

Farm Subsidies: Designing Efficient Policies around Household Heterogeneity

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Abstract

This research sets out to analyse the impact of policy design on the efficiency of voluntary agri-environmental schemes; defining efficiency in terms of the cost effectiveness of policies. We build on previous work on scheme adoption both within agricultural economics and across a broader spectrum of economics such as labour and fiscal studies. Through the application of a choice experiment the paper aims to identify how proposed scheme characteristics and their interaction with household characteristics affect the contingent participation decision of agricultural decision makers. In particular the paper aims to assess the implications of heterogeneous access to labour and product markets for policy design. The problem will be reviewed through a case study which explores the contingent participation of small holdings owners (crofters) in the Rural Stewardship Scheme in Scotland.

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Introduction

In recent years there has been an awakening of environmental concern and the development of policies aimed at promoting environmental preservation and development. In agriculture, agro-forestry and agri-environmental policies have been designed to introduce financial incentives for farmers to adopt more environmentally oriented management practices and production methods. Examples of such schemes include the Conservation Reserve Program in the US, the Less Favourable Areas Scheme in the Netherlands, the Framework Management Programme in Germany, the recent Entry Level Scheme in England and its counterpart, the Rural Stewardship Scheme, in Scotland. An ongoing objective of all governments is to improve the effectiveness of policy intervention. Policy efficiency can be evaluated through cost-effectiveness analysis, where the objective is to achieve maximum policy impact relative to incurred cost. With regards to agri-environmental schemes, cost effectiveness is determined by participation and costs. Designing more efficient policies requires an understanding of these factors.

This paper examines the issue of contingent participation within a voluntary intervention through the administration of a stated preference choice experiment. In particular the paper aims to assess the implications of heterogeneous access to labour and product markets for efficient policy design. The problem will be reviewed through a case study exploring the contingent participation of small holdings owners (crofters) in the Rural Stewardship Scheme. Section 1 discusses the supporting literature and places this study within the literature. Section 2 develops a model of scheme participation incorporating household heterogeneity. The case study, applying this model to the case of the Scottish Crofter, is presented in section 3. Section 4 explores the choice experiment and section 5 discusses the results. An illustrative policy simulation, based on the results of the choice experiment, is presented in section 6. Section 7 reviews the findings and policy implications of the paper.

1. Background

Efficient policy design is achieved through understanding and catering to the determinants of participation and scheme costs. The participation problem has been studied in a number of policy contexts such as benefit schemes, entrance into higher education and health care cover. A number of papers addressing the issue of participation in benefit schemes have been produced by the institute of Fiscal Studies. Using data on actual participation the take up of standard housing benefit, supplementary benefits and Family Income support schemes were studied by Fry and Stark (1987), Blundell, Fry and Walker (1988) and Fry and Stark (1991). Dorset and Heady (1991)

extended this work by analysing the impact of interactions between scheme characteristics on participation. Changes in participation in light of reforms to these schemes were reviewed by Fry and Stark (1993). Policy simulations have also been conducted in the context of participation in benefit schemes. Blundell (2000) used survey data in a policy simulation model of in work benefits based on a discrete choice model. The participation decision has also been studied in the context of job training schemes (see, for example, Heckmann and Smith (2003)) and health cover schemes (Bansak and Raphael (2004)).

In the context of agri-environmental schemes the decision making process is based on the intertemporal decision making model, see Janvry and Sadoulet (2006). The earliest articles were based on observed data and opinion surveys (see, Potter and Gasson (1988) and Brotherton (1989)) and later work extended to experimental and quasi-experimental methodology (Wossnik and van Wenum (2003)). The early articles focused on the impact of scheme characteristics such as the level of payment and restrictions on production, with later articles exploring the role of household characteristics (Brotherton (1989)), the production environment, attitudes of the respondent and perceptions of risk (Wossnik and van Wenum (2003)). After a decade of work examining participation in agro-forestry schemes Pattanayak et al (2003) collated the results of 120 articles relating to small holdings. From these articles 32 containing studies¹ from tropical areas were used to analyse the relevance of five key categories identified by the authors as being the driving forces behind agro-forestry technology adoption². The meta-analysis showed that preferences and resource endowments were the features most intensively surveyed in studies. In addition, the analysis showed that biophysical factors and risk had a greater impact across the studies on the adoption of technology. The inclusion of market incentives revealed a prevalent influence of distance to market and differences in prices, factors which can be interpreted as the result of heterogeneous access to markets.

