Evaluating the potential contribution of contract auctions to Agri-Environmental Policy efficiency: A simulation model for Emilia-Romagna (Italy)

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Abstract

Auctions are a potentially suitable policy tool for increasing the efficiency of Agri-Environmental Schemes (AES) through an improved allocation of contracts. In theory, through the auction mechanism, farmers have incentives to reveal their compliance costs, helping to reduce information rents and increase policy cost-effectiveness. The aim of this paper is to simulate the potential contribution of auction mechanisms to the efficiency of AES in Emilia-Romagna (Italy). The results show advantages for auctions compared with traditional flat rate payments based on average compliance costs. However, their performance is worse than flat payments based on marginal compliance costs.

Key words: *Auction, Contract, Agri-Environmental Policy, Information asymmetry*

JEL Classification: Q15, Q18

Introduction

The EU Agri-Environmental Schemes (AES) may be seen as a collection of contracts in which the public administration (society) purchases public environmental goods or services from farmers. Since their inception in 1992, the design and implementation of AES's has seen very little innovation, particularly at the level of individual measures. In the implementation of EU AES the public administration usually offers a payment designed to compensate compliance costs (EC reg. 1698/2005). In the local implementation of such measures, this compensation is usually designed as a flat rate payment. The flat rate mechanism does not differentiate across farmers according to their compliance costs, and is likely to generate (important) rents to (some) participants. Various alternative payment mechanisms can be applied with the aim of reducing information asymmetries leading to overcompensation and increasing the efficiency of the measures in terms of participation/expenditure ratios. These include, in particular, self-selecting contracts obtained though mechanism design and auctions of conservation contracts (Glebe, 2008). The auction mechanisms are addressed in a growing body of literature concerning public procurement in general (e.g. McAfee and McMillan, 1987; Laffont and Tirole, 1993; Klemperer, 2002). They are also the subject of an increasing number of ac-

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tual policy experiences involving the awarding of agricultural conservation contracts. By way of auctions, AES contracts are awarded through a competitive bidding mechanism, in which farmers are expected to have higher incentives to reveal their true compliance costs. Models for this kind of mechanism are proposed in the existing agricultural economics literature (e.g. Latacz-Lohmann and Van Der Hamsvoort, 1997; 1998; Hailu and Schilizzi, 2004), but applications are still in their infancy in EU. However, auctions for conservation agriculture have been implemented in the United States and Australia and this mechanism is mentioned among the possible options under the EU regulatory framework for rural development for the years 2007-2013 (EC reg. 1698/2005).

Auctions for awarding conservation contracts can be implemented using different mechanisms. A major distinction concerns the decision-making framework for the public administration, which has two main alternatives: to establish a target of contracted land area or to establish the budget available. In both cases the farmer must set his price in response to the public administration's contract offer. In the case of fixed target auctions, the public administration is not able to determine the final overall expenditure in advance. This could be a problem for the public administration as this mechanism could result in excessive expenditure. This is solved in the case of a fixed budget which, however, has the disadvantage of not providing information in advance regarding the resulting amount of land under environmental contracts. The two options also can be represented through a different modelling approach. In the field of AES studies, the hypothesis of budget constrained auctions seems to reflect the general policy problem better, as budgets are usually allocated to these programs in a more specific way compared to participation targets. However, the existing literature offers little insight into fixed budget auctions (Schilizzi, and Latacz-Lohmann, 2005).

The aim of this paper is to develop an empirical model to simulate the potential contribution of auction mechanisms to the efficiency of AES's in Emilia-Romagna (Northern Italy). We focus on a simple budget constrained model of auction and compare it with two flat rate options. The two flat rate options are calculated by referring, in turn, to the average compliance cost and to the marginal compliance cost.

A common problem encountered in these kinds of models (both for the auctions and the flat rate option) is the estimation of the farmer's compliance cost function. To this aim, we also develop a simple methodology to derive compliance costs from FADN data, based on the same rationale used in the calculation of compliance costs in the justification of payments for the RDP in the programming period 2007-2013 (EC reg. 1698/2005) for the case study area.

