Beneficial selection and the efficient procurement of ecosystem services

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Abstract

It has bee suggested by many authors that adverse selection in government schemes for the procurement of ecosystem services impairs both the efficiency of these schemes and the value for money that they deliver to taxpayers and funding agencies. However, recent research considers that these types of procurement system may not be characterised by adverse selection but by what might labelled as "beneficial selection". And this research goes on to show that even with beneficial selection there will still remain potential inefficiency arising from a continuing need for payment of information rents to the participating farmers in the scheme.

This paper presents and analyses a model that represents the tradeoffs in designing efficient mechanisms for the procurement of ecosystem services. A key characteristic is the payment of informational rents to participants so as to increase overall efficiency. The impact of beneficial selection is carefully explored in this context, and we investigate implications for policy makers. In particular we suggest that some conventional policy advice in this area, that ignores the possibility of beneficial selection, may be mis-directed.

Keywords: Asymmetric Information, Beneficial Selection, Adverse Selection, Payment for Ecosystem Services

JEL codes: D82 Asymmetric and Private Information; Q57 Ecosystem Services;

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(RESULTS OF PRELIMINARY ANALYSIS: NOT FOR QUOTATION WITHOUT AUTHORS' PERMISSION)

The role of adverse selection in government schemes for the procurement of ecosystem services has been investigated by a wide range of authors, including Connor et al. (2008), Ferraro (2008) and Quillerou and Fraser (2010). The general consensus is that adverse selection impairs both the efficiency of these schemes and the value for money that they deliver to taxpayers and funding agencies. However, recent research on the UK Environmental Stewardship Scheme (Russell and Sauer, 2011) suggests that these types of procurement system may not be characterised by adverse selection but by what might labelled as "beneficial selection"[1]. Russell and Sauer base their results on the analysis of a simple theoretical model and confirm the empirical implications of beneficial selection using a unique dataset of the characteristics of agreement holders in the UK Higher level Stewardship Scheme. However they suggest that even with beneficial selection there will still remain potential inefficiency arising from a continuing need for payment of information rents to the participating farmers in the scheme.

This current paper extends this analysis using a more complete model that focuses specifically on the Principal- Agent characteristics of this problem and sets out to investigate the design tradeoffs that arise in ecosystem procurement mechanisms where payment of information rents might be used to increase overall efficiency. The impact of beneficial selection is carefully explored here, and we consider implications for policy makers that suggest the conventional policy advice may be mis-directed since it ignores the possibility of beneficial selection.

[1]Hemenway (1990) and de Meza and Webb (2001) discuss the closely related notions of "propitious selection" and "advantageous selection" respectively, in the context of markets for insurance. Fang et al. (2008) provide a more recent analysis of advantageous selection that focuses on markets for health insurance. In addition Quillerou et al. (2011) note the likely existence of "auspicious selection" in a UK Environmental Stewardship scheme.

Information Rents and Market Efficiency

In analysing the trade-off between payment of information rents and market efficiency we focus on farmer participation in a government funded scheme that provides payments for ecological conservation and enhancement. We consider a stylised scenario where a government agency offers contracts for farmers to undertake specified eco-friendly activities in order to ensure the supply of certain types of ecosystem services. In tendering for these contracts a farmer voluntarily agrees to manage a particular ecosystem according to specified rules in return for conditional payments. The payments are intended to cover the farmer's costs of following these rules.

The analysis focuses on the asymmetric distribution of information between the Agency and the farmer about these costs; each farmer knows their specific costs but the Agency knows only the range of costs across farmers and their probability distribution. Thus we focus on how this hidden information influences the behaviour of both parties prior to concluding the contract. Since farmers have better information than the Agency about their costs of meeting the contract provisions, we pay particular attention to how they can secure higher payments by not disclosing these costs. In this way they can use their private information as a source of market power to extract informational rents in the form of payments that exceed the minimum necessary to ensure their participation in the scheme.

The Basic Model: We assume that all farmers are capable of contributing to the supply of a single homogenous ecosystem service. The Agency offers a contract that specifies which activities are to be undertaken by the farmer to facilitate supply of this service and a corresponding payment.

The costs of taking on the contract and participating in the scheme will depend on the level of participation and the implied changes for existing farming operations; in our model these requirements are summarised in a single variable h, referred to as farmer 'effort'. The costs of participation will also depend on the characteristics of the farmer and the farming operation and these are summarised by a single variable γ, referred to as the farmer 'type'. Farmer 'type' reflects

conservation opportunity costs on the land related to agricultural productivity, management characteristics, etc.

The participation costs function can be defined as follows; $C = C(h, \gamma);\ C_h, C_\gamma > 0;\ C_{hh}, C_{\gamma\gamma} > 0;\ C_{h\gamma} > 0;\ C(0, \gamma) = 0$. Here we assume that marginal costs of participating in the scheme are positive and convex in both effort (h) and farmer type (γ). Assuming $C_{h\gamma} > 0$ reflects the 'Spence-Mirrlees' condition (see for example Laffont and Martimort, 2002) and requires that marginal costs of effort increase with farmer type[2]. The final assumption $C(0, \gamma) = 0$ asserts that zero costs are incurred when farmers exert zero effort[3].