Whilst revealed preference methods are useful for understanding the determinants of participation in established schemes there are two drawbacks of this approach. Firstly, data is often unavailable at an aggregated level limiting the degree to which household heterogeneity can be integrated into policy analysis. Secondly, using revealed preference data limits the scope of policy changes which

¹ A mixture of opinion surveys, correlation studies, regression analyses (Least squares, Probit and Tobit) and experimental and quasi-experimental studies. The studies focus on adoption in Asia, Africa, Canada and the USA.

² The five categories used in their analysis of entry into the Environmentally Sensitive Area Scheme in Scotland were preferences, resource endowments, market incentives, biophysical factors and risk/uncertainty.

can be analysed³. Consequently there has been a growing application of contingent valuation and choice experiment methodology which facilitate a more targeted analysis of participation. This approach had been combined with a focus on access to markets in the literature on participation in agricultural schemes. Birol et al (2006) investigated the private economic values of agrobiodiversity attributes of home gardens in Hungary. Results from the study were consistent with the hypothesis that constrained access to markets would alter households' valuations of home garden attributes. The paper's main conclusion is that economic development will diminish the private returns to home gardens and suggests that in the future their cultivation will be less prominent. Groom et al (2007) also addressed the topic of off-farm constraints in their revealed preference analysis of the scope for gains under the Sloping Lands Conversion Programme. Mullan (2008) conducted a contingent participation study of the possible continuation of the SLCP, finding that constrained access to off-farm labour and markets had a significant impact on participation.

This paper builds on previous approaches to address the issue by first identifying the impact of heterogeneous access to markets on contingent participation. Using stated preference data the paper then simulates participation under alternative policy specifications, the most interesting of which is a separating policy designed to internalise heterogeneity whilst maintaining a simplistic scheme structure to reduce compensation costs without inflating administrative costs. This paper therefore extends the current literature to investigate the efficiency of the current subsidies in the light of heterogeneity between farm households, providing a case study to test the application of the theory.

2. Theoretical model

As in the supporting literature (see, Groom et al (2007)) the decision process can be modelled as a random utility model coupled with a Kuhn Tucker⁴ optimization problem to determine the quantity of land devoted to agri-environmental purposes.

The Basic Model

$$V_{ij} = V_{ij}(c_i, l_i, f(l_f, q_y, A); z_j(q_e, \psi_j))$$

Defines the level of utility V_{ij} , for individual i , dependent on:

c_i : The level of household consumption

³ Of course established policies can be compared and contrasted. See, for example, Falconer and Saunders' (2003) comparison of the Wildlife Enhancement Scheme (WES) with under hand and under seal agreements in the North of England

⁴ Janvry and Sadoulet (2006) discuss household production decisions as an inter-temporal optimisation problem in a Kuhn-Tucker framework.

- l_i : The amount of leisure time
- l_f : The amount of labour used in production
- l_e : The amount of labour used in agri-environmental schemes
- T_i : The total amount of labour and leisure time available
- q_y : The amount of land used in production
- q_e : The amount of land devoted to agri-environmental schemes
- Q_i : The total amount of land available
- $z_j(q_e, \psi_j)$: The attributes of the agri-environment scheme ψ_j and the amount of land submitted by the household.

For households to participate in the scheme the constraint $V_{ij} \geq V_{i0}$ must be satisfied, where V_{i0} is the utility available without participating in the scheme. Altering the regulations surrounding the sale of farm land may affect the nature of the participation constraint. Households use land for farm production and divide their time between leisure, farm labour, off-farm labour, subject to non-negativity constraints and a total time allocation constraint. Within farming land may be allocated to either agri-environmental or non ecosystem service providing farming, expanding the decision process by an additional step.

Maximisation in the Absence of the Scheme

If it is beneficial for the household to maintain ownership of the land, V_{i0} relates to the result of the optimisation problem of the household in the absence of an agri-environmental scheme⁵.

