Agri-environmental measures and farmers' rent: evaluating the potential contribution of auctions to increase the efficiency of Agri-environmental schemes in Emilia-Romagna (Italy).

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Summary

This work compares the cost-effectiveness of a simulated auction model (AM) with that of classical payment mechanisms as a marginal flat rate payment (MFR) and average flat rate payment (FR). The study provide an extension of the one-shot budget constrained auction model (BC) first introduced by Latacz-Lohmann and Van Der Hamsvoort (1997), and subsequently by Viaggi et al. (2008) and Glebe (2008). In this formulation, the model allows farmers to offer multi-dimensional bid as a combination of payment and a measure of a share of their land to commit to a hypothetical agri-environmental measure (AEM). The results show that the performance of the auction (i.e. 7.5 % and 27 % of the total UAA of the sample) is always located halfway between that of FR (i.e. 5% and 21 % of the total UAA of the sample) and that of MFR (i.e. 17% and 100% of the total UAA of the sample). According with Schillizzi and Latacz-Lohmann (2007) the flat rate option provides an amount of rents that is one and a half the auction's rents with a lower budget and around two times greater with the higher budget level. The results confirm that the auction has the potential to reduce farmers' information rent when compared with uniform policy instruments. However, the scale of saving depends crucially on auction design hypotheses and farmers' expectation about the maximum acceptable bid cap. The results of this research while attempting to provide a useful empirical exploration of auction theory cannot provide a comprehensive solution in most real world settings. However, it can contribute to feed the debate at EU policy level about the role of tendering instruments in agri-environmental programs to reduce the inefficiency related to the actual agri-environmental payments.

Keywords: agri-environmental policy, conservation auction, compensation payments, information asymmetry, adverse selection.

JEL Classification codes: Q18; Q58

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1. INTRODUCTION

Where desirable environmental benefit or public goods are undersupplied, a significant role of agricultural policy is to establish procurement contracts and provide incentives, through the design of agri-environmental payments, to induce the production of such goods (Moxey et al., 1999).

Despite the rising importance of Economic instruments, the debate about the design of more effective and efficient payments is still subject to a good deal of discussion. One of the main concerns regards the unneeded farmers rent generated by the miscalculation of payments due to the lack of information about farmers' compliance costs. The presence of information asymmetries about farmers production technologies and compliance costs, does not allow the public administration to set a proper level and differentiation of payment. Consequently, if the proposed payment is higher than farmers' compliance costs, the difference between payment and cost generates a surplus, for all those farmers that have to cover lower compliance costs, reducing the cost-effectiveness of the programmes. Other common inefficiencies regard the lack of targeting, the lack of monitoring as well as the lack of evaluating the expenditure.

According with a large pool of economic literature, one potential way to reduce farmers' rent is to design and implement tendering instruments. Agri-environmental auctions represent quasi-markets for the production of environmental goods (Latacz-Lohman and Schillizzi, 2005) that use bidding rules and the competition among farmers to mitigate or avoid rent seeking (and the resulting inefficiencies) arising from hidden information about farmers' parameters (i.e. compliance costs, resource setting).

The objective of this paper is twofold. First, to develop and test a numerical model of an agri-environmental auction that allows multi-dimensional bid, analysing the potential benefit of the auction approach in allocating contracts for the provision of agri-environmental nonmarket goods. Second, to provide a comparative evaluation of the auction performance (budgetary cost-effectiveness) with that of two uniform payment mechanisms. The model is developed with data from Farm Accountancy Data Network 2011 (FADN) of the Emilia-Romagna Region (E-R).

The bidding model is based on the Budget-Constrained auction model (BC) first introduced by Latacz-Lohmann and Van Der Hamsvoort (1997), and subsequently by Viaggi et al. (2008) and Glebe (2008). The developed model, differ from the BC model in order to achieve different auction results. The main novelty of the auction model (AM) developed in this paper is that allows farmers to offer a combination of payment and a measure of their uptake in the agri-environmental program, calculated as a quota of their land to allocate to the measure. Thus, unlike the BC model, farmers can choose a share of their land to commit to the measure. In AM each farmer can bid for an agri-environmental payment and for a share of his or her agricultural area to allocate to the agri-environmental scheme.

AM in this fashion still assumes that only a single, but multi-dimensional, bid for each farmer is accepted in order to achieve economic efficiency defined by the classical theoretical auction assumptions. Although empirical studies (Stoneham et al., 2003; Schillizzi and Latacz-Lhomann, 2007; Glebe, 2008;) have reported substantial cost saving through conservation auctions and in the recent decades there has been a widespread use, in the budget constrained format, in the major agri-environmental programs of United States and Australia, the transition from theory to practice in Europe is still in its infancy. The outstanding feature of conservation auctions to reveal, at least partly, farmers' compliance costs (Latacz-Lohman and Schillizzi, 2005) can be a key feature for policy-makers with limited information that needs cost-efficient way of allocating funds for rural areas.

The paper outline is the following: section 2 provides an overview of the main literature about agri-environmental auctions. Section 3 describes the modelling approach, followed in section 4 by the results of a case study and in section 5 with a discussion. The paper ends in section 6 with some concluding remarks.

2. AGRI-ENVIRONMENTAL AUCTION DESIGN WITH LIMITED INFORMATION

Agri-environmental contracting is characterized by the presence of the asymmetric distribution of information between government and farmers. Since the latter know best the management techniques and the site-specific production costs, they are considered to have an informational advantage over the government (hidden information), typically before the contractual relationship (adverse selection). When the agent has also an informational advantage on the actions taken (hidden action), which occurs after the conclusion of the contract, we are talking about moral hazard. Since usually the utility of the agent differs from the utility of the principal, the agent may exploit the information asymmetry behaving opportunistically. The fundamental assumption behind this theory is that the results of the transactions cannot be traced back to the actions chosen by individuals or through their characteristics. Uncertainty enables opportunistic agents to conceal information about their behaviour and characteristics.

Latacz-Lohmann and Schillizzi (2006) argue that the adverse selection arise when the agency, which is unable to observe the individual farmers' compliance costs, provides to those farmers with low potential for producing high quality environmental output, an agri-environmental payment that is higher than their compliance cost. In economic terms, the difference between payments and compliance cost generates an economic rent for these farmers, while for the other that have to cover greater compliance costs, it becomes unprofitable to participate to the measure. Adverse selection occurs also when the public administration direct payments to those farmers that have to make less severe changes to current agricultural practices resulting in lower compliance costs, like farmers who have already managed their land in an environmentally friendly way.

According with Nicita and Scoppa (2005) the economics of information addresses what are the main consequences of moral hazard and adverse selection under the market forces and it analyses the contractual or institutional mechanisms adopted by agents with the aim of preventing the developing of the opportunistic behaviours. In this context, the role of incentives become critical, since players must be encouraged to undertake certain behaviours efficiently.

Latacz Lhomann and Schillizzi (2006) consider auction mechanism as one of the main approach to address adverse selection and reduce hidden information. Auctions (Riley and Samuelson, 1981; Mcafee and McMillan, 1987; Milgrom, 1989; Klemperer, 2002; Klemperer, 2004) create decentralised incentives to offer bids close to farmers' opportunity costs, even when the government holds little information about these opportunity costs. Holt (1980) suggests that the award of contracts based on competitive bidding is a method used in procuring goods and services for which there are no well-established markets, as in the case of the provision of environmental benefits that are a public-type non-market good. Thus, an agri-environmental auction can be viewed as a procurement auction (Laffont and tirole, 1993) where the government (auctioneer) announces a contract for the procurement of environmental improvements and calls for bids from farmers (bidders): the auctioneer establishes a set of rules including the prescription of some AEMs in order to reach an environmental target. The bidders offer sealed bids describing actions they are willing to take and the associated payment they are willing to accept. The government subsequently select and rank bids for funding based on some measure of cost-effectiveness until a fixed budget is exhausted or a pre-set reserve price is reached.