Participating farmers are assumed to generate ecosystem benefits that depend on both farmer effort and farmer type giving the following benefits function:

$$B = B(h, \gamma);\ B_h, B_\gamma > 0;\ B_{hh}, B_{\gamma\gamma} < 0;\ B_{h\gamma} > 0$$

Marginal benefits are assumed positive and concave in effort and in farmer type. This latter asserts that for a given level of effort, the benefits delivered by farmers with higher agricultural productivity are greater than those generated by lower productivity farmers, reflecting the presumed higher productivity of these farmers in generating both marketed agricultural output and non-marketed ecological services. This is a key assumption in this analysis since it implies that farmers with lower opportunity costs of participating (and thus higher incentives to participate) are those who deliver lower ecological benefit. This means that self-selection encourages participation by farmers that reduces scheme performance, a classic case of adverse selection. Assuming $B_{h\gamma} > 0$ asserts that the additional benefits of applying additional effort are also higher for higher productivity farmers[4].

[2] This is a 'constant-sign' condition that also ensures the 'single-crossing' property of the farmer rent contour maps in figures 1, 2 and 3. Note also that $C_\gamma > 0$ ensures that potential information rent payable to the lowest cost producer (see footnote 5) is positive while $C_{h\gamma} > 0$ ensures this rent increases with effort.

[3] This ensures that the break-even (zero) rent contours go through origin in figures 1, 2 and 3.

[4] This also represents the Spence-Mirrlees constant-sign single-crossing condition for the agency surplus contour maps in figures 1, 2 and 3.

These parallel the assumptions used in conventional models of contracting under asymmetric information.

In the simplified analysis in this paper we assume that farmers can be one of only two types; for farmers with high agricultural productivity and high opportunity costs of participating in the scheme γ = H, while for farmers with low opportunity costs γ = L , i.e. $\gamma \in \{H, L\}$. Thus the agency, acting on society's behalf, can offer farmers a menu of contracts, one for each type of farmer that specifies payment, $t(.)$ and effort,$h(.)$, e.g. $K^H = (t^H, h^H)$, $K^L = (t^L, h^L)$. Farmers will only consider accepting contracts that cover their opportunity costs i.e. where information rent, $R^H = t^H - C^H \geq 0$ and $R^L = t^L - C^L \geq 0$.

The Full information Scenario: Following the conventional approach to analysis of this type of problem, our benchmark solution assumes that the Agency has full information about the specific type of each farmer and how type influences farmer costs and conservation benefits. In this scenario the optimal 'First Best' outcome involves offering each type of farmer individually a contract that pays the cost of providing the level of effort that equates the marginal cost and marginal benefit; i.e. choose $h^{*L} and\ h^{*H}$ such that $B_h^L = C_h^L\ and\ B_h^H = C_h^H$ respectively, and provide transfer payments that deliver zero information rent to each type of farmer i.e. such that $R^L = t^L - C(h^{*L}, L) = 0$ and $R^H = t^H - C(h^{*H}, H) = 0$. A graphical representation of these contracts (labelled $K^{*L}\ and\ K^{*H}$ respectively), is presented in Figure 1, where paying zero information rents to each type of farmer means that each contract lies on the zero-rent contour (R^L_0 and R^H_0 respectively) for each type of farmer.

Introducing asymmetric information: We contrast the First Best solution with the optimal solution obtainable when farmer's type is private information. This means that, while the Agency can offer the first best optimal contracts as a menu of options it cannot now insist that each type take on the contracts intended for them. This means that while type H will accept $K^{*H} = (t^{*H}, h^{*H})$, type L will prefer to also take on K^{*H} since this contract provides greater rent than $K^{*L} = (t^{*L}, h^{*L})$.

In figure 1 contract K^{*H} paying positive rent to L is denoted by the fact that it lies on the R^L_1 rent contour, the dashed line parallel to R^L_0. Thus the Agency ends up being compelled to pay an information rent to L while at the same time accepting a level of effort and output that is less than L's first best efficient level. In these circumstances self-selection by the agent reduces efficiency and increases payments of information rents. However, we can show that the Agency can improve on this situation by offering a more carefully calibrated menu of contracts that reduces the effort required of the high cost farmer thus reducing the attractiveness of this contract to L even as efficiency of H is reduced. The advantage to the Agency of this strategy is that a much lower (though still positive) rent is demanded by L, thus in some sense the Agency trades off loss of efficiency in return for being able to reduce rent payments.

The key property of this new menu of contracts is to ensure that $K^L = (t^L, h^L)$, the contract designed for L, is attractive only for L, while the contract designed for H, $K^H = (t^H, h^H)$ is attractive only for H. There are two parts to this; ensuring that the contracts are actually acceptable to their intended farmers (a *Participation* property), and ensuring that the contracts are not acceptable to the 'other' farmers (an *Incentive Compatibility* property). Formally, these can be imposed as constraints on the contract design problem as follows;

