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Adverse Selection in the Environmental Stewardship Scheme: Does the Higher Level Entry Scheme Design Reduce Adverse Selection?

Authors (including postal and e-mail address for the main author(s))
Emmanuelle Quillérou
Kent Business School, University of Kent, Canterbury, CT2 7NZ, United Kingdom
Email: E.Quillerou@kent.ac.uk

Prof. Rob Fraser
Department of Economics, University of Kent, Canterbury, CT2 7NZ, United Kingdom
Email: R.W.Fraser@kent.ac.uk

Abstract

The Environmental Stewardship Scheme provides payments to farmers for the provision of environmental services based on agricultural foregone income. This creates a potential incentive compatibility problem which, combined with an information asymmetry on farm land heterogeneity, could lead to adverse selection of farmers into the scheme. However, the Higher Level Scheme (HLS) design includes some features that potentially reduce adverse selection. This paper studies the adverse selection problem of the HLS using a principal agent framework at the regional level. It is found that, at the regional level, the enrolment of more land from lower payment regions for a given budget constraint has led to a greater overall contracted area (and thus potential environmental benefit) which has had the effect of reducing the adverse selection problem. In addition, for landscape regions with the same payment rate (i.e. of the same agricultural value), differential weighting of the public demand for environmental goods and services provided by agriculture (measured by weighting an environmental benefit function by the distance to main cities) appears to be reflected into the regulator's allocation of contracts, thereby also reducing the adverse selection problem.

Keywords and JEL codes
Adverse selection, agri-environment, Environmental Stewardship, principal-agent, contract
D78; D82; H44; Q18; Q58

1. Introduction

From 1992, the European Common Agricultural Policy's successive reforms have shifted away from production support by including a parallel agri-environmental policy based on the idea of the multifunctionality of agriculture. This agri-environmental policy provides payments to farmers for providing environmental goods and services. The main agri-environmental scheme in England since 2005 has been the Environmental Stewardship Scheme, which builds up from cross compliance requirements (the baseline for paid environmental service provision) (Defra, 2005a). It is a nationally-set two-tiered scheme, corresponding to two levels of increasing environmental commitment: the ELS/OELS (Entry Level Scheme/Organic Entry Level Scheme) tier with a broader approach (and higher participation), and the HLS (Higher Level Scheme) tier with a more focused approach and higher level of environmental commitment (with limited entry). The ELS tier (along with the OELS, its equivalent for organic agriculture) is based on a whole-farm approach and opened to all farmers and landowners, within 5-year contracts (Defra, 2005a). It is relies on self-selection by farmers of environmental options within a given 'menu', each option corresponding to a given number of points reflecting on the agricultural income foregone (nationally estimated) (Defra, 2005a). ELS (OELS) agreements are guaranteed providing farmers meet a 30-point (60-point) target per hectare for a corresponding payment of £30/ha (£60/ha) (Defra, 2005a). The second tier or Higher Level Stewardship (HLS) corresponds to a higher level of environmental commitment than ELS or OELS and targets more complex types of management and capital work plans (Defra, 2005a, 2005b). Farmers still self-select land management options within a set 'menu', but entry is discretionary with applications competitively selected by Natural England by a scoring and threshold mechanism derived from the previous Countryside Stewardship scheme, assessing the environmental value provided (Defra, 2005a, 2005b). Scoring of applications is spatially differentiated, based on 159 Joint Character Areas i.e. areas of the English countryside with similar landscape character, each with a specific association of wildlife and natural features (Defra, 2005b). Each Joint Character Area has a corresponding set of environmental key and secondary targets (detailed in specific 'targeting statements') for the management of a variety of features, against which farm applications are scored, with priority given to Sites of Special Scientific Interest (SSSIs) and Scheduled Monuments (Defra, 2005b).