This implementation mechanism can be different if the public administration decides to establish a target of contracted land area (Viaggi et al., 2008). In both cases, the farmer must decide his or her price in response to the public administration's contract offer, while in the case of target participation is difficult for the public administration to determine ex-ante the global expenditure. However, in both cases the condition that the auctioneer accepts bids until the budget or the reserve price is met generates competition among farmers. According with Latacz Lhomann and Schillizzi (2005) the competition must be the driving force behind the cost revelation mechanism of the auction: bidders facing competition are more likely to reveal their true valuation than strategically inflated the value. Latacz-Lohmann and van der Hamsvoort (1997) has demonstrated through theoretical model that optimal bids increase with both the bidders' opportunity costs and his or her expectations about the bid cap. The bid cap correspond at least to the highest accepted bid within the available budget, and representing the reserve price per unit of environmental good. According to the literature, the government must keep this value secretly to the potential bidders, since when they formulate their own choice they must ignore its exact value and they must face a trade-off between a higher net gain from a higher bid and a reduced probability of winning. The expectation about the bid cap and the probability of winning the auction induce farmers to reveal their true opportunity cost of producing the environmental good in question and reduce the probability of overbidding by farmers. In these terms, the auction mechanism represents a price discovery mechanism that takes account of private information since it is determined through a decentralised process where each farmers express his or her own valuation. Thus, comparing with a centralised uniform price policy, the auction prices appear to reflect better the farmers' true opportunity cost.

The main contributions of the literature on auction theory are formed by game-theoretic models (Rothkopf and Harstad, 1994; Klemperer, 2002) based on the Revenue Equivalence Theorem (RET) introduced by Vickrey (1961, 1962), further developed by Myerson (1981) and Riley and Samuelson (1981), which constitute the guide to construct and assess auction design.

The RET suggests that all major auction designs will lead to the same expected revenues for the auctioneer. This theorem provides the rationale for the developing of environmental auction models that are underpinned by some of the main RET assumptions, including: (i) bidders are risk neutral; (ii) bidders have independent privates value; (iii) there is symmetry among bidders; (iv) payment is a function of bid alone; (v) there are no costs associated with bid construction and implementation. Auction literature refers to this model as the benchmark model.

However, in the context of agri-environmental auction these approaches are often constrained by analytical tractability due also to several features that distinguish the environmental auctions from the benchmark model. In other word, to deal with environmental auction some of the restrictive assumptions that form the RET in some cases need to be relaxed, making the model more realistic. For example, most of the classic auction theory has dealt with the sale of a single indivisible unit (Klemperer, 2002), while most of the agri-environmental problems have been analysed with multi-unit approach of divisible unit. Schillizzi and Latacz-Lohmann (2006) argues that the Nash-equilibrium of a multi-unit procurement auction can be calculated if bidders offer a single unit each, but agri-environmental auction generally involves information asymmetry and the supply of multiple unit each that make the computation of equilibrium bidding strategies more complicated. Hansen (1988) and Che (1993) have developed multi-dimensional auction models where only a single bid is accepted and where the economic efficiency is achieved only if the government announces his true utility functions through a scoring rule. Moreover, bids tend to have multiple dimensions as monetary compensations are weighted with estimated environmental benefits (Iho et al., 2014).

In the light of the complexities related to game-theoretic approaches and of the practical limits of the RET assumptions, some contributions in the simulation and experimental economics literature have analysed the efficiency of hypothetical auction models subject to controlled manipulation of the classical assumptions (Connor et al., 2008). For example, Latacz-Lohmann and van der Hamsvoort (1997), used a utility theoretical simulation model to compare the optimal bid response of auctions to uniform payment policy. Modelling farmers’ expectations of the highest acceptable bid as an exogenous variable they found that the optimal bid level is an increasing function of the uncertainty associated with the agency reservation price and they conclude that as bidder uncertainty regarding auction reservation prices converges to zero, the optimal responses of the auction and the uniform payment converge. In other words, when the level of uncertainty about the auctioneer reservation price is high, a discriminant price auction can lead to inefficient outcomes. About the convergence of the outcomes of auction and uniform policy Hailu and Schillizzi (2004) has observed that can only occur in the context of repeated auctions, where the government treat the information about the reserve price in a way that creates room for bidders to learn about the reservation price. Meanwhile, Banerjee et al. (2015) use laboratory experiments to investigate the impact of information revelation on the performance of an iterative auction with spatial targeting and they conclude that rent seeking is intensified with more information and increased bidder familiarity with the auction. Other studies since dealing with one-shot auctions do not need to capture potential learning effects of repeated auctions (Hailu and Schillizzi, 2004). Viaggi et al. (2008) simulates the bidding behaviour of individual farmers on the basis of the budget constrained model proposed in Latacz-Lhomann and van der Hamsvoort (1997) comparing the results with those of two alternative mechanisms based on flat rate payments. Considering a one-shot one-dimensional auction approach, their results confirm that the auction is more cost-effective than traditional flat rate payment based on average compliance cost. Morever, they demonstrate that the payment based on marginal compliance cost can be even better than the other approaches, but it is difficult to implement because it implies a greater degree of information about compliance costs on the part of the regulator.

By extending the modelling framework of Latacz-Lhomann and van der Hamsvoort (1997), Glebe (2008) develops a bidding model that allows farmers to propose input levels of their own choosing. The two dimensions (i.e. the input quota and the compensation payment) are integrated into a single ranking system through a defined scoring index. Within this approach, farmers are informed about the calculation of the scoring index, but not about its critical value, above which no bids will be accepted. The announcement of the scoring system aims to induce farmers to propose input quotas that are targeted by the regulator and it will be determined at a level ensuring that the environmental target can be reached with the smallest programme outlays. The analysis of the bidding model compared with that of a self-selecting contract demonstrated the potential of the auction approach to reduce farmers' rent and consequently the programme outlays. However, the author suggests that this savings depend on the assumptions that the expected bid cap is uniformly distributed, and that the scoring system is additively separable inducing optimal price-quality combination. Thus, when the scoring system assumes that the optimal input quotas depend on financial bid, the cost-effectiveness of the auction model can be enhanced, if the scoring system induces farmers to offer the input quotas that are targeted by the government with the related financial bids. However, Glebe (2008) concludes that the budget cost savings may be easily eroded if farmers' expectations about the bid cap are increasingly suboptimal. Moreover, for a systematic analysis of the attributes and properties of scoring auctions, we refer to Che (1993), Branco (1997) and Asker and Cantillon (2008). Asker and Cantillon (2008) provides a complete analysis of the situation in which a buyer cares about attributes other than price when evaluating the offers submitted by suppliers. Thus, they analyse the equilibrium behaviour in scoring auctions when suppliers' private information is multidimensional demonstrating the dominance of scoring auctions on other commonly used procedure for buying differentiated products (i.e. menu auction, the beauty contest and price-only auctions with minimum quality thresholds).

Finally, few studies provide evidence-based assessment of transaction costs involved in agri-environmental auctions. Fang and Easter (2003) analyses the Minnesota River nutrient trading programme. They found that when the transaction costs of participating in the programme are included, the net benefits of the auction might be negative. Connor et al. (2008) provides similar conclusion suggesting that the estimated cost savings under the auction may be reduced slightly when transaction costs associated with auction implementation are considered, and Glebe (2008) points out that a crucial factor determining the relative cost-effectiveness of a bidding approach relates to transaction costs arising from programme implementation and monitoring.

Despite auctions demonstrates a potential to increase programmes cost-effectiveness, they are complex incentive mechanism, involving a higher risk of failure. For example, with a small group of bidders there may arise a problem of insufficient bidding competition that can increase farmers' likelihood of collusion and strategic behaviour. Moreover, there may also arise the risk of bidders' learning in repeated auctions.

3. METHODOLOGY

Following the one-shot budget constrained auction model first introduced by Latacz-Lohmann and van Der Hamsvoort (1997), and subsequently by Viaggi et al. (2008) and Glebe (2008), in this paper we simulate the performance of a new bidding behaviour model of individual farmers (AM).

While the classical BC model, as in Latacz-Lohmann and van Der Hamsvoort (1997), dealt with one-dimensional bids, the AM further extends their analysis allowing farmers to offer a multi-dimensional bid formed by a combination of a per hectare payment and a measure of their uptake in the agri-environmental programme, calculated as a quota of their land allocated to the scheme.

The hypothesis is that the regulator seeks to purchase multiple units of environmental goods that substitute a mix of traditional cultivation selecting numerous farmers to participate in the agri-environmental auction. According with the previous literature, the model assumes that farmers differ in the costs of compliance they incur participating in the AEM and considers bidders' expectations of the highest acceptable bid as an exogenous variable.

The farmers can choose how to allocate their agricultural area between the profitable traditional production and the less profitable or unprofitable agri-environmentally friendly one, but for which they can receive, if their bids will be accepted by the public administration, the agri-environmental payment.