Participation Constraints: $t^L - C(h^L, L) \geq 0$ and $t^H - C(h^H, H) \geq 0$

Incentive Compatibility Constraints: $t^L - C(h^L, L) \geq t^H - C(h^H, L)$

$t^H - C(h^H, H) \geq t^L - C(h^L, H)$

In solving for this menu of contracts, rather than maximising some form of social welfare function, we follow much of the literature on asymmetric information (for example Laffont and Martimort, 2002; Canton et al, 2009; Bolton and Dewatripont, 2008) and assume that the Agency maximises the surplus arising from the excess of benefits generated over transfer payments; in the context of government schemes that provide payment for the provision of ecological services (PES

schemes) this is equivalent to maximising an additive measure of 'value-for-money'. This objective function (where θ is the proportion of farmers of type L) may be specified as follows:

$$\max_{(tH,hH)(tL,hL)} \theta\,[B(h^L,L) - t^L] + (1-\theta)[B(h^H,H) - t^H]$$

Using the definitions of information rents above, $R^L = t^L - C(h^L,L)$ and $R^H = t^H - C(h^H,H)$, we can rewrite this objective function as follows by substituting for $t^L$and t^H, giving:

$$\theta[B(h^L,L) - C(h^L,L)] + (1-\theta)[B(h^H,H) - C(h^H,H)] - [\theta R^L + (1-\theta)R^H]$$

This restatement of the problem implies that the Agency wishes to maximise the expected net conservation value less the expected payments of information rent and highlights the potential trade-off between a first-best efficient outcome that maximises the net environmental value generated by the contracts, and the possibility of accepting lower efficiency (i.e. ecological output that differs from the 'first-best' levels) in return for reductions in payments of information rent.

Defining the cost difference,$\Delta^H = C(h^H,H) - C(h^H,L)$[5], the Incentive and Participation constraints can also be rewritten in terms of rental payments and the cost of conservation effort as follows:

Participation Constraints: $R^L \geq 0$ and $R^H \geq 0$

Incentive Compatibility Constraints: $R^L \geq R^H + \Delta^H$ and $R^H \geq R^L - \Delta^L$

A conventional shortcut in solving this optimisation problem is to exploit the special structure of the constraints to eliminate from consideration the participation constraint of L and the incentive constraint for H since these will always be satisfied and non-binding with rational participating farmers. Both remaining constraints will be binding at optimum, giving $R^H = 0$ and $R^L = \Delta^H$, and we can substitute both into the objective function giving an unconstrained maximising problem:

$$MAX\ \ \theta[B(h^L,L) - C(h^L,L)] + (1-\theta)[B(h^H,H) - C(h^H,H)] - \theta\Delta^H$$

[5] This represents the additional profits the low cost producer could achieve if they insisted on taking on the high cost contract. They represent the potential rental payments to this producer in order to induce them to accept the 'low cost' contract.

This differs from the maximand in the first best scenario only by the subtraction of expected rent payments to L, the low cost producer. It can be shown that since this rent depends only on the effort of H (not L) the second best outcome for L, $\hat{h}^L$ will be identical to the first best outcome, h^{*L}, i.e. the first order condition with respect to h^L is still $B_h^L - C_h^L = 0$ as in the first best scenario. However, the first order condition with respect to h^H now becomes $\left[B_h^H - C_h^H\right] = \frac{\theta}{(1-\theta)}\Delta_h^H$, so that, given declining marginal benefits of effort and positive potential information rents that increase with effort $\hat{h}^H < h^{*H}$[6]. Thus the efficiency of effort by H is traded off against the payment of information rent to L; by reducing the effort required by H the Agency can reduce the rent it needs to pay to L in order to induce participation. This situation is illustrated in Figure 2.

In both figure 1 and figure 2 the contracts are presented as [transfer, effort] combinations. The first best contracts under full information (Figure 1) are $\mathrm{K}^{*\mathrm{L}} = \left(\mathrm{t}^{*\mathrm{L}}, \mathrm{h}^{*\mathrm{L}}\right)$ and $\mathrm{K}^{*\mathrm{H}} = \left(\mathrm{t}^{*\mathrm{H}}, \mathrm{h}^{*\mathrm{H}}\right)$. The second best contracts under asymmetric information (Figure 2) are $\widehat{\mathrm{K}}^{\mathrm{H}} = \left(\hat{\mathrm{t}}^{\mathrm{H}}, \hat{\mathrm{h}}^{\mathrm{H}}\right) and\ \widehat{\mathrm{K}}^{\mathrm{L}} = \left(\hat{\mathrm{t}}^{\mathrm{L}}, \hat{\mathrm{h}}^{\mathrm{L}}\right)$. We can show that $\hat{\mathrm{h}}^{\mathrm{L}} = \mathrm{h}^{*\mathrm{L}}$ and that $\hat{\mathrm{h}}^{\mathrm{H}} < \mathrm{h}^{*\mathrm{H}}$. The diagram also illustrates that the transfer to H is reduced while still providing zero rent; by contrast, L is now exerting optimally efficiency effort levels while receiving a positive rent.

In summary, the optimal menu of contracts under the second best scenario with asymmetric information requires, first of all, that effort from the low cost farmer remains at the same level as for the first best full information scenario; $\hat{h}^L = h^{*L}$ and $B_h^L - C_h^L = 0$. Secondly, reduced effort is required from the high cost farmer; $\hat{h}^H < h^{*H}$ and $\left[B_h^H - C_h^H\right] = \frac{\theta}{(1-\theta)}\Delta_h^H$. Together these mean reduced contract efficiency since the combined effort of both types of farmer will not generate maximum possible benefits, resulting in a reduction in Agency surplus $\hat{\mathrm{S}}^{\mathrm{H}}$. Thirdly, information rent given by $\hat{R}^L$ $(= \hat{\Delta}^H)$ is paid to the low cost farmer and this is lower than the rent that might have been paid using the 'first best' contracts as the second best contract menu.