The Environmental Stewardship Scheme aims at delivering environmental benefits, but is based on incentive payments typically calculated as an average of the agricultural income foregone by farmers (or 'opportunity cost', OC) and not as the environmental benefit derived from the land entered into the scheme. Since agricultural income and environmental benefit are not necessarily (spatially) correlated (OECD, 2004, Fraser, 2009), the discrepancy between farmer incentives to enter the Environmental Stewardship Scheme based on their individual OC of agricultural production and the government agencies' (Defra and Natural England) objective of paying farmers for an environmental benefit potentially leads to an incentive-compatibility problem (Fraser and Fraser, 2006). In combination with information asymmetries regarding farmer's OC of environmental service provision and land quality, this incentive incompatibility can lead to adverse selection of farmers for entry into the schemes. From the payment set up, the increased potential for adverse selection into the scheme would be expressed as the lowest agricultural quality land entered into the scheme by farmers rather than the highest environmental quality land as targeted by the government. The quasi-market payment for agri-environment provision is thus unlikely to be optimal (compared to a full information situation), and the combination of incentive incompatibilities and information asymmetries is likely to lead to systematic misallocation of taxpayer funding, both within and between landscape regions (Fraser, 2009).

Although all Environmental Stewardship tiers are likely to be subject to the incentive-compatibility problem, this problem is potentially reduced in the case of the HLS as it includes some explicit selection based on environmental benefit criteria – more specifically, farmers with the lowest agricultural OC have the greatest incentive to apply for the scheme (adverse selection), but because of the selection mechanism, only farmers providing higher environmental benefit are admitted into the scheme, thereby potentially reducing the adverse selection problem. In addition, the operation of the HLS subject to a budget constraint on total payments to farmers may encourage the selection of 'low cost' farmers which, if they are providing similar environmental benefits to 'high cost' farmers, will improve the overall effectiveness of the Scheme. Therefore, this paper focuses not just on the adverse selection problem arising from incentive incompatibility and asymmetries of information in the HLS tier of the Environmental Stewardship Scheme, but more importantly on the features of the HLS policy design that could decrease the potential for adverse selection, thereby improving the efficiency of the scheme.

More specifically, HLS contracting is based on option self-selection by farmers from a nationally-set menu, a direct revelation mechanism potentially reducing the information asymmetry (Harris and Townsend, 1981, Latacz-Lohmann and Schilizzi, 2005). Contract allocation based on a competitive scoring and a threshold mechanism (auction), in relation to limited public funding: farmers bid on the type and quantity of environmental service supplied (per individual option and in total) to meet the threshold, based on a quality score (against each Joint Character Area target met). This choice of auction mechanism increases incentive compatibility by explicitly assessing applications on environmental features (scoring and threshold) and potentially reduces the information asymmetry by inducing truthful revealing of farmer OC (competition and uncertainty on threshold value). The different weights of environmental targets met across Joint Character Areas for application scoring purposes, by spatially targeting local environmental priorities for application scoring, also potentially increase incentive compatibility. The threshold (entry decision criterion or cut-off score) is regionally set after all applications have been made, depending on the regional quality of applications and available budget, and all applications above the threshold are retained for contracting. Because of this scoring mechanism and varying threshold, Natural England is able to retain some bargaining power in agreement design, making Natural England advisers able to influence contract option selection. The scoring and 'moving' regional threshold (higher if many high-score applications for a given round) mechanism has two main advantages for Natural England: it helps to discriminate between applications to allocate funding in relation to a budget constraint, and explicitly integrates (regional) environmental benefit criteria for entry into HLS (reduced incentive incompatibility from scoring).

Most of the literature on adverse selection is based on contract design mechanisms to reduce incentive incompatibilities (Wu and Babcock, 1996, Moxey *et al.*, 1999, Feng, 2007), but very few studies have actually empirically tested the extent of this information problem for agri-environmental contracts. The HLS contract design is taken as given in this analysis, and instead the focus is placed on the HLS contract allocation mechanism. This paper will in particular evaluate the potential for adverse selection reduction by explicit government selection for environmental benefits subject to a budget constraint on total payments to farmers. The next section will thus develop a principal-agent model to assess the potential for adverse selection reduction in the HLS at the regional level (as compared to a spatially uniform national policy), followed by empirical evidence of whether adverse selection has been reduced. The paper ends with a summary and conclusions.

