Contract design in agri-environmental schemes with fixed private transaction costs and countervailing incentives

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Abstract— The aim of this paper is to test the relevance of considering private fixed transaction costs for contract design of Agri-Environmental Schemes, when transaction costs are negatively correlated to marginal compliance costs. In order to do so, a principal-agent model of contract design under adverse selection, including fixed private transaction costs, is developed. The model is applied to the design of payments in the Emilia Romagna region of Italy. The results show that fixed transaction costs in the range of those actually faced by farmers may significantly affect the optimal amount of environmental good to be produced by each farm type. In some cases, fixed transaction costs can even reverse the standard insight that more of a public good should be produced when the cost of its provision is lower (countervailing incentives). The results call for a higher attention to private transaction costs in the design of agri-environmental contracts.

Keywords— Agri-environmental schemes, principal-agent, countervailing incentives.

I. INTRODUCTION AND OBJECTIVES

Agri-Environmental Schemes (AES) have represented a growing part of the Common Agricultural Policy (CAP) in Europe and are still a major part of rural development programmes for the period 2007-2013. Existing academic and administrative evaluation exercises raise doubts about the effectiveness and efficiency of such schemes. In particular, they emphasise the needs of improving the adaptation of AES design to the costs of different types of farmers and to the environmental needs of each area [1,2].

Economic research has dealt with this issue from different perspectives in recent years. Two promising areas of research are contract design under asymmetric information and transaction costs theory. In spite of the close connections between the two areas, these issues have rarely been considered together. Transaction costs theory focuses on the costs associated with economic transactions. In the field of (agri-) environmental policies, this translates mainly in estimating the amount of such costs from a public or a private perspective [3]. Contract design under asymmetric information deals mainly with searching for optimal contract design, taking into account agents' rent due to non-completely-informed design conditions by the principal [4].

The objective of this paper is to discuss the relevance of fixed private transaction costs in the design of AES contract mechanisms.

The paper outline is as follows: a short overview of transaction cost issues linked to AES's is provided in section 2. A model of AES contracts including transaction costs is developed in section 3. In section 4, an example is provided with reference to empirical data from Emilia Romagna (Italy). Finally, some further discussion is provided in section 5.

II. OVERVIEW OF TRANSACTION COSTS IN AES'S AND CONTRACT DESIGN ISSUES

Transaction costs have been defined as "the costs of running the economic system" [5]. They include information, negotiation, monitoring and enforcement costs.

Public transaction costs have been widely studied in the specific field of AES (see, for example, [6,7,8]). Private transaction costs have been much less studied (*or* have received much less attention). They may include the information gathered to decide about the contract and its characteristics, payments to consultants, extra labour required (for example for paperwork and recording), administrative costs connected to the contract, etc. In many cases transaction costs are even difficult to define, as they may include subjective attitudes towards particular tasks (e.g. paperwork), risk perception or expectations.

In a recent report, Mettepenningen *et al*. [9] analyse private transaction costs produced by AES's in 10 case study areas in Europe. They find that transaction costs are in the range of 0-10% of compliance costs in most countries, with an average of 5,4%. However, in some cases they may reach up to 100% of the compliance costs.

One major issue where modelling is concerned, are the economic characteristics (and mathematical forms) to be

attributed to transaction costs, with respect to their fixity/variability. It may be expected that some share of transaction costs are fixed costs with respect to the payment or to the area involved. For example, some costs of negotiation, information, and design of policy measures do not change with the size of the AES contract. On the other hand, there may be costs that are proportional to the amount of payments. In most cases, transaction costs may be assumed to grow less than proportionally with the increase of land devoted to the scheme, or to the budget, as the result of the combination of a fixed and a variable component. The fixed component is likely the most relevant, when transaction costs are mainly or solely represented by the cost of drawing up a contract, and there is no project cost proportional to the land area involved. The expectation that a large part of transaction costs are fixed costs is shared by the literature [10], and corroborated by empirical evidence. For example, Mettepenningen *et al.* [9] found that total transaction costs per hectare decrease when the area under contract increases.

III. THE MODEL

The use of principal-agent models to deal with contract design has gained growing attention in recent decades [11]. A number of cases have been analysed in the literature on the subject of AES's, assuming asymmetric information with either adverse selection, moral hazard or both [4,12,13,14,15,16].

Most of them, however, do not explicitly take into account the issue of private transaction costs and their consequences on contract design. In the present paper, transaction costs are explicitly considered in the form of a fixed (with respect to the provision of the public good) private cost connected to the participation in the environmental scheme. Such cost, denoted by φ_i, is differentiated according to farm type.