[6]For completeness, it is also assumed that the Agency can make 'take-it-or-leave-it' offers and that the farmer will accept break-even contracts that offer positive net social benefits, i.e. assume farmers' preferences display weak altruism.

Beneficial versus Adverse Selection

A key issue addressed in many previous studies of ecosystem services procurement is that voluntary self-selection by the farmer participants adversely affects scheme efficiency and cost-effectiveness, because those most likely to join the scheme contribute least to the scheme objectives. This is illustrated in the basic model by the positive relationship between scheme benefits and farmer type asserting that ecological benefits are greatest on more agriculturally productive farms with highest opportunity costs of participation in the PES scheme. In these circumstances incentives to participate will be greatest among those low opportunity cost farmers who deliver least benefits. This is regarded as a particular problem where payment levels are related to average participation costs for a given group of participants since the probability of participating for profit maximising producers is negatively correlated with the opportunity costs of participation and thus with agricultural and ecological productivity. The resulting adverse selection has been highlighted in the Quillerou and Fraser study of the UK Higher Level Stewardship scheme and they go on to show that the impact of this is reduced to some extent by certain features of scheme implementation.

However, it has also been suggested that land lower agricultural productivity generates a higher level of ecological services. This is because the land tends to be farmed less intensively with less consequent damage to the ecological infrastructure. A number of studies confirm this in a European context, including Kleijn et al. (2009), Tscharantke et al. (2005), Reidsma et al. (2006) and Stoate et al. (2001). The Kleijn et al. paper also points out that conservation benefits are disproportionately less costly to achieve on low-intensity farms. Taken together these relationships imply that when participation is highest among farmers with lower participation costs it is *pari passu* highest among those farmers that generate higher levels of ecological services. This supports the idea that these schemes are characterised, not by 'adverse selection' that impairs scheme efficiency, but by an opposite phenomenon that might be described as 'beneficial selection'[i]. However, while

this will reduce the costs of dealing with asymmetric information, it will not totally eliminate these costs, as noted below.

Implications of Beneficial Selection

Beneficial selection is represented in this model by assuming that conservation benefits are negatively related to the productivity characteristics of participating framers. This means that conservation benefits are negatively correlated to farmer type such that for $B = B(h, \gamma), B_h > 0, \boldsymbol{B_\gamma} < 0;\ B_{hh}, B_{\gamma\gamma} < 0;\ and\ \boldsymbol{B_{h\gamma}} < 0$, highlighting changes from the benefits function specification used in the previous analyses.

The implications of these changes are most clearly seen in the trade-off between efficiency and information rents that is at the core of the process leading to the optimal second best solution as discussed above and illustrated in Figure 3. The ability of the Agency to adjust the contract for type H participant, thereby reducing the information rent payable to type L, depends on the balance between the loss in conservation benefits as h^H is reduced below its first best optimum and the gain from reduced rental payments. As pointed out above, a measure of potential rental payments is given by $\Delta^H = C(h^H, H) - C(h^H, L) = C_\gamma$. The reduction in rental payment as h^H is reduced is given by $\Delta_h^H = C_{h\gamma}$. We have also pointed out that efficiency reduction is indicated by the reduction in Agency surplus $\hat{S}^H = B^H - t^H$ and this is equal to $B^H - C^H$in equilibrium since $t^H = C^H$ along the break-even rent contour R_0^H. In these circumstances $B_h^H - C_h^H$measures the rate of change in efficiency.

Figure 4 provides an illustration of the differences in optimal effort levels between Beneficial and Adverse selection scenarios. Here we show marginal participation costs and marginal ecological benefits for high cost and low cost farmers and we use these to illustrate optimal effort under both full information ($h^{*\cdot\cdot}$) and asymmetric information ($\hat{h}^{\cdot\cdot}$). C_h^L and C_h^H are the marginal participation costs for low cost and high cost farmers respectively, B_h^L is marginal ecological benefits

for low cost farmers, while B_h^{HA} and B_h^{HB} are the marginal ecological benefits for high cost farmers under adverse and beneficial selection respectively. The slopes and positions of these curves follow directly from the assumptions on cost and benefit functions above and the optimal effort levels follow from the first order conditions presented in previous sections of this paper.

As illustrated on this diagram we can also show that:

- Both first best optimal effort and second best optimal effort is lower under beneficial selection than under adverse selection: $\mathrm{h}^{*\mathrm{HB}} < \mathrm{h}^{*\mathrm{HA}}$ and $\hat{\mathrm{h}}^{\mathrm{HB}} < \hat{\mathrm{h}}^{\mathrm{HA}}$
- For both adverse and beneficial selection, second best optimal effort for the high cost farmer is less than first best effort: $\hat{\mathrm{h}}^{\mathrm{HA}} < \mathrm{h}^{*\mathrm{HA}}$ and $\hat{\mathrm{h}}^{\mathrm{HB}} < \mathrm{h}^{*\mathrm{HB}}$