The paper outline is the following: section 2 describes the methodology adopted, followed in section 3 by the results of a case study. Finally, some discussion is provided in section 4.

The model

In this paper we compare simulated auction performance (AC) with the simulated results of two alternative mechanisms: marginal flat rate payment (MFR) and average flat rate payment (AFR).

In the auction model (AC), the bidding behaviour of individual farmers is based on the budget constrained (BC) model proposed in Lactaz-Lohmann and Van der Hamsvoort (1997). The hypothesis is that the farmer can choose between a conventional production technology and compliance with some agri-environmental prescription, generating respectively profit Π_0 and Π_1, perfectly known to the farmer. The farmer's profit is expressed per hectare, without considering the agri-environmental payments, so that the difference can be used as a measure of compliance costs.

In order for it to be profitable to participate in the AES, the farmer must receive a payment that is at least equal to his compliance cost $(\Pi_0 - \Pi_1)$. However, under the auction mechanism, the payment is not certain. The farmer will submit a bid b if the expected utility in case of participation exceeds his reservation utility:

$$U(\Pi_1 + b)\left[1 - F(b)\right] + U(\Pi_0)F(b) \geq U(\Pi_0) \tag{1}$$

where $1 - F(b)$ is the probability that the bid b is accepted, b is the individual farmer bid and $U(\cdot)$ is a monotonically increasing, twice differentiable von Neumann-Morgenstern utility function.

We assume that there are no transaction costs in the preparation and implementation of the bid, that payments are only a function of the bid, and that farmers are risk neutral. The farmer's problem is then to decide the optimal b which maximizes the expected utility (on the left hand side of equation 1) over the reservation utility (on the right hand side of equation 1).

The main determinant of this choice is the trade-off between the value of the bid and the probability that the bid is accepted: a higher bid increases the net profit in case of acceptance, but decreases the probability that the bid is accepted. If the farmer simply maximizes the net economic payoff, i.e. if $U(\Pi_1 + b) = \Pi_1 + b$ and $U(\Pi_0) = \Pi_0$, equation (1) can be simplified in:

$$(\Pi_1 + b - \Pi_0)\left[1 - F(b)\right] \geq 0 \tag{2}$$

Maximizing equation (2) with respect to b, and taking first order conditions, the optimal bid (b^*) is obtained as:

$$b^* = \Pi_0 - \Pi_1 + \frac{\left[1 - F(b)\right]}{f(b)} \tag{3}$$

In order to progress further, we need to introduce some assumptions regarding the distribution of the farmer's expectations about the range of accepted bids. Considering the simplest option, we assume that expectations are uniformly distributed in the range of $\left[\underline{\beta}, \overline{\beta}\right]$, where $\underline{\beta}$ and $\overline{\beta}$ are respectively the minimum and maximum bids that farmers expect to be acceptable to the public administration. Under this hypothesis the optimal bid can be obtained as:

$$b^* = \max\left\{\frac{\Pi_0 - \Pi_1 + \overline{\beta}}{2}, \underline{\beta}\right\} \tag{4}$$

$$\text{s.t.} \quad b^* \geq \Pi_0 - \Pi_1 .$$

Equation (4) shows that the optimal bid is given by the maximum between the semisum of the compliance cost plus the maximum expected bid, and the minimum expected bid. The optimal bid is hence an increasing linear function of participation costs $(\Pi_0 - \Pi_1)$ and maximum expected bid $\bar{\beta}$.