The maximisation problem is

$$\text{Max}_{l_f, l_a} \quad V_{i0} = V_{i0}(c_i, l_i, f(l_f, q_y, A))$$

$$\text{s.t.} \quad c = f(l_f, q_y, A) + w_j l_a + SFP_{i0}$$

$$T_i = l_i + l_a + l_f$$

⁵ Groom et al (2007) discuss household optimisation in a similar framework beginning with an outline of optimisation in the absence of the SLCP. Their model includes a distribution of levels of productivity over different parcels of land, an on farm production constraint and a land constraint to represent particular restrictions in the Chinese markets.

For unconstrained households the conditions for a maximum are that marginal returns to labour be equated across the markets to which the household supplies its labour. Constrained households are bounded by additional factors, for example constrained labour market access may mean that there is an upper limit to the quantity of labour which can be supplied off-farm, or off-farm wages may be lower and imperfect access to product markets may introduce additional costs which, *ceteris paribus*, reduce the marginal returns to production. As a result constrained households may not be able to fully optimise leading to inefficiently high rates of labour supply on farm⁶. Consequently the reservation utility level will be lower for a constrained household than for an identical but unconstrained household.

Maximisation in the Presence of the Scheme

Let us now introduce an agri-environmental scheme which provides payments for environmental services and changes in the level of single farm payment. The maximisation problem requires households to compare the maximum utility from participation with the maximum utility from opting out. The maximisation problem is as follows,

$$\text{Max}_{l_f, l_a, l_e, q_y, q_e} \quad V_{ij} = V_{ij}(c_i, l_i, f(l_f, q_y, A); z_j(q_e, \psi_j))$$

$$\text{s.t.} \quad c = f(l_f, q_y, A) + w_j l_a + SFP_{ij} + Rq_e$$

$$T_i = l_i + l_a + l_e + l_f$$

$$Q = q_y + q_e$$

and a set of non-negativity constraints.

Maximising the objective function results in the following first order conditions:

$$q_e : \frac{\delta V_{ij}}{\delta z_j} \cdot \frac{\delta z_j}{\delta q_e} - \lambda \left[\frac{\delta f}{\delta q_e} + R \right] = \mu \frac{\delta l_e}{\delta z_j}$$

⁶ This is a standard economic result in constrained optimization, although utility may be increased by diverting some labour away from the farm this is not feasible and leads to lower on farm marginal productivity of labour. It is identified through the nature of the complementary slackness condition, for a further discussion refer to Simon and Blume (1994).

$$z_j : \frac{\delta V_{ij}}{\delta z_j} - \lambda \frac{\delta f}{\delta z_j} = \mu \frac{\delta l_e}{\delta z_j}$$

$$l_a : -\lambda w_j = \mu$$

$$l_f : -\lambda f_{l_f} = \mu$$

The first states that the sum of i) the return to an additional unit of land devoted to the agri-environmental scheme, ii) the utility derived from the services and iii) the subsidy payment should be equal to the cost of diverting this unit from production and the opportunity cost of the diverted labour (l_e)⁷. The final two conditions combine to show that optimally the marginal product of on farm labour should be equated with the wage paid for off farm labour (w_j). In the absence of any additional constraints these conditions will be met. As the single farm payment (SFP) increases either consumption rises or the amount of leisure rises, both increase the level of utility available affecting the probability that a household will prefer to maintain the farm as opposed to selling it.

The agri-environmental payment alters the production decisions, encouraging reallocation of land and labour towards agri-environmental services, but only when the level of payment, R , is large enough to offset the loss in output. As R rises, labour supply both on and off the farm must still satisfy the condition that returns to labour supplied on and off the farm are equalised, however the total labour supplied to these two is reduced and some labour is diverted to ecosystem services.

Constrained households

We now wish to introduce additional household heterogeneity in the form of imperfect access to markets. In particular we want to distinguish between households with imperfect access to land, labour and product markets, hereafter referred to as “constrained” and those with more liberal access to these markets, hereafter “unconstrained”.

