Agri-Environmental payments design in Europe, USA and Australia: the potential of auctions and self-selecting contracts for designing better agri-environmental payments.

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Summary

Various alternative agri-environmental payments approach have been theoretically and empirically designed in Europe (EU), United States (US) and Australia (AUS) with the aim to reduce information rent and increasing the cost-effectiveness of the measures. Despite much theoretical analysis on incentive-compatible agri-environmental contracts and wide experimentation of conservation auction in the US and AUS, the main debate on the EU agri-environmental payment still focused on problem of efficiency instead of facing the effectiveness. The main obstacle to designing and implementing more efficient and targeted agri-Environmental Payments (AEP) is limited information on the side of policy makers which can give rise to adverse selection and moral hazard limiting the effectiveness of the schemes and making them expansive to run. Auctions are a category of innovative policy mechanism designed to address adverse selection and to induce farmers to reveal, through competitive bidding, their compliance costs to the government. This paper provide a simulation of an input based menu of contracts model, and of a one-shot procurement auction with data from Farm Accountancy Data Network 2012 (FADN) of Regione Emilia-Romagna (RER), in order to test the relevance of the two methods for designing more cost-effective AE payments. The case study developed for Emilia-Romagna (E-R) demonstrates the heterogeneity in compliance cost. The results of the auction model highlight a significant cost saving compared with the traditional flat rate schemes. The result of the contract model confirm that the recourse of the revelation principle and mechanism design have a potential to reduce information rent and negotiation cost. However, though not directly addressed in this paper, there are several recognized limitation in the literature, which could affect both simulation results and the ability of the methods to contribute in the design of cost-effective AE payments.

Keywords: agri-environmental policy, auction, contract, information asymmetry, adverse selection.

JEL Classification codes: (Times New Roman 10)

Agri-Environmental payments design in Europe, USA and Australia: is an auction more cost-effective than a self-selecting contract schedule?

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1. INTRODUCTION

In the recent decades, there was an increasing attention about agri-environmental issues in most of the OECD countries (Baylis et al., 2007). EU, US and AUS have placed increasing effort on agri-environmental programs introducing a large number of policy measures to purchase environmental goods and services from rural landscapes.

The EU Agri-Environmental Measures (AEM), currently regulated by Council Regulation (EC) 1305/2013, can be tailored as set of contracts between the governments (public administrations) and farmers. Farmers that voluntary accept to participate in the scheme agree to manage a list of predetermined environmentally-friendly management prescriptions and in return they receive the agri-environmental payment that is conditional on compliance with the contract (Ferraro, 2008). In the implementation of the AEM the national/regional administration usually offer to farmers an AE payment designed as a flat rate payment, based on the additional costs and income foregone (plus transaction costs) due to the participation to the measures (DG Agriculture and Rural Development, 2005). This payment must be set high enough to cover compliance cost but also should prevent as much as possible unneeded farmers' rents. Indeed, while the payments are usually designed as uniform between different areas and targets, the compliance costs are not uniform (Viaggi et al., 2008). Moreover, the presence of asymmetric information conditions, such as the farmer having information about compliance costs that are not disclosed to the regulator, causes a higher profitability to participate for those farmers who have to cover lower compliance cost. In economic terms the difference between payments and compliance cost generate an economic surplus for those farmers and consequently a deadweight loss from the perspective of cost effectiveness of the measures. Such information asymmetries can obstacles the implementation of more efficient payments schemes and make them expensive to run. Various alternative payments approach have been developed in the EU, US and AUS with the aim to reduce information rent and increasing the efficiency of the measures in terms of participation/expenditure ratio (Viaggi et al., 2008). From the one hand, there are approaches based on the procurement of public goods theory (Laffont and Tirole, 1993) that focus on mechanism design (Wu and Babcock, 1996; Moxey et al., 1999; White, 2001) to analyse the effects of offering to farmers differentiated contracts. From the other hand, there is a growing body of literature that analyses the opportunity of designing auction of conservation contracts (Stoneham et al., 2003; Latacz-Lohmann and Schilizzi, 2005; Glebe, 2008; Viaggi et al. 2008). Agri-environmental procurement auctions (Klemperer, 2004; Riley and Samuelson, 1981) use bidding rules through market competition to reduce incentive for farmers to increase their contract price. Despite much theoretical work on incentive-compatible contracts in the context of agri-environmental programs, their design have not been developed under agri-environmental policies in practice due to the difficulties to know the distribution of farmers type and the sophisticated calculation that requires. According to Ferraro (2008), this lack in the field does not necessarily imply their impossibility of being applied in practice. However it remain an open research question for both academics and conservation managers. At the opposite side, procurement auction have been widely used in the US and AUS conservation programs. Two of the most important examples in the literature about conservation auction are the US Conservation Reserve Program (CRP) and the AUS Bush tender trial. In these countries, the public administration increasingly recognise the potential of auctions as a policy tool for allocating public resources (Latacz-Lohman and Schillizzi, 2005). However, there have not been significant application in the EU, despite this approach is still mentioned among the possible option under the EU regulatory framework for agri-environmental measures.