In order to model the bidding behaviour of a population of farmers, we represent the compliance costs as a function of the area under agri-environmental contract, θ. We use $h(\theta)$ to represent the cumulative compliance costs and $h'(\theta) = \Pi_0(\theta) - \Pi_1(\theta)$ as the marginal cost, where the profit is a function of the area θ. In this case, the optimal bid can be also represented as a function of θ, by applying equation 4 to the compliance costs of each additional hectare potentially under environmental contract:

$$b^*(\theta) = \max\left\{ \frac{h'(\theta) + \bar{\beta}}{2}, \underline{\beta} \right\} \tag{5}$$

When $\underline{\beta} = 0$, the total cost for the public administration is equal to:

$$K = \frac{h(\theta) + \bar{\beta}\theta}{2} \tag{6}$$

We will further assume that the sole objective of the public administration is to maximize participation, measured by the degree of uptake, without consideration, for example the value of different environmental services produced by different farmers. Under this hypothesis and further assuming the condition of a fixed budget (B) available, the public administration will maximize the area under contract (θ) with the constraint:

$$\frac{h(\theta) + \bar{\beta}\theta}{2} \leq B \tag{7}$$

As this budget constraint will always hold with equality, from equation (7) it is possible to obtain the maximum area under contract (θ^*) as:

$$\theta^* = \frac{2B}{\bar{\beta}} - \frac{h(\theta)}{\bar{\beta}} = \frac{2B - h(\theta)}{\bar{\beta}} \tag{8}$$

This result can be compared with the one obtained in the situation of a flat rate payment per hectare. We consider two options for this: marginal flat rate payment (MFR) and average flat rate payment (AFR).

In the first case (MFR), we assume that the public administration can fix the payment equal to the compliance cost of the marginal participating farmers; then the maximum θ is achieved as:

$$\theta_1^* = \frac{B}{h'(\theta)} \tag{9}$$

This implies a greater degree of information about compliance costs on the part of the public decision maker, compared with the auction mechanism, at least for the farm in the left tail of the distribution. This is not completely unrealistic if measures are targeted to some specific area that also is characterised by compliance costs different from the average. The effect would be a screening, restricting participants to only those having costs below the resulting payment. This payment does not correspond to the optimal (less expensive) first best situation where each farmer is remunerated with exactly the amount corresponding to his compliance costs. In effect, considering this flat payment, a surplus is kept by those farmers who have a compliance cost which is lower than the flat payment.

In a more realistic context, and following the EU regulation, the public administration sets a payment (P) based on the average compliance cost of all farmers in the same area. In this case (AFR), assuming that the budget allows participation only for a "small" group of farmers (i.e. those whose cost of compliance is below P, or, in other words, those located in the left tail of the cost distribution compared to the average-costing farm), participation is simply determined by:

$$\theta_2^* = \frac{B}{P} \tag{10}$$

This also implies a rent (R) for individual farmers, that will be determined by the difference $P - h_2^{*\prime}(\theta_2)$. On the other hand, when R<0, the farmer is not expected to participate according to profit maximizing behaviour. Let us define as θ^{av} the cumulative UAA of the population of potential participants, ordered by increasing compliance costs, corresponding to the position occupied by the average-cost farm. If B is "high" we can reformulate (10) as:

$$\theta_2^* = \min\left(\frac{B}{P}, \theta^{av}\right) \tag{10'}$$

The case with $\frac{B}{P} \geq \theta^{av}$ implies a share of the unused remaining budget, equal to:

$$B^u = P\frac{\left(\frac{B}{P} - \theta^{av}\right)}{B} \tag{11}$$

The theoretical comparison between the three instruments is not straightforward, as it depends on the difference between $\bar{\beta}$ and the marginal cost on the one hand, and on the level of B compared to the total cost, on the other.

A variant of each of these three payment models is obtained by changing the assumptions about farmers' incentive perceptions. In particular, we assume now that farmers expect to be paid a sum different from the pure compliance cost. Accordingly, the money they want to earn from the transaction should cover $gh'(\bar{\theta})$ rather than $h'(\theta)$, where g represents a coefficient indicating the ratio between the expected payment necessary for participation to be considered as profitable by the farmers and the compliance cost. Assuming that the farmers know their costs, the coefficient g assumes values equal or greater than 1. The situation with g>1 could be justified by the presence of transaction costs not detected in the computation of the compliance cost, or by an additional profit that farmers require to undertake the contract. The difference g–1 represents the share of this additional profit requirement, or hidden perceived cost, on the compliance cost.

