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Adverse Selection in the Environmental Stewardship Scheme: Evidence in the Higher Level Stewardship Scheme?

Emmanuelle Quillérou [1], Prof. Rob Fraser [2] and Dr Iain Fraser [2]

[1] Kent Business School, University of Kent, Canterbury, CT2 7PE, United Kingdom

[2] School of Economics, University of Kent, Canterbury, CT2 7NP, United Kingdom

Summary or abstract of the paper (no more than 200 words)

The Environmental Stewardship Scheme provides payments to farmers for the provision of environmental services based on foregone agricultural 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 and therefore reduced cost-effectiveness of the Scheme. This reduced cost-effectiveness would be represented by a systematic overpayment of farmers for the land enrolled into the Scheme, compared to the opportunity cost of production. This paper examines the potential adverse selection problem affecting the higher tier of the Environmental Stewardship, the Higher Level Stewardship, using a principal agent framework combined with farm-level data on participation in the HLS. Empirically, it is found that, at the farm level, HLS participation is negatively related to cereal yields, suggesting the existence of adverse selection in the HLS and farmer overcompensation from entering the scheme.

Keywords and JEL codes:

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

1. Introduction

Since 1992, the Common Agricultural Policy has been subject to a series of reforms that have gradually transferred support from agricultural production toward the provision of environmental goods and services. The resulting agri-environmental policies provide farmers with financial incentives for producing environmental goods and services. Since 2005, the main agri-environmental scheme in England has been the Environmental Stewardship Scheme (ESS) (Defra, 2005a). ESS is a national scheme composed of two tiers: the lower tier ELS/OELS (Entry Level Stewardship/Organic Entry Level Stewardship) with general agri-environmental requirements; and, the higher tier HLS (Higher Level Stewardship) with more specific environmental requirements and higher levels of environmental commitment.

The ELS employs a whole-farm approach. Any farmer and landowner can participate and will receive a 5-year contract (Defra, 2005a). The ELS relies on self-selection by farmers of the environmental options they will undertake from a pre-specified 'menu'. For each option selected there is a corresponding number of points reflecting the agricultural income foregone (which is nationally estimated) (Defra, 2005a). An ELS (OELS) agreement is guaranteed providing a farmer meets a 30-point (60-point) target per hectare. This in turn yields a corresponding payment of £30/ha (£60/ha) (Defra, 2005a).

The higher tier HLS is implemented in a very different manner. First, it targets more complex types of agri-environmental activities and land use management (Defra, 2005a,b). In common with the ELS, it is left to an individual farmer to select farm specific land management options from a pre-specified set and for which there are predetermined fixed per unit payments per option. Second, entry into the HLS is at the discretion of Natural England, the operating authority. Thus, participation in the HLS is competitively determined. To do this, Natural England selects applications by employing a scoring and threshold mechanism. This approach to contract allocation is based on that previously employed with the Countryside Stewardship Scheme. The purpose behind employing discretion in the assessment of agri-environmental contract offers is to help the selection of contracts such that they provide "good 'value for money' " (Defra, 2005a,b).

From 2005 to 2007, each application has been scored on a spatially differentiated base. The spatial differentiation has been based upon the 159 Joint Character Areas. These are areas of the English countryside with "similar" landscape character, each with a specific association of wildlife and natural features (Defra, 2005b). Each of the 159 Joint Character Area has a corresponding set of environmental targets against which bids submitted to the HLS are scored. In addition, an application that contains proposed actions to enhance a Site of Special Scientific Interest (SSSIs) or a Scheduled Monument (Defra, 2005b) is given a higher priority for entry into HLS. All scored applications are then pooled for all Joint Character Areas within the same administrative region (roughly corresponding to the government office regions). Finally, a threshold entry decision criterion (i.e. cut-off score) is then set for all Joint Character Areas within the same administrative region, subject to the available budget for the scheme. Thus, all applications that attain a score greater than the regional threshold are offered a contract.

