Green payment programs, asymmetric information and the role of fixed costs

Arguedas, C. [1], Meijerink, G.W. [2] and van Soest, D. [3]

[1] Universidad Autonoma de Madrid. Madrid, Spain
[2] LEI Wageningen UR, The Hague, The Netherlands
3 Tilburg University, Tilburg, The Netherlands

Abstract— **Many conservation programs offer financial compensation to farmers in exchange for socially desired services, such as soil conservation or biodiversity protection. Realization of the conservation objective at minimum cost requires payments to just cover the extra costs incurred by each individual (type of) farmer. In the presence of information asymmetries regarding costs, incentivecompatible contracts can be designed to mitigate excess compensation, but these typically only provide partial improvement because of several distortions. We argue that these distortions are inevitable only if all conservation costs are variable in nature. If there are fixed costs too, we find that the least-cost solution can be incentive compatible. We identify the exact conditions under which these maximum savings can be obtained and conclude that, given the relevance of fixed costs in conservation services provision, incentive—compatible contracts deserve a second look.**

Keywords— **Asymmetric information, environmental benefits, , mechanism design.**

I. INTRODUCTION

Over the past decade, increasingly more conservation programs have been set up that offer financial compensation to farmers in exchange for the provision of socially desired services, which they would not have provided otherwise. Such activities include, among others, implementing measures to conserve soils or to protect biodiversity. These so-called green payment programs have been implemented in developed and developing countries alike (see for example OECD, 1997; Ferraro, 2001), and usually take the form of contracts between the donor (or regulator) and individual landowners. These contracts specify the type and level of conservation activities the landowner is required to undertake on her land, as well as the amount of money she receives in compensation. Participation is in most instances voluntary, and hence the amount of money offered should at least cover the extra costs incurred.

The problem is that in many instances (i) some landowners can provide conservation services at lower costs than others, and (ii) landowners have better information about these costs than the donor (cf. Ferraro, 2005). That means that low-cost landowners have an incentive to overstate the costs of providing specific levels of conservation activity in order to secure more generous compensation payments. Overgenerous payments are typically costly to the donor either because the available funds are limited (in case of a fixed conservation budget) or because there are non-zero costs to raising funds (cf for example Smith and Tomasi, 1999). Hence, the donor has a stake in separating the low- from the high-cost landowners.

To ensure incentive-compatibility, contracts are such that compensation payments to the low-cost farmers are still larger than actual costs incurred (in other words, they still receive informational rents), while the conservation level required from the high-cost farmers is below the complete information solution's optimal level. Because of this double cost, the net benefits of designing incentive-compatible contracts are likely to be low, and attention seems to have shifted towards alternative instruments, such as for example procurement auctions for conservation contracts (cf. Latacz--Lohmann, 2004; Ferraro, 2005; Latacz-Lohmann and Schilizzi, 2006) .

The double cost of incentive-compatible contracts materializes because of one key characteristic of the models developed in this literature, and that is their focus on variable conservation costs. Typically, agents are assumed to differ with respect to a certain characteristic, and this characteristic is assumed to affect the marginal benefits (or costs) of the regulated input. This paper contributes to this literature by not only taking into account heterogeneity regarding variable conservation costs but also with respect to fixed costs. While these fixed compliance costs can be substantial in practice, they have been largely ignored by researchers and policy makers alike (cf. European Commission, 2005: 22). Fixed costs can be the costs of setting up management plans, but they can also take the form of up-front investments without which conservation is not feasible. Using the example of biodiversity conservation, such investments may include planting trees, digging ponds, or building hedgerows, to create a minimum amount of habitat for species to survive or to establish themselves.

We find that when taking into account both fixed and variable conservation costs, incentive-compatible contracts can achieve maximum efficiency after all: that is, the double cost of separation does not necessarily arise. We develop a model with two farmer types differing in both variable and fixed costs, where the objective of the donor is to achieve a certain aggregate conservation objective at minimum cost . We find that separating contracts always result in lower subsidies than uniform contracts, and that maximum efficiency can be achieved especially for intermediately high conservation targets. Our policy conclusion is therefore contrary to the one drawn by Ferraro (2005). Even though the information requirements may be quite substantial, the benefits of implementing separating policies may be sufficiently large to warrant implementation.

In addition to showing that the complete information solution can be incentive compatible (and under what circumstances), this paper offers two more contributions to the extant literature, one arising because of the existence of fixed costs, and one because of the fixed conservation objective. Regarding the role of fixed costs, we show that in those cases in which the complete information's optimal solution is not incentive-compatible in the presence of asymmetric information, informational rents accrue to the type with lowest total costs, and hence not necessarily to the type with the lowest variable costs. And if the aggregate conservation objective is fixed, both farmer types' management requirements are distorted when the complete information solution cannot be implemented: low (high)-variable-cost farmers are required to exert larger (lower) conservation efforts than under the complete information contract.