2. Methodology

The analysis is based on a theoretical principal-agent modelling of optimal farmer participation relative to the social optimum, in relation to land heterogeneity both within and between 'regions', as developed by Fraser (2009). A principal-agent model is developed to analyse HLS contract allocation by the principal (Natural England), in relation to the potential effects of the adverse selection of farmers into the HLS, as well as the combination of policy mechanisms aimed at reducing adverse selection at the regional level. The reference point for assessing adverse selection reduction will be taken as a nationally uniform scheme (nationally-uniform payment rate and environmental benefit per hectare). The focus is placed only on those HLS options involving entering land into the scheme, as these most directly compete with agricultural production.

Under this framework, farmers are profit-maximisers, which consequently leads to adverse selection by their selection of lower agricultural value land (with the highest returns to entering the scheme) for HLS entry. The risk-neutral principal (Natural England) maximises social welfare – i.e. the expected environmental benefit (EB) across regions by assumption - subject to a budget constraint:

$$\max_{Q} \quad \mathrm{E}\left(EB_{HLS}\right) = \sum_{r} w_r \,\mathrm{eb}\,.\, q_r \qquad (\mathbf{1})$$

$$\text{subject to the budget constraint: } \sum_{i,j,r} q_{i,j,r}\, p_{j,r} \;\leq\; \text{Total Budget}$$

with EB_{HLS} the total environmental benefit from HLS scheme allocation for government (Natural England);
w_r the regional weight reflecting relative regional environmental values;
eb the environmental benefit per hectare entered into HLS, a decreasing function of q_r (the function is assumed the same across regions);
Q the total quantity of environmental service over England (sum of q_r for all regions r);
q_r the quantity of environmental service in region r;
$q_{i,j,r}$ the quantity of environmental service for contract i, option j, and in region r;
$p_{r,j}$ the regional payment rate for option j in region r (national average foregone agricultural income adjusted for regional variations).

It is assumed that eb is a decreasing function of the quantity of land offered for entry into HLS: the more hectares entered into HLS, the lower the environmental benefit per hectare. For modelling purposes, the environmental benefit per hectare eb is assumed the same over a given region and across regions, for a given quantity of land (i.e. the environmental benefit *function* is the same within and across regions), but the weighted environmental benefit per hectare for a given region (w_r eb), varies across regions. By construction, w_r eb also is a decreasing function of the quantity of land entered into HLS.

Under the stated assumptions and the budget constraint, the social-welfare (EB) maximising first-order condition under the budget constraint and after rearranging the terms:

$$\begin{aligned}&\sum_{r}\left(w_r\,\mathrm{eb}\,q_r\right)\frac{\partial \ln(q_r)}{\partial Q} - \lambda\sum_{i,j,r} q_{i,j,r}\,p_{j,r}\,\frac{\partial \ln(q_{i,j,r})}{\partial Q}\\ &= \left[\lambda\sum_{i,j,r} q_{i,j,r}\,p_{j,r}\,\frac{\partial \ln(p_{j,r})}{\partial Q}\right] - \left[\sum_{r} w_r\,\mathrm{eb}\,q_r\,\frac{\partial \ln(w_r\,\mathrm{eb})}{\partial Q}\right]\end{aligned} \qquad (\mathbf{2})$$

From equation 2, the marginal net environmental benefit for the principal from the land entered into HLS (left hand-side) can be decomposed into the net benefit obtained by varying the payment rates regionally (first term on the right hand-side) plus the net benefit obtained from the regional variation of environmental benefit per hectare (second term on the right hand-side). The terms on the right-hand-side for equation 2 are equal to zero for a nationally uniform scheme (respectively nationally-uniform payment rates and environmental benefits per hectare). The marginal net environmental benefit for the principal from the land entered into HLS for a spatially differentiated scheme consequently represents the efficiency gains from a reduction in adverse selection.

Following equation 2, the principal's objective function can be decomposed into 2 parts**:**

- selection of Q by varying q_r between regions for different regional payment rates $p_{r,j}$ for a given constant weighted environmental benefit per hectare (constant w_r).
- selection of Q by varying the weighted environmental benefit per hectare between regions w_r eb for a given constant payment rate ($p_{r,j}$).