Imperfect access to the labour market reduces the total quantity of off farm labour which can be supplied. This creates the possibility of a boundary solution to the optimisation problem where households would prefer to supply more off farm labour but are unable to do so. As a result the on

⁷ Condition three provides an interpretation of $-\mu/\lambda$ as the marginal productivity of off-farm labour w_j which is equated at the optimum with the marginal productivity of farm labour.

farm labour supply is too great and the marginal productivity lower than the return to off farm labour.

Land market constraints may also affect the participation decision of farm households because additional costs or imperfectly operating markets reduce the returns to working the land, consequently reducing the reservation level of utility that can be attained. Land is thus likely to be used more intensively by constrained households and, assuming that productivity is diminishing in labour, the marginal productivity of land is also likely to be lower for constrained than for unconstrained households. This suggests that in areas where land markets are imperfect households are more likely to participate in a subsidy scheme.

Scheme attributes affect the utility derived from the scheme and the productivity of farm land. As can be seen from the second optimisation condition, when utility is linear in scheme attributes the first partial derivative is a constant. For constrained households the marginal productivity of farm output with respect to the scheme attributes is lower, this means that small payments may provide a large incentive to participate in the scheme. On the other hand, higher payments will be needed to encourage unconstrained households to participate in the scheme. Attributes of the scheme which restrict the production process will have a larger impact on households which use the land most intensively. This is most limiting for households who cannot respond to lower farm productivity by transferring labour. Therefore restrictions on the use of land within the scheme are likely to impact constrained households more severely. The duration of the scheme is also likely to affect the two types of households in divergent ways. For constrained households, more heavily dependent on farm land for subsistence, longer scheme duration brings both security and inflexibility. Longer duration represents a special type of restriction on production which introduces uncertainty over the income that can be generated from the farm. The problem is reduced for unconstrained households whose access to alternative employment relieves the burden of production controls. From the theory outlined above we can draw three key hypotheses:

Relative to unconstrained households:

- H1. Constrained households are more likely to participate in agri-environmental schemes
- H2. Constrained households' participation is more severely affected by farming restrictions
- H3. Constrained households' participation is less responsive to financial incentives

These will be tested using a stated preference study and the results applied to a discussion of policy design.

3. The Case Study

To enhance the reliability of our analysis our case study should ideally be based on an existing scheme with credible possibilities for reform and a jurisdiction spanning both constrained and unconstrained households. To this end, our case study analyses stated preference responses of crofters⁸ regarding participation in the Rural Stewardship Scheme (RSS).

The RSS is currently undergoing revision; the reformed policy has been renamed the Scottish Rural Development Programme. It was initiated in 2001 replacing the Countryside Premium Scheme and the Environmentally Sensitive Areas Scheme to encourage the adoption of environmental management techniques. These include the planting and maintenance of hedgerow, provision of late cover for Corncrakes and the creation and management of wetlands. The actions encouraged under the schemes are designed specifically to support the creation and management of habitat for bird species. At the time of our study, the RSS runs as a five year scheme, there are two years of the last round of the scheme remaining. Households have the option of applying to enter the scheme and choose the amount of land which they would like to put in independently, alternatively they can decide not to participate in the scheme. Applications must be made to participate in the scheme and not all applications are successful. In order to avoid high administrative costs applicants must be willing to submit a minimum of 15 units. One unit is equivalent to one hectare of land committed to the scheme, but in the current scheme other activities such as participating on courses can also be taken on by households to meet the 15 unit criterion.

To analyse the factors affecting the contingent participation decision and test hypotheses 1-3 respondents were sampled from two counties exhibiting significant differences in their location and consequent access to labour and output markets. ‘Constrained’ households were sampled from Orkney, an isolated island county, while ‘unconstrained’ households were interviewed in Lochaber, Inverness-shire, a relatively central and integrated county.

Lochaber is considered to be a cross roads between the highlands and isles and the lowlands. Its landscapes are a composed of mountain ranges interspersed with urbanised settlements and arable holdings. It is home to Scotland’s highest peak and deepest loch and some of the rarest wildlife species in Britain. Lochaber has a growing tourist industry with many visitors attracted by the

⁸ A croft is defined as a piece of land surrounded by regulations but more broadly relates to farm holdings in Scotland established as crofts under the 1886 Crofters holding act.

recreational facilities such as the downhill bike run at Anoch moar and scenic hikes. The population of Lochaber totals 19,620⁹ and it spans a total area of 4,468 square km.