Since the objective of this paper is to analyze the effect of fixed costs on the feasibility of the least-cost solution under asymmetric information, our approach is admittedly simplified in several other respects. First, we abstract from the moral hazard problem that is inherently present in real world situations -that complying with the required conservation levels is hard to detect (but see amongst others Ozanne et al., 2001; White, 2002). Second, we assume that the donor has perfect information about the (economic) characteristics of the various farmer types but does not know which farmer is of what type. We therefore focus on an asymmetry in status information but not in information collection ability (cf. Goeschl and Lin, 2004). Third, we assume that the donor just knows the distribution of types, but does not have any farmer-specific information on the basis of which she could assign prior believes regarding the farmer's type (but see Moxey et al., 1999). Fourth, our model is such that even under asymmetric information, the amount of conservation effort is always higher in case of a conservation scheme than in its absence because we assume that the privately optimal level of conservation effort is zero (but see Motte et al., 2004; Di Corato, 2006).

The setup of this paper is as follows. We present the model in section 2, and provide the solution to the complete information problem in section 3. In section 4 we analyze whether the least-cost incentive-compatible contract under asymmetric information is uniform or separating. In section 5, we characterize the optimal policy under asymmetric information and, in particular, we show the circumstances under which the complete information solution is incentive compatible. We draw conclusions in section 6. The details of the optimization problem under asymmetric information can be found in the appendix.

II. THE MODEL

The objective of the donor is to induce a group of farmers to undertake a certain amount of biodiversity conservation effort. There are two types of farmers, indexed i=1,2, where n_i>0 denotes the total number of farmers of type i Conservation effort of a farmer of type i is denoted by b_i. The minimum aggregate level of conservation effort required is $\overline{B} > 0$. Therefore, $\overline{B} \leq \sum_{i=1}^{2} n_i b_i$.

To provide positive levels of conservation services (i.e., $b_i > 0$), the farmer needs to incur both fixed and variable costs. These two types of costs are denoted by F_i and $c_i(b)$, respectively, and hence total private conservation costs are $C_i(b) = F_i + c_i(b)$. Here, $F_i \geq 0$, and $c(b)$ is assumed to be increasing and convex in b with $c_i(0) = c'_i(0) = 0$. Also, we arbitrarily assume that $c'_2(b) > c'_1(b)$ and $c''_2(b) > c''_1(b)$ for all $b > 0$, so that type 1 farmers are always the low-variable-cost providers of conservation services.

Participation is voluntary, which means that farmers of type i need to receive compensation payments (or subsidies, S_i) that are at least as large as the amount of conservation costs incurred for the effort prescribed ($S_i \geq C_i(b_i)$). Subsidies are costly in the sense that money spent on the current project cannot be spent elsewhere. Therefore, the objective of the donor is to achieve total conservation effort $\overline{B}$ at minimum budget.

If the donor has perfect information about each particular farmer, the problem is to find the menu $\{(S_1, b_1), (S_2, b_2)\}$ which satisfies the following:

$$\min \ \tilde{S} = n_1 S_1 + n_2 S_2, \tag{1a}$$

$$s.t. \quad \overline{B} \leq n_1 b_1 + n_2 b_2, \tag{1b}$$

$$F_i + c_i(b_i) - S_i \leq 0, \ i = 1, 2. \tag{1c}$$

However, in case of asymmetric information, the donor has to take into account the incentive compatibility constraints. This means that the menu offered has to be such that each farmer actually prefers the particular policy targeted at its type. That is, the donor needs to ensure that:

$$c_i(b_i) - S_i \leq c_i(b_j) - S_j, \tag{2}$$

where i=1,2 and $i \neq j$.

The donor can design a uniform policy, that is a single combination of b and S that is offered to all farmers. Such a uniform policy, (S^u, b^u), is trivially incentive compatible and that means that one of the participation constraints will not be binding. Since the donor wants to achieve $\overline{B}$, the uniform policy is straightforward:

$$b^u = \frac{\overline{B}}{n_1 + n_2}; \ S^u = \max\{C_1(b^u), C_2(b^u)\}. \tag{3}$$

The donor may also offer a menu of policies consisting of specific combinations of S and b targeted at the different farmer types. In case of two farmer types, a separating policy would thus consist of two combinations of subsidies and management requirements, (S_1^s, b_1^s) and (S_2^s, b_2^s). The key question is whether such a separating scheme is better than a uniform contract, with regard to achieving a given aggregate conservation effort at lower aggregate subsidies.

III. COMPLETE INFORMATION

Let us first determine the menu of subsidies and management requirements (S_1^c, b_1^c) and (S_2^c, b_2^c). which yields the complete information solution to problem (1). The Lagrangian is the following:

$$L = n_1 S_1 + n_2 S_2 + \mu\left[\overline{B} - n_1 b_1 - n_2 b_2\right] + \sum_{i=1}^{2} \lambda_i \left[F_i + c_i(b_i) - S_i\right],$$

where $\mu \geq 0$, $\lambda_i \geq 0$ are the Kuhn-Tucker multipliers associated with the conservation objective and the participation constraints, respectively. The first-order conditions are[1]:

$$\lambda_i c'_i(b_i) + \mu n_i = 0; \tag{4a}$$

$$n_i - \lambda_i = 0; \tag{4b}$$

$$\mu\left[\overline{B} - n_1 b_1 - n_2 b_2\right] = 0; \ \overline{B} - n_1 b_1 - n_2 b_2 \leq 0; \tag{4c}$$

$$\lambda_i\left[F_i + c_i(b_i) - S_i\right] = 0; \ F_i + c_i(b_i) - S_i \leq 0. \tag{4d}$$