While profit $\Pi_0 = \Pi_0(X)$ expresses the total conventional profit without participating to the measure as a function of the total agricultural area X, with $\Pi_0'(.) > 0$ and $\Pi_0''(.) < 0$. Profit $\Pi_1(X - x)$ represents the farmer's profit linked to the agri-environmental prescription that is a decreasing function of the share of the agricultural area *x* that the farmer commits to the measure. If farmers do not participate to the scheme, so with *x=0*, $\Pi_1(X)$ correspond to the conventional profit $\Pi_0 = \Pi_0(X) = \Pi_1(X - 0) = \Pi_1(X)$.

Both profits are perfectly known by the farmer and are net return to land expressed per hectare without considering the agri-environmental payments, thus the difference between the two represents the marginal compliance cost as a function of the contracted area x:

$$k_X(x) = \Pi_1(X) - \Pi_1(X - x) \quad (1)$$

In AM, it is hypothesized that the farmer, taking constant the marginal profit, and on the basis of his/her expectation about the maximum bid cap $\overline{\beta}$, will offer bid that is a combination of a share of land *x* and a per hectares payment b higher enough to cover the compliance costs. Thus, the model assumes that farmers are profit-maximizing agent and they choose to participate to the scheme, if they will receive a payment that must be at least equal to the compliance cost defined through equation (1). Thus, under the auction mechanism, each farmer offer a bid *b* if the expected utility in case of participation exceeds his or her reservation utility:

$$U[\Pi_1(X - x) + b] \cdot P(b \leq \beta) + U[\Pi_1(X)] \cdot [1 - P(b \leq \beta)] > U[\Pi_1(X)] \quad (2)$$

Where β indicates the farmers' expectations about the maximum bid cap above which all bids are rejected by the public administration; P denotes the probability that the submitted bid is accepted and $U[\Pi_1(X - x) + b]$ is the expected utility in case of participation. Following Lactaz-Lohmann and van der Hamsvoort (1997) the probability that the bid is accepted can be expressed as:

$$P(b \leq \beta) = \int_{\underline{\beta}}^{\overline{\beta}} f(b)db = [1 - F(b)] \quad (3)$$

Where $f(b)$ indicates the density function, $F(b)$ the distribution function, $\underline{\beta}$ represents the bidder's minimum expected bid cap and $\overline{\beta}$ the maximum upper limit to his or her expectations. *U(·)* is a monotonically increasing twice differentiable von Neumann-Morgenstern utility function. In the case that the submitted bid is rejected, the bidder's utility coincides to the reservation utility $U[\Pi_1(X)]$.

Equation (2) shows that the farmer must find out the balance between net payoff and the acceptance probability. If he/her submits a higher bid, he/her increases the net payoff but reduces the probability of winning, and vice-versa. Thus, the farmer's problem is to determine the optimal combination of land and payment, which is the one that maximizes the expected utility on the left-hand side of equation (2), over and above the reservation utility on the right-hand side of equation (2).

Since it is a budget-constrained auction, the public regulator will set ex post, after all bids have been received, the maximum acceptable bid cap. This bid cap correspond at last to the highest accepted bid within the available budget, and representing the reserve price per unit of environmental good/services. According to Lactaz-Lohmann and Schillizzi (2006), we have assumed that the government keeps secretly its value to the potential bidders. Moreover, we have assumed that there are no cost in the preparation and implementation of the auction, thus the payment is only function of the bid.

Assuming a risk-neutral farmers' behaviour in the auction, called for simplicity Auction behaviour (Ab), for which each farmer simply maximizes expected net payoff, the bidder's problem becomes to decide the optimal quota of participating land x and the bid b that maximizes his or her expected utility. According with equation (2) and (3), the bidding problem can be rewritten in as:

$$\text{Ab}(x, b) = [\Pi_1(X - x) + bx\,] \cdot [1 - F(b)] + \Pi_1(X) \cdot \text{F}(b) - \Pi_0 > 0 \quad (4)$$

The optimal bidding behaviour $\text{Ab}(x^*, b^*)$ is then obtained maximizing equation (4) with respect to x and b, taking first order conditions and solving each system of derivatives as:

$$\frac{\partial \text{Ab}(x,b)}{\partial x} = 0 \quad (5)$$

$$\frac{\partial \text{Ab}(x,b)}{\partial b} = 0 \quad (6)$$

for equation (5), solving the derivative with respect to x, we obtain:

$$\frac{\partial \text{Ab}(x,b)}{\partial x} = [\Pi_1{}'(X - x) + b\,] \cdot [1 - F(b)] = 0 \quad (7)$$

$$b^* = -\Pi_1{}'(X - x^*) \quad (8)$$

Intuitively, the farmer finds it optimal to maximize his/her expected total surplus submitting a bid that must at least cover the marginal cost of changing cultivation by adopting the AEM.

If we solve now the equation (6) from the first order condition, with respect to b, we obatin:

$$\frac{\partial \text{Ab}(x,b)}{\partial b} = x \cdot [1 - F(b)] - \Pi_1(X - x) \cdot f(b) - bx \cdot f(b) + \Pi_1(X) \cdot f(b) = 0 \quad (9)$$

$$bx \cdot f(b) = \Pi_1(X) \cdot f(b) - \Pi_1(X - x) \cdot f(b) + x \cdot [1 - F(b)] = 0 \quad (10)$$

$$b = \frac{\Pi_1(X) - \Pi_1(X - x)}{x} + \frac{[1 - F(b)]}{f(b)} \quad (11)$$

Supposing that for a risk-neutral farmer, the expectations about the maximum bid that is accepted β are uniformly distributed in the range $\left[\underline{\beta},\ \overline{\beta}\right]$, in accord with Latacz-Lohmann and van der Hamsvoort (1997) the density and distributions functions of a rectangular distribution are defined as:

$$f(b) = \begin{cases} 0 & if\ b < \underline{\beta} \\ \frac{1}{\overline{\beta} - \underline{\beta}} & if\ \underline{\beta} \le b \le \overline{\beta} \\ 0 & if\ b > \underline{\beta} \end{cases} \quad (12)$$

$$f(b) = \begin{cases} 0 & if\ b < \underline{\beta} \\ \frac{b - \underline{\beta}}{\overline{\beta} - \underline{\beta}} & if\ \underline{\beta} \le b \le \overline{\beta} \\ 0 & if\ b > \underline{\beta} \end{cases} \quad (13)$$

Which states that for the farmer does not make economic sense to submit a bid that is lower (greater) than the minimum (maximum) expected bid cap. Taking the properties of equation (12) and equation (13), we expand and analyse the last right-hand terms of equation (11), and we obtain:

$$\frac{[1-F(b)]}{f(b)} = \frac{\left[1-\frac{b-\underline{\beta}}{\overline{\beta}-\underline{\beta}}\right]}{\frac{1}{\overline{\beta}-\underline{\beta}}} = \left[\frac{\overline{\beta}-\underline{\beta}-b-\underline{\beta}}{\overline{\beta}-\underline{\beta}}\right] \cdot \frac{\overline{\beta}-\underline{\beta}}{1} = \overline{\beta} - b \tag{14}$$

taking this result, and substituting equation (14) into equation (11), the optimal bid b^* of a risk-neutral farmer becomes:

$$b = \frac{\Pi_1(X)-\Pi_1(X-x)}{x} + \overline{\beta} - b \tag{15}$$

$$b^* = \frac{\frac{\Pi_1(X)-\Pi_1(X-x^*)}{x^*}+\overline{\beta}}{2} = \frac{\Pi_1(X)-\Pi_1(X-x^*)+\overline{\beta}x^*}{2x^*} \tag{16}$$

substituting equation (1) into equation (16), the optimal bid becomes:

$$b^* = \frac{k_{x^*}(x^*)+\overline{\beta}x^*}{2x^*} \tag{17}$$

Which states that optimal-bid is an increasing linear function of farmer expectation about maximum acceptable bid and marginal compliance cost.