This approach to policy delivery means that ESS participation is not determined based on the environmental benefit derived from the land entered into the Scheme, but the agricultural income foregone by farmers. Clearly there is no reason *a priori* for agricultural income and environmental benefit to be positively correlated (OECD, 2004, Fraser, 2009). Indeed, there may well be an important difference between farmer incentives to enter the ESS based on individual opportunity cost of agricultural production and the government objective of paying farmers for the provision of environmental benefits. As such there is likely to be an incentive-compatibility problem (Fraser and Fraser, 2006). Furthermore, the additive effect of the incentive compatibility problem and the information asymmetries regarding a farmer's opportunity cost of environmental service provision and land quality can give rise to adverse selection of land being entered into the HLS. This will in turn result in a reduced cost-effectiveness of the HLS and a socially sub-optimal provision of environmental goods and services (Fraser, 2009). Specifically, the potential for adverse selection into the HLS would manifest itself as low quality agricultural land being offered for inclusion in the HLS by farmers as opposed to the highest environmental quality land. Thus, payment for environmental service provision will be sub-optimal (compared to a full information situation). The combination of incentive-compatibility problems and information asymmetries are likely to lead to systematic misallocation of taxpayer funding, both within and between landscape regions.

To date, the economics literature on adverse selection in agri-environmental scheme design and implementation has been based on theoretical analyses of contract design mechanisms (Wu and Babcock, 1996, Moxey *et al.*, 1999, Feng, 2007). There currently exists very little research that has attempted to empirically examine this information problem. The examples that do exist in the literature have considered policy cost-effectiveness issues relating to auction mechanisms (Stoneham *et al.*, 2003, Latacz-Lohmann and Schilizzi, 2005, Asker and Cantillon, 2008, Connor *et al.*, 2008, Windle and Rolfe, 2008) or (spatial) benefit targeting (Langpap *et al.*, 2008, Hajkowicz, 2009, Merckx *et al.*, 2009).

In this paper we take a different approach to examine issues of adverse selection. Specifically, the emphasis is placed on an empirical assessment of farmers' HLS option selection for application for entry into the scheme. On this basis, the paper analyses the adverse selection problem arising from incentive incompatibility and asymmetries of information in the HLS tier of the ESS. It aims to provide empirical evidence of adverse selection of land for entry into the Scheme i.e. the entry of land for a lower agricultural OC. In so doing, this paper evaluates both theoretically and empirically the potential for adverse selection reducing HLS cost-effectiveness, by explicit option selection by applicants based on their individual opportunity cost of provision. In the next section we develop a principal-agent model to assess the potential for adverse selection in the HLS at the farm level. This is then followed by empirical evidence of whether there is some adverse selection. The final section of the paper offers a summary and conclusions.

2. Methodology

The analysis is based on the theoretical principal-agent modelling of farmer participation in environmental service provision, in relation to land heterogeneity both within and between 'regions', as developed by Fraser (2009). The principal-agent model is developed to analyse HLS option selection by farmers (agents) and to evaluate the potential for adverse selection at the farm level (Fraser and Fraser, 2006).

Under this framework, farmers are assumed to act as rational "agents" holding the property rights to alter the environment ("paid stewardship") (Hodge, 2001, Hynes and Garvey, 2009). That is, in relation to the voluntary nature of the HLS and the information asymmetry, farmers maximise their utility from entering HLS by maximising their profit from the scheme subject to meeting the threshold score requirement (with a zero pay-off if they choose not to enter the HLS). In relation to set payments per hectare, this implies that within a given region (i.e. same fixed payment rates per hectare), the quantity of environmental service (land) entered (or offered) into the HLS Scheme will be greater for farms with lower agricultural land quality (i.e. with lower agricultural yields or because of higher farm land heterogeneity) because this provides higher net returns to entering the Scheme. Farms with lower agricultural land quality, as measured by yield, will thus have a greater incentive to participate in the HLS, which is the hypothesis tested in the empirical part of the paper. Under perfect information, farmers would be exactly compensated for their individual opportunity cost of entering the HLS (zero financial profit), which is not the case under adverse selection.