Under these assumptions, the results of AC and MFR provided respectively in equation (8) and (9), are revised by substituting $gh'(\theta)$ for $h'(\theta)$, which yields a reduction of the optimal θ. The effect of $g > 1$ on AFR in equation (10) is less straightforward, as the marginal compliance cost of the participants will normally be lower than the payment (for the "low" participation rate discussed above). Consequently, there is a change in the outcome of the measure only when $gh'(\theta) > P$ for a share of farmers willing to participate according to (10). In this case, P being fixed, there will be an uptake lower than the one calculated in (10) and, as a consequence, some budget would remain unused even if $\theta_2^* \le \theta^{av}$.

Case study and results

The methodology described in the previous section has been applied to a simulation exercise of an auction for agro-environmental services in Emilia-Romagna (Northern Italy). Two different agri-environmental measures (AEMs) are considered: a) the provision of a generic agri-environmental good that substitutes wheat cultivation (AEM1); and b) the replacement of conventional wheat cultivation by integrated wheat cultivation (AEM2). AEM1 is an hypothetical measure the economic properties of which are very similar to various landscape improvement measures applied in the area in both the 2000-2006 and 2007-2013 programming periods. The main difference between the actual measures implemented and AEM1 is that, in order to simplify, we assume no investment or maintenance costs, so that the compliance costs are only connected to the opportunity cost by way of the substitution of a cultivated crop. In addition, we approximate this opportunity cost by assuming the replacement of a specific crop (wheat) while in reality a differentiated mix of crops is normally replaced when the measure is implemented. AEM2 is a real measure which was very popular in Emilia-Romagna, particularly in the programming period 2000-2006. The measure actually concerns a number of crops, but we restrict our attention to wheat. In both cases the compliance cost function is obtained on the basis of FADN data. We consider all the FADN farms that cultivated wheat in both 2004 and 2005 in Emilia-Romagna (231 farms) and calculated the compliance cost as: a) for AEM1, the income loss due to the replacement of wheat; and b) for AEM2, the cost of changing the conventional cultivation to the integrated one. In the case of AEM1, the income forgone is simply that which was generated by wheat, assuming a total replacement with a non-profitable/non-costly land use. In the case of AEM2 the computation of compliance costs entails that the estimation of Π_0 and Π_1. Π_0 is taken as the income derived from FADN. Π_1 is calculated on the basis of FADN data by:

i) reducing the gross revenue;
ii) adjusting cultivation costs; and
iii) adding administrative and transaction costs.

The percentage adjustment for i) and ii), and the estimation of the value of iii) are those used for the justification of payments in Emilia-Romagna and have been derived from the regional RDP (Regione Emilia-Romagna, 2007). The compliance cost for each measure is first calculated on individual FADN farms. The farms are then ordered according with increasing compliance costs, and the compliance costs are plotted against the cumulative UAA, assuming that each farm in the FADN sample represents a fraction equal to 1/231st of total wheat UAA in Emilia-Romagna. The estimation of the marginal cost function for each measure is achieved by interpolation of these individual costs as a function of the cumulative UAA, using a 3rd degree equation.

The cost function is used directly for the calculation of the expected outcome in the cases of average payment (AFR) and marginal payment (MFR), following equations 9 and 10, respectively. In the case of auctions (AC), the bid function is first obtained by applying equation (5) to the individual costs level. In analogy with the costs function, the resulting bids are then plotted against the cumulative wheat UAA and interpolated with a 3rd degree equation. In the calculation of the bid, we have assumed $\underline{\beta} = 0$, whilst $\overline{\beta}$ has been assumed equal to the average of the payments for the same measures in the RDP programming period 2000-2006.

In order to take into account the possibility of extra-profit seeking by farmers, we also need an estimation of the coefficient relating the actual expected remuneration and compliance costs (*g*). In an auction experiment carried out with students, similar to the one conducted by Schilizzi and Latacz-Lohmann (2005), we found that a bidder expects a 10-20% "profit" over compliance costs. We then took an extra-profit expectation equal to 20% (i.e. $g = 1,2$) and re-estimated the performance of auctions compared to the other mechanisms for the two measures considered.