The application refers to the problem of adverse selection without moral hazard. The model is designed following mainly Moxey *et al.* [4], with some slight modifications.

The setting is that of a regulator willing to induce farmers to produce some public good purely competitive with farming activities. In order to do so, the regulator offers the farmers a menu of contracts which include different combinations of payment and required levels of production of a given environmental good. We assume the existence of two farm types (i=1,2) with different productivity and, as a consequence, a different cost for the provision of competitive public goods. Farm type 1 is more efficient in producing the environmental goods, and farm type 2 is less efficient. We assume that the farms' cost function for the provision of the public good $c(.)$ is convex with $c'(.)>0$ and $c''(.)>0$. We also assume that the environmental benefit is linear with respect to the amount of the public good produced.

Fixed transaction costs are added to the reservation utility arising from alternatives to the acceptance of the contract, and are assumed to be differentiated across farmers. In case of two types, if transaction costs are higher for the least efficient farm, it can be shown that the payments must be increased, but the contract design does not change [11].

However, a frequently reasonable assumption is that the farm that is more efficient in producing the environmental good also encounters higher transaction costs (i.e. fixed private transaction costs and marginal compliance costs are negatively correlated). Throughout the paper, we assume that the reservation utility is zero, while φ_i is zero for farm type 2, and is strictly positive for farm type 1.

In the second best problem with mechanism design, the maximisation problem facing the regulator may be written as:

$$\text{max:} \quad z_i = \gamma\left[va_1^a + \left(b_1^a - c_1\left(a_1^a\right) - \varphi_1\right) - (1+e)b_1^a\right] + (1-\gamma)\left[va_2^a + \left(b_2^a - c_2\left(a_2^a\right)\right) - (1+e)b_2^a\right]$$

(1)

s.t.

PC1: $b_1^a - c_1\left(a_1^a\right) - \varphi_1 \geq 0$ (2)

PC2: $b_2^a - c_2\left(a_2^a\right) \geq 0$ (3)

IC1: $b_1^a - c_1\left(a_1^a\right) \geq b_2^a - c_1\left(a_2^a\right)$ (4)

IC2: $b_2^a - c_2\left(a_2^a\right) \geq b_1^a - c_2\left(a_1^a\right)$ (5)

Where:

z_i = objective function of the decision maker related to farmer i;

b_i = payment to farmer i;

a_i = amount of environmental good produced by farmer i;

c_i = costs for the provision of the environmental good by farmer i;

e = shadow cost of public funds due to the distortionary effect of taxation;

U_i^0 = reservation utility of the agent if he refuses the contract.

γ = subjective prior probability that the regulator assigns to the farm being of type 1 (quantified, for example, on the basis of the total land expected to belong to farm type

1) and the superscript a is a reminder for "asymmetric information".

IC, incentive constraints, ensure that each type of farm will find it profitable to choose the contract that is designed for it.

The fixed transaction cost enters the regulator objective function only in the part concerning the efficient farm, because for the other farm type, it is assumed to be zero. For the same reason, it enters only the participation constraint of the efficient farmer. In the incentive constraints, φ is not considered as it cancels out for the efficient farmer incentive constraint and is zero for the inefficient one.

Of the four constraints, only the participation constraint of the less efficient (PC2), and the incentive constraint of the more efficient farm (IC1), are binding. In this case, the optimal contract design produces a menu of contracts differentiated with respect to the farm type for which they are designed.

When $\varphi = 0$ for both farms, for the more efficient farm, the optimum is given as in the first best:

$$(1 + e)c_1'\left(a_1^a\right) = v \qquad (6)$$

Instead, for the less efficient farm, the optimal level of production of the environmental good is given as:

$$(1 + e)c_2'\left(a_2^a\right) = v - \frac{\gamma}{1-\gamma} e\left[c'_2\left(a_2^a\right) - c'_1\left(a_2^a\right)\right] < v \qquad (7)$$

The result is that the production of environmental good by the least efficient farm is lower in the second best case with respect to the first best. In addition, in this case, a rent is gained by the more efficient type. This is a relatively standard result of contract theory with adverse selection. For more analytical details and demonstration, see [4].

When a positive fixed transaction cost is added for the most efficient farm, the results change depending on the size of the transaction cost. Five cases can be devised [11, p. 101].