Where i = 1,2. From (4b)_, we obtain $\lambda_i = n_i > 0$. This implies $F_i + c_i(b^c_i) - S_i^c = 0$ (see (4d)) and $\mu = c'_1(b^c_1) = c'_2(b^c_2)$ (see 4a)). In words, the required conservation efforts are such that marginal costs are equal, and subsidies are paid to exactly cover conservation costs. Since $c'_2(b) > c'_1(b)$ for all $b > 0$, we trivially have $b^c_1 > b^c_2$. Thus, the effort level required from type 1 farmers is larger than that of type 2 farmers. However, there is no trivial ranking with

1. [1] Our assumptions ensure that these are necessary and sufficient conditions for an optimum.

respect to the required subsidy levels because of the presence of fixed costs. Clearly, $c_1(b^c{}_1) > c_2(b^c{}_2)$[2].

IV. ASYMMETRIC INFORMATION: UNIFORM VERSUS SEPARATING POLICIES

Let us now turn to the case where information is asymmetric. Each individual farmer knows her type; the donor only knows the characteristics of the two types (F_i and $c_i(b)$, i = 1,2) and the total number of farmers (n_1 and n_2) but does not know which farmer is of what type. Before characterizing the exact optimal policy (in the next section), we first establish whether the optimal solution under asymmetric information is separating, or uniform. Here, the donor needs to take into account the incentive compatibility constraints given in (2) , and the problem is to find the menu $\{(S_1,b_1)\ ,\ (S_2,b_2)\}$ which satisfies the following:

$$\min \quad \tilde{S} = n_1 S_1 + n_2 S_2, \tag{5a}$$

$$s.t. \quad \overline{B} \leq n_1 b_1 + n_2 b_2, \tag{5b}$$

$$F_i + c_i\left(b_i\right) - S_i \leq 0,\ i = 1,2, \tag{5c}$$

$$c_i\left(b_i\right) - S_i \leq c_i\left(b_j\right) - S_j, \quad i,j = 1,2, i \neq j. \tag{5d}$$

Isocost functions are a useful tool to evaluate farmer preferences when comparing multiple policy combinations. These functions represent the sets of policy combinations (S,b) for which farmer type i's total (net) costs are constant and equal to $k_i = F_i + c_i(b) - S$. Since $\left.\frac{db}{dS}\right|_{k_i} = \frac{1}{c_i'(b)}$, isocost functions are upward-sloping and concave in (S,b) space; see Figure 1. Because $c'_2(b) > c'_1(b)$, the isocost function of a type 1 farmer is strictly steeper in any policy combination (S,b) than that of a type 2 farmer; $\left.\frac{db}{dS}\right|_{k_1} > \left.\frac{db}{dS}\right|_{k_2}$. Finally, costs decrease whenever the required effort level is lower and the subsidy is larger, and hence isocost functions located to the south-east are preferred to those located to the north-west (as is illustrated in Figure 1 for type 1 farmers, where $\overline{k'_1} > \overline{k_1}$). Or, put differently, for a given isocost function, all policy combinations located to the south-east (north-west) of this function result in lower (higher) net total costs.

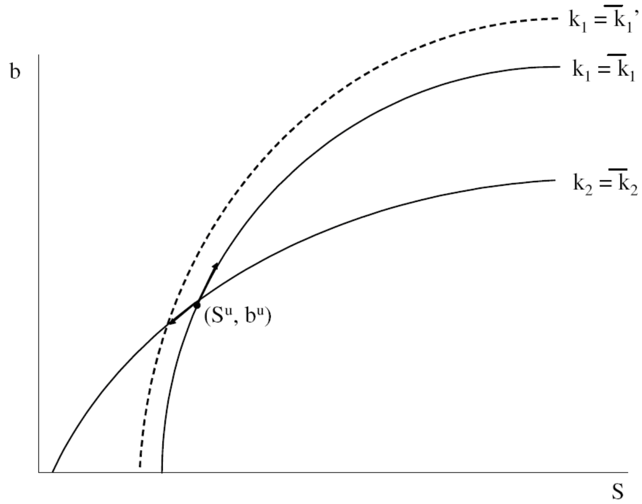

Fig. 1 : A subsidy-saving deviation from the least-cost uniform policy

Figure 1 allows us to show the intuition behind the result that under asymmetric information the least-cost uniform policy (3) is never optimal. Consider (S^u,b^u) as depicted in Figure 1. We can have either $\overline{k_1} = 0$ (if $C_1(b^u) > C_2(b^u)$, implying $\overline{k_2} < 0$) or $\overline{k_2} = 0$ (if $C_1(b^u) < C_2(b^u)$, implying $\overline{k_1} < 0$). We now prove that the total amount of subsidies can always be decreased (as compared to the uniform case) by designing a menu of policy combinations. We do this by showing that the aggregate amount of subsidies offered falls if the donor sets the policy combination targeted at type 1 farmers on the $k_1 = \overline{k}_1$ line to the north-east of (S^u,b^u) , and the combination targeted at type 2 farmers on the $k_2 = \overline{k}_2$ line to the south-west of (S^u,b^u). Such a set of combinations is both incentive-compatible and decreases the total amount of subsidies paid.