The objective of the paper is twofold: a) first we compare different approach to agri-environmental payments (AEP) design with limited information in EU, US and AUS to draw lessons about policy design options for reducing information rents in real life; b) second we test the relevance of the auction and contract methods for designing more cost-effective AE payments, simulating an input based menu of contracts model and one of a one-shot procurement auction with data from Farm Accountancy Data Network 2012 (FADN) of Regione Emilia-Romagna (RER) taking a simple fixed-rate payment scheme (which is the norm in the EU Rural Development Programme) as a benchmark. The flat rate payment is calculated by referring to the marginal compliance cost.

Since the lack of information on farmer's compliance cost is one of the main issues in these kinds of models, we have try to overpass the problem adopting a simple methodology developed by Viaggi et al. (2008). This methodology have been used to estimate farmer's compliance cost function from FADN as well as for the justification of payments of the Rural Development Programme (RDP) 2007-2013 for RER.

The paper outline is the following: section 2 describes the EU, US and AUS approach to AE payments. 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 PAYMENTS DESIGN WITH LIMITED INFORMATION: DRAWN LESSONS ABOUT POLICY DESIGN OPTIONS FOR REDUCING INFORMATION RENTS IN REAL LIFE

The agri-environmental payments have been widely used in the agricultural policy mixes of the three OECD countries to induce farmers and other landholders to address environmental problems (e.g. reduce nitrogen pollution, reduce the amount of pesticide used) and /or to promote the provision of environmental goods and services associated with agriculture (Table 1).

Table 1. Agri-environmental payments applied in EU, US and AUS in 2008

Programme/Country	EU	US	AUS
Land improvement (liming, soil erosion prevention)	X	X	X
Payments for nitrate reduction	X	X	X

Nutrient management plan	X	X	X
Extensive crop production	X		
Organic Farming	X	X	
Integrated production	X		
Reduced Tillage/Mechanic weed control	X		X
Crop rotation	X	X	
Green manure crops			X
Green set aside/fallows	X	X	X
Catch crops, green/winter cover	X	X	
Extensive management of all land	X	X	
Extensive grassland management (pastures/meadows)	X	X	
Conversion of arable land into grassland	X	X	
Grassland/biodiversity/habitat schemes	X	X	X
Biodiversity – local breeds	X		
Biodiversity – local species and varieties of crops	X		
Maintenance of wetlands and ponds	X		X
Protected environmentally sensitive areas	X	X	X
Shelter belts/buffer strips	X	X	X
Landscapes elements/Amenities	X		
Maintaining and improving ground cover		X	X

Source: Vojtech (2007).

Each countries support through the agri-environmental payment a large variety of agri-environmental measures promoting different forms of sustainable farming. From one country to another there are differences concerning the type, the level of payments and the mix of policy measures selected to address the environmental concerns.

According to Glebe (2008) and Uthes (2010), the EU approach on agri-environmental programs has been to offer to the farmers a fixed payment for the provision of environmental good and services including measures to reduce intensive resource use and improve rural landscapes. The US and AUS have been developed an alternative approach based on agri-environmental auction, while there are also some common features. According to Glebe (2008) and Vojtech, 2007 the budgetary limit to the spending on agri-environmental policies constitutes a challenge for searching cost-effective solution to address agri-environmental issues. Indeed there is often a quite limited evidence of their cost-effective application and impacts and it is a complex task, to link expenditure to outcomes, measuring environmental effects in practice, selecting the appropriate environmental target and evaluating cost-effectiveness. Implementing a relatively cost effective agri-environmental program requires a great deal of information on potential environmental benefits and the adequate system of incentives.

According to Ozanne and White (2008), farmers' participation to the measure involves an gri-environmental contracts that must specify the agricultural practices, the attended outcomes in terms of environmental benefits and the minimum level of payment that farmers require to accept the contract as a compensation for their action in order to obtain the established benefits. Thus, the transaction generates by the voluntary agreement must be accompanied with a well-defined environmental service that is being purchased by the public administration from farmers. This other common feature of agri-environmental contracting represents one of the most discussed weaknesses of the approach. The agreement is subject to asymmetric information between farmers and government and can be described by the fact that the farmers know more about on-site costs and local impacts than the government. Information asymmetries can causes one of the above mentioned obstacles to designing and implementing more efficient payments schemes and make them expensive to run. Two are the most important types of information asymmetries in the design of contract. First, the presence of hidden information or adverse selection (Chambers, 1992; Wu and Babcock 1996; Latacz-Lohmann and Van der Hamsvoort, 1997; Moxey et al., 1999; White, 2001) that creates the incentive for farmers to claim compensation payment higher than their own compliance cost. More in detail, farmers use their private information as a source of bargaining power to extract informational rents from governments. Second, the government's difficulties to monitor each individual compliance perfectly can give rise to hidden action or moral hazard (Choe and Fraser, 1998, 1999; Ozanne et al., 2001 and Fraser, 2002), which create the incentive for farmers to seek profit through non-compliance on the prescriptions stated in the contracts.

According to Ferraro (2008), there are three design approaches to reduce both informational rents. The first rely on *costly-to-fake signals* to gathering more information about farmers' compliance costs. This approach aim to obtain information on observable farmers characteristic linked with opportunity costs and use these attributes to establish the participation prices. Then eligibility criteria can be based on this information reinforcing the distinction of contract types and prices. This approach have been commonly uses in EU and US agri-environmental schemes where price have been differentiated on the basis of targeting mechanism or zoning system (Uthes et al., 2012) to reflects regional differences in opportunity cost.