This diagram also helps illustrate the trade-off, between reductions in efficiency for the high-cost farmer and reductions in information rents paid to the low-cost farmer that provides the underlying rationale for the second-best optimal solution under asymmetric information, and one of the key differences between adverse selection and beneficial selection. This trade-off involves a balancing between the reductions in potential information rents payable and reduction in net ecological benefits achievable as effort is reduced for the high cost farmer. Using the terminology and notation from the model, efficiency losses per unit rent reduction can be represented by the ratio $\frac{\left[B_h^H - C_h^H\right]}{\frac{\theta}{(1-\theta)}\Delta_h^H} = \frac{\left[B_h^H - C_h^H\right]}{\frac{\theta}{(1-\theta)}[C_h^H - C_h^L]}$. Three of the four marginal cost and benefit terms in this ratio remain unchanged under both adverse and beneficial selection; the only change is a reduction in marginal ecological benefits B_h^H under Beneficial Selection so that the 'Efficiency Loss' ratio is lower under these circumstances. This means that under beneficial selection any given reduction in information rental payments can be achieved for smaller loss in efficiency and ecological benefits. Note that this effect becomes more important when the proportion of low-cost farmers increases.

Policy and Research Implications

Much of the literature on payment schemes for ecological conservation and ecosystem services, including Canton et al. (2009), Ferraro (2008) and Quillerou and Fraser (2011), emphasise the importance of

reducing the payment of information rents in the procurement of ecosystem services by government agencies. A number of these studies stress the contribution of this strategy to maximising the services obtained from limited budgets and reducing concerns about additionality.

The main contribution of this study is that it introduces the notion of beneficial selection into the debate. The emphasis here is on the negative relationship between ecological benefits and agricultural productivity and the implications of this change for efficient ('smart') contract design. What is shown here is that with beneficial selection, there is a potentially significant reduction in the opportunity costs of adjusting contract provisions to reduce payments of information rent, putting increased emphasis on information about participants that is correlated with ecological benefits. This is in contrast to recommendations from other studies that emphasise the need to collect information on participant characteristics that is correlated with participation costs. At the same time our results point to the continuing need to be concerned about information rents and the potential contribution of competition between farmers as a mans of reducing rental payments. The potential role of some type of competitive tendering mechanisms, including auctions, could be investigated here.

This study has also highlighted a number of gaps the ongoing research agenda in this area and corresponding deficiencies in the current study. For example the current model cannot address issues related to 'pooling contracts' where identical contracts are optimally offered to heterogenous groups of farmers; many would suggest that this is abetter representation of practical PES schemes than the 'separating contracts' that are the exclusive focus of the model in this study. Also this current model does not directly address issues of additionality where the agency is not in a position to prevent farmers taking on contracts that would effectively require zero effort on their part i.e. where the contract provisions can be met with altering the pre-contract profit maximising farming activities. This is an extreme case of payment of information rents. The model could also be extended to consider a number of other issues with practical implications such as fixed participation costs.

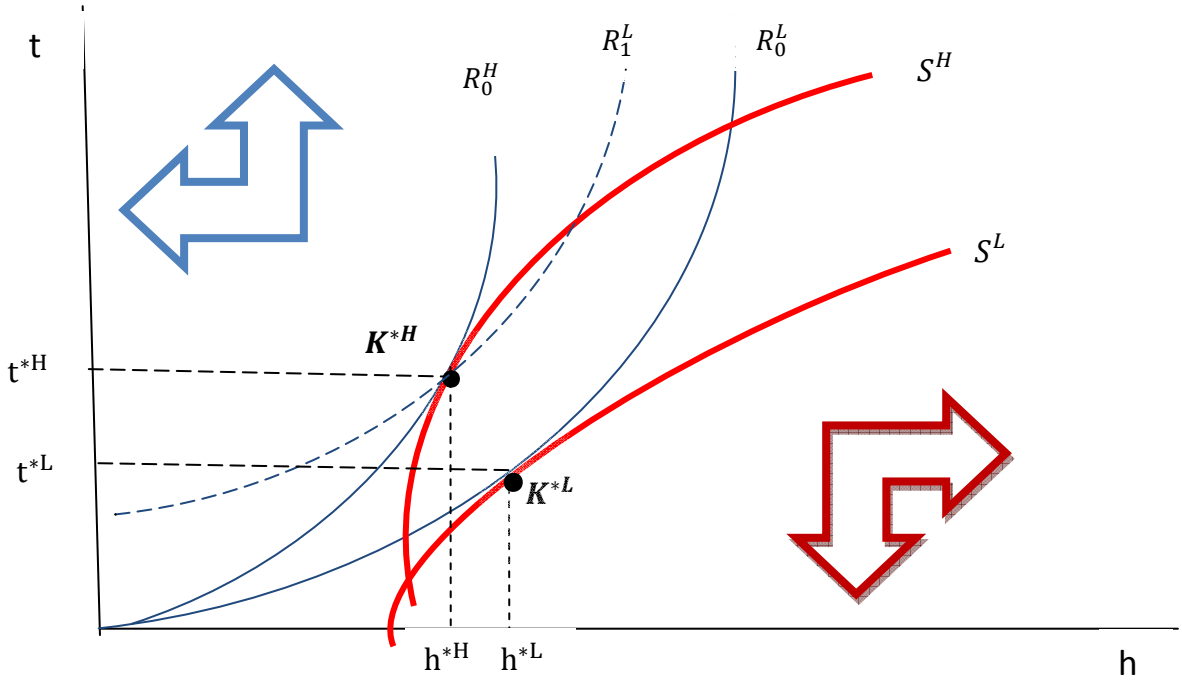

Figure 1. Menu of Contracts in the First Best full information scenario $K^{*L} = (t^{*L}, h^{*L})$ and $K^{*H} = (t^{*H}, h^{*H})$

Note: R_0^H and R_0^L represent the zero rent contours (participation constraints) for each type of farmer. S^H and S^L represent the Agency surplus contours from the agency's objective function. See Appendix A for a discussion of their relative slopes and curvatures.