The HLS scheme requires farmers to choose options providing an environmental service, such as the quantity of land or a length of linear landscape features such as hedgerows (Defra, 2005b,c). Regional payment rates for each option p_j are assumed the same within a given region, with farmers being price-takers for HLS environmental service provision.

Within a given region assuming a fixed set of option payment rates, a rational farmer i maximises profit ($\prod_{\text{HLS, i}}$) from offering a total quantity of environmental service q_i into the HLS. Thus, the sum of the profits made for each HLS option j selected for application, subject to meeting the threshold requirement is as follows:

$$\max_{q_i} \ \prod\nolimits_{\text{HLS, i}} = \sum_j \left[q_{i,j} p_j - OC_{i,j}\right] \tag{1}$$

subject to meeting the regional score threshold.

with $\prod_{\text{HLS, i}}$ profit made from entry into HLS for farmer i;
q_i the quantity of environmental service offered on farm i (sum of $q_{i,j}$ for all options j);
$q_{i,j}$ the quantity of environmental service offered on farm i for option j;
p_j the regional payment rate for option j (national average forgone agricultural income adjusted for regional variations);
$OC_{i,j}$ the opportunity cost of farm i for option j.

Option payment rates are set per hectare (i.e. options involving some area of land such as field margins or pastures), per meter (or 100 meters, for options involving hedges, stone walls or footpaths), or per item (i.e. educational visits). For each option, OC_{ij} is decomposed into forgone agricultural income and maintenance and restoration costs, depending on the type of option. For the purposes of this study, the focus on arable options follows the higher HLS uptake for cereal farms (Boatman *et al.*, 2007), and potential associated uptake of arable options. Also, these arable options have been found potentially subject to Adverse Selection in the previous schemes now replaced by the HLS.

Within a given region, farmers are assumed to always satisfy the threshold (which is not linked to the quantity of land entered into HLS but the number and type of environmental priorities met) and maximise their profits over the arable options they select, especially as these options are the most likely to directly compete with agricultural production. The opportunity cost of choosing the HLS arable options is assumed to be mainly determined by the forgone agricultural profit (i.e. with no maintenance or restoration costs for all farmers within the same region).

Fixed costs of the (current) agricultural production are here assumed equal to zero (or annualised into the variable cost component of agricultural production). These fixed costs can act as a barrier for agri-environmental policy adoption (with the probability of entry reduced for higher current agricultural fixed costs), but not on the quantity of land entered once this decision is made. Fixed costs of the environmental provision (i.e. new agricultural practice or transaction costs) could also act as a barrier to entry (i.e. with a reduced quantity of land provided) (see Arguedas *et al.*, 2008, and Barreiro-Hurle *et al.*, 2008). This type of fixed costs should be captured by the estimation of the maintenance and the restoration costs for each HLS option, and are therefore not considered to impact on the forgone agricultural income.

The above assumptions lead us to model the OC problem as follows (Equation 2):

$$OC_{i,j} = p_{crop}\ y_{crop,i}\ q_{i,j} - VC_{crop,i} \tag{2}$$

with
p_{crop} the price per ton for a given crop;
$y_{crop,\,i}$ the yield (in ton per hectare) on farm i for a given crop;
$q_{i,\,j}$ the quantity of land offered on farm i for option j;
$VC_{crop,\,i}$ the variable cost on farm i for a given crop.

Farmers are assumed to be price-takers for agricultural production (as well as for HLS options) i.e. p_{crop} is assumed constant across farms for a given crop. For simplicity, yields are assumed uniform within farms, and vary only between farms. It is also assumed that returns to agricultural production are decreasing. Marginal costs of agricultural production are assumed constant with respect to the environmental quantity entered into the scheme (q_i), or with respect to yields ($y_{crop,\,i}$) i.e. $\frac{\partial^2 VC_{crop,i}}{\partial y_{crop,i}\ \partial q_i} = 0$.