Figure 1 shows the compliance cost to measure AEM1 (substitution of wheat), that illustrates a relevant degree of heterogeneity, captured by the interpolate. This function provides a particularly good fit (R^2 = 0,977). The dotted line represents the bid calculated through equation (8) and the interpolation of the results.

(AEM1)

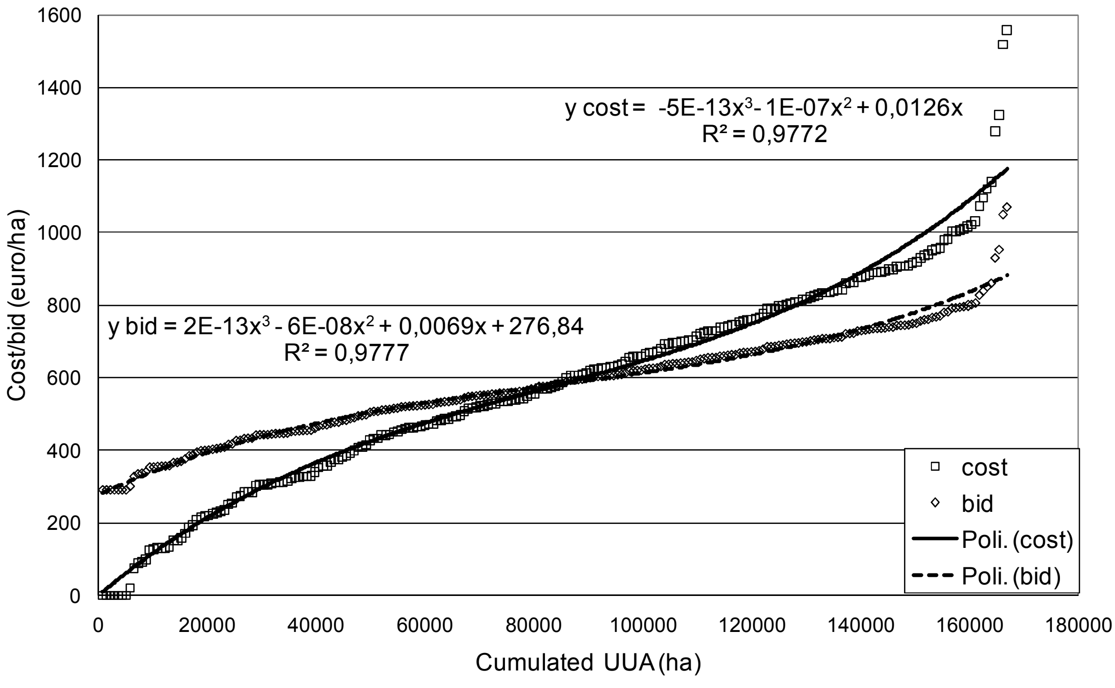

Figure 1. Cost and auction bid as a function of participating UAA– Substitution of wheat culti-