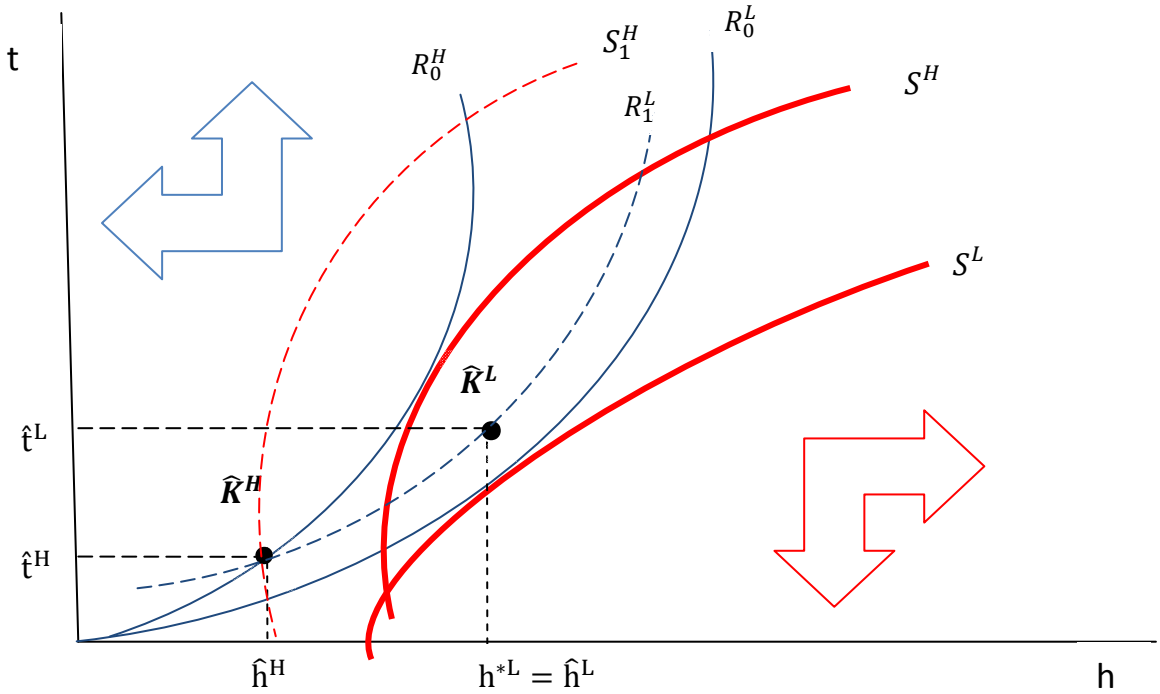

Figure 2. Menu of Contracts in the Second Best asymmetric information scenario with Adverse Selection, $\widehat{\mathbf{K}}^{\mathbf{H}} = (\hat{\mathbf{t}}^{\mathbf{H}}, \hat{\mathbf{h}}^{\mathbf{H}})$ *and* $\widehat{\mathbf{K}}^{\mathbf{L}} = (\hat{\mathbf{t}}^{\mathbf{L}}, \hat{\mathbf{h}}^{\mathbf{L}}) = \mathbf{K}^{*\mathbf{L}}$

NOTE: In the absence of full information the contract K^{*H}, if offered, will be chosen by type L as well as by type H since it provides positive rents to type L. Making the menu of contracts incentive compatible means changing both contracts as indicated in the Second Best menu so that contract $\widehat{K}^L$ is at least as good as contract $\widehat{K}^H$ for type L (and will be chosen by L under the 'weak altruism' assumption). As in Figure 1 R_0^H and R_0^L represent the zero rent contours (participation constraints) for each type of farmer. S^H and S^L represent the Agency surplus contours from the agency's objective function. See Appendix A for a discussion of their relative slopes and curvatures.