When entering the HLS, individual farmers thus maximise their profit over the total quantity of arable options selected for entry:

$$\max_{q_i}\ \Pi_{\mathrm{HLS,\,i}} = \sum_j \left[q_{i,j}\, p_j - \left(p_{crop}\ y_{crop,i}\ q_{i,j} - VC_{crop,i} \right) \right] \tag{3}$$

with
q_i the quantity of land offered on farm i (sum of $q_{i,\,j}$ for all arable options j);
$q_{i,\,j}$ the quantity of land offered on farm i for arable option j;
p_j the regional payment rate for arable option j (national average forgone agricultural income adjusted for regional variations);
p_{crop} the price per ton for a given crop;
$y_{crop,\,i}$ the yield (in ton per hectare) on farm i for a given crop;
$VC_{crop,\,i}$ the variable cost on farm i for a given crop.

Under the stated assumptions, the profit maximising first-order condition, after rearranging the terms, becomes:

$$\sum_j p_j = p_{crop}\ y_{crop,i} \left(1 + \frac{\partial \ln y_{crop,i}}{\partial \ln q_i} \right) - \frac{\partial VC_{crop,i}}{\partial q_i} \tag{4}$$

with $$p_{crop}\ y_{crop,i} \left(1 + \frac{\partial \ln y_{crop,i}}{\partial \ln q_i} \right) - \frac{\partial VC_{crop,i}}{\partial q_i}$$

corresponding to the marginal opportunity cost (MOC) of entering land into the HLS (arable options), which increases with farm yield (for decreasing returns to agricultural production).

From Equation 4, the quantity of HLS arable option q_i maximising farm profit is such that the total payment per hectare across all options chosen (left hand-side of Equation 4) is equal to the marginal opportunity cost (MOC) of entering the HLS scheme (right hand-side of Equation 4).

Differentiating the profit-maximising first order condition (Equation 4) with respect to yield ($y_{crop,\, i}$), for given option payment rates (p_j), crop prices (p_{crop}) and marginal variable costs ($\frac{\partial^2 VC_{crop,i}}{\partial y_{crop,i}\ \partial q_i} = 0$), leads, after rearranging, to:

$$\frac{\partial \ln q_i}{\partial \ln y_{crop,i}} = -1 < 0 \qquad (5)$$

From Equation 5, the total quantity of land q_i offered for HLS maximising profit is such that, within a given region, the proportion of land offered for entry is inversely related to farm yields ($y_{crop,\, i}$) (given the same marginal variable costs per hectare, option payment rates and crop prices). This can be restated formally as follows:

> *Hypothesis: Within a given region (same payment rates and homogenous environmental benefit per hectare), the quantity offered for HLS entry is greater for farms with lower agricultural production yields (lower forgone agricultural income).*

This is illustrated for two farms with different marginal OC (MOC) in Figure 1 (with $MOC_1 < MOC_2$). For given payment rates ($\sum_j p_j$ in Figure 1), farm 1 supplies q_1 hectares of land for MOC_1 and region 2 supplies q_2 hectares of land for MOC_2 ($q_1 > q_2$). MOC are here assumed determined by farm yields (with a higher MOC for higher yields). For the same marginal variable costs per hectare and option payment rates, because more hectares are offered overall by lower yield farms (farm 1 in Figure 1 with MOC_1), for given payment rates ($\sum_j p_j$ in Figure 1), lower yield farms are more likely to meet more environmental priorities and consequently the environmental threshold.