In order complete the farmer decision-making problem and derive the bidders' optimal share x^* of agricultural land to commit under the AEM, we further explicit the profit function using a quadratic form, as:

$$\begin{cases} \Pi_0 = \Pi_1(X) = aX - cX^2 \\ \Pi_1(X-x) = a(X-x) - c(X-x)^2 = aX - ax - cX^2 - cx^2 + 2cX \cdot x \end{cases} \tag{18}$$

In order to make more simply the next analytical part of the problem, we derive now the marginal profit function under the AEM, $\Pi_1{}'(X-x^*)$, making the first derivative of $\Pi_1(X-x)$ of equation (18) with respect to x, which becomes:

$$\frac{\partial \Pi_1(X-x)}{\partial x} = \frac{\partial a(X-x)-c(X^2+x^2-2X\cdot x)}{\partial x} = 2c \cdot X - 2c \cdot x - a = \Pi_1{}'(Xt-x) \tag{19}$$

We are now able to find out the farmers optimal share x^* of agricultural land, taking the results from the optimization problem, equation (8) and equation (16) and using the marginal profit equation (19), we need to operate by substitution and solve with respect to x the following system of results:

$$\begin{cases} b^* = -\Pi_1{}'(X-x^*) \\ b^* = \frac{\Pi_1(X)-\Pi_1(X-x^*)+\overline{\beta}x^*}{2x^*} \\ \Pi_1{}'(Xt-x) = 2c \cdot X - 2c \cdot x - a \end{cases} \tag{20}$$

By equating the equations in the first two lines of the system with respect to b^*, and substituting the explicit formula of the marginal profit (third line), we calculate the optimal share as follow:

$$-2c \cdot X + 2c \cdot x + a = \frac{\Pi_1(X)-\Pi_1(X-x^*)+\overline{\beta x^*}}{2x^*} \tag{21}$$

$$-4c \cdot X \cdot x + 4c \cdot x^2 + 2a \cdot x = \Pi_1(X) - \Pi_1(X-x) + \overline{\beta}x \tag{22}$$

$$-4cXx + 4cx^2 + 2ax = aX - cX^2 - aX + ax + cX^2 + cx^2 - 2cXx + \overline{\beta}x \quad (23)$$

Operating simplification in equation (23), we obtain:

$$x(a - 2cX + 2cx - \overline{\beta}) = 0 \quad (24)$$

from which we derive the optimal quota of land x^* as follows:

$$x^* = \frac{2cX - a + \overline{\beta}}{3c} \quad (25)$$

Equation (25) states that the optimal quota of land x^* increases linearly with the expectation about the maximum bid cap, and that farmers have an incentive to commit more land when the profit from traditional cultivation is lower.

According with Viaggi et al. (2008) in order to compare the AM performance with those of two uniform payment approaches, according with equation (1) and equation (17), the optimal bid function can be written as:

$$\text{b*}(X) = \max\left[\frac{1}{2}\left(\frac{k_{x^*}(x^*) + \overline{\beta}x^*}{x^*}\right), \underline{\beta}\right] \quad (26)$$

and when $\underline{\beta}$=0, the total cost for the public regulator (TC), is equal to:

$$\text{TC} = \left[\frac{1}{2}\left(k_{x^*}(x^*) + \overline{\beta}x^*\right)\right] \quad (27)$$

Assuming that regulator objective is to maximize the uptake to the AEM, thus the problem becomes to maximize the contracted area under a fixed budget constrain B:

$$\text{TC} = \left[\frac{1}{2}\left(k_{x^*}(x^*) + \overline{\beta}x^*\right)\right] \leq \text{B} \quad (28)$$

That will always hold with equality obtaining the maximum area under contracts x^* as:

$$x^* = \left[\frac{2B - k_{x^*}(x^*)}{\overline{\beta}}\right] \quad (29)$$

Is now possible to compare this result with the one that can be obtained considering a marginal flat rate payment (MFR). If the government can fix the payment equal to the compliance cost of marginal participating farmers, the maximum x* becomes:

$$x^*_{MFR} = \left[\frac{B}{k_{x^*}(x^*)}\right] \quad (30)$$

To apply the mechanism described by equation (30) the government needs a great degree of information about compliance cost compared to the optimal bidding results equation (29). Thus, if we consider the opportunity to screening contracts and targeting the payment to some specific area where compliance costs are different from the average this solution is still feasible.

Another approach would be, according to the EU regulation, to set a flat rate payment (FR) φ based on the average compliance cost of all farmers in the same area. This mechanism restrict the participation to those farmers whose compliance cost is below the average marginal payment, determined by:

$$x^*_{FR} = \left[\frac{\text{B}}{\varphi}\right] \quad (31)$$

Equation (31) imply a rent *(R)* for individual farmers that is determined by the difference $R = \varphi$-$k_{x^*}(x^*)$. Moreover when $R<0$ farmers do not participate to the programme according to their incentive rationality constraint. According to Viaggi et al. (2008), the theoretical comparison between the three instruments is not straightforward. From the one hand, it depends on the farmers' expectation on the maximum acceptable bid cap $\overline{\beta}$ and marginal cost. From the other hand, it depends on the level of budget compared to total cost.

4. CASE STUDY AND RESULTS

The empirical model is developed with the FADN crop dataset of E-R (2011). The case study region has a heterogeneous territory that includes hills and mountains and is located in the highly productive, densely populated and industrialized Po valley (northern Italy). E-R covers an area of more than 2.2 million hectares, of which, in 2007, the Utilized Agricultural Area (UAA) was nearly 1.1 Million hectares with an average of 12.8 ha per farm and with approximately 82,000 farms. The UAA is about the 47.6 percent of the entire area of the region that is the highest percentage of utilized agricultural area of all of the Italian regions, even higher than the national average (42.3 per cent), whilst among the top for European regions. Given the relevant impact of agriculture on the regional economy, the Rural Development Policy through the provision of the agri-environmental measures has always played a major role to mitigate the significant environmental pressures from agriculture and to provide environmental goods and eco-system services to the region.

According with the Regulation (EC) 1698/2005 and 1305/2013, the E-R agri-environmental policy is defined by the RDP 2014-2020, mostly by the measures 10, 11 and 12 concerning Agri-environmental and climate payments. In E-R the agri-environmental and climate payments are organized into several sub-measures (operations[1]) that target different environmental objectives and areas.

These actions cover a substantial part of the RDP budget: in 2010 the share of public resources was about 30% of the entire RDP, with total budgetary resources of approximately 296 million of euros (Regione Emilia-Romagna, 2010). In the current programming period (2014-2020), this support is increased to about 42.8% of the total RDP budget, with total budgetary resource of 509 million of euros for the macro-theme of environment and climate, of which the 74%, approximately 376 million of euros, are dedicated to agri-environmental support through payments.

The overall strategy of the Region through the RDP agri-environmental and climate measures is to promote sustainability and combat climate change promoting agricultural practices capable of producing and protecting public goods such as biodiversity, agricultural landscapes, air, soil and water.

Under this regional framework, we assumed for the simulation model a hypothetical agri-environmental service (AEM) that substitutes a mix of conventional crops with a non-profitable environmentally friendly land use, providing most of the economic properties of various landscape improvement measures that have been applied within the programming period 2000-2006, 2007-2013, defined in the current RDP under measure 10. More in detail, we assume that AEM mirrors several landscapes improvement and biodiversity protection

[1] Operation 10.1.01 concerns the integrated production measure. Operation 10.1.02 regards the manure managements, the operation 10.1.03 is directed to increase the organic matter of soils, operation 10.1.04 aims to conservation agriculture practices contributing to increase the organic matter of soils. The operations 10.1.05/06 are directed to protect agro-biodiversity, operation 10.1.07 provides no-tillage and extensive grassland measure and operation 10.1.08 is related to the management of buffer strips along water courses to contain the transfer of pollutants from soil to water sources. Operation 10.1.09 regards the management of Natura 2000 areas and the conservation of natural and semi-natural habitats and of the agricultural landscapes, while operation 10.1.10 is set-aside. Moreover operations 01 and 02 of measure 11 are related to organic farming measures.

measures described by the operation 10.1.09 and 10.1.10 of the abovementioned measure 10 of the current E-R RDP. These measures aim to preserve the quality of cultivated landscapes, and can be viewed as horizontal measures (Uthes et al., 2010) that indirectly aim to protect birds and other wildlife, to improve the network of habitats and to reduce the entry of harmful substances in the bordering habitats protecting flora and fauna. The E-R region attaches great importance to these actions in relation to the biodiversity targets of the RDP and supports unprofitable investment, such as hedges of tree, with purpose of buffer strips to reduce the transport phenomenon of polluting elements and also groves, ponds, lakes, and reservoirs for the phytoremediation of water. Since this type of measure concerns a wide number of crops, we implicitly assume that AEM can be applied on a mix of crops. Thus, adopting "the number of cops" (n≥4) as selection criteria, we selected from the FADN 2011 dataset a sample of 100 farms that grow the largest number of crop in E-R. The selected farms thus represent the ones that produce the largest number of crops at regional level in 2011.