Case 1
The case in which:

$$\varphi_1 < c_2\left(a_2^a\right) - c_1\left(a_2^a\right) \qquad (8)$$

In this case, only the participation constraint of the less efficient (PC2) and the incentive constraint of the most efficient farm (IC1) continue to be binding. The existence of a fixed transaction cost erodes the rent of the efficient farm type and the value of the regulator's objective function. However, it is irrelevant for the determination of the optimal amount of the environmental good to be produced. When such a condition is satisfied, the optimal level of the environmental good provided and the related contract is the same as in the optimal second best solution without transaction costs.

Case 2
Case two occurs when:

$$c_2\left(a_2^p\right) - c_1\left(a_2^p\right) > \varphi_1 > c_2\left(a_2^a\right) - c_1\left(a_2^a\right) \qquad (9)$$

In this case, PC1 becomes binding and both PCs and the efficient agent's IC hold with equality. As a result, the amount of the public produced by the least efficient type is increases compared to case 1, while the contract structure is the same as in the first best for the more efficient type. This happens because maintaining the first best solution for the least efficient type would make the contract attractive for farm type 1. In other words, the principal can afford less distortion in the amount produced by the inefficient type. The optimal amount of the environmental good is determined by:

$$\varphi_1 = c_2\left(a_2^{a'}\right) - c_1\left(a_2^{a'}\right) \qquad (10)$$

where a' denotes the optimal second best solution in the cost range defined in (9). Clearly, the lower the difference between $c_1(.)$ and $c_2(.)$, the higher the change in a_2, for the same amount of φ.

Case 3
Case three arises when:

$$c_2\left(a_1^p\right) - c_1\left(a_1^p\right) > \varphi_1 > c_2\left(a_2^p\right) - c_1\left(a_2^p\right) \qquad (11)$$

In this case, the output of both farmers is at its first best. As long as IC2 is not binding, the optimal solution is to contract the first best optimal level of environmental output for both farm types. The rent of farm type 1 is increased in order to compensate its transaction costs.

Case 4
This case arises when, growing φ, the inefficient type's incentive constraint becomes binding. We are in the range:

$$c_2\left(a_1^{CI}\right) - c_1\left(a_1^{CI}\right) > \varphi_1 > c_2\left(a_1^p\right) - c_1\left(a_1^p\right) \qquad (12)$$

where CI stands for countervailing incentives. The situation is somehow symmetric to case 2. At this stage, the inefficient type would be induced to choose the contract designed for the efficient type, unless a_1 is increased. The amount a_2^p does not change compared to the first best, while a_1 is now determined by:

$$\varphi_1 = c_2\left(a_1^{CI}\right) - c_1\left(a_1^{CI}\right) \qquad (13)$$

The efficient type's contract is distorted upwards and incentives are inversed with respect to the usual model. This is the origin of the term 'countervailing incentives' [11,17].

Again, the lower the difference between $c_1(.)$ and $c_2(.)$, the higher the change in a_1, for the same amount of φ

Case 5

When φ further increases, the situation may become completely reversed compared to the beginning, with:

$$\varphi_1 > c_2\left(a_1^{CI}\right) - c_1\left(a_1^{CI}\right) \qquad (14)$$

When (21) is true, the efficient type PC and the inefficient type IC are binding. Maximising the objective function, the resulting contract shows that a_2^p does not change compared to the first best, while a_1^{CI} is moved upwards compared to the first best and is determined by:

$$(1+e)c_1'\left(a_1^{CI}\right) = v + \frac{1-\gamma}{\gamma}e\left[c'_2\left(a_1^{CI}\right) - c'_1\left(a_1^{CI}\right)\right] > v \qquad (15)$$

IV. AN EXAMPLE

The model is tested in the Municipality of Argenta, Emilia Romagna (Northern Italy). In the region, both reg. 2078/92 and reg. 1257/99 have been applied, involving altogether about 15% of total usable farmland area.

In the specific area of the Municipality of Argenta, a particularly important measure is that of wetland restoration, as the area was formerly characterised by extensive marsh and natural wetlands. In the 20th century most of the area was subject to land reclamation. Presently, the reduced importance of food production, and the increased demand for recreation sites make recovering of traditional biotopes and landscapes a priority. Wetland restoration was already funded under reg. 2078/92 and received further support under reg. 1257/99. However, in

both cases, the uptake has been substantially unsatisfactory up to now.

An average marginal cost function for land diversion towards wetlands in the area has been estimated as:

$$\bar{c}(a) = 695{,}435a^2 + 562{,}21a$$

where:

a (0 to 1) = share of land devoted to wetland by farm;

$\bar{c}(a)$ = average compliance cost.