The second approach develops *screening contracts* to induce farmers to reveal their type by offering incentive compatible contract (Laffont and Tirole, 1993) for each of the different type of farmers that participates in the scheme (i.e. see the next section). Despite the appeal of SC and their theoretical power, their design have not been developed under agri-environmental policies in practice.

The third approach consider *procurement auction* (AC), in which farmers bids for agri-environmental contracts. AC, as mentioned above, have been mostly used in the US and AUS conservation programs. In these countries, the public administration increasingly recognise the potential of this policy tool for allocating public resources (Latacz-Lohman and Schillizzi, 2005). According with Ferraro (2008), procurement auctions focus on market competition to reduce information asymmetries. In the US, the competition is assured by the limit imposed to the main USDA programs on budget and acreage enrolment. Through competitive bidding, the policy makers can learn what farmers are willing to offer for participating to the program, which farming practices they are willing to adopt and what level of payment they are willing to accept (Claassen et al., 2008). Unlike SC, auctions do not require the specification of the distribution of farmers' type, since farmers reveal this distribution through their bids. In order to obtain cost-effective programs outcomes, the major strategy adopted in the US and AUS AC, involves the collection of the relevant farmer's information during application and the use of a benefit-cost indices to select program participants. As mentioned above, the US CRP, represent an example of a compensation program based on benefit-cost indexes. This program remunerates agricultural producers to provide conservation benefit on environmental sensitive land. Participating farmers choose from a menu of practices focusing on long-term (e.g. the menu include soil conservation measure, measure to improve water quality, air quality, and enhance wildlife habitat). The Farm Service Agency (FSA) of the United Department of Agriculture (USDA) administered the program. While with regard the voluntary nature of the CRP, it is comparable to EU agri-environmental measures, the selection and enrolment procedure and the targeting mechanism, however, is much more selective and competitive (Table 5). Program application and enrolment follow a screening phase in which eligibility rules determines which farmers can apply. After that phase the provision of an agri-environmental payments select only the interested farmers.

Table 5. Selection process and eligibility criteria in EU, US and AUS agri-environmental programs.

Payment program	Regulated by	Eligibility criteria	Additional selection criteria
EU agri-environmental payments	EU RDP regulation and regional rural development plans	First, eligibility is determined by the objective of the specific regional rural development plans refined through the specific objectives of the single measure. Second criteria of RDP measures generally answered to the "who"-question, defining who is a candidate participant (e.g. based on the type of business, farming orientation, age or other factors). Then there is the "where" criteria responding to the designation or exclusion of zones with specific characteristics. Then there are criteria that define "When" (e.g. indicating starting date or cutting after a certain date) and for "how long".	Different rural priorities scheme can administered the measure, ranging across each EU region from a competitive process based on a scoring system and zoning policies to relatively simple criteria based on "First come, first serve principle".
US CRP	FSA – USDA	Focus on highly erodible land. Annual sign-ups and offers where ranked according to the EBI index, which is comprised of five environmental factors plus cost. Each of the environmental factors and the cost factor consist of sub-factors related to specific practices offered by farmers and physical site factors. The points achieved for each sub-factor are added up to calculate the final EBI. Bids with EBI scores above a cut-off level are accepted. The FSA determines the offer acceptability (cut-off level) based on the ranking results.	If different types of land usage occur an area-weighted average is calculated. Land that meet more stringent guidelines can also be enrolled through continuous sign-up.
AUS Bush Tender	Victorian Department of Primary Industries	The first version was a field trial that focused on biodiversity through the improvement of bush vegetation. After that trial, the Victorian Government have been run the Bush Tender 1, the Bush Tender 2, River Tender Auction, Plains Tender and EcoTender. Pre-negotiated contracts were evaluated according to the Biodiversity Benefit Index (BBI) defined as the ratio between the product of the conservation value score (define the value of the site) and the habitat amelioration score (value of farmer's effort) and the cost announced by farmers. Bids were ranked according to the BBI ratio, from highest value per	

dollar bid down, until the budget limit.

Source: own elaboration.

Producers who are interested in participating offer a bid that indicate what land will be enrolled, what practices will be adopted and the desired payment. Once all bid are collected, the FSA assesses the potential benefits and provides the rank of the selected bidders. Famers were ranked according to their ability to deliver environmental benefit per dollar of program expenditure (Claassen et al., 2008). Then the application can be accepted in rank order until the budget is exhausted or the acreage cap is reached. However, the selection is conditioned by the contract term of the program. In long-term program, as CRP, public managers may decide to reject some current application in order to receive in the future better application in term of delivery of agri-environmental outcomes.

In Victoria, Australia, the Bush Tender trial was carried out in 2001-2003 offering biodiversity conservation measures to improve the bush (i.e. native vegetation) and its management.

In this pilot auction, were first collected all the relevant ecological data and expression of interest and then government officers visited the farm and the land areas in order to discuss several management options with farmers. Farmers then submitted sealed bid including their proposed conservation activities and their required payments (Ferraro, 2008). Bids were ranked according with the Biodiversity Benefit Index (BBI), from highest value per dollar bid down, until the budget constraint was hit. Moreover, two other conservation auction was performed in Australia, namely: EcoTender and the Auction for Landscape Recovery (ALR). Ecotender was an offshoot of BushTender, while the Western Australia ALR with similar intent, was developed to achieve multiple environmental benefits (e.g. salinity control, biodiversity enhancement and water quality).