The analysis is as follows. First note that decreasing b_2 implies increasing b_1 as the aggregate conservation objective $\overline{B}$ always needs to be met. Totally differentiating the conservation constraint yields $db_1/db_2 = -(n_2/n_1)$. Next, given db_i we can infer

[2] This can be seen as follows. The first order condition is that $(\mu =)\ c_1'\left(b_1^c\right) = c_2'\left(b_2^c\right)$, and hence $db_1^c/db_2^c = c_2''/c_1'' > 1$. Now for any level of b_2^c (with corresponding b_1^c), we have $d(c_1\left(b_1^c\left(b_2^c\right)\right) - c_2\left(b_2^c\right))/db_2^c = c_1'\left(b_1^c\right)db_1^c/db_2^c - c_2'\left(b_2^c\right) = \mu[db_1^c/db_2^c - 1] > 0$. Straightforward integration yields $c_1\left(b_1^c\right) - c_2\left(b_2^c\right) > 0$ for all $b_2^c > 0$.

the required increase in subsidies *(dS_i)* such that the farmer's total net costs remain unchanged; this equals $\partial S_i(b^u)/\partial b = c_i(b^u)$. Now the aggregate amount of subsidies required $(\tilde{S})$ varies with b_2 as follows: $d\tilde{S}/db_2 = n_1 \frac{\partial S_1(b^u)}{\partial b_1}\frac{db_1}{db_2} + n_2 \frac{\partial S_2(b^u)}{\partial b_2} = n_2(c_2'(b^u) - c_1'(b^u)) > 0$. Therefore, starting from (S^u,b^u), marginally decreasing b_2 (and concomitantly increasing b_1) reduces the total amount of subsidies paid. Finally, when moving along the two $k_i = \bar{k}_i$ lines as indicated, each farmer strictly prefers the new policy combination targeted at her type.

Hence, the uniform policy is never optimal; independent of the number of farmers being of type 1 or type 2 (n_1 and n_2), it is always cheaper to induce the low-cost (high-cost) farmers to undertake slightly more (less) conservation effort. Also note that incentive compatible policies are then characterized by higher (lower) effort levels and subsidies intended for the low (high) variable cost type. Note that this result is independent of the level of the fixed costs.

V. THE OPTIMAL POLICY UNDER ASYMMETRIC INFORMATION

Let us now address the question whether the complete information solution (4a)-(4d) can be incentive compatible in the presence of fixed costs. The complete information solution is incentive compatible if and only if (5c) holds with strict equality for i = 1,2, and (5d) is met for (i,j) = (1,2) and (i,j) = (2,1). Combining these four equations, we find that the complete information solution is incentive-compatible if and only if

$$c_2\left(b_2^c\right) - c_1\left(b_2^c\right) \le F_1 - F_2 \le c_2\left(b_1^c\right) - c_1\left(b_1^c\right). \qquad (6)$$

A necessary condition for (6) to hold is that $F_1 > F_2 \geq 0$. The reason is that $c'_2(b) > c'_1(b)$ for all $b>0$, and hence $c_2(b) - c_1(b) > 0$. That means that when $F_2 \geq F_1 \geq 0$, the first inequality in condition (6) never holds. In case $F_1 > F_2 \geq 0$, the condition is met for at least some values of F_1 and F_2: because $b^c_1 > b^c_2$ and $c'_2(b) > c'_1(b)$ for all $b > 0$, we have $c_2(b^c_2) - c_1(b^c_2) < c_2(b^c_1) - c_1(b^c_1)$[3].

The reason why the two fixed costs appear in the incentive compatibility constraint is that their levels affect the amount of subsidies provided. This result is clear when analyzing the two inequalities in (6 separately. The first inequality can be rewritten as $c_2(b^c_2) + F_2 \leq F_1 + c_1(b^c_2)$, and hence $0 \leq F_1 + c_1(b^c_2) - S^c_2$. In words, this inequality is about the incentives for type 1 farmers to misrepresent their type under the complete information solution. Their net costs are zero if they choose the policy combination aimed at their type, and this is incentive compatible if their net costs are positive if they misrepresent themselves. So, even though $c_1(b^c_2) < c_1(b^c_1)$, type 1 farmers may still prefer the policy targeted at their type if S^c_2 is sufficiently small compared to S^c_1, and this is the case if F_2 is sufficiently small compared to F_1. And a similar analysis applies to the second inequality, which can be rewritten as $c_1(b^c_1) + F_1 \leq c_2(b^c_1) + F_2$ so that $0 \leq F_2 + c_2(b^c_1) - S^c_1$. Type 2 farmers have an incentive to choose the combination aimed at their type because $c_2(b^c_2) < c_2(b^c_1)$, but they will only do so if S^c_1 (S^c_2) is sufficiently low (high), which is the case if F_1 (F_2) is sufficiently small (large)[4].