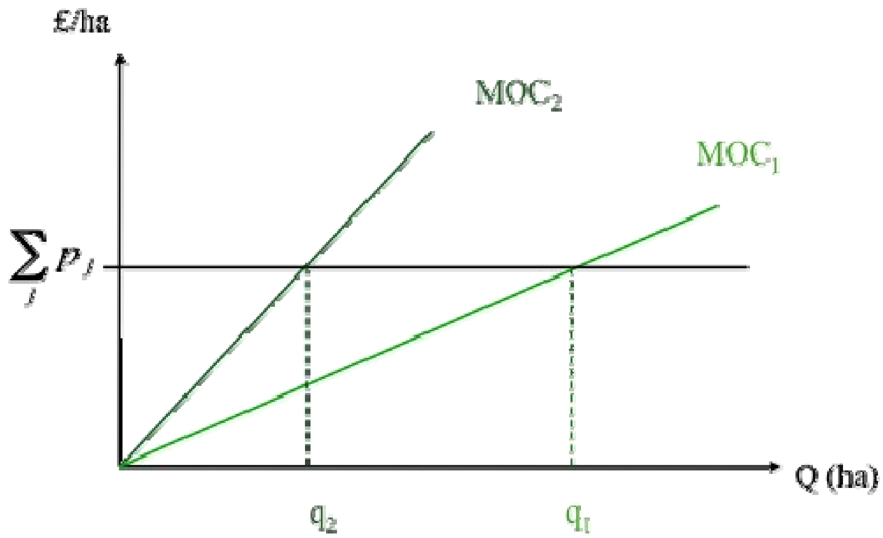

Figure 1: Comparison of areas offered for entry between farms 1 and 2 with different marginal opportunity costs (MOC), within the same region (same payment rate per option)

Because payment rates are based on national average OC rather than a farm average (true) OC, this profit-making by farms with lower than average yields has the effect of overcompensating farmers actually accepted into the scheme, and thus decreasing HLS cost-effectiveness through Adverse Selection (assuming a uniform environmental benefit per hectare of land entered into the scheme within the region). Farms with a higher proportion of lower agricultural quality land (i.e. with lower agricultural yields or because of higher farm land heterogeneity) have a lower MOC of agricultural production (right hand-side of Equation 4), and thus offer more hectares for contracting with the lowest agricultural quality land put into the scheme first (Equation 5).

This would correspond to the findings of studies by Rygnestad and Fraser (1996) in relation to an incentive compatibility problem for set-aside policy in situations of heterogeneous land quality, with lowest quality land set-aside first. Studies by Shoemaker (1989), Osterberg (1999, cited by Ferraro, 2008), Osterburg and Nieberg (1999, cited by Latacz-Lohmann and Schilizzi, 2005), Osterburg (2001) also showed higher participation rates in regions of poorer soils, lower yields and a lower share of intensive crops, and a generally lower intensity of land use (hill areas). This is also consistent with the most recent findings of higher participation in the Irish agri-environmental scheme (Rural Environment Protection Scheme, REPS) for more extensive systems of farming (less environmentally degrading) or for lower soil quality (Hynes and Garvey, 2009).

3. Data, Analysis and Results

From the above analysis, adverse selection of farmers into HLS arises for farmers making a non-zero profit over the options taken up. Evidence of adverse selection would here, following our hypothesis, be a statistically significant negative relationship, within a given region, between the number of hectares entered into HLS and the associated yields. Our hypothesis was modified in relation to the type of data available, and in this Section we test whether a significant relationship between HLS entry and agricultural yields exists. That is, are the higher agricultural yields, the less likely farms are to participate in the HLS?

The farm-level data used for this analysis comes from a survey collected and described in Bailey *et al.* (2009). This survey includes various farm characteristics (size, farm type), agricultural characteristics (crops, yields, prices, self-assessed profitability relative to similar farms in the same area), environmental scheme characteristics (in particular HLS, ELS, Countryside Stewardship Scheme, Environmentally Sensitive Area scheme), socio-economic characteristics (farm status of respondents, in full-time or part-time farming, years in farming), and postcode (area code only). Agricultural yields for the complete dataset have been found in line with national averages by Bailey *et al.* (2009). As such the data set can be considered to be reasonably representative. Given the focus of the research undertaken by Bailey *et al.*, on the use and adoption of pest management technologies in cereal production, the majority of responses in the data are from arable or mixed farms. This is not an issue for analysing the HLS as there has been a relatively high HLS uptake for cereal farms, 27% of numbers and 40% of the area in the HLS (Boatman *et al.*, 2007).

From the data collected by Bailey *et al.* (2009), entries in England were selected for analysis, with each entry spatially matched to government office regions from its postcode area using ArcGIS (ESRI, 2006). Postcode areas often overlap across several government office regions, so only entries that could be allocated to a single government office region were retained for the analysis. This yielded a sample of 135 observations.