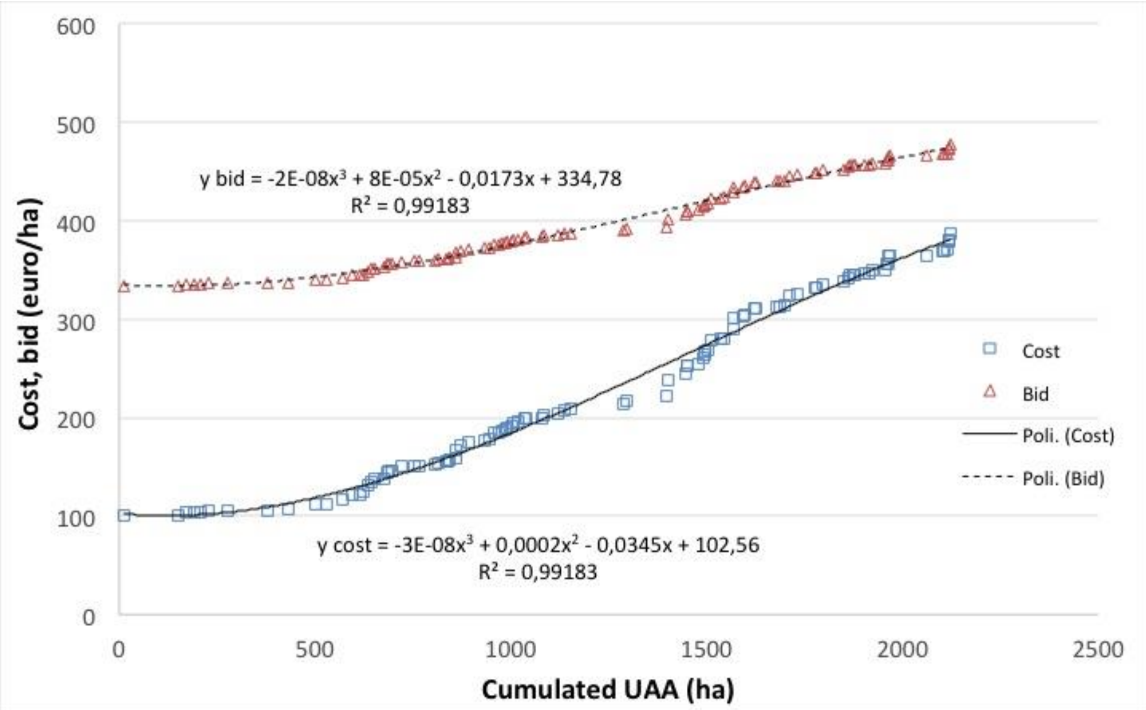
For AM, we have assumed that the main difference between our hypothetical scheme AEM and the real measure implemented in the RDP of E-R is that for AEM no investment or maintenance cost are linked with participation to this measure, thus the compliance costs are represented by the opportunity cost due to substitution of the conventional initial mix of crops. Following the procedure developed by Viaggi et al. (2008) and equation (1) we approximated compliance cost of each farmer to the difference between profit Π_0 and profit $\Pi_1(X-x)$. While, profit Π_0 is derived by calculating the gross margin for each farm considering the conventional mix of crops directly from FADN, profit $\Pi_1(X-x)$ expresses the profit as function of the share of the agricultural area x that each individual FADN farm is willing to commits to the AEM. Thus, assuming a partial replacement with a non-profitable land use, we calculated $\Pi_1(X-x)$ from FADN data, by the following steps:

1. In a first step, we computed the gross revenue and the marginal revenue for each farm's crop. Then, we ordered the gross revenues in descending order of marginal revenue and we calculated the cumulative gross revenue and the cumulative cultivated area.
2. According with the functional form expressed in equation (18), in a second step, we estimated the function of conventional profit $\Pi_0(X)$, as a function of the total agricultural area X, by plotting the cumulated gross revenue against the cumulated cultivated area. We estimate profit using a 2^{nd} degree equation.
3. In a third step, we derived the optimal share of land x^* for each individual farm, following equation (25) and using the coefficients from each estimated profit functions $\Pi_0(X)$. Moreover, according with equation (25), since the optimal share of land x* depends also on farm expectation about the maximum acceptable bid, we assumed a reserve bid $\underline{\beta}$=0, and we formulated four hypotheses of bid cap $\overline{\beta}$ to analyse the different auction performance. The first assumed a maximum bid cap equal to the average of the payments for a similar measure in the RDP E-R 2000-2006 such as (i.e. 567 euros/ha). In the second we hypothesize $\overline{\beta}$=567/2 euros/ha, in the third $\overline{\beta}$=567x1,5 euros/ha , and in the fourth $\overline{\beta}$=567x2 euros/ha.
4. In a four step, we calculated the profit $\Pi_1(X-x^*)$ and according with equation (16) we derived the relative optimal payment for each individual farm. We repeated this step for each of the different bid cap hypotheses.
5. In the last step, adding administrative and transaction cost, following equation (1) and with the four hypothesis of bid cap, we estimated the compliance cost of each farm participating to AEM through the difference between the profit derived from the FADN dataset and the

estimated profit $\Pi_1(X - x^*)$. The percentage of adjustment used for calculating the gross revenue, the cultivation costs and the percentage used to estimate the transaction costs are those used for the justification of payments in the RDP of E-R (Regione Emilia-Romagna, 2007).

Then, the farms have been ordered according with increasing compliance cost and have been plotted against the cumulative offered optimal share of UAA. Finally, the compliance cost function has been estimated for AEM by interpolation of each individual compliance cost as a function of the cumulative offered share of UAA, using a 3^{rd} degree equation (Figure 1).

Figure 1: Cost and bid as a function of the cumulative offered share of UAA ($\overline{\boldsymbol{\beta}} = \mathbf{567}$ euros/ha) – Substitution of a mix of conventional cultivation (AEM).

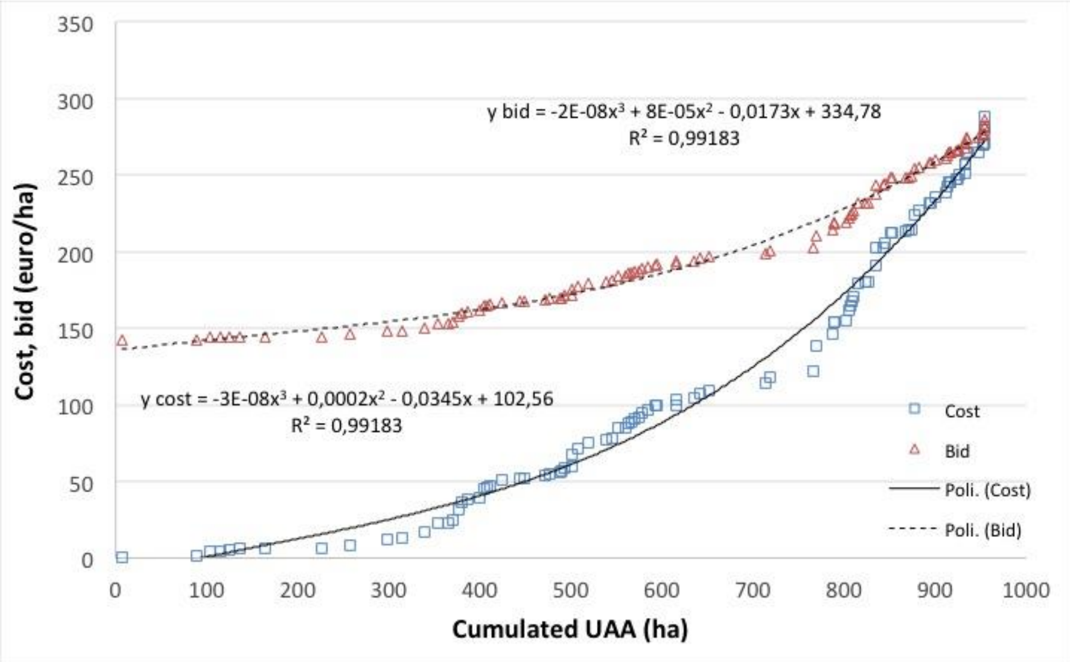


The total UAA of the sample is about 7545 hectare of which the maximum cumulated share of UAA offered by farmers with AM under the first hypothesis of bid cap (i.e. $\overline{\beta} = 567$ euros/ha) is 2121 hectares. The continuous line represents compliance costs to AEM that range from the minimum value of 99 euros/ha to the maximum value of 387 euros/ha. More in detail, the mean value is about 231 euros/ha, with the median around 207 euros/ha and the standard deviation about 90 euros/ha. Despite we have focused on a sample of 100 farmers, the variability measure of compliance costs confirms a certain degree of heterogeneity between farmers.