However, the set of rules and the design features described for auctioning agri-environmental contracts (e.g. the bidder asymmetry and multi units of environmental benefit) violate some of the standard assumption in auction theory (Ferraro, 2008) leading the auction mechanism to a less efficient result than the one predicted by the theory. In addiction, auction theory still does not provide clear answers about the appropriate rules for agri-environmental auctions. Thus, there is still an increasing interest among Policy designers and scientists to evaluate the performances of alternative auction environments with experimental economics and agent-based modelling (i.e. through simulations). Moreover, reducing rents is an important task for the public administration that aims to maximize the environmental services obtained from their limited budget.

From the policy design experiences, which have been analysed in this section, several insights about the potential approaches to reduce information rents can be drawn (Table 6). These approaches will be further analysed in the next sections, from a theoretical point of view and through the simulation analysis, in order to draw specific insights about the design features and on the relative cost effectiveness of such schemes.

Table 6. Approaches to reduce information rent in agri-environmental contracts

Approach	Institutional Complexity	Informational Complexity	Technical Complexity	Rent reduction	Distortion to contracted services	Comments

Target based on costly-to-fake signals	+	++	+	+	++	Good when correlations between signals and farmers are strong; information acquisition can be costly; field examples.
Screening contracts	++	+++	+++	++	+++	Powerful theoretically; Technically challenging; No field examples.
Procurement auctions	+++	+	++	++	+	Requires competition to achieve rent reduction; uncertainty with repeated format; field examples.
+Low; ++Medium; +++High						

Source: Ferraro (2008).

3. METHODOLOGY

In this paper we simulate the performance of an auction (AC) and of a self-selecting contract model (SC) taking a marginal flat rate payment (MFR) and an average flat rate payment (AVG) as a benchmark hypothesis between the two models.

The SC model is based on the principal agent relationship developed by Laffont and Tirole (1993), Moxey et al., (1999), in which a government (principal) offers an AE payment to induce farmers (agents) to adopt agri-environmental measures on their land. The principal objective is to minimise payments by reducing farmers' information rents. As we have explained above, farmers' rents arise because the government is not able to observe each individual farmer's compliance cost due to the lack of knowledge on site-specific production technologies. Following Moxey et al. (1999) we hypothesize that the principal only knows the existences of two types of farm that can be distinguished by their productivity as a low productivity type, $i=1$ (i.e mountain farmers), and a high productivity type, $i=2$ (i.e. hill and plane farmers). Thus, this exercise represents just a preliminary attempt to provide, through the empirical application of the SC and AC models for E-R, the main insights of this approaches for designing better EU AEP.

Assuming that the principal activities focuses only on the contract design, while monitoring activities will be decided separately, the government objective function is defined as:

$$\Phi_i(b_i, x_i)=\delta a_i+(s_i - k_i(x_i))-(1+e)\, s_i \quad (1)$$

$$\text{with } a_i=(x_i^*-x_i) \quad (2)$$

Where s_i represents the AE payment and the factor (1+e) is the cost of transfer payments or the shadow cost of public funds determined by the distortionary effects of taxation (Laffont and Tirole, 1993; Moxey et al., 1999). The parameter δ measure the benefit per hectares of enrolled area under the measure (or hectares per unit of input abatement) defined as a_i, in which x_i^* is the optimal unconstrained input of production for farm type i and x_i is the constrained input quota under agri-environmental program for farm type i. The utility of participating, is defined for farmers by the difference between the AE payment and the abatement cost function. In the contract farmers can choose between a traditional farming practice and compliance with some agri-environmental measure that aim to reduce the input, generating respectively the unconstrained and constrained profit Π_0 and Π_1 (both expressed per hectare), on which they have perfect information. Since the constrained profit does not include the agri-environment payments, thus the difference between the two profits can be used as a proxy of compliance cost:

$$k_i(x_i) = \Pi_0 - \Pi_1 \quad (3)$$

Moreover, supposing that the principal is able to observe the farmers' type, then equation (1) is maximized subject to individual rationality constraint, assuming that farmers accept compensation, which just cover their compliance, cost:

$$s_i^p - k_i(x_i^p) \geq 0 \quad (4)$$

which give as optimal solution:

$$-(1+e)k_i'(x_i^p) = v \quad (5)$$

That represents the result achieved in Moxey at all. (1999) in the case of perfect information (i.e. first best). This result equals the marginal social cost of participating to the scheme to the marginal social benefit, and defining a contract that offer to farmers the payment coupled with the input reduction $[b_i^p, x_i^p]$ with $x_2^p > x_1^p$. More in detail, the principal have no incentive to give any rent to the farmers, thus, as demonstrated by the relevant literature, the incentive compatibility constraints (i.e. equation 4 for each of the two farmers' types) are binding.