This can also be shown graphically. Let us first consider the case where $F_2 \geq F_1 \geq 0$ so that $C_2(b) > C_1(b)$ for all b>0, as represented in Figure 2. Here, the k_1 = 0 line is strictly located to the north-west of the k_2 = 0 line. Therefore, type 1 farmers prefer the contract intended for type 2 farmers. For b = 0, the minimum amount of subsidies required when farmers are forced to invest is $S_i = F_i$, and $F_2 \geq F_1$ implies that the horizontal intercept of the k_1 = 0 is (weakly) to the left of that of the k_2 = 0 line. Next, because $\left.\frac{db}{dS}\right|_{k_1} > \left.\frac{db}{dS}\right|_{k_2}$ for all b>0, the k_1 = 0 line is located strictly to the north of the k_2 = 0 line. Therefore, in this case the complete information solution (4a)-(4d) is never incentive compatible.

[3] Note that together with $c'_1(b) > c'_2(b)$ for all $b > 0$, the cases $F_2 \geq F_1$ and $F_1 > F_2$ exhaust all possible combinations of levels of fixed costs being high or low, and the levels of variable costs being high or low.

[4] Note that this case includes F1 = F2=0; the first best is never incentive compatible if there are only variable conservation costs.

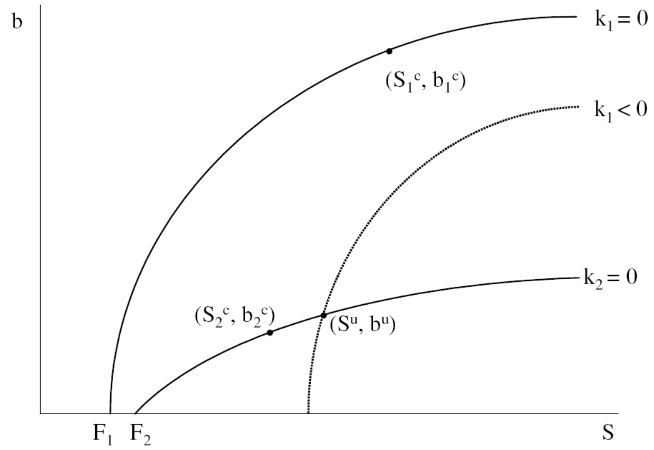

Fig. 2 : Incentive compatibility of the complete information contracts if $F_2 \geq F_1 \geq 0$

The optimal policy when $F_2 \geq F_1 \geq 0$ is characterized by the following conditions (for a formal proof see the appendix):

$$n_1 \left[c_2'\left(b_2^s\right) - c_1'\left(b_2^s\right)\right] = n_2 \left[c_1'\left(b_1^s\right) - c_2'\left(b_2^s\right)\right], \tag{7a}$$

$$\overline{B} = n_1 b_1^s + n_2 b_2^s, \tag{7b}$$

$$S_2^s = F_2 + c_2\left(b_2^s\right), \tag{7c}$$

$$c_1\left(b_1^s\right) - S_1^s - c_1\left(b_2^s\right) + S_2^s = 0. \tag{7d}$$

In this case, type 1 farmers have an incentive to misrepresent their type under the complete information solution, but type 2 farmers do not. Therefore, the farmers of the latter type receive a subsidy that just covers their conservation costs (7c), whereas the former type receives an informational rent so that their incentive compatibility constraint is binding (7d). Therefore, the optimal policy is that the subsidy intended for type 1 farmers (S_1^c) more than covers their private costs of exerting the effort level b_1^s, and the informational rent equals $R_1 \equiv S_1 - F_1 - c_1(b_1) \geq 0$. The question is then what levels of conservation effort should be imposed on the two farmer types. Substituting (7c) into (7d), adding and subtracting F_1 and rewriting yields $R_1 = c_2(b_2) - c_1(b_2) + F_2 - F_1 > 0$. Changing b_1 affects R_1 and, using $db_2/db_1 = -(n_1/n_2)$ (because of (7b)), we have $dR_1/db_1 = [c'_2(b_2) - c'_1(b_2)](db_2/db_1) = -(n_1/n_2)[c'_2(b_2) - c'_1(b_2)] < 0$. Increasing the amount of conservation effort required from type 1 farmers increases their conservation costs and thus lowers the informational rent they receive. Therefore, the `golden rule' of $c'_1(b_1) = c'_2(b_2)$ (see the solution of (4)) needs to be modified by adding dR/db_1 to the LHS, which yields:

$$c_1'\left(b_1^s\right) - \frac{n_1}{n_2}\left[c_2'\left(b_2^s\right) - c_1'\left(b_2^s\right)\right] = c_2'\left(b_2^s\right), \tag{8}$$

and this is identical to (7a). Thus, the net marginal cost of type 1 farmers are larger than those of type 2 farmers: $c'_1(b^s_1) > c'_2(b^s_2)$. Therefore, $b^s_1 > b^c_1$ and $b^s_2 < b^c_2$ and, consequently, $S^s_1 > S^c_1$ and $S^s_2 < S^c_2$. Since there is a fixed aggregate conservation objective, $\overline{B}$, both individual effort levels are adjusted to satisfy the optimality condition and the constraint $\overline{B}$.