The bid function for AM is obtained by applying equation (17) to each individual cost level, plotting the results to the cumulative optimal share of UAA and interpolated with a 3^{rd} degree equation (i.e. triangular point in the Figure 3). The minimum bid is about 333 euros/ha and the maximum is about 477 euros/ha. With regard to the mean bid, the value is about 399 euros/ha, the median 387 euros/ha and the standard deviation 45 euros/ha, which results in a more flattened function if we compare with the bidding function of Viaggi et al. (2008).

When we hypothesize that the expected bid cap is halved (i.e. assuming $\overline{\beta}$=567/2 euros/ha), according with equation (17) and (25) since the optimal bid and the optimal share of UAA that farmers offer in AM depend on their expectation about the maximum acceptable bid cap, farmers find convenient to reformulate their previous bids in order to be accepted. Thus when the maximum bid cap decreases the farmers reduce their previous bid. As a consequence the relevant supply curve (the bid function) decreases and also their offered share of UAA is lower (Figure 2).

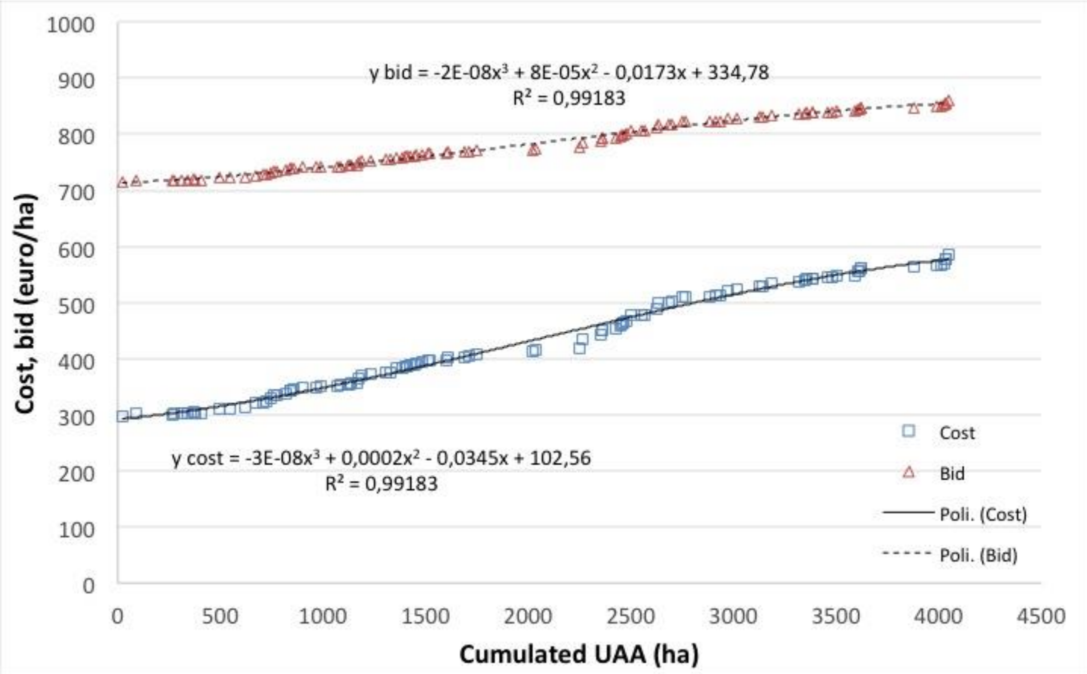
Figure 2: Cost and bid as a function of the cumulative offered share of UAA ($\overline{\boldsymbol{\beta}} = 283{,}5$ euros/ha) – Substitution of a mix of conventional cultivation (AEM)



Since farmers decrease their bids, the total offered share of UAA under the second hypothesis of bid cap (i.e. $\overline{\beta} = 567/2$ euros/ha) becomes 954 hectares. According with equation (1) when the offered share of UAA decreases also the compliance cost function decreases, which ranges in this case from the minimum value of 4 euros/ha to the maximum value of 288 euros/ha. The mean value of compliance cost is about 132 euros/ha, with the median around 108 euros/ha and the standard deviation about 90 euros/ha. Moreover, the minimum bid is about 142 euros/ha and the maximum is about 285 euros/ha. With regard to the mean bid, the value is about 208 euros/ha, the median 195 euros/ha and the standard deviation 45 euros/ha.

By contrast when we hypothesize that the expected bid cap is doubled (i.e. assuming $\overline{\beta}$=567x2 euros/ha), farmers find convenient increasing their previous bids. The result is that we have an increase of the relevant bid function and of the offered share of UAA (Figure 3).

Figure 3: Cost and bid as a function of the cumulative offered share of UAA ($\overline{\boldsymbol{\beta}} = 1134$ euros/ha) – Substitution of a mix of traditional cultivation (AEM).



The total offered share of UAA under the fourth hypothesis of bid cap (i.e. $\overline{\beta} = 567*2$ euros/ha) becomes 4455 hectares. Moreover, according with equation (1) the increase in the offered share of UAA determines an increase of the compliance costs, which range from the minimum value of 298 euros/ha to the maximum value of 586 euros/ha. The mean value of compliance cost is about 430 euros/ha, with the median around 406 euros/ha and the standard deviation about 90 euros/ha. Moreover, the minimum bid is about 716 euros/ha and the maximum is about 860 euros/ha. With regard to the mean bid, the value is about 782 euros/ha, the median 770 euros/ha and the standard deviation 45 euros/ha.

For each of the bid cap hypothesis, we have used these cost functions to derive the expected outcome with MFR and FR payments, following equation (30) and (31).

Focusing on the maximum UAA of the sample (i.e. 7545,22 hectares) we assumed two different budget levels, whose amount is established respectively at 0,2 million of euros per year for the first, and at 0,8 million of euros per year for the second. We decided these levels by considering the size of UAA of the sample and of the population of farmers to support. As abovementioned in AM we do not consider the whole regional UAA, but the simulation has been carried out for a smaller sample of 100 FADN farms each of which produce the largest mix of cultivations at regional level in 2011.

Once all bids have been received and the offered shares of UAA have been analysed, the public administration selects the participants with a given budget level, starting to pay each farmer, from the lowest bid to the highest one, according also with the share of land that he or she has offered, until the budget is exhausted. We must therefore remember that not all the offered share of land will be accepted under the AEM, but it will participate only that one the administration is able to pay according with the given budget level.

Within the two budget levels (i.e. 0,2 and 0,8 millions of euros per year) the results of AM represent the total quota of participating UAA. We compare the Auction approach (i.e. equation 29), the MFR payment (i.e. equation 30) and the FR payment (i.e. equation 31), in the case of a generic agri-environmental measure that substitutes a mix of traditional cultivation (AEM), assuming a maximum acceptable financial bid cap of 567 euros/ha (Table 1).

Table 1. Comparison of different payment mechanism in case of substitution of a mix of conventional cultivation with AEM2 (Percentage of total participating share of UAA in AEM on total UAA of the sample; $\overline{\beta} = 567$ euros/ha).

	Percentage of participating UAA	
Policy Instruments	0,2 (low-budget)	0,8 (high-budget)
MFR	17,16%	100%
AM	7,55%	27,29%
FR	5,01%	21,18%
MFR/AM	2,27	3,66
FR/AM	0,66	0,77

Source: own elaboration.

Under the two budget levels the performance of the auction is always located between marginal flat rate and flat payment results. However, when the budget increases, the difference between the performances of AM and of the MFR slightly increases, and has an opposite trend in the FR case.

Within a high-level budget, whereas there are only 100 participating farms that have been paid according to their bid for the share of land that they offered, with MFR payment the administration achieves the maximum percentage of up-take with a saved budget of the 44% on the total budget.

With the lowest budget level, the maximum UAA up-taken with the MFR is around twice the up-taken area with the auction. The difference slightly increases under the highest budget level, to more than three times. Moreover, the percentage of up-take with FR, which is two-third (i.e. 0,66) of the auction approach with a lower budget, slightly increases to three-fourths with a higher budget level (i.e. 0,77). According to Figure 3, this is because the cost of the auction mechanism for the public administration rising more than proportionally compared to the cost of the uniform policy, which increases constantly at the same rate per hectare.