Under information asymmetry, the government is not able to observe each farmer type, and consequently creates room for the low productivity farmer to cheat, declaring himself or herself as the high productivity farmer. In this case, the overall environmental benefit is reduced determining a cost for the government that is measured by the utility given to the low productivity type utility:

$$U_1^c = s_2^p - k_1(x_2^p) > s_1^p - k_1(x_1^p) \quad (6)$$

Let know assume a subjective prior probability for the two farmer types γ, the government objective function in this case (superscript "a" indicate asymmetric information) become:

$$\Phi = \gamma[\delta(x_1^* - x_1^a) + (s_1^a - k_1(x_1^a)) - (1+e)\, s_1^a] + (1-\gamma)[\delta(x_2^* - x_2^a) + (s_2^a - k_2(x_2^a)) - (1+e)\, s_2^a] \quad (7)$$

s.t.

$$s_1^a - k_1(x_1^a) > s_2^a - k_1(x_2^a) \quad \text{Incentive Compatibility 1} \quad (8)$$

$$s_2^p - k_2(x_2^a) > s_1^a - k_2(x_1^a) \quad \text{Incentive Compatibility 2} \quad (9)$$

$$s_1^a - k_1(x_1^a) \geq 0 \quad \text{Incentive Rationality 1} \quad (10)$$

$$s_2^a - k_2(x_2^a) \geq 0 \quad \text{Incentive Rationality 2} \quad (11)$$

According to Moxey et all. (1999), incentive compatibility assures the existence of a unique separated solution of the problem removing the incentive for one type of farmer to cheat declaring themselves as another type. In addition, individual rationality guarantees that farmers must at least compensate for their opportunity cost of participating to the measure. The second-best solution for the two types is derived in Moxey et al. (1999) optimizing equation 6 to the constraints and deriving first-order condition, which lead to:

$$-(1+e)k_1'(x_1^a) = v \tag{12}$$

$$-(1+e)k_2'(x_2^a) = v + \frac{\gamma}{1-\gamma} e[k_2'(x_2^a) - k_1'(x_2^a)] < v \tag{13}$$

Equation 12 requires that the low productivity producer abates optimally, while in the solution for the high productivity type since $k_2'(x_2^a)$-$k_1'(x_2^a)$<0, thus $x_1^a = x_1^p$, $x_2^a > x_2^p$ and $x_2^a > x_1^a$. A complete proof of this result is given in Moxey et al., (1999). This solution is optimal since the low productivity type become indifferent between the contract designed for his type or one designed for the high productivity producer.

The bidding model is derived from the budget-constrained auction proposed in Lactaz-Lohmann and Van der Hamsvoort (1997) and Lactaz-Lhomann and Schillizzi (2005). The hypothesis is that the regulator seeks to purchase multiple units of the agri-environmental good selecting numerous farmers to participate in the agri-environmental measure. The auction considers heterogeneous agri-environmental goods or activity, and each farmer can bid for a different level of such activity. Since it has been assumed also an heterogeneity in costs, thus different parcels of land deliver different participation cost, each farmer must receive a payment that is at least equal to his compliance cost defined in equation 3.

Under the auction mechanism, farmer offers a bid *b* if the expected utility in case of participation exceeds his reservation utility:

$$U(\Pi_1 + b) \cdot [1-F(b)] + U(\Pi_0) \cdot F(b) > U(\Pi_0) \tag{14}$$

Where $1-F(b)$ is the probability that the bid is accepted, and $U(\Pi_1 + b)$ *is* the expected utility in case of participation. According to Lactaz-Lohmann and Van der Hamsvoort (1997) $U(\cdot)$ 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 $U(\Pi_0)$. Since it is a budget-constrained auction, the public regulator will set *ex post*, after all bids have been received, a maximum acceptable bid cap β. 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. According to the literature, 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, that the payment is only function of the bid and that farmers are risk neutral. Within this rules the bidder's problem becomes to decide the optimal b that maximizes his/her expected utility, so equation (14) can be simplified in:

$$(\Pi_1 + b - \Pi_0) \cdot [1-F(b)] > 0 \tag{15}$$

The optimal bid b^* is then obtained maximizing equation (2) with respect to *b* and taking first order conditions:

$$b^* = \Pi_0 - \Pi_1 + \frac{[1-F(b)]}{f(b)} \tag{16}$$

Assuming that for a risk neutral farmer, the expectations about the maximum bid that is accepted β are uniformly distributed in the range $\left[\underline{\beta},\ \overline{\beta}\right]$, where $\underline{\beta}$ represents the bidder's minimum expected bid cap and $\overline{\beta}$ the maximum, Lactaz-Lohmann and Van der Hamsvoort (1997) determined the optimal bid as follows:

$$b^{*}=max\left[\frac{1}{2}\left(\Pi_0-\Pi_1+\overline{\beta}\right),\underline{\beta}\right] \quad (17)$$

$$\text{s.t. } b^{*}>\Pi_0-\Pi_1 \quad (18)$$

Equation 18, states that the optimal bid increases linearly with both bidder's opportunity costs and his expectation about the bid cap $\underline{\beta}$ and $\overline{\beta}$.