Now, let us consider the case where $F_1 > F_2 = 0$, so that the total costs incurred by type 2 farmers are not always larger than those incurred by type 1 farmers. This case implies that $k_2 = 0$ and $k_1 = 0$ intersect at one particular level of b, labelled $\tilde{b}$ in Figure 3. We know from the previous section that the optimal solution is always a separating policy, and we show that in this case the complete information's optimal (separating) policy may even be incentive compatible. Here, the outcome depends on the relative values of the fixed costs incurred, the aggregate conservation objective and on the variable cost functions.

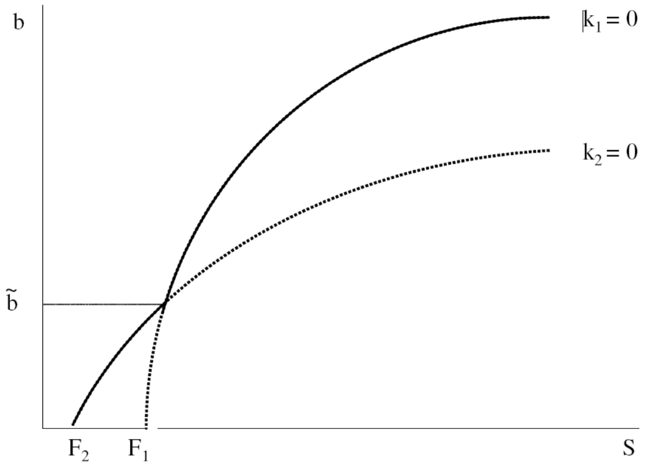

Fig. 3 : Incentive compatibility of the complete information contracts if $F_2 > F_2 \geq 0$

Suppose that the complete information solution is such that either $b^c_2 < b^c_1 < \tilde{b}$, or $\tilde{b} < b^c_2 < b^c_1$. That means that in either case, one of the two policy combination is located on the dotted part of either of the two isocost functions in Figure 3, and the complete information's optimal policy is not incentive compatible. If $\tilde{b} < b^c_2 < b^c_1$, the situation is analogous to the one depicted in Figure 2 and hence here type 1 farmers strictly prefer the contract intended for type 2 farmers. In fact, condition $\tilde{b} < b^c_2 < b^c_1$ is equivalent to $F_1 - F_2 < c_2(b^c_2) - c_1(b^c_2)$, which violates (6). In that case, the optimal separating policy is again given by the conditions (7a)-(7d), that is an informational rent must be given to type 1 farmers.

If, however, $b^c_2 < b^c_1 < \tilde{b}$, type 2 farmers strictly prefer the contract intended for type 1 farmers. Here, condition $b^c_2 < b^c_1 < \tilde{b}$ is equivalent to $F_1 - F_2 > c_2(b^c_1) - c_1(b^c_1)$. The optimal policy is then again a separating contract, characterized now by the following conditions:

$$n_2\left[c_2'\left(b_1^s\right) - c_1'\left(b_1^s\right)\right] = n_1\left[c_1'\left(b_1^s\right) - c_2'\left(b_2^s\right)\right], \tag{9a}$$

$$\overline{B} = n_1 b_1^s + n_2 b_2^s, \tag{9b}$$

$$S_1^s = F_1 + c_1\left(b_1^s\right), \tag{9c}$$

$$c_2\left(b_2^s\right) - S_2^s - c_2\left(b_1^s\right) + S_1^s = 0. \tag{9d}$$

The interpretation is analogous to that of equations (7a)-(7d). Type 1 farmers have no incentive to misrepresent their type when facing the complete information's optimal policy menu, but type 2 farmers do. Therefore, type 1 farmers are just compensated for their extra costs (9c), but type 2 farmers receive an informational rent such that their incentive compatibility constraint (9d) is binding. From (9b)-(9d) we can derive (9a) in exactly the same fashion as we obtained (7a) from (7b)-(7d). In this case, we also have $b^s_1 > b^c_1$, $b^s_2 < b^c_2$, $S^s_1 > S^c_1$ and $S^s_2 > S^c_2$.

If, however, $b^c_2 \leq \tilde{b} \leq b^c_1$ (with at least one of the two inequalities being strict), the complete information solution is incentive-compatible, since condition (6) holds. For type 2 farmers the difference in subsidies (S^c_1 - S^c_2) is always smaller than the increase in variable costs they incur when representing themselves as type 1 farmers; for type 1 farmers the change in subsidies is always larger than the variable cost savings they obtain because of having to meet less strict management requirements (b^c_2 versus b^c_1).

Next, we address the question how likely it is that $b^c_2 \leq \tilde{b} \leq b^c_1$. Or, equivalently, how likely is it that condition (6) holds in practice? As seen before, a necessary condition is that the farmer type with low marginal conservation costs has larger fixed costs, i.e., $F_1 > F_2$. For a certain level of aggregate conservation, $\overline{B}$, the difference $F_1 - F_2 > 0$ must lie between two bounds, as shown in (6).