With regard to the lower budget level, if we keep constant the participating quota of UAA, the total expenditure with a uniform mechanism will be higher than the expenditure with the auction approach, which is determined by the lower bids value (i.e. left tail of Figure 1). This means that with the auction we still have a share of saved budget, which the public administration can use in order to increase the quota of participating UAA. Thus the participating land quota with the auction, within a low budget level, results higher than the one with the FR payment.

However when the budget level increases the public administration is then able to increase with both instruments the level of participating UAA, but for the auction at an increasing cost rate, according to the bidding function and the bid shading behaviour. Therefore, the difference in terms of cost between the two mechanisms decreases and the uptake with the FR2 becomes closer to the uptake with the auction.

We represent now, the total quota of participating UAA under the three mechanisms, when the maximum acceptable bid cap vary according to the hypothetical levels defined above (i.e. when the bid cap becomes a half of first, when is one and a half times more and when is twice), according with the two assumed budget levels per year (Table 2).

Table 2. Comparison of different payment mechanism in case of substitution of a mix of conventional cultivation with AEM (Percentage of total participating quota of UAA in AEM on total UAA of the sample; $\overline{\beta} = 283{,}5$ euros/ha; $\overline{\beta} = 870{,}5$ euros/ha; $\overline{\beta} = 1134$ euros/ha)

Panel A: Maximum acceptable bid cap $\overline{\beta} = 283{,}5$ euros/ha

	Percentage of total participating quota of UAA	
Policy Instruments	0,2 (low-budget)	0,8 (high-budget)
MFR	100%	100%
AM	100%	100%
FR	5,29%	100%
MFR/AM	1	1
FR/AM	0,05	1

Panel B: Maximum acceptable bid cap $\overline{\beta} = 850{,}5$ euros/ha

	Percentage of total participating quota of UAA	
Policy Instruments	0,2 (low-budget)	0,8 (high-budget)
MFR	12,61%	35,74%
AM	4,21%	19,59%
FR	5,11%	21,32%
MFR/AM	2,99	1,82
FR/AM	1,21	1,08

Panel C: Maximum acceptable bid cap $\overline{\beta} = 1134$ euros/ha

	Percentage of total participating quota of UAA	
Policy Instruments	0,2 (low-budget)	0,8 (low-budget)

MFR	6,58%	28,63%
AM	3,55%	14,31%
FR	4,97%	21,19%
MFR/AM	1,85	2
FR/AM	1,4	1,5

Source: own elaboration.

With regard to Panel A, when the maximum acceptable bid cap is halved from the first level (i.e. $\overline{\beta} =$ 567 euros/ha) and the farmers total offered land share decreases from 2121 hectares to 954 hectares. Then, with a lower budget level, the administration just needs an average payment of about 209 euros/ha in order to support the whole offered land quota. Since the average payment with the auction and with the MFR, are lower than this amount, through the application of these two instruments the public administration can accept the 100% of the UAA offered by farmers. Instead, for the uniform payment, being 500 euros/ha, the administration is only able to cover the 5.29% of the UAA offered by farmers.

With regard to Panel B and Panel C, when the maximum acceptable bid cap is one and a half times more the first one (i.e. $\overline{\beta} = 567$ euros/ha) or even doubled, within both the budget levels, the auction's performance worsens, becoming the latest mechanism, which follows the FR and MFR payment. Despite agreeing with existing literature (Latacz-Lohman and Schillizzi, 2006), those results are to be considered within the framework of the hypotheses of the study. For those hypotheses, the most coherent result are still the one reported in Table 1: the auction mechanism is always located between marginal flat rate and flat payment results. More in detail, the cases in which the FR approach performs better than the AM, are those where we have assumed the public administration can vary the relevant bid cap. But we know that this variation has been just theoretical (i.e. functional to our analysis in order to test the model), because in the reality of agri-environmental programs, the decision about the relevant bid cap should be linked to a measure of the average compliance cost in relation to the availability or a variation of budget resources. In addition, if there is a variation of the available resources we expect a change of fixed payment, which, however, we did not. Moreover, the relevant bid cap is generally calculated from a measure of past payment rates from previous programs. Indeed, we followed this approach for the first hypothesis (i.e. $\overline{\beta} = 567$ euros/ha) that has been taken from the average of the payments for a similar measure in the RDP E-R 2000-2006 and in the light of this, it gives us the most consistent result.

However, when the farmers' expectations about bid cap grow, farmers find convenient to reformulate and increase their previous bids. Since the value of the bids exceed the value of the uniform payment, the performance of the auction decreases. Thus, with regard to Panel C, the difference between the MFR and the auction increase from 1,85 with a lower budget to 2 with a higher budget level. The same result happens to the difference between the FR and the auction, which slightly increase from 1,4 to 1,5.

In order to deepen the analysis of the performance of AM, we proceed to compare the rate of information rent among the analysed mechanisms when changing the expectations about the bid cap (Table 3). As we explained previously the total payments with AM and FR and the total compliance cost depend on the total participating UAA in AEM, which in this case changes in dependency of the farmers' expectation about the bid cap and of the budget level. Thus, these measures, particularly with regard to the total payments with FR, change in dependency of the hypothesis made about the budget level and of the maximum bid cap. Moreover, we do not have calculated the total payment with FR with the total available UAA, but we have used the participating UAA from the total share of UAA offered with AM.

Table 3. Comparison of the rate of information rent between AM and FR within two-budget level (AEM)

Panel A1: Maximum acceptable bid cap $\overline{\beta} = 283,5$ euros/ha

	0,2 (low-budget)			0,8 (low-budget)		
Policy Instruments	Total payment (TP) euros	Total compliance cost (TC) euros	Rent ratio (TP/TC) euros	Total payment (TP) euros	Total compliance cost (TC) euros	Rent ratio (TP/TC) euros
AM	173318,21	76031,64	2,27	173318,21	76031,64	2,27
FR	199736,84	4068,74	49,09	477257,11	76031,64	6,27
FR/AM			21,62	FR/AM		2,76

Panel B1: Maximum acceptable bid cap $\overline{\beta} = 567$ euros/ha

	0,2 (low-budget)			0,8 (low-budget)		
Policy Instruments	Total payment (TP) euros	Total compliance cost (TC) euros	Rent ratio (TP/TC) euros	Total payment (TP) euros	Total compliance cost (TC) euros	Rent ratio (TP/TC) euros
AM	191907,78	60423,20	3,17	794730,05	421605,29	1,88
FR	189055,85	38969,15	4,85	799049,97	265278,05	3,01
FR/AM			1,52	FR/AM		1,60

Panel C1: Maximum acceptable bid cap $\overline{\beta} = 850,5$euros/ha

	0,2 (low-budget)			0,8 (low-budget)		
Policy Instruments	Total payment (TP) euros	Total compliance cost (TC) euros	Rent ratio (TP/TC) euros	Total payment (TP) euros	Total compliance cost (TC) euros	Rent ratio (TP/TC) euros
AM	167159,73	63875,39	2,61	798509,076	339364,40	2,35

FR	193032,47	77791,07	2,48	775410,84	360872,83	2,14
FR/AM			0,95	FR/AM		0,91

Panel D1: Maximum acceptable bid cap $\overline{\beta} = 1134$ euros/ha

	0,2 (low-budget)			0,8 (low-budget)		
Policy Instruments	Total payment (TP) euros	Total compliance cost (TC) euros	Rent ratio (TP/TC) euros	Total payment (TP) euros	Total compliance cost (TC) euros	Rent ratio (TP/TC) euros
AM	191996,86	80069,56	2,39	777410,48	329636,47	2,35
FR	187616,12	112489,60	1,66	799664,19	508971,49	1,57
FR/AM			0,69	FR/AM		0,66

Source: own elaboration.

Starting from Panel A1, with the first level of bid cap (i.e. $\overline{\beta} = 283{,}5$ euros/ha) under the two budget level the rate of information rent with auction is lower than the one with the flat rate payment. With a lower budget, the rent associated with FR is twenty times larger than the one associated with AM. This value decreases when we increase the budget level, thus the rent with FR becomes around three times larger than the one with AM.