Ideally the preferred dependent variable in our analysis would be the quantity of land entered into the HLS per farm. However, this measure was not available for empirical analysis, so an indicator of whether farms were already into HLS, or intended to enter within the next 3 years, was used. Therefore, a binary variable (i.e. HLS entry/non-entry) was constructed to include both current entries and intended entries. All intended entries were considered as effective entries, as most farms were already enrolled into the Environmentally Sensitive Area scheme or Countryside Stewardship Scheme (schemes now replaced by the Environmental Stewardship), or into the ELS (lower tier) already.

In terms of independent variables farm size (Total farm area) was included, as this has previously been found to potentially influence participation in agri-environmental schemes (Bonnieux *et al.*, 1998, Boatman *et al.*, 2007, Defrancesco *et al.*, 2008, Hynes and Garvey, 2009). More generally, the adoption of the latest English agri-environmental schemes has been found to depend on farm structural characteristics and farm size. For example, these agri-environmental schemes are often less attractive for intensive production systems and smaller holdings. Also, scheme participation tends to be higher for cereal farms (Boatman *et al.*, 2007, Natural England, 2009).

The number of arable crops (Number of crops) was employed as an explanatory variable. It was calculated as the sum of the types of wheat and barley cropped. The number of farm activities (Number of farm activities) was derived from the types of farm recorded in the dataset, as this is expected to influence participation (Boatman *et al.*, 2007, Hynes and Garvey, 2009).

Yield variables for different cereal crops (i.e. wheat for milling or animal feed, barley for animal feed) and other crops (as surveyed) were included as explanatory variables, in relation to the tested hypothesis.

A question asking farmers to self-assess their relative level profitability was included in the questionnaire. This information has been used by employing two dummy variables that takes the form Less Profitable and More Profitable, with the classification Equally profitable retained as the reference level. Farmer status was included in the analysis as a dummy variable to capture farm tenure. It was derived from the survey response assuming one if the farm manager, and zero if the farm owner or the tenant farmer. To date in the literature there is mixed evidence regarding the impact of farm tenure on Scheme participation (see Wynn *et al.*, 2001, Defrancesco *et al.*, 2008, Hynes and Garvey, 2009). We also included a dummy variable of whether respondents were in full-time agriculture (Fulltime) as opposed to part-time farming or agribusiness).

The number of years (Year decider) respondents have been the main decision-makers on the farm is included as an explanatory variable, as farmer age has been found a significant explanatory variable in previous studies (e.g. Bonnieux *et al.*, 1998, Wynn *et al.*, 2001, Hynes and Garvey, 2009). Finally, Education level measured as a category variable was also included, as it has previously been found to be negatively related to participation in agri-environmental schemes by existing research studies (Bonnieux *et al.*, 1998, Defrancesco *et al.*, 2008).

Finally, government office region dummies were included so as to control for between-region variations (with the East of England region taken as reference), of agricultural and environmental characteristics, and of different HLS budgets.

In summary, the explanatory variables used in our analysis are the total farm area, the number of different crops (for wheat and barley), the number of farm activities, yields of 3 crops (wheat for milling, wheat for animal feed, barley for animal feed), the relative level of profitability (dummies), the type of farmers (farm manager by reference to farm owner and tenant farmer), the number of years the respondent has been the main decision-maker (Year decider), and government office regions (dummies). A summary of the variables employed in our analysis are reported in Table 1.