Orkney sits 10 miles from Caithness and is composed of 70 islands, 20 inhabited, totaling 990 square km and with a population of 19,900. The mainland is connected to South Ronaldsay via the Churchill causeways built in the 1940s, together these islands total an area of 572 square km and have a population of 15,315. The geography is substantially flatter than Lochaber despite the presence of hills. The land is low-lying with indented coastlines and rugged cliffs on the west coast. Orkney also receives a large number of tourists attracted by the historic sites, in particular the neolithic feats of Skara Brae and Mae's Howe, and by the wide variety of wildlife¹⁰. Both Lochaber and Orkney have suffered from a loss of native woodland, soil erosion and declining biodiversity which agri-environmental policies have been developed to address.

Contact addresses for all owner-occupied crofts were obtained from the crofter's commission. Letters inviting households to take part in the survey were sent to households identified as owner-occupied crofts. The letters explained that the project was analysing crofting and subsidies but did not go into detail about its hypotheses or motivations in order to avoid influencing the responses of participants. Letters were then followed up with a phone call to arrange face-to-face interviews with those willing to participate. A total of 96 responses were collected, each choice set was administered an equal number of times to maintain orthogonality. Data was collected during July 2008.

Table 1 presents some summary information for the two inherent sub-samples.

	Age	Croft income	Croft subsidies	Alt Income	RSS	Current Schemes	Internet	Holidays	Debt
Lochaber	58.5	£4,960	£1,330	£13,388	£167	6	28	0.67	£239
Orkney	58.2	£7,585	£16,451	£12,916	£1,690	25	38	0.56	£11,720

Table 1: Summary statistics for Orkney and Lochaber

⁹ www.lochaber.com

¹⁰ Orkney has the widest recorded variety of wildlife species of any region in Britain.

4. Methodology

A combination of a review of the existing literature and consultation with a focus group led to the identification of four relevant policy attributes and a corresponding range of levels for the choice experiment attributes: (i) the per unit payment under the scheme, (ii) restrictions on land use (iii) the requisite period of commitment to the scheme and (iv) the annual reduction (modulation) of other subsidies.

Table 2 presents these attributes alongside the range of values used in the choice experiments. The levels were identified through the current policy levels (see <http://www.scotland.gov.uk/Topics/Agriculture>) in addition to consultation with the focus group and RSPB recommendations for habitat management (see www.RSPB.co.uk).

Scheme Characteristic	Attribute Levels
Payment level per hectare in scheme (RSP)	£150, £200, £250
Modulation of single farm payment	10% increase, 10% decrease, 30% decrease, 50% decrease
Restrictions placed on use of In-bye grassland	None, one month, two months
Guaranteed duration of the scheme	1 year, 5 years

Table 2: Scheme characteristics and associated levels used in the choice experiments.

Based on these characteristics set of 32 orthogonal choice experiments were designed, each presenting respondents with two policy alternatives and an opt-out option. These were then divided into 16 blocks of 8 questions, drawn in a manner, which controlled for potential ordering effects and then randomly assigned to respondents. To ensure a balanced sample across the 16 blocks of questions a sample of 96 responses was collected ensuring that each choice block was administered an equal number of times to maintain orthogonality. An example of the choice sets presented to respondents is shown in Figure 4.1.

	Option A	Option B	Status Quo
Subsidies (% of current)	90%	50%	70%
Rural Stewardship Payment Per unit	200	250	
Shut down In Bye Grassland until:	None	June	
Scheme Duration (years)	5	1	
Please select one			
Assume now that decrofting was not permitted for a period of 5 years under Options A and B			
Please select one			

Figure 4.1: Choice set

The policy scenario presented to respondents explained that the Rural Stewardship Scheme was currently being reviewed and asked them to consider the new proposals¹¹ (options A and B) in each choice set and choose between the two proposed schemes and a status quo option which allowed them to not participate in the scheme but subjected them to a proposed modulation of their single farm payment of 30%. This is not far removed from the decisions currently faced by households as modulation of the single farm payment to fund agri-environmental schemes is ongoing (presently at a rate of 10% per year).