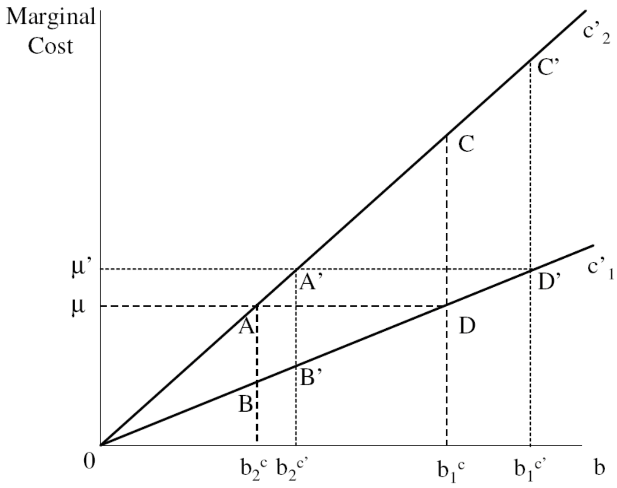

Fig. 4 : The range of differences infixed costs (ABCD and A'B'C'D') for which the complete information contracts are incentive compatible

Consider Figure 4, where we depict the complete information solution (b^c_1, b^c_2), such that $c'_1 = c'_2 = \mu$ and $\overline{B} = \sum_i n_i b_i^c$. Note that the left-hand side of (6) equals area 0AB, while its right-hand side equals 0CD. If F_1 - F_2 is larger than 0AB but smaller than 0CD, the complete information solution is incentive compatible. Now assume an increase in the required level of conservation effort, $\overline{B}$, increasing the corresponding individual effort levels to ($b^{c'}_1$, $b^{c'}_2$). Graphically, it is easy to see that both the left- and right-hand side bounds of (6) increase, but that the increase of the right-hand side bound is larger (as $db^c_1/db^c_2 > 1$)[5]. This analysis shows that, on the one hand, the interval for the `allowable' difference in fixed costs (i.e., the range of differences in fixed costs that result in the complete information's optimal policy being incentive compatible) increases if aggregate conservation effort $\overline{B}$ increases. On the other hand, a

[5] Mathematically, the bandwidth for $F_1 - F_2$ is given by $Z \equiv [c_2(b_1^c) - c_1(b_1^c)] - [c_2(b_2^c) - c_1(b_2^c)]$. If $\bar{B}$ increases by $d\bar{B}$, then $db_2 = d\bar{B}/[n_1(c_2''/c_1'') + n_2] > 0$, and $db_1 = (c_2''/c_1'')db_2 > db_2 > 0$. Hence, $dZ/d\bar{B} = \frac{1}{[n_1(c_2''/c_1'')+n_2]}[c_2'(b_1^c) - c_1'(b_1^c)](c_2''/c_1'') - [c_2'(b_2^c) - c_1'(b_2^c)] > 0$.

higher $\overline{B}$ also implies that the lower bound of the interval is increased, so that smaller differences in fixed costs prevent the complete information solution from being incentive compatible. As a consequence, when $F_1 > F_2$, only intermediate levels of aggregate conservation can be implemented without any informational distortions.

VI. CONCLUSIONS

This paper revisits the conclusions of the literature on incentive-compatible contracts and finds that, when taking into account the presence of fixed conservation costs, the double cost of separation (that is, the informational rents plus the distortions on individual conservation efforts) do not necessarily occur. While in the case of just variable costs the low-cost farmers always obtain an informational rent whereas the high-cost farmers are confronted with less strict management requirements than under complete information, this is not necessarily the case when conservation entails fixed costs too. Then, if farmers with lower variable conservation costs face higher fixed costs (and vice versa), the complete information solution can be incentive compatible. Given the relevance of fixed costs in conservation issues, we conclude that incentive-compatible contracts should be given a second chance as a policy measure to induce conservation.

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- Author: Daan van Soest
- Institute: Universiteit van Tilburg
- Street:
- City: Tilburg
- Country: The Netherlands
- Email: d.p.vansoest@uvt.nl

APPENDIX

Creating marshland on agricultural land for birds

Creating marshland on agricultural land is one of the nature management options (beheerspakket) open for subsidies under the SAN program. This option specifies that an area of grassland has to be inundated with 20 cm of water until 15 April (a second option is 15 May which we will not include).

The costs of implementing this option consist of two parts: (i) costs of pumping water into the meadow (once a week) and (ii) opportunity costs of foregone fodder that would have been provided by the grassland. The costs depend on the physical conditions (soil, climate) of the meadow. A low-lying meadow that is already wet will need less pumped water than a higher, dry meadow. We assume here that low-lying meadows near streams that a farmer will convert to a marshland are usually further away from the homestead than higher dry meadows. Besides the variable cost component there is a fixed cost component that consist of the farmers' time spent on driving to the meadow to installing the pump, and again to dismantle the pump. These are costs the farmer needs to make irrespective of the extent of the area that is being inundated. But the height of the costs does depend on the location of the marshland – those further away will take more time than those close to the homestead.