Table 1: Variables description and statistics of regression sample (N= 135)

Variable	Units	Mean	Std. Dev	Min	Max
HLS entry	dummy	0.58	0.50	0	1
Total farm area	ha	385.21	439.72	5.26	2,374.00
Number of crops		1.70	0.91	0	4
Number of farm activities		1.50	0.50	1	2
Yield wheat milling	t/ha	3.62	4.26	0	10.20
Yield wheat feed	t/ha	5.36	4.25	0	11.25
Yield barley feed	t/ha	2.44	3.43	0	10.00
Yield other crops	t/ha	2.97	8.90	0	101.00
Less profitable	dummy	0.11	0.32	0	1
More profitable	dummy	0.24	0.43	0	1
Farm manager	dummy	0.14	0.35	0	1
Fulltime	dummy	0.88	0.32	0	1
Year decider	years	21.80	11.58	0	55
Education	categories	3.78	1.10	1	5
East Midlands	dummy	0.13	0.33	0	1
North East	dummy	0.07	0.25	0	1
North West	dummy	0.02	0.15	0	1
South East	dummy	0.14	0.35	0	1
South West	dummy	0.19	0.40	0	1
West Midlands	dummy	0.06	0.24	0	1
Yorkshire and the Humber	dummy	0.10	0.30	0	1

From Table 1 we can observe that 58% of the sample farms are in HLS or intend to enter in the next 3 years, which is much higher than the national average (0.5% of holdings in 2006, Boatman *et al.*, 2007). Differences in yield averages between crops are mostly due to the number of zero-observations, and not to a difference in the range of yields. Observations were mostly in the South East, the South West as observed by Boatman *et al.* (2007), but with the lowest number of farms in the North West instead of Yorkshire and the Humber as observed by the same study. This discrepancy in geographical repartition of observations could stem from the sample reduction from the original dataset in relation to uncertainties on the allocation to only one government region from the postcode area.

Given the form of the dependent variable we employed limited dependent variable regression methods. All estimation was performed using Stata 9 (StataCorp, 2005). A logit regression model was estimated with coefficients and marginal effects are reported in Table 2.

Table 2: Logit regression results of HLS participation

Variable	Parameters estimates Coef.		Std. Err.	Marginal effects dy/dx		Std. Err.
Total farm area	0.001	*	(0.001)	0.000	*	(0.000)
Number of crops	0.904	**	(0.413)	0.216	**	(0.098)
Number of farm activities	0.598		(0.458)	0.143		(0.109)
Yield wheat milling	-0.076		(0.070)	-0.018		(0.017)
Yield wheat feed	-0.136	**	(0.063)	-0.033	**	(0.015)
Yield barley feed	-0.145	*	(0.077)	-0.035	*	(0.018)
Yield other crops	0.021		(0.033)	0.005		(0.008)
Less profitable	0.078		(0.683)	0.019		(0.161)
More profitable	-0.353		(0.523)	-0.086		(0.128)
Farm manager	-0.641		(0.731)	-0.157		(0.181)
Fulltime	1.293	*	(0.691)	0.312	**	(0.153)
Year decider	-0.013		(0.020)	-0.003		(0.005)
Education	0.171		(0.199)	0.041		(0.048)
East Midlands	-0.369		(0.679)	-0.090		(0.168)
North East	1.048		(1.210)	0.215		(0.197)
North West	0.510		(1.380)	0.114		(0.282)
South East	-0.059		(0.677)	-0.014		(0.163)
South West	-0.952		(0.630)	-0.233		(0.151)
West Midlands	-0.733		(0.864)	-0.181		(0.212)
Yorkshire and the Humber	-0.320		(0.765)	-0.078		(0.190)
Constant	-2.286	*	(1.365)			
Number of observations	135					
Log likelihood	-77.39					
LR Chi2 (20)	29.10	*				
Pseudo R^2	0.158					

(*: significant at a 10% level; **: significant at a 5% level; ***: significant at a 1% level of significance)

First of all from Table 2 we can observe that the pseudo R^2 value is relatively low (16%), as could be expected for cross-sectional data. The Likelihood Ratio (LR) Chi^2 test statistic is significantly different from zero (p-value of 0.0859), suggesting the parameters are jointly significant.

Turning to the explanatory variables, the total farm area and number of crops (structural factors) have a significant positive influence on HLS entry (respectively at a 10% and 5% level of significance), which is consistent with the findings of Boatman *et al.* (2007). The coefficient for total farm area is however very low (0.0% increase in HLS participation for each extra hectare of farm land), which could be a units issue. Farm type (proxied here by the number of activities) is, however, found to be insignificant.