Viaggi et al. (2008) introduced then the opportunity to model the bidding behaviour of a population of farmers representing compliance costs as a function of the contracted area for the AEM. If k(τ) represents the cumulative compliance costs and $k_t(\tau)=\Pi_0(\tau)-\Pi_1(\tau)$ the marginal cost with the profit as a function of the area, the optimal bid (equation17) become:

$$b^{*}(\tau)=max\left[\frac{1}{2}\left(k_t(\tau)+\overline{\beta}\right),\underline{\beta}\right] \quad (19)$$

that is the optimal bid as a function of the area. Then when $\underline{\beta}$=0 the total cost for the government become:

$$TC=\left[\frac{1}{2}\left(k(\tau)+\overline{\beta}\tau\right)\right] \quad (20)$$

Following Viaggi et al. (2008) we assume that government aims to maximize the participation rate, measured by the degree of the uptake to the measure, thus the problem becomes to maximize the contracted area under a fixed budget constrain B:

$$TC=\left[\frac{1}{2}\left(k(\tau)+\overline{\beta}\tau\right)\right]\leq \text{B} \quad (21)$$

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

$$\tau^{*}=\left[\frac{2B-k(\tau)}{\overline{\beta}}\right] \quad (22)$$

Now we compare this result with the one that can be obtained considering marginal flat rate payment. If the government can fix the payment equal to the compliance cost of marginal participating farmers, the maximum τ^{*} becomes:

$$\tau^{*}{}_{MFR}=\left[\frac{B}{k_t(\tau)}\right] \quad (23)$$

To apply this payment mechanism (equation 23) the government needs a great degree of information about compliance cost compared to the optimal bidding results (behaviour equation 22). Thus, if we consider the opportunity to screening contracts, as it has been mentioned in section 2, and targeting the payment to some specific area where compliance costs are different from the average this solution is still feasible. However, this payment does not correspond to the first best solution that the government would achieve with a self-selecting contract result (equation 5), while farmers with lower productivity receive a rent. Another approach would be, according to the EU regulation, to set the flat payment P 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:

$$\tau^*{}_{AVG} = \left[\frac{B}{P}\right] \tag{24}$$

Equation 24 imply a rent (R) for individual farmers that is determined by the difference P- $K_2^*(\tau)$. Moreover when R<0 farmers do not participate to the program 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 on the level of budget compared to total cost.

4. CASE STUDY AND RESULTS

The models described in the previous section have been applied through a simulation exercise for AEM in E-R. The Measure considered is an agri-environmental good that substitutes traditional wheat cultivation with less intensive use of nitrogen (AEM1) and provide most of the economic and environmental services of various landscapes improvement measures that have been applied in the RER during the programming period 2006-2006 and 2007-2013. Despite the measure concerns a wide number of cultivation, the focus in the research is on wheat that is one of the most common crop in E-R.

It has been assumed that no investment or maintenance cost are linked to the participation in this measure, thus the compliance costs are represented by the opportunity cost by way of substitution of the traditional cultivated wheat. In addition we have assumed a specific crop (wheat) as a replacement crop, while usually the measure is implemented with a differentiate mix of crops.

As mentioned above, the compliance cost function is derived from FADN data for RER 2012. We have included all the 306 farmers that cultivate wheat in 2011 and we have utilized the procedure developed by Viaggi et al. (2008) for the estimation of compliance cost entailing the calculation of Π_0 and $\Pi_1$from FADN.

First, we have calculated from each individual farm their compliance costs for the measure. Second, the farms have been ordered according with increasing compliance cost, and then have been plotted against the cumulative UAA, assuming that each farm in the FADN sample can be considered as 1/231st of total wheat UAA in E-R. Finally, the cost function was estimated for AEM1 by interpolation of each individual compliance costs as a function of the cumulative UAA, using a 3^{rd} degree equation (Figure 1).