The feasibility of the policy scenario was enhanced by the fact that the scheme is currently under review and the widespread knowledge that a new scheme is to be proposed. There have also been media reports of a move towards environmental management schemes and modulation of the single farm payment. For each choice experiment the number of eligible hectares and the number of hectares which the respondent hypothetically committed to the policy was also recorded. Respondents were asked to comment on whether production would change; in particular they were asked whether a reduction in the single farm payment due to modulation would stifle the feasibility of production.

In order to take account of respondent characteristics a respondent details form was administered alongside the choice experiments. The information requested was based on the list of characteristics found to be relevant in the literature review and proxies for the variables to which individuals are likely to refuse to respond, such as income.

¹¹ To be implemented at the end of the current RSS round in two years.

Face to face interviews were conducted at respondents homes, each respondent was presented with one choice block (8 choice sets) and a respondent details form which took roughly half an hour to complete.

The Model

The participation decision regarding the reformed Rural Stewardship Scheme was modelled by a multinomial logit model. The Random Utility Model (RUM) framework for choice analysis developed by McFadden (1974) is consistent with consumer demand theory and utility maximisation. The model defines a utility function over each choice alternative, most commonly this utility function is linear in its arguments;

$$V_{ij} = \beta_1 Z_j + \beta_2 \theta_i + \beta_3 Z_j \theta_i + \epsilon_{ij} \quad [4.1]$$

For individual i selecting choice j , where Z_j are the policy attributes and θ_i are socio-economic characteristics and ϵ_{ij} is an i.i.d. deterministic error term following a Weibull distribution.

As choice experiments model choices made by a single decision maker attributes such as their socio-economic characteristics remain fixed across the alternatives, as such these characteristics fall out of the model. To include these attributes as explanatory variables it is necessary to identify the theoretical influence they have and use this to construct appropriate interaction terms, for example age may diminish the marginal effect of increasing the payment offered because the marginal returns to physical labour diminish with age whilst the returns to alternative labour remains constant or increases, to capture this effect an interaction effect age*payment may be constructed and included in the utility specification.

Using this framework the analysis of stated preference in a choice experiment context can obtain estimates of the marginal effects of attribute levels and interaction terms and can be used to analyse the willingness to accept for variations of the reformed RSS. We can also augment equation [4.1] to test for the effect of additional constraints upon the participation decision and consequently the willingness to pay and consumer surplus estimates.

5. Results

Specifying utility as a linear function of scheme characteristics, income and interaction terms accounting for socioeconomic characteristics the results were fit to a multinomial logit model. The inclusion of relevant interaction terms provided a means of testing the three main hypotheses developed in section 2.

This section will focus on the main effects and the results relating directly to hypotheses 1-3. The corresponding coefficient estimates are presented in table 3.

Attribute	Coeff.	Std.Err.	t-ratio	P-value
Income	0.0000009	0.0000003	2.8020200	0.0050800
RSP	-0.0050161	0.0011752	-4.2684400	0.0000200
Month	-0.2085330	0.0908679	-2.2949100	0.0217400
Duration	-0.1545980	0.0604145	-2.5589600	0.0105000
CurrentScheme.RSP	0.0134186	0.0015627	8.5866900	0.0000000
CurrentScheme.Income	0.0000007	0.0000002	2.6689300	0.0076100
Alt.Emp.Income	0.0000018	0.0000004	4.3105000	0.0000200
Alt.Emp.Duration	0.1300480	0.0541216	2.4028800	0.0162700
Wage.Income	-0.0000002	0.0000000	-5.8243600	0.0000000
Wage.RSP	0.0002098	0.0000454	4.6160300	0.0000000
Units.Duration	0.0132863	0.0039592	3.3558100	0.0007900
Lochaber.Modulation	-0.0175861	0.0035564	-4.9449500	0.0000000
Lochaber.Alt.Emp.Income	0.0000017	0.0000007	2.4155400	0.0157100

Table 3: Results from estimation of equations [5.1] and [5.2].

All coefficients are significant at the 5% level.