All the yield coefficients for wheat and barley display the expected negative signs, they are also found to be statistically significant for animal feed crops (respectively at a 5% and 10% level of significance). An increase in yields for animal feed wheat and barley by 1 t/ha leads to an increase in HLS participation by 3.3% and 3.5% respectively. The coefficient for the yields of other crops is found insignificant, possibly because of a high level of heterogeneity.

The self-assessed level of profitability and farmer status are found to be insignificant.

Being in fulltime agriculture has a positive influence on HLS entry (at a 10% level of significance), contrary to the findings of Hynes *et al.* (2008) for the Irish REPS. This discrepancy could be due to the HLS being designed as the highest tier of the ESS, globally more environmentally demanding and with 10-year agreements. It could also be down to differences in farming in England and Ireland, or to differences in scheme design especially with respect the types of environmental goods and services being valued or the type of farming implicitly supported.

The number of years respondents have been the main decision-makers on the farm is insignificant. None of the regional dummy coefficients are found significantly different from zero.

In summary, we have established that entry into the HLS significantly decreases with increasing yields of crops for animal feed (wheat and barley) within the different government regions (as no regional dummy was found significant). This result implies there is some evidence of farmers entering land of lower agricultural quality (yield) than average into the HLS, thereby resulting in adverse selection and reduced cost-effectiveness of the Scheme. This is consistent with our Hypothesis and the findings of Rygnestad and Fraser (1996) who demonstrated a choice of land for set-aside linked to soil quality, and more recently to the findings of Hynes and Garvey (2009), with less polluting farms (associated with a poorer soil type) more likely to enter the Irish REPS.

4. Conclusion

The ESS, because of potential incentive incompatibility and asymmetric information, has the potential for adverse selection for the land entered into the scheme, leading to reduced cost-effectiveness of the Scheme. Section 2 of this paper developed a principal-agent model in relation to the adverse selection problem, for arable options. This led to hypothesise a relationship between yield (opportunity cost) variations across farms and participation into HLS. To evaluate this hypothesis the empirical research reported in Section 3 focused on determinants of farmers' participation in the HLS, including cereals yields.

The results in Section 3 showed that, HLS participation is significantly influenced by the yields of wheat and barley for animal feed, total farm area, the number of crops, and whether farmers are in full-time agriculture. Within a given region, farmer participation in the HLS is significantly negatively related to farm yields. This suggests that the entry of lower agricultural quality land (with lower yields than the national average) into HLS thereby leads to farmer overcompensation and adverse selection, thereby decreasing scheme cost-effectiveness.

Further research in relation to this Hypothesis would require data on the quantity and quality of land entered into the HLS at farm-level in combination to data on farm cereal yields. The same regression was run using indicators of revenue from the survey data (computed as the product of yield and price for each crop), therefore providing some quality-adjusted measure of yields. These were not found significant, but might be when combined to the quantity of land offered for entry and variable agricultural costs, following the model in Section 2. Also, the same type of analysis could be applied to types of options other than just the arable ones (e.g. for grassland options). It would also be interesting to apply the same approach, controlling for landscape regions (lower geographical level than government office regions), to test whether the relationship holds at a lower level of analysis.

Finally, while all Environmental Stewardship tiers are likely to be subject to incentive-incompatibility, as has been demonstrated in this paper, this problem is potentially reduced in the case of the HLS for two reasons. First, the HLS includes explicit selection based on environmental benefit criteria. Second, this selection is subject to a budget constraint. In particular, although farmers with the lowest agricultural opportunity cost have the greatest incentive to apply for the Scheme, the selection mechanism means that only farmers assessed as providing higher environmental benefit are admitted into the Scheme, thereby potentially reducing the adverse selection problem and increasing the cost-effectiveness of the Scheme. In addition, the operation of the HLS subject to a budget constraint on total payments to farmers encourages the selection of 'low cost' farmers which, where they are providing similar environmental benefits to 'high cost' farmers, could also improve the overall cost-effectiveness of the Scheme [1].

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[1] For further details see Quillérou and Fraser (2010).

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