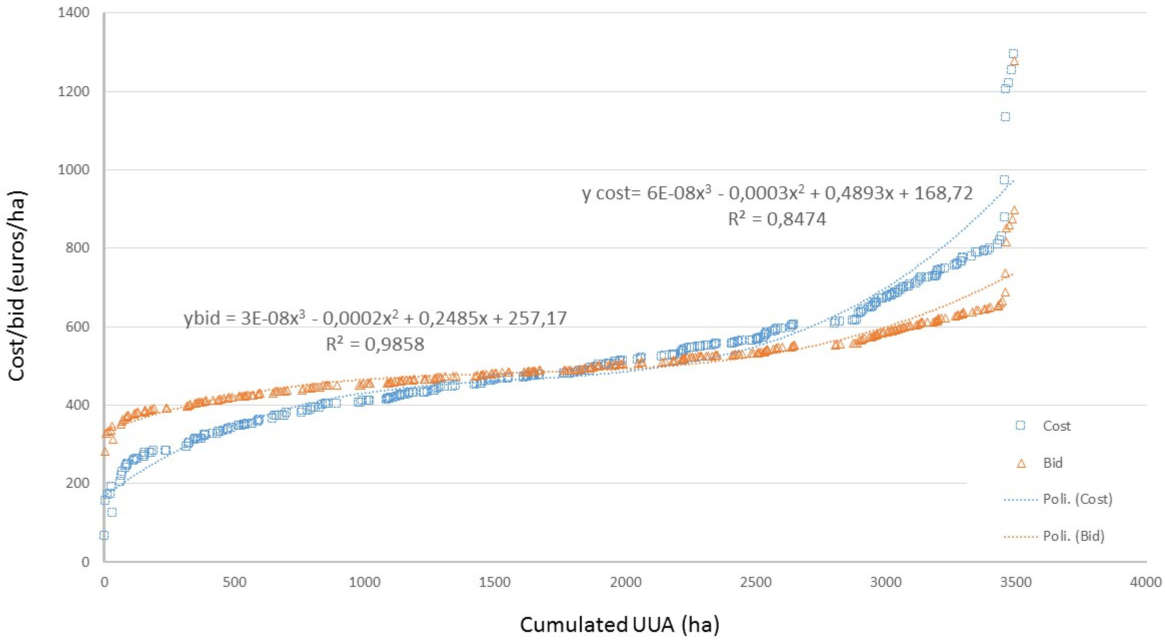

Figure 1. Cost and auction bid as a function of participating UAA – AEM1

Compliance cost to measure AEM1 range with a high degree of heterogeneity. The cost function has been used directly for the computation of MFR and AVG payments, following equation 23 and 24. For the AC, the bid function is obtained by applying equation 19 to each individual cost level and plotting the results to the cumulative wheat UAA and interpolated also with a 3^{rd} degree equation (i.e. triangular point in the Figure 1). More in detail, we have assumed a reserve bid $\underline{\beta}$=0 and the bid cap $\overline{\beta}$ has ben assumed equal to the average of the payments for the AEM1 in the RDP E-R 2000-2006.

Considering a low budget scenario with a budget amounting at 0.2 million of euros and a high budget scenario of 2 million of euros the results of the simulation (Table 7) are represented by the % of total UAA of wheat in E-R participating in the three mechanisms (i.e. equation 22, 23, 24).

Table 7. Approaches to reduce information rent in agri-environmental contracts

Instruments/Budget scenario	Low budget 0.25 (million of euros)	High budget 2 (million of euros)
MFR	1,35	3,44
AC	0,26	1,75
AVG	0,13	1,10

Source: own elaboration.

Under the two budget scenario hypotheses the performance of the auction is always located between marginal flat rate and average payment results followed by the performance of the average flat rate payment. Within the lowest budget scenario hypothesis the maximum UAA up-taken with the MFR is around 5 times the area up-taken with the auction. This difference decreases under the highest budget scenario.

The part that follows about the contract represents only an exercise to test the theoretical mechanisms analysed in the previous section providing just a first attempt of an empirical simulation. In addition to test the theoretical results, this exercise aims to understand from a numerical point of view the potential in reducing information asymmetries and designing more cost-effective payments. Moreover it aims to identify what are the major constraints to simulate this approach at regional level in accord to the main constraints emerged from the results reported in Table 6.

First, due to several data constrains and a lack of studies that specify a production function for wheat crop in E-R that link the yield production to the input used, we have assumed, for the purpose of the contract simulation example, a production technology estimated from a previous European study conducted by Moxey and White (1999) and Ozanne and White (2008). Since this is not the most suitable approach, the numerical exercise can be only considered just a preliminary attempt to provide such estimation. Further studies will involve an estimation of production technologies for E-R.

In addition to the lack of regional data to carry out such type of simulation, this exercise also presents different degrees of complexity. The choice of a contract model that discriminates between two types of farmers, although it has many theoretical advantages and it reduces the complexity from a numerical point of view, it only mirror the reality. A better approach from an empirical standpoint that would be more close to the methodology used in the auction case would be to offer contracts under the assumption of the continuum of types. In addition, even assuming to have estimation for a regional wheat production function, the two types case, does not reflect all the variability emerged from the estimate of the compliance function. Since heterogeneity in compliance cost represent an important issue, this approach partially reflects the problem mentioned in the case of a flat rate payments, but on the contrary it deals with adverse selection, thus we expect a better solution in terms of cost-effectiveness of the payment.

In the case of a self-selecting contract for AEM1, we assume that the public administration can only distinguishes between two types of farmers of RER. From the one hand, there is the Regional Landscape Territorial Plan that identifies the "plain", the "hill" and the "mountain" areas and the RER report on productivity of Wheat crop (BUR ER, 2014) that establishes different productivity values depending on the localization (i.e. plain, hills, mountains). From the other hand in E-R almost the 90% of the regional wheat producers are localized in the plain/hills areas, while only the 10% produces wheat in mountains (INEA, 2013). Thus, we have identified as mountain-hill producers, a percentage of the FADN farms that produce wheat with costs very close with the lower left-tail of the cost function constituting the low-productivity cluster. At the opposite, positioned more versus the right-tale of the cost function they are grouped hills and plains producers. These farms represent the high productivity type, for which the replacement of the wheat crop with the AEM1 involves a greater compliance cost in terms of opportunity cost.

Compared to the case of auctions in which we have evaluated compliance cost on the basis of the methodology proposed by Viaggi et al. (2008), which refers to the cost of substituting the traditional cultivation with an environmental-friendly one, in this case we have considered a contract that constraints wheat producers to reduce their input in order to obtain an AE payment. Thus, for this exercise we have referred to the numerical exercise developed by Moxey et al. (1999) assuming a farm's production function for wheat yield y=$A_i x^{\beta}$, where x indicates the nitrogen input. Moreover, all the relevant production parameters (Table 9) for the two farmer types and data about marginal benefit in changing the crop and the value of the shadow cost of public fund were obtained from the literature (Moxey et al., 1999, Ozanne and White 2008). Output price reflect an average regional price for wheat (Bologna Chamber of Commerce, 2014).

Table 8. Simulation Parameters

Parameters	**Symbol**	**Value**
Low productivity land	A1	0.90
High productivity land	A2	1.15
Production function slope	β	0.350
Output price (Euros/per tonne wheat)	P	190
Input price (Euros per kg nitrogen)	W	2.3
Profit maximizing input:		
Low productivity land (kg per ha)	x_1^*	151.75
High Productivity land (kg per ha)	x_2^*	220.85
Probability of Type i=1	γ	0,5

Source: own elaboration.