vation

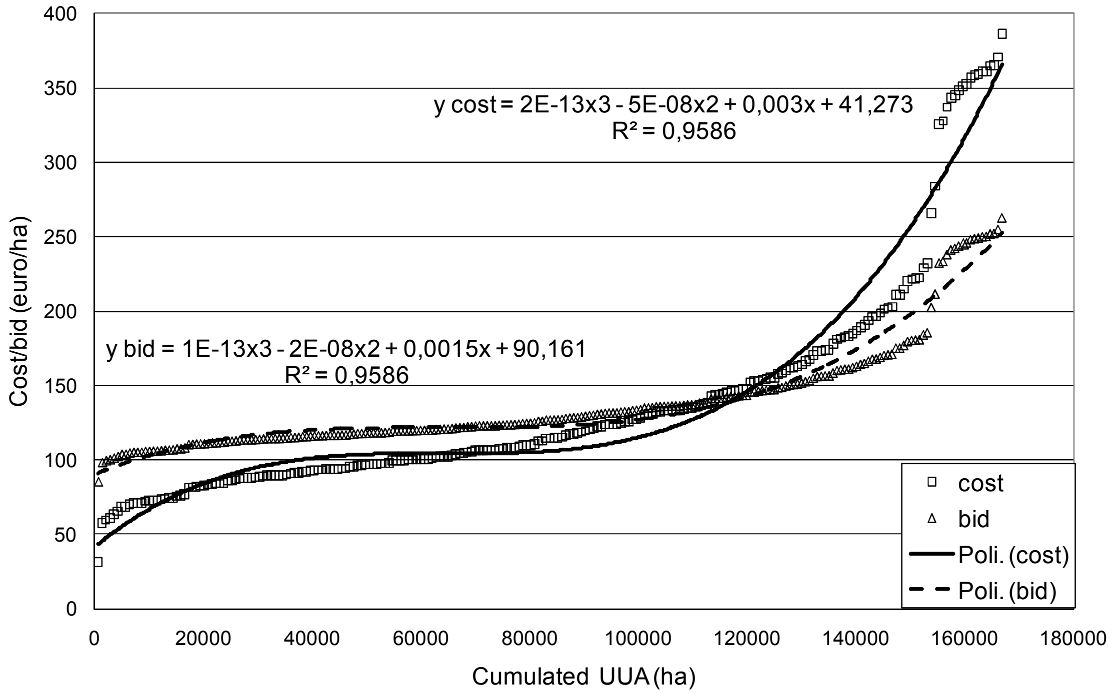

Figure 2. Cost and auction bid as a function of participating UAA - Integrated wheat cultivation (AEM2)

Figure 2 differs from figure 1 as it refers to the situation of integrated wheat cultivation (AEM2). The fit is also good in this case (0,9586). Costs are to a large extent represented by paperwork and administrative costs that are assumed in the RDP to be fixed across farms, yielding a flatter compliance cost function compared to the AEM1measure. As a result, the function has a positive intercept and is flatter in the central part.

Table 1 reports the results of the simulation, represented by the maximum UAA participating in the in the three payment mechanisms in the case of a generic environmental measure that substitutes the wheat cultivation (AEM1) with 4 different budget levels.

The performance of auctions is always located between marginal flat rate and average payment results. The difference decreases when the budget increases in the marginal flat rate situation and has an opposite trend in the average payment case. In particular, considering a fixed budget of 250.000 euros, the maximum UUA up-taken with the marginal flat rate approach is more than 5 times the area up-taken with the auction approach. This rate decreases for larger budgets; for example, with a budget of 2 million euros, it is less than 2. The auction results are closer to the average payment output (about 0,5).

If we hypothesise that farmers have an expectation of profit equal to 20% of the compliance costs, the difference between auctions and contracts with the average flat rate payment is almost negligible, whilst the difference reduces more visibly with the marginal flat payment. This occurs because, in this last option, the marginal payment is affected by the increased compensation expectation (including profit). On the contrary, in the auction and average flat options the effect of profit expectations are partially "absorbed" by, respectively, the maximum bid component and the difference between *P* and the marginal compliance cost.

Table 1. Comparison of different payment mechanisms in case of elimination of wheat cultivation (AEM1) (% of total UUA of wheat in Emilia-Romagna)

	Budget (million of euro)			
	0,25	**0,5**	**1**	**2**
***g*=1**				
Marginal flat rate payment (MFR)	2,72%	3,87%	5,54%	7,95%
Auction (AC)	0,53%	1,04%	2,00%	3,77%
Average flat rate payment (AFR)	0,26%	0,52%	1,03%	2,06%
MFR/AC	5,13	3,73	2,76	2,11
AFR/AC	0,49	0,50	0,52	0,55
***g*=1,2**				
Marginal flat rate payment (MFR)	2,46%	3,50%	4,99%	7,14%
Auction (AC)	0,53%	1,04%	1,99%	3,71%
Average flat rate payment (AFR)	0,26%	0,52%	1,03%	2,06%
MFR/AC	4,63	3,37	2,51	1,92
AFR/AC	0,48	0,50	0,52	0,56

Similar trends are shown in table 2 which refers to AEM2 (integrated wheat cultivation).