Differentiating the welfare-maximising first order condition (equation 2) with respect to the regional payment rate $p_{r,j}$ for a given environmental benefit per hectare (w_r constant across regions) leads to after rearranging:

$$\frac{\partial \ln(q_r)}{\partial \ln\left(\sum_j (p_{j,r} - 1)\right)} = -1 < 0 \qquad \textbf{(3)}$$

From equation 3, the total quantity of land Q entered into the HLS maximising environmental benefit is such that, for each extra hectare of land entered into the scheme, the proportion of land entered in each region is equal to the opposite of the proportional change in payment rates for the region (given the same weighted environmental benefit per hectare). This is equivalent to the following:

Hypothesis 1: For the same given HLS budget (and equal regional weights), the quantity admitted into HLS will be greater in regions with lower payment rates (reflecting lower foregone agricultural incomes or agricultural values).

This implies that, for the same environmental benefit derived from each hectare of land entered into the scheme (assuming equal regional weights), because more hectares can be contracted overall by contracting a higher land area in lower payment regions, for a given budget there is an overall associated higher total environmental benefit. This would thus effectively reduce adverse selection between regions through the mechanism of the budget constraint.

If one region displays a higher environmental benefit per hectare (i.e. the total willingness-to-pay per hectare is higher), the objective function can be adjusted to weight one region more highly (i.e. w_r now varying across regions). Differentiating the welfare-maximising first order condition (equation 2) with respect to the weighted environmental benefit per hectare w_r eb for given regional payment rates per option ($p_{r,j}$ constant across regions) leads to after rearranging:

$$\frac{\partial \ln(q_r)}{\partial \ln(w_r\,\mathrm{eb})} = 1 \quad > 0 \qquad \textbf{(4)}$$

From equation 4, the total quantity of land Q entered into the HLS maximising environmental benefit is such that, for each extra hectare of land entered into the scheme, the proportion of land entered in each region is equal to the proportion of (weighted) environmental benefit per hectare for that region (constant payment rates). This is equivalent to the following:

Hypothesis 2: For differing regional weights, the quantity of land contracted will be higher in the regions with higher weighted environmental benefit for the same regional fixed payment rates per hectare (i.e. similar agricultural value).

This will imply that for the same budget, regions with a higher weighted environmental benefit per hectare are likely to display a higher rate of land admitted into the HLS. This would effectively reduce adverse selection between regions, again through the mechanism of the budget constraint. In this case the principal is expected to choose mainly farmers from the region with higher environmental benefit per hectare, thus achieving a higher total environmental benefit given the budget constraint.

Landscape, wildlife (biodiversity), flood management, and access features are already explicitly included as environmental priorities in the JCA targeting statements. In the empirical evaluation regional weights have been proxied by distances to some of the main cities (assumed inversely related to the environmental use value, Hanley *et al.*, 2003, Bateman *et al.*, 2006) in the principal's objective function, implying that the principal allocates for a given budget proportionately more contracts in regions closer to cities (i.e. with a higher environmental benefit per hectare) than in regions with similar agricultural OC but further from cities.

3. Empirical evidence

From the above analysis, evidence that adverse selection is being reduced would be a statistically significant link between the number of hectares entered into HLS in one given region and the regional payment rates (hypothesis 1), and with the distance to the main cities (hypothesis 2).

Contract data for all Environmental Stewardship tiers were provided by Natural England for 9 landscape regions in Yorkshire and the Humber, with some contract characteristics detailed at option-level and others at contract-level. The quantity of land entered into the HLS per contract (qland) and total payment received per contract for the land entered into HLS were summed for each contract for all HLS options (aggregation per contract). The average payment rate per contract was obtained by taking the ratio of the total payment received for all HLS options to the total quantity of land entered into HLS for each contract. Mappy.co.uk was used to get for each contract the fastest travelling distances to Hull (most Eastern city), Leeds and Manchester (respectively most central and South-Western city) as two of the biggest conurbations in Northern England (Defra, 2000). An average of these 3 distances was then calculated for each contract: by construction, the greater the average distance, the further away from the major East-West travelling link in the study area. The data used have been summarised in Table 1.