The cost function has been derived through linear programming modelling of farmers' behaviour in the area [18].

For the purpose of discussing the impact of fixed transaction costs on contract design, the diversification among farms is a critical issue. In this case, it has been assumed that cost functions of different farms may be obtained as a fixed proportion of the average cost function, assuming a range of plus or minus 15%. One unknown parameter is the value of the environmental good to be produced (v). For the purpose of this study, a value in the range of actual payments awarded up to now by AES's in the area has been selected and set at 800 euro/ha. A further unknown parameter is the shadow cost of public funds. In this case, e=0,2 has been selected, as it is in the range of values that can be found in the literature [11,15].

With respect to γ we perform a sensitivity analysis by computing the optimal contracts with opposite values of γ: 0,8 (likely close to the true value) and 0,2.

As the value of fixed transaction costs is also a particularly variable parameter, we opted for a parametrisation between reasonable values (0 to 90 euro/ha) that represents a percentage of the payment similar to those found in the literature, and discussed in section 2 (0-11%).

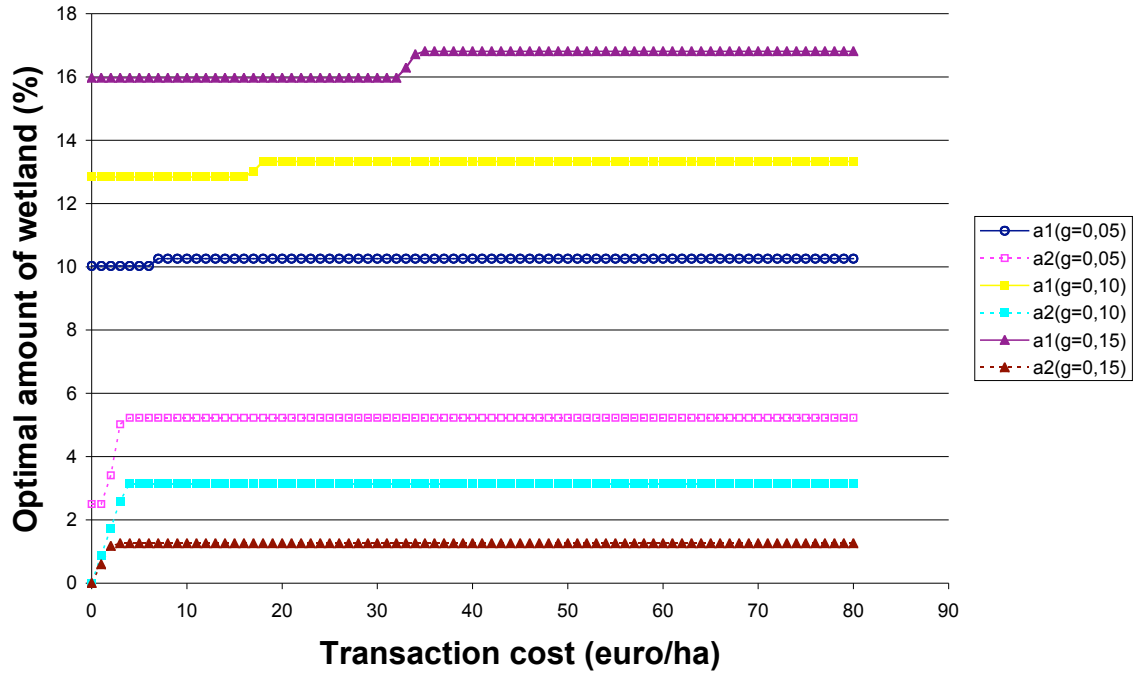Figure 1 shows the optimal contract solution for g=0,05, 0,1 and 0,15, when γ =0,8.