Table 2. Comparison of different payment mechanisms in case of replacement of conventional wheat cultivation by integrated wheat cultivation (AEM2) (% of total UUA of wheat in Emilia-Romagna)

	Budget (million of euro)			
	0,25	**0,5**	**1**	**2**
***g*=1**				
Marginal flat rate payment (MFR)	3,63%	4,81%	8,17%	13,87%
Auction (AC)	1,59%	3,08%	5,82%	10,77%
Average flat rate payment (AFR)	1,08%	2,15%	4,31%	8,62%
MFR/AC	2,28	1,56	1,40	1,29
AFR/AC	0,68	0,70	0,74	0,80
***g*=1,2**				
Marginal flat rate payment (MFR)	2,38%	4,17%	7,11%	11,99%
Auction (AC)	1,52%	2,93%	5,53%	10,26%
Average flat rate payment (AFR)	1,08%	2,15%	4,31%	8,62%
MFR/AC	1,57	1,43	1,29	1,17

AFR/AC	0,71	0,74	0,78	0,84

For the same policy mechanism and budget, the up-taken area is much higher in this case, due to the lower compliance costs per hectare. Also, compared to AEM1, the auction mechanism performs better in this case. The auction results are still in the middle between the other two mechanisms, hence auctions perform better than the average payment and worse than the marginal flat rate payment, but the relative differences with the best mechanism (MFR) are smaller than in the previous measure. This is due to the fact that the cost function is flatter and that, particularly in the case of higher budgets, the gap between the marginal and average payment mechanisms tends to narrow sharply.

When the simulations include a farmer's profit expectation, the effect is similar to the case of crop replacement, though the impact appears to be slightly more significant.

Discussion

The study carried out in this paper shows clear advantages for auctions compared with traditional flat rate payments based on average compliance costs. On this basis, the variability of compliance costs seems to justify the application of complex contract allocation mechanisms such as auctions, while a flat rate payment calculated on the average of all compliance costs overcompensates the farmers in the left tail of the cost function (those actually getting involved in the measures given the available budgets).

However, our results also confirm that auctions could have some limitations. In particular, we show that a marginal flat payment, considering only the left part of the cost function, could have a much higher rate of participation than auctions with the same budget. The feasibility of such a payment strongly depends on the information available to public decision makers. However, it also calls for higher attention to "cost targeting", i.e. focusing payment justification on the costs of the farmers who would be most likely participate, rather than on the average, and on their connection with identifiable locations/characteristics. When the simulations include a farmer's profit expectation, for example 20% of compliance costs, the auction's performance is closer to the efficiency of the marginal flat rate contract.

In addition, though not directly addressed in this paper, some well-established limitations raised in the literature apply to auctions. The efficiency benefits associated with auctions are strongly affected by farmers' expectations about the transaction costs, budget levels and maximum payment levels. When we restrict the population of farmers through smaller "auction basins", the auction's performance could be affected by the farmer's knowledge of the compliance costs of competitor bidders or by explicit collusion. The circulation of information and the possibility of comparing costs create an information advantage for farmers that could generate individual surpluses and inefficiency in the auction mechanism.

The lack of disaggregated data influences both simulation results and the ability to design efficient auctions. In fact, when the data are not able to capture the real heterogeneity of compliance costs, the different mechanisms show similar performance levels. The use of simple computation strategies as adopted in this paper is not completely satisfactory. However, such strategies hint at the fact that heterogeneity matters and should be considered more explicitly in *ex-post* compliance cost estimations.

Altogether, this study confirms that, in spite of the potential drawbacks, auctions deserve greater attention from public decision makers, as well as further research to support effective use.

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