Table 1: Variables description and statistics

Variable	Description	Units	Mean	Std. Dev.	Min	Max
qland	quantity of land entered into the HLS per contract	ha	154	219	3	1,092
	total payment received per contract for the land entered into HLS	£	100,308	118,705	2,991	564,984
avepr	average payment rate per contract	£/ha	1,041	625	337	2,893
avedist	Average of fastest travelling distances to Hull Leeds and Manchester	km	117	23	70	171

Log-linear regressions were performed using Stata 9 (StataCorp, 2005), by regressing the quantity of land entered into HLS (qland) over the payment rate per contract (avepr) and the average distance to the three main cities (avedist). HLS data are truncated as HLS successful entrants are mostly selected from a population of farmers enrolling into the (O)ELS part of the Environmental Stewardship Scheme. A truncated and OLS regressions on the log-transformed variables for the given sample led to similar results, so the OLS results (log-linear model) only are reported in Table 2.

Under a given budget constraint and controlling for the weighted environmental benefit per hectare (distance to cities here), the quantity of land entered is hypothesised to decrease for higher average payment rates (hypothesis 1). A negative coefficient for the average payment rate per contract is consequently expected in the regression analysis. With land closer to cities having a higher environmental value per hectare, for constant payment rates, the quantity of land entered is hypothesised to decrease as the distance from the main cities increases. A negative coefficient for the average distance to main cities is thus expected in the regression analysis (hypothesis 2).

Table 2: Log-linear regression results for estimating log(qland).
(*: significant at a 10% level; **: significant at a 5% level; *: significant at a 1% level of significance**

	Coefficients
avepr	-2.001 ***
(standard error)	(0.296)
avedist	-2.494 ***
	(0.815)
constant	29.546 ***
	(5.136)
N	46
R^2	0.52
Adjusted R^2	0.49
Breusch Pagan test (heteroskedasticity)	
Chi2 test statistic (1)	0.21
P-value	0.65
Durbin-Watson	
d-statistic(3, 46)	2.26
P-value	0.65

The adjusted R^2 value is relatively high (49%) for cross-sectional data, possibly because of the sample being drawn from the same area and presenting similar characteristics. All coefficients display the expected negative signs, and both the coefficients for average payment rates and for the average distance to main cities were found significant at a 1% level of significance. No heteroskedasticity was detected (Breusch-Pagan / Cook-Weisberg test: Chi2 test statistic (1) = 0.21; p-value of 0.65). First-order autoregressive errors (AR(1)) would be the most likely to arise for the spatially ordered data, but were not found statistically significant (Durbin-Watson d-statistic (3,46) of 2.26).

As expected, the quantity of land entered significantly decreases as the payment rates increase (increasing foregone agricultural incomes). Therefore, there is some evidence that, for a given environmental benefit per hectare, more land is enrolled into the HLS in lower payment regions under a given budget constraint (hypothesis 1). For a given budget, given the same environmental benefit per hectare for all regions, more land overall will be entered into the HLS across all regions from lower payment areas, resulting in a higher total environmental benefit from the scheme.

Also as expected, the quantity of land entered is negatively related to the average distance to main cities, i.e. a decreasing quantity of land is entered for decreasing environmental value. Therefore, there is some evidence that, for regions with the same payment rate (i.e. same agricultural land value) but varying environmental benefit weights (represented by distance to the main cities), more land is enrolled into the HLS from areas of higher environmental benefit (i.e. closer to the main cities) under a given budget constraint (hypothesis 2). Given the distance to the main cities (capturing use value) is a good indicator of environmental value as assumed in this case, HLS contract allocation seems to reflect some allowance for differing environmental demand by region.

4. Conclusion

The Environmental Stewardship Scheme, because of incentive incompatibility and asymmetric information, has a potential for adverse selection for the land entered into the scheme, leading to implementation inefficiencies. However, the analysis in section 2 of this paper has hypothesized that adverse selection into its HLS component could be reduced by the explicit selection of contracts based on environmental benefit criteria embedded into the HLS policy design, and by the operation of a total payment budget constraint. To evaluate these hypotheses the empirical research reported in section 3 focused on the impact of spatially differentiated payment rates (reflecting opportunity costs of entering HLS) and differences in weighted environmental benefit per hectare (inversely related to distances to main cities) as potentially reducing adverse selection when combined with a budget constraint.

