | |
| Sales guarantee | ‡ **0.535** (0.029) | | | |

| Willingness to enroll | |
|---|---|
| Age (18-30) | |
| 31-40 | 0.442 (0.163) |
| 41-50 | 0.411 (0.095) |
| 51-60 | 0.383 (0.065) |
| 61-70 | ‡ **0.235** (0.012) |
| >71 | ‡ **0.190** (0.011) |

| | | |
|---|---|---|
| Proportion of holding sales – to processor (0%) | | |
| | 1-30 % | ‡ **3.348** (0.005) |
| | 31-60 % | 0.058 (0.922) |
| | 61-100 % | -0.169 (0.680) |
| Proportion of holding sales – to private wholesaler/retailer (0%) | | |
| | 1-30 % | 0.486 (0.065) |
| | 31-60 % | ‡ **0.350** (0.036) |
| | 61-100 % | 0.830 (0.650) |
| Reduced land rent | | ‡ **2.334** (0.001) |

**Note:** The reference modality of the explanatory variable is in parentheses. * VU = Very Unlikely, U = Unlikely, N = Neutral, L = Likely, VL = Very Likely; p-values in parentheses; ‡ **in bold** indicates the 0.05 level of statistical significance.

In terms of odds ratio, for those who have previously experienced land tenure-alike measures, the odds of being more likely to consider "understandable" the land tenure contract solution is 5.8 greater. By a unit increase in the scoring of *self-chosen measures*, the odds of being more likely to easily understand the LT contracts is 1.8 times greater.

The older the respondent, the lower the odds of perceiving "applicable" the LT contracts, while for an increase in the scoring of *control by authority* the odds of being more likely to consider "applicable" the LT contract is 1.4 times greater.

*Economic benefit* is influenced by the holding exposure to direct consumers (in terms of the amount of sales). Asymmetric effects are generated by the increase in the scoring of *self-chosen measures*, hinting at lower odds of being more likely to consider "economically beneficial" the LT contract. For higher scoring of *reduced land rent*, the odds of being more likely to perceive the "economic beneficial" of the LT contract is 1.9 times greater. *Control*

*by authority* has also a positive impact on the odds of being more likely to consider "beneficial" the LT contract. By a unit increase in the scoring of *sales guarantee*, the odds of being more likely to perceive "economically beneficial" the LT contract decreases.

*Willingness to enroll* is negatively influenced by *age*, but it is strongly and positively impacted by the exposure of the holding towards the sales to processors and private wholesalers/retailers, as well as by the increase in the scoring of *reduced land rent* (odds ratio is 2.3 times greater).

## 4. Discussion

The results suggest different patterns behind the farmers' perceptions in terms of understandability, applicability, economic benefit, and willingness to enroll related to the four incentive contract solutions investigated.

The respondent's age often plays a key role in determining the overall "acceptability" of the innovative contract solutions, as it is highlighted, e.g., by Šumrada et al. (2022) for the result-based schemes in Slovenia. We find empirical evidence that being older hints at lower levels of the overall "acceptability" of innovative contract solutions. Older farmers often also show a limited willingness to enroll.

In line with the research findings of the literature on the subject (see, e.g., Gailhard et al., 2015; Westerink et al., 2017) we find that the previous experience of similar and/or specific "contract solution-alike" measures has a very strong say in determining the preferences of the farmers/land managers. This is straightforward, for example, in terms of the more solid perception of the easiness of understanding related to both the collective and value chain contracts.

Some structural characteristics of the holdings play a peculiar role in influencing the respondents' perceptions, as it is suggested by Gailhard and Bojnec (2015) and Russi et al.

(2016). Considering the VC contract solution this is particularly evident. Indeed, both the holding exposure to certain channels of trade and the amount of sales are relevant boosts of the perceived easiness of understanding and applicability in the farm. In the case of RB contracts, producing organic positively influences the perceived applicability in the farm of such contracts, differently from Šumrada et al. (2021) which found no evidence of the holdings' structural characteristics in influencing the adoption of result-based schemes in Slovenia. We find also that the perception about the applicability of Co contracts is negatively influenced by the size of the farm, in line with the findings of Gailhard et al. (2015) on the agri-environmental measures, while, even if limited to RB contracts, other findings show a non-significant influence of the farm's size in the adoption of potential payment-by-result measures (Birge et al., 2017).

## 5. Conclusions

We investigated four novel contract solutions that are expected to target more efficiently and effectively the provision of agri-environmental-climate public goods. Namely, the result-based (RB), collective (Co), value chain (VC), and land tenure (LT) contracts. These contract types have been analyzed in terms of farmers' acceptability and willingness to uptake, by assessing i) farmers' perception of the easiness of understanding related to the innovative contract solution; ii) farmers' perception of the contract's applicability in the farm; iii) farmers' perception of the economic benefit deriving from the contract; iv) farmers' willingness to enroll.

The main policy implications concern the fact that farmers show to be rather open toward the contract solutions investigated. At the same time, different farmer's/farm characteristics may affect acceptance of different contract solutions and this requires careful consideration in the choice of the policy measures and their policy design.

By summarizing the main results, with no intention of "profiling" the potential "contractor" of such incentive contract solutions, we can highlight that the general preference of farmers is driven by the following aspects:

- RB contracts, the most well-acknowledged instrument, are largely appreciated by the agricultural holdings that produce organic, as well as by farmers being members of nature conservation/environmental organizations. These two aspects act as relevant leverage of the understanding and the perceived applicability of such contract solution (potentially, also as a boost for the perceived importance of the result-based instruments).

- Co contracts are particularly opposed by big farms which tend to consider them as unapplicable in their agricultural context. In contrast, those receiving direct CAP payments tend to be more inclined toward the adoption of such a type of contract.

- The most innovative contact solutions (in terms of diffusion and knowledge from the point of view of "contractors"), like VC and LT contracts, are largely influenced by the previous experience of the contractor with respect to "contract solution-alike" measures. Being absent such an experience (or perception of experience), VC and LT contract solutions appear to be far more complicated to understand and non-trustworthy.

- VC contracts seem to be attractive, above all, for those agricultural holdings that are already exposed to the value chains of the supply system, e.g., in terms of sales to wholesalers/retailers and/or direct consumers. These farms are positively impacted in terms of understandability and applicability related to such contract solutions. In addition, farms that tend to have a more solid tradition in value chains, such as livestock specialized holdings, are far more interested in VC contracts.

- Across the four contract solutions, age has a peculiar (but well-acknowledged in the literature on the subject) role: the older the farmer, the lower the willingness to consider the new contract solution as applicable.

The acceptance of contract types is also affected by the perception of individual contract features. As expected, the perceptions of the contractual elements that more evidently characterize each contract solution influence more relevantly the acceptance of farmers about the incentive contract type (e.g., the collective agreement for Co contracts or the reduced land rent for LT contracts). However, there are additional contract features that can play a role in impacting the level of acceptance. For example, with respect to RB contracts, a positive perception of the possibility of freely deciding about the management practices to achieve the specified environmental result(s) can increase the perceived understandability of the contract.

Overall, our findings hint at the fact that improved contract solutions can be based on a mix of instruments and that these can be more profitably implemented when tailored to the need of farmers/land managers through a flexible combination of a larger set of different contractual elements contributing to the contract design.

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