The final model, after elimination of insignificant variables, took the form¹² :

¹² Over 30 variations of the model were run, beginning with a main effects only model. The model was then extended to account for the impact of total income under the scheme, further models included the interaction terms identified through the theoretical model and reviewed literature. Variables were eliminated if they were found to be consistently insignificant across a variety of specifications. These variables included household characteristics such as whether the household has access to the internet, had taken a holiday in the past year and had purchased any vehicles or machinery in the last year, as well as the age of other household members, the number of dependents, whether the farm had a successor, the number of cattle and farm size. The final model contains robust variables which were significant across the various specifications. The explanatory power improved substantially compared with the main effects only model, increasing the adjusted R-squared by 0.264 indicating that the majority of the explanatory power derives from the interaction effects.

$$\begin{aligned}
V_{ij} = & \beta_1 \text{Income}_{ij} + \beta_2 \text{RSS}_j + \beta_3 \text{Month}_j + \beta_4 \text{Duration}_j + \gamma_1 \text{Retired}_i \text{RSSP}_{ij} + \gamma_2 \text{Pension}_i \text{RSSP}_{ij} \\
& + \gamma_3 \text{Currentscheme}_i \text{RSS}_j + \gamma_4 \text{Currentscheme}_i \text{Income}_{ij} + \gamma_5 \text{Alt.Emp}_i \text{Income}_{ij} \\
& + \gamma_6 \text{Alt.Emp}_i \text{Duration}_j + \gamma_7 \text{Wage}_i \text{Income}_{ij} + \gamma_8 \text{Wage}_i \text{RSS}_j + \gamma_9 \text{Debt}_i \text{Duration}_j + \gamma_{10} \text{Units}_i \text{Duration}_j \\
& + \eta_1 \text{Lochaber}_i \text{RSS}_j + \eta_2 \text{Lochaber}_i \text{Modulation}_j + \eta_3 \text{Lochaber.Alt.Emp}_i \text{Income}_{ij} + \varepsilon_{i1}
\end{aligned}$$

[5.1]

$$V_{i0} = \rho_1 \text{Modulation}_0 \text{SFP}_i + \varepsilon_{i0} \quad [5.2]$$

The estimated model, represented by equations [5.1] and [5.2], had an adjusted R-squared of 0.3109. The interpretation of the adjusted R-squared is not the same as when running an OLS regression, in this case an adjusted R-squared of over 0.3 represents a fairly good fitting model. The model correctly predicts 57% of the choices made in the sample¹⁴. Compared to a base model including only an alternative specific constant for the policy options the final model performs well. At the five percent level, the chi-squared test allows us to reject the null hypothesis of no additional explanatory power and all but one of the coefficients¹⁵ are consistent with our theoretical predictions.

The model allows us to calculate the probability of an individual *i* choosing option *j*. This is calculated for the average individual using equation [5.3].

$$\overline{P}_{ij} = \frac{e^{\overline{V}_{ij}}}{\sum_{k \in C} e^{\overline{V}_{ik}}} \quad [5.3]$$

Calculating the probability of participation for an average individual in each area, participation is 0.5% more likely for the average Orcadian than for the average Lochaber crofter. Section 6 will discuss the composition of the participants in a number of schemes in more detail.

The Main Effects

The first four entries relate to the pure effects of attributes on individuals without alternative employment and with no previous involvement in agri-environmental schemes. Note that modulation does not appear independently of income, this is because the model returned an insignificant co-efficient, under all specifications, for modulation but a significant coefficient for

¹³ Where Income_{ij} relates to income under scheme *j* for individual *i* and modulation refers to the proportion of the single farm payment received after modulation, hence: $\text{Income}_{ij} = \text{RSS}_j \text{Units}_i + \text{Modulation}_j \text{SFP}_i$.

¹⁴ 421 of the 728 choices.

¹⁵ The coefficient on $\text{Lochaber.Modulation}$

income. The co-efficient for income is positive, as predicted by the theory and supporting literature, however whilst the co-efficient is significant it is of very small magnitude¹⁶. The final row in table 3 displays the coefficient on the income level of the status quo option, the coefficient is statistically significant and a Wald test rejects the null hypothesis that $\beta_1 \neq \rho_1$, which implies that the marginal utility of income is constant across alternatives.