When the expectation about the bid cap is doubled (i.e. Panel B1), under the lowest budget level, the rate of information rent of AM increases of about the 40%, while it decreases for the FR approach of about the 90%. Thus, the rate of information rent associated with FR becomes just one and a half the rate of AM. Then, when we move to the highest budget, each rent decreases, but with a greater degree for AM. However the rate of FR almost remain just slightly more than one and a half the rate of AM.

In Panel C1, the rate of information rent of AM slightly exceeds the one related with FR2 (i.e. the ratio FR/AM is less than one, which means that the farmers' rent with auction becomes greater than the one with uniform policy). We observe the same results under both budget levels. Moreover, with regard to Panel D1, when the expected bid cap is twice the one in Panel B1 (i.e. 1134 euros/ha), the two rates of information rent decrease, but mostly for FR, while the one for AM continues to be larger than the one with FR. The rate of information rent with AM becomes almost the double of the one with FR within both the budget levels.

5. DISCUSSION

Trading mechanism as auction can be designed in order to achieve allocative efficiency (i.e. selection of participants with the highest benefit-ratio) and budgetary cost-effectiveness (i.e. buying the most conservation benefit with a given public budget). The analysed literature, seems to converge on cost reductions through conservation auctions that can be substantial, though the scale of saving depends crucially on the specific auction design (Glebe, 2008; Schillizzi and Latacz-Lhomann, 2007; Stoneham et al., 2003).

The results of the empirical analysis confirm and extend the findings reported in Latacz-Lohmann and van der Hamsvoort (1997) and Viaggi et al. (2008) for a multi-dimensional bid auction model within hypothetical agri-environmental measures. The heterogeneity captured in the estimated compliance cost confirming the needs for a different payment mechanism for AEM in order to reduce the farmers' rent associated with the lower compliance cost farmers (i.e. left tail of Figure 1) and increase the participation to AEM of the high cost farmers (right tail). Indeed, the bid function seems to fit well to this heterogeneity even if, given the discriminatory price auction format choose for AM, it always remains a certain degree of bid shading, especially with regard to lower-compliance cost pool. Considering two budget levels for AM2 (i.e. 0,2 and 0,8 millions of euros), and assuming a maximum acceptable financial bid cap of 567 euros/ha, the performance of the auction is always located between marginal flat rate and flat payment results

In the light of the hypothesis we made about the opportunity for the public administration to change the maximum acceptable bid cap, we observe that when this relevant parameter decrease (increase) from the first and most coherent hypothesis of bid cap (i.e. $\overline{\beta} = 567$ euros/ha) the auction performance slightly increase (decrease). However, we should take carefully this result because in the formulation of such bid cap hypotheses, we did not took into account the opportunity for the administrations to choose the relevant bid cap on the basis of the average compliance cost in relation to the availability of budget resources or on the basis of a measure of past payment rates. Thus we should point out that the most consistent result remains the one with the $\overline{\beta} = 567$ euros/ha, which is the hypothesis of bid cap that has been taken from the average of the payments for a similar measure in the RDP E-R 2000-2006.

With the lower bid cap expectation and the lower budget level, the maximum saved budget is achieved with the MFR approach (i.e. 61%) that result four times larger than the savings with AM (i.e. 13%). With the higher budget level the percentage of saved budget with AM, increase to 78%. White and Sadler (2011) obtain a similar result, although not directly comparable to our case, but in the light of which we can be better frame our findings in the extant literature, since empirical evidence on auction performance is often spurious and capable of distortions. Analysing the optimal conservation investment for a biodiversity-rich agricultural landscape White and Sadler (2011) find that the maximum cost saving that could be achieved by a price discriminating conservation auction is about the 17%. Moreover, with an expectation about the maximum bid cap of 283,5 euros/ha we found similar result, though not directly comparable, of the simulated auctions for phosphorus load reduction from a Finnish pilot by Iho et al. (2014). We obtain from AM an average bid of 208 euros/ha with an average per hectares rent of about 54 euros/ha that is close to the one computed by Iho et al. (2014) of about 250 euros/ha, of which 16,9% is composed by farmers rent (42,2 euros/ha).

However, the simulation while reflects a number of plausible assumptions, also remains rather simplified and could be improved in the further research. Despite the estimated compliance cost function demonstrates "well behaving" in terms of the sought of the economic properties required for this type of cost function and that the procedure of estimation have been selected from a consolidated procedure of estimation for this type of cost in E-R by Viaggi et al. (2008). The assumption on which are based such estimation remains rather simplified, which means that it is difficult to imagine to apply the same mechanism with other type of agri-environmental measures. This in turn can reflect that the knowledge about the compliance cost becomes a key factor that can limit the auction implementation and the ability of models to represent this instrument for AM. Another weakness of the modelling strategies adopted for AM is that despite this model allows for dealing with two types of bid (i.e. one bid is a share of farmers' conventional UAA to replace with AEM and the other is an agri-environmental payment), we considered just the budget cost-effectiveness criteria to rank bid. While the literature suggests the use of multi-criteria indexes. Thus, the model focusing only on budget cost effectiveness is not capable, in this formulation, to take into account agri-environmental benefits.

One more point worth mentioning is that both models do not take into account some well-established issues raised from the analysis of the auction literature. The proposed payments depend crucially on farmers' expectation about maximum acceptable bid cap and budget level, but the simulation strategy just assume that they are exogenously given and there are no mechanism able to understand how farmers form the critical expectation about bid cap. Both models only try to understand what happen on farmers bid when changes in these parameters occur. Moreover, despite a percentage of transaction costs have been added to farmers into the computation of compliance costs, the model do not consider also the transaction cost that can occur during the design and implementation of the auction. With regard to the analysis of auction performances all the cases in which we have assumed that the public administration is able to change the critical bid cap, represent only theoretical hypotheses. A more coherent and reliable approach would be to link the decision of the relevant bid cap to a measure of the average compliance cost in relation to the availability of budget resources. Moreover, we could expect also to change the value of the flat rate policy according with the variation of the budget resources. However, according with Connor et al. (2008) auction mechanism can provide the greatest reductions in costs relative to payment policies that involve little use of a priori information regarding bidder opportunity costs to differentiate payment levels. The results of this research while attempting to provide a useful empirical exploration of auction theory cannot provide a comprehensive solution in most real world settings. However, it can contribute to feed the debate at EU policy level about the role of auction design in limiting the inefficiency related to the actual agri-environmental measures.

6. CONCLUDING REMARKS

This paper focused on the most relevant conditions that lead to a cost-effective implementation of auctions compared to a uniform policy to test with a simulation exercise for the E-R the feasibility and the potential of using different approach to support the design of EU AEM policies. An assessment of a multi-dimensional auction in terms of budgetary cost-effectiveness has been provided and the results have been discussed in comparison with those of the two flat rate payment options.

The overall message goes in the direction that a better management and allocation of the resources is desirable because it can contribute to enlarge the benefit of agri-environmental policies for society and spread consciousness and benefits among farmers, leading to increase the overall sustainability of agriculture.

The results confirm the findings in Latacz-Lohmann and van der Hamsvoort (1997) and Viaggi et al. (2008). We found that the variability of compliance costs seems to justify the application of complex contract allocation mechanism such as auctions, while traditional flat rate payment policy tend to overcompensate farmers. Moreover the analysis of the performance of the auctions compared with the two flat rate options highlights that cost saving may easily be eroded under the discriminatory auction format since the optimal bids and the relative bid shading quota increase with both the bidder's opportunity costs and his/her expectations about the critical bid cap.

While the discussion showed several weaknesses of the developed approaches in the current form, further improvements are possible, and they would require a consistent development of implementation data collection, data analysis and ex-ante policy design and evaluation. Despite this limitation, the analysis showed the potential in contributing to the design process of an alternative incentive scheme based on auction instead of the classical flat rate payments.

Further research could involve the development of a simulation model for a self-selecting contract in order to make a comparison with the auction model, evaluating the performance of these approaches with regard to farmers' rent. Moreover, according with Banerjee et al. (2015), further studies should consider to implement scoring rules that reward pairs of sets of bids for adjacent land use projects in order to test the effects on auction performance of improving targeting objectives. The agglomeration of land uses can often produce much greater conservation benefit than if they are disconnected (Dallimer et al., 2010).

Finally, the results of the improved models could be compared also with an outcome-based agri-environmental payment in order to provide further clarity in the context of the debate surrounding the relationship between payments and results in future EU RDP programmes. Outcome-based payment considers the interests of the local people and their demand for environmental services and goods (Groth, 2005).

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