Differences in payment rates between two regions for a given total budget constraint were indeed found to be significantly negatively related to the amount of land admitted into the scheme for each landscape region. This provides evidence that spatial differentiation of payment rates in combination with the budget constraint reduces adverse selection, and thus increases Scheme efficiency by increasing the overall amount of land entered into the Scheme, for a given environmental benefit per hectare. In addition, differences in environmental benefit weights between regions (as measured by travelling distance to cities) for a given total budget constraint were also found to be significantly negatively related to the amount of land admitted into the scheme for each landscape region. For landscape regions with the same payment rates (i.e. of the same agricultural value), differential weighting of the public demand for environmental goods and services provided by agriculture (measured by weighting an environmental benefit function by the distance to main cities) thus appears to be reflected into the regulator's allocation of contracts, thereby also reducing the adverse selection problem.

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References

Bateman, I. J., *et al.* (2006). The aggregation of environmental benefit values: Welfare measures, distance decay and total WTP. *Ecological economics,* 60(2), 450-460.

Defra (2000). *Yorkshire and the Humber: Geographic Area and Physical Context*. Department for Environment, Food and Rural Affairs. Edition: 01/10/2000. Last updated: 17/08/2005. Available from: http://www.defra.gov.uk/erdp/docs/yhchapter/yhsection11/default.htm [Accessed 22/09/2008].

Defra (2005a). *Environmental Stewardship: Look after your land and be rewarded*. PB10487.Department for Environment, Food and Rural Affairs. Available from: http://www.defra.gov.uk/erdp/schemes/es/default.htm [Accessed 06/07/2007].

Defra (2005b). *Higher Level Stewardship handbook: Terms and conditions and how to apply*. PB10382.Department for Environment, Food and Rural Affairs. Available from: http://www.defra.gov.uk/erdp/pdfs/es/hls-handbook.pdf [Accessed 22/06/2007].

Feng, H. (2007). Green payments and dual policy goals. *Journal of Environmental Economics and Management,* 54(3), 323-335.

Fraser, R. (2009). Land Heterogeneity, Agricultural Income Forgone and Environmental Benefit: An Assessment of Incentive Compatibility Problems in Environmental Stewardship Schemes. *Journal of Agricultural Economics*, 60(1), 190-201.

Fraser, R. and I. Fraser (2006). The Implications of Information Asymmetries for Agri-Environmental Policies. *OECD Workshop on Information Deficiencies in Agri-environmental Policies, OECD Workshop on Information Deficiencies in Agri-environmental Policies,* Paris, 06/06/2006.

Hanley, N., F. Schläpfer and J. Spurgeon (2003). Aggregating the benefits of environmental improvements: distance-decay functions for use and non-use values. *Journal of environmental management,* 68(3), 297-304.

Harris, M. and R. M. Townsend (1981). Resource Allocation Under Asymmetric Information. *Econometrica,* 49(1), 33-64.

Latacz-Lohmann, U. and S. Schilizzi (2005). *Auctions for Conservation Contracts: A Review of the Theoretical and Empirical Literature*. Project No: UKL/001/05. Available from: http://www.scotland.gov.uk/Resource/Doc/93853/0022574.pdf [Accessed 14/01/2008].

Mappy.co.uk. Mappy SA. Available from: http://mappy.co.uk/ [Accessed 11/11/2008 & 15/01/2009].

Moxey, A., B. White and A. Ozanne (1999). Efficient contract design for agri-environment policy. *Journal of Agricultural Economics,* 50(2), 187-202.

OECD (2004). *Agriculture and the environment: lessons learned from a decade of OECD work*. Available from: http://www.oecd.org/dataoecd/15/28/33913449.pdf [Accessed 25/06/2007].

StataCorp (2005). *Stata Statistical Software: Release 9*. College Station, TX: StataCorp LP.

Wu, J. and B. A. Babcock (1996). Contract Design for the Purchase of Environmental Goods from Agriculture. *American Journal of Agricultural Economics*, 78(4), 935-945.