In our example high fixed costs (low lying meadow far away) are associated with low variable costs (less water needed) and vice versa. The data is based on the study by Tolkamp et al. (2006) in which average costs for a farmer implementing the marshland package on 1 ha were calculated.

We assume that the farmer creates a marshland of 1 ha. After this, the farmer pumps water every week to keep the area inundated. We assume that a "high cost" farmer represents the average farmer in the study by Tolkamp et al. and needs 5 hours a week to pump water on 1 ha. We assume that a "low cost" farmer needs 4.5 hours a week to pump water on 1 ha, because the farmland is a low-lying wet area. The opportunity costs for fodder are assumed to be equal for both farmers. A low lying area, which is further away, leads to higher fixed costs: it takes the farmer 1 hour every week to drive to the meadow and install the pump. A higher lying dry area, which is close by, takes the farmer less than half that time – we assumed 27 minutes (45% of an hour). The costs of labour are based on minimum wages. Table 1 shows the data.

Table 1: variable and fixed costs of maintaining a marshland

		Units	High costs	Low costs
Variable costs **Pumping water**				
Hours a week		Hours	5	4.5
Number of weeks to April		Weeks	8	8
Pump	1.47	euro/hour	58.8	52.92
Use of tractor	7.5	euro/hour	300	270
Use of fuel	7.36	Litre/hour		
Fuel costs	4.37	Euro/l/hour	174.8	157.32
Subtotal			**533.6**	**480.24**
			0.05336	**0.048024**
Opportunity costs in nutritional value of fodder				
Purchase of grass	0.1	euro/kVEM		
Yield in kVEM normal average per ha	7700	kVEM/ha	770	770
Total (1 ha)			**1303.6**	**1250.24**
Total (m2)			**0.13036**	**0.125024**
Fixed costs				
Manhours		hour/week	1	0.45
Costs of labour	25.83	euro/hour		
Labour costs			206.64	92.988

We assume increasing marginal costs, which indicates that it increasingly costs more to add an additional unit of marshland. When farmland is slightly concave, at first relatively less water is needed, because the groundwater levels are high (sometimes even above surface level). But at increasing size of the area, relatively more water will be needed to saturate the soil with water until groundwater levels (figure 1). We have assumed a conservative marginal cost (1.1), because land is fairly flat in the Netherlands:

$Ci(b) = Fi + c^{1.1}i(b)$. We assume that both farmers face the same marginal cost.

Fig. 1: increasing marginal costs of pumping water

The two types of farmers are:

	Variable costs	Fixed costs
Farmer 1	0.13	207
Farmer 2	0.13	93

Figure 1 shows the amount of marshland (b1) implemented by farmer 1 that will minimize subsidies (S), which is 12,100 m2. This implies that farmer 2 will implement 7900 m2 (as b1 + b2 = B = 2 ha). The total amount of subsidies associated with this solution is 6699 euro. This solution is incentive-compatible.

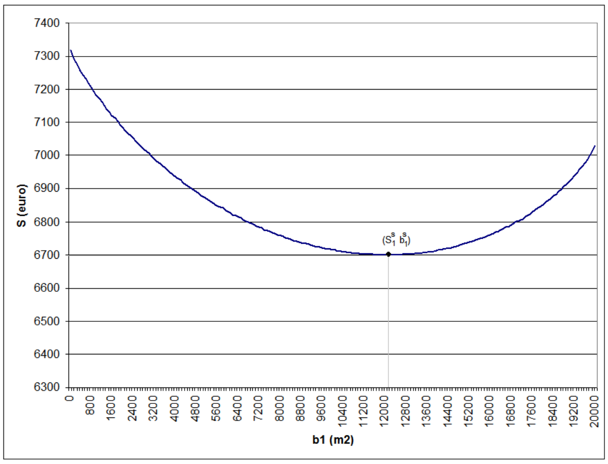

Fig. 2: area of marshland created by farmer 1

When we calculate the uniform policy we get

	b1	S1	b2	S2
(Su,bu) =	8600	2867	8600	2867

Figure 2 presents the uniform policy

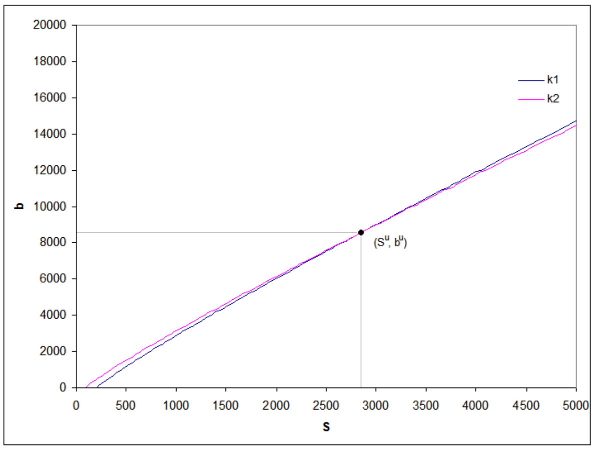

Fig. 3: Uniform policy