The coefficient on the payment level under the RSS (RSP) has the opposite sign to that predicted by the theory, suggesting that higher levels of per unit payment reduce the probability of acceptance of the policy. This is not offset by the positive co-efficient on income, due to its small magnitude, which suggests that this negative co-efficient represents an aversion to receiving income from the scheme rather than from the single farm payment. This opinion was expressed explicitly by some of the respondents who commented that they did not consider agri-environmental schemes to be “as worthy” as traditional farming. The magnitude of the co-efficient suggests that this opinion was also shared by other respondents.

The coefficients on Month and Duration are also both statistically significant and negative. This was expected for Month because it represents the impact of restricting the use of In-Bye grassland for an additional month, which constrains farmers who graze the land over the summer. The negative co-efficient on Duration implies that the longer the commitment period of the scheme the less likely participation in the scheme is. Theoretically, respondents may prefer longer durations because this provides security of income for the period, on the other hand some respondents may appreciate the flexibility of shorter policies. Households who have not previously taken part in agri-environmental schemes and who do not have alternative employment are thus less likely to participate in schemes of longer duration as compared the same scheme with a shorter duration.

Hypothesis 1: Differences in Participation

The multinomial logit model facilitates the testing of H1 through its inclusion of interaction terms. If heterogeneity creates significant differences in the utility derived from scheme participation then the interaction terms should have statistically significant coefficients. This was indeed confirmed by the model. All of the interaction terms in [5.1] had statistically significant coefficients, suggesting that the probability of participating in any given agri-environmental scheme is affected by the nature of access to labour and output markets.

¹⁶ Consequently, estimates of marginal prices and willingness to accept will be very large and should be interpreted with caution.

Hypothesis 2: Farming Restrictions

The multinomial logit results support the prediction that constrained households are more averse to scheme attributes which subject them to extended uncertainty or inflexibility. The results also suggest that unconstrained households are more likely to participate in schemes of longer duration. The log likelihood ratio is 0.13 higher, *ceteris paribus*, for households with alternative employment.

Hypothesis 3: Financial Incentives

The interaction effect between income and alternative employment shows that, in support of H3, unconstrained households are more responsive to financial attributes of the scheme. There is also a significant and negative interaction between the alternative wage and income. This suggests that higher off farm wages diminish the additional responsiveness to financial incentives, which fits well with the intuition that despite the financial rewards households with higher off farm wages still have a higher return from alternative labour than from devoting labour and land to the agri-environmental scheme. The model also captured the interaction between the off-farm wage rate and the per unit payment offered under the scheme. When interacted with the off-farm wage rate, the corresponding coefficient is positive suggesting that the sensitivity of respondents to financial incentives is increasing in off-farm wage rates.¹⁷

Previous Participation and Attitudes

Theoretically previous participation may signify an attitudinal predisposition in favour of environmental schemes, suggesting that individuals who had previously taken part would be more likely (at any given level of payment/income) to participate. Interestingly, this is supported by the significant and positive coefficients on the interactions between current schemes and i) RSP and ii) income. In contrast with the negative coefficient on RSP for previous non-participants this appears to represent an attitudinal divide amongst the population.¹⁸

¹⁷ Interaction effects encompassing location based constraints were also predominantly consistent with H3. Households located in Lochaber with alternative employment (less constrained) are also more responsive to changes in income from the scheme than their equivalent Orcadian counterparts.

¹⁸ Models were also run which included interaction effects between current schemes and month and duration, however in all cases the coefficients were insignificant.

6. Policy simulation

The results of the multi-nominal logit model, presented in section 5, identify the key attributes of significance and their marginal effects. The results also give an indication of the attributes which can be adjusted to reform the RSS to enhance its efficiency. This section will provide pair wise comparisons between proposed reformations of the RSS and the continuation of the RSS under its current structure. The attribute levels comprising the scenarios are presented in Table 4.

The aim of the study was to identify ways of improving the efficiency of the scheme by understanding and utilising household heterogeneity. This must be balanced against maintaining the core principles of the scheme which in this case means ensuring that the scheme remains compatible with RSPB recommendations for creating and