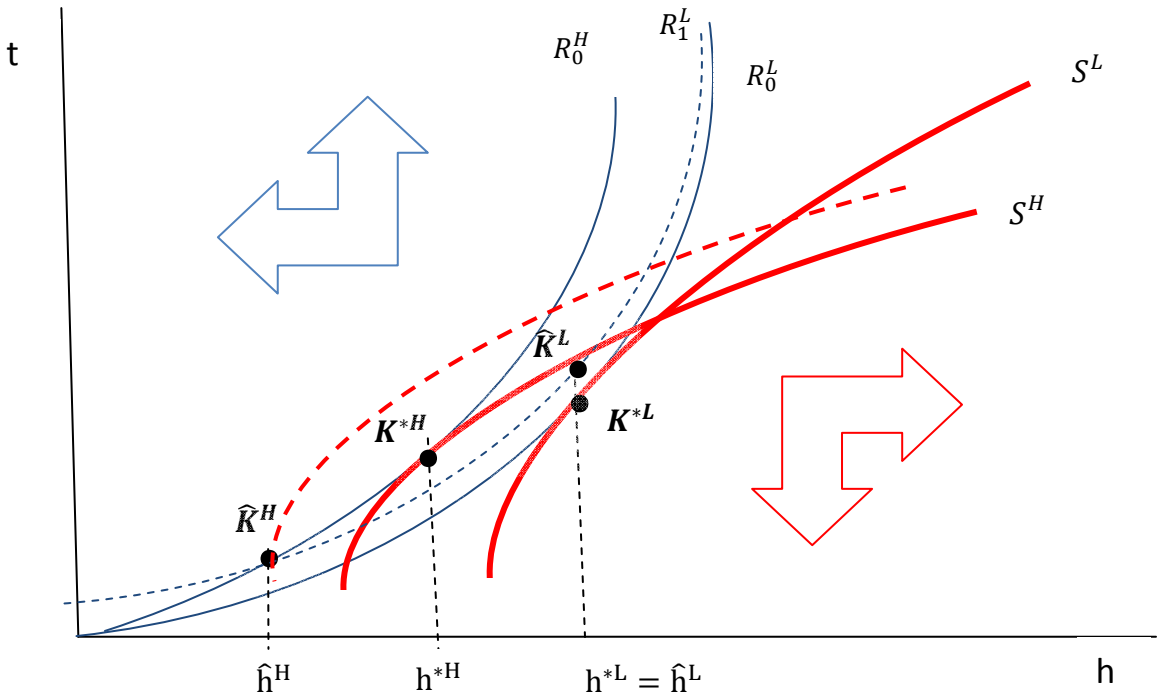

Figure 3. Menu of Contracts in the Second Best Asymmetric Information Scenario with Beneficial Selection $\widehat{K}^H = (\hat{t}^H, \hat{h}^H) and\ \widehat{K}^L = (\hat{t}^L, \hat{h}^L) = K^{*L}$

NOTE: With Beneficial Selection the agency surplus contour for type H is now flatter than the corresponding contour for Type L (See Appendix A). As in the case of Adverse Selection the optimal second best contract points to a trade off between rental payments to Type L and systematic distortion of effort level for Type H away from the first best optimum level. However a comparison of Figure 2 with Figure 3 suggests that both rental payments to Type L and effort distortion for Type H are reduced compared to what happens with Adverse Selection.

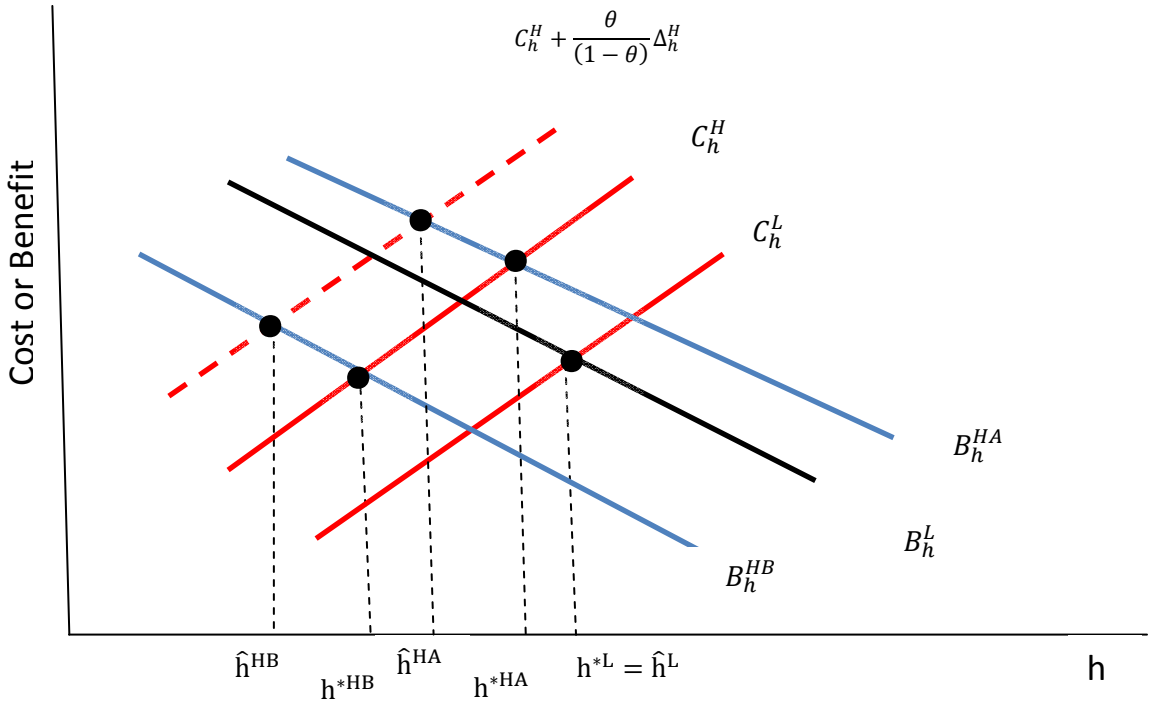

Figure 4. Comparing Optimal Effort with Adverse Selection and with Beneficial Selection

Appendix A: Relative Slopes and Curvature of Farmer Rent and Agency Surplus Contours (See figures 1, 2 and 3)

Farmer Rent Contours:

These represent the 'contour map' in (t, h) space of the farmer's Rent function given by $R^{\gamma} = t(\gamma) - C(h_{\gamma}, \gamma) = 0$. For any given type, γ and transfer t, increasing effort, h, will lead to a reduction in rent accruing to the farmer since $C_h > 0$. Thus along a constant rent contour t must increase to compensate so the contour must be positively sloped. The convexity of the opportunity cost function, C , ensures that the contours are convex.