Figure n. 1 – Optimal amount of wetland (γ =0,8)
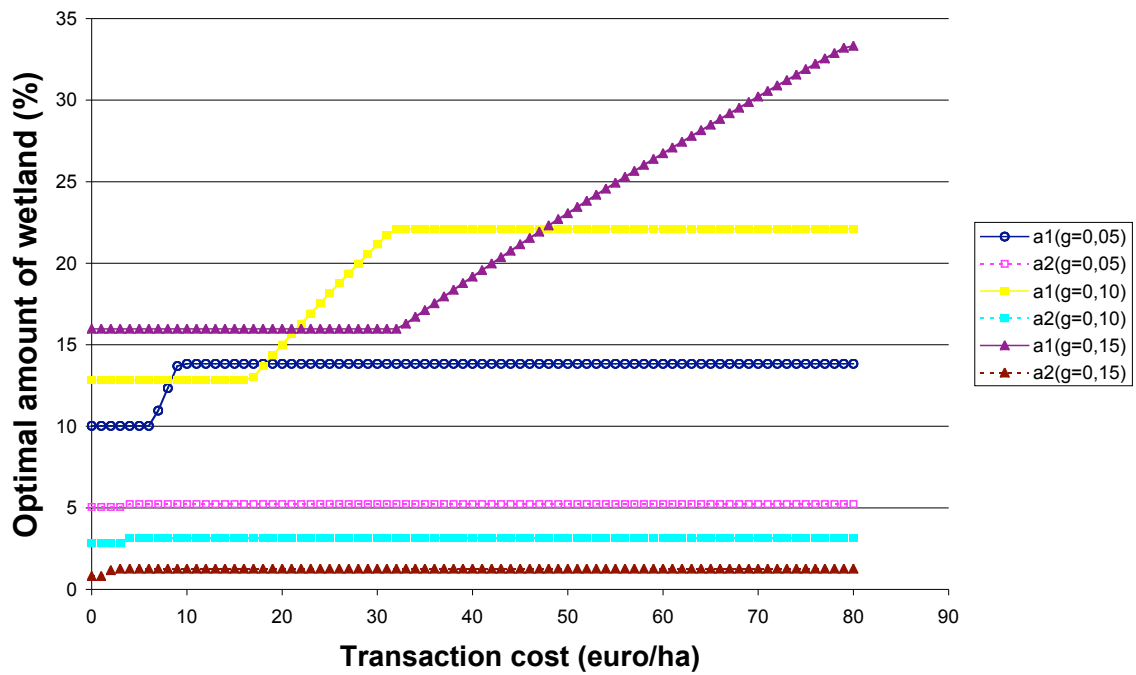

Figure n. 2 – Optimal amount of wetland (γ =0,2)

Even very low fixed costs affect the optimal contract design. The impact is stronger for the less efficient farm (see equation 14), where even a few euros per hectare affect the optimal amount of wetlands to be awarded. Results are more evident when g is lower. On the contrary, the amount of wetland to be awarded to the most efficient farm is rather stable due to the minor upward distortion as a result of the value of γ (see equation 22).

The opposite result arises when $\gamma=0,2$, as in this case the amount of wetland to be awarded to the most efficient farm shows to be the most sensitive to the change in fixed transaction costs (figure 2).

In this case, the efficient farm appears more directly affected by transaction costs. The optimal amount of wetlands allocated to the most efficient farm when the transaction costs are very high are up to about twice the amount with $\varphi=0$ when the case of $g=0,15$ is taken into account.

Major impacts associated with transaction costs occur when φ is between 10 and 80 euro/ha, which is in the range of actual transaction costs in the area. In this case, it is interesting to note that the curves for farm type 1 intersect each other at different points. This means that, depending on the value of transaction costs, lower compliance costs may or may not imply a higher amount of environmental good to be produced by the most efficient farm. For example, in the range of transaction costs between 20 and 50 euro/ha, the amount of wetland to be produced is higher when $g=0,10$ than when $g=0,15$, even if, in the latter case, the cost of the provision of the public good is lower.

V. DISCUSSION

This paper provides an analysis and an empirical application of the effect of fixed transaction costs on optimal contract design for agri-environmental policy, when transaction costs are negatively correlated to marginal compliance costs.

The fact that fixed transaction costs could affect the way contracts are designed is known from the literature, and is confirmed by the empirical findings of this paper.

The main finding of this paper is that fixed transaction costs in the range of actual transaction costs for a given farm may even have a strong affect on the optimal contract design. In some cases transaction costs can even reverse the intuitive result that more of a public good should be produced when the cost of provision is lower.

When the share of efficient farms is higher, the contracts aimed at the least efficient type is more affected by transaction costs, and this occurs for relatively low levels of transaction costs. When the share of efficient farms is lower, the most efficient farm's contract is more affected by transaction costs, and the impact is extended to a wider range of the value of transaction costs.

This result confirms the need for more focused research in two directions. First, the structure and economic properties of transaction costs should be better scrutinised, in order to achieve a better understanding of their role in decision making by farmers. Second, the interaction between transaction costs and contract design needs to be better understood in order to ensure higher empirical relevance for the insights arising from contract design literature.

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