The contract model has been developed in Mathematica and the solution under perfect information and the solution under asymmetric information with adverse selection were computed for AEM1 applying the contracts models (i.e. equations 1 and 7). The results were then compared with the scenario of absence of policy and with the benchmark scenario of a flat rate payment (Table 9).

Table 9. Simulation Results

Scenarios	**Input Quotas**		**Transfer Payment**	
	x1	*x2*	*s1*	*s2*
No Policy	151.75	220.85	0.00	0.00
First-Best Perfect Information	64.1	93.2	58.0	84.5
Asymmetric Information adverse selection	93.2	93.2	84.5	84.5
Second-Best Asymmetric Information	87.0	73.13	109.2	125.8
Undifferentiated contract (MFR flat rate)	78.49	78.49	81.46	81.46

Source: own elaboration.

The second line represent, first-best solution, is the case where the policy maker now each compliance cost and farmer's type. Last line represents the traditional EU choice for designing AE payments, the undifferentiated flat payment, constituting our benchmark option against which, the other mechanism are compared. In terms of payments the AC results demonstrates the positive impact of the mechanism against the flat rate payment. Also the second-best solution of the contracts shows a reduction in the associated transfer payment reflecting for the measure a lower profit foregone. This type of contract remove the incentive for the low productivity farmer to select the contract designed for the other type, as occur in the case under asymmetric information with adverse selection.

5. DISCUSSION

The analysis of agri-environmental policies has revealed the potential to develop new mechanism and design approach for a better targeting of the measure through more cost-effective payments. While countries like US and AUS have been implementing policies with a focus on outcome results and with market-based instruments such as auction, the EU is still in their infancy. Despite the recent evolution of the monitoring and evaluation framework with the introduction of the CMEF indicators for the RD policies, there are still many open questions about the AEM effectiveness and their impact. The limit on budget spending and the needs to link measure to more targeted outcomes open the research for new instruments such as auction.

The simulation exercise confirms the results of Moxey at all. (1999) and Viaggi et al. (2008). The auction model and a self-selecting contract schedule have the potential to reduce farmers' information rent compared with a flat rate payment mechanism. The variability of compliance cost seems to justify the application of complex contract mechanism such auction or self-selecting contracts.

Moreover in the design of a self-select menu of differentiated contracts the difference between the payments obtained under first-best solution and the truth telling second-best solution indicates the maximum gain to be made from contracting and to improve the government's information base. The difference between the undifferentiated flat rate payment and the auction and contract payment indicates that several potential saving can occur addressing information asymmetry with such mechanism.

However, the simulation while reflects a number of plausible assumptions, also remains rather simplified and could be improved in the further research. The main weakness of the self-select contract analysis is that considers only two types of farmers, while in the reality the government face heterogeneity of farmers with different characteristics, and thus different compliance cost. With regard to the auction the simulation do not take into account some well-established issues raised in the auction literature. The proposed payments depend crucially on farmers' expectation about maximum acceptable bid cap, budget level and transaction cost that occur during the design and implementation of the auction. All of these aspects are only indirectly modelled in the paper, while represent a crucial aspect for the beneficial effect of the mechanism. The numbers of bidders (e.g. in a smaller auction with less farmers) and the possibility to repeat the auction can determine the circulation of information influencing the farmers' knowledge of the compliance cost of the competitor bidders, the knowledge of other relevant information for the government such as the critical bid cap and the level of budget or inducing collusive behaviour trough the farmers.

In addition, the models can be improved on several other grounds, particularly considering the opportunity to link both the contract and the auction on the environmental outcomes that the AEM measure should provide and the opportunity to introduce the monitoring activities to control the moral hazard. An extension of the two-producer type case to a continuum of farmers will be the further development of this research. Extension to a continuum of producers type is provided by Laffont and Tyrole (1993), Wu and Babcock (1996), White and Ozanne (1997).

Since the compliance cost have been tentatively modelled through a simple computation strategies, the results confirm the relevance of the heterogeneity of costs that should be considered more explicitly, despite the lack of disaggregated data, in ex-post evaluation searching for optimal incentive-compatible payments.

6. Concluding remarks

This paper focused on the main insights of theoretical and applied contract and auction theory 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.

Based on the ex-post information about compliance cost to explain the determinants of incentive compatible contract and auction approach, the paper highlights the relevance of considering such differentiation in optimisation tools searching for optimal incentive-compatible mechanism. The overall message goes in the direction that further improvements are possible in efficiency of AEMs. Such improvements would require a consistent development of implementation data collection, data analysis and ex-ante policy design and evaluation.

The discussion also showed the weaknesses of this approach in the current form. Despite this limitation, due mainly to data availability, the analysis showed the potential in contributing to the design process of an alternative incentive scheme based on auction and self-selecting contracts instead of the classical flat rate payments. Many improvements in the design of the models including the opportunity to develop the continuum of case (Laffont and Tirole, 1993), are required.

Further research could involve the comparison of the two model from a numerical standpoint, using experimental auctions and contracts in Emilia-Romagna (Italy) and in Western Australia (WA) under a common policy design to compare results from the two countries and to verify the main results obtained in this initial study. Moreover, outcome-based agri-environmental payments could be analysed in order to provide further clarity in the context of the debate surrounding the relationship between payments and results in future EU RDP programmes.

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