With $C_{\gamma}, C_{h\gamma} > 0$ the marginal cost of effort is increasing with type. Thus as h increases, rent for a farmer with higher type is declining faster, requiring a faster increase in t to compensate. Constant rent contours must therefore be steeper in (t, h) space for higher types.

Finally, given $C(0, \gamma) = 0$ (zero effort incurs zero costs for both types of farmer) the break-even zero rent contours must go through origin.

Agency Surplus Contours:

These represent the 'contour map' in (t, h) space of the Agency's Surplus function given by $B(h_{\gamma}, \gamma) - t(\gamma)$. For any given type, γ, increasing effort, h, will lead to an increase in the surplus accruing to the Agency since $B_h > 0$. Thus along a constant surplus contour t must increase to compensate so the contour must be positively sloped. The concavity of the ecological benefits function, B, ensures that the contours are concave.

With $B_{\gamma}, B_{h\gamma} > 0$ the marginal ecological benefit of effort is increasing with type. Thus when dealing with a farmer of higher type a given increase in effort will require a larger increase in t to compensate by offsetting the additional benefits. Constant surplus contours must therefore be steeper in (t, h) space for higher types. Exactly the opposite reasoning applies when $B_{\gamma}, B_{h\gamma} < 0$ and this scenario is illustrated in Figure 3.

References

Bolton, P. and Dewatripont, M. (2005), Contract Theory, Massachusetts Institute of Technology Press.

Canton, J., S.De Cara and P.A.Jayet (2009). Agri-environmental schemes: Adverse selection, information structure and delegation, Ecol Econ 68(7):2114-2121.

Claassen, R., A.Cattaneo and R.Johansson (2008), Cost-effective design of agri-environmental payment programmes: US experience in theory and practice, Ecol Econ 65(4):737-752

Connor, J.D., J.R.Ward and B.Bryan (2008), Exploring the cost effectiveness of land conservation auctions and payment policies, Aust J Agric and Res Econ 52(3):303-319.

Ferraro, P.J. (2008) Asymmetric information and contract design for payments for environmental services, Ecol Econ 65(5):810-821.

Fang, H., M.P. Keane and D. Silverman (2008) Sources of advantageous selection: evidence form the Medigap insurance market. J. Polit. Econ. 116:303-350.

Khanna, M. and A.W.Ando (2009) Science, economics and the design of agricultural conservation programmes in the US, J Envir Plan Manag 52(5):575-592.

Khanna, M., M.Isik and D.Zilberman (2002), Cost-effectiveness of alternative green payment policies for conservation technology adoption with heterogeneous land quality, Agric Econ 27(2):157-174.

Kleijn, D., F.Kohler, A.Baldi, P.Batary, E.D.Concepcion, Y.Clough, M.Diaz, D.Gabriel, A.Holzschuh, E.Knop, A.Kovacs, E.J.P.Marshall, T.Tscharantke, and J.Verhulst (2009), On the relationship between farmland biodiversity and land-use in Europe, Proc Roy Soc B-Biol Sci 276(1658):903-909

Laffont, J-J and D. Martimort (2002), The Theory of incentives – The Principal Agent Model, Princeton University Press.

Latacz-Lohmann, U. and C.P.C.M. Van der Hamsvoort (1997). Auctioning Conservation Contracts: a theoretical analysis and an application, Am J. Agric. Econ., 79:407-418.

Moxey, A., B.White and A.Ozanne (1999), Efficient contract design for agri-environmental policy, J Agric Econ, 50(2):187-202.

Quillerou, E., and R.Fraser (2010), Adverse selection in the Environmental Stewardship scheme: Does Higher Level Stewardship scheme design reduce adverse selection, J Agric Econ 61(2):369-380.

Quillerou,E., R.Fraser and I.Fraser (2011), Farmer compensation and its consequences for environmental benefit provision in the Higher Level Stewardship scheme, J Agric Econ 62(2): 330-339

Reidsma, P., T.Tekelenburg, M. van den Berg and R.Alkemade (2006) Impacts of land-use change on biodiversity: An assessment of agricultural biodiversity in the European Union, Agric Ecosys & Envir 114(1):86-102.

Russell,N. and J.Sauer (2011), On Self Selection in PES Schemes, May 2011, Agecon Search, University of Minnesota, http://ageconsearch.umn.edu/,

Stoate, C., N.D.Boatman, R.J.Borralho, C.R.Carvalho, G.R. de Snoo and P. Eden (2001), Ecological impacts of arable intensification in Europe, J Envir Manag 63(4):337-365

Strijker, D., F.J.Sijtsma and D.Wiersma (2000) Evaluation of nature conservation – An application to the Dutch Ecological Network, Env and Res Econ 16(4):363-378.

Waetzold, F. and M.Drechsler (2005), Spatially uniform versus spatially heterogeneous compensation payments for biodiversity-enhancing land-use measures, Env and Res Econ 31(1):73-93.

Wu, J. and B.A.Babcock (1996), Contract design for the purchase of environmental goods from agriculture, Am J Agric Econ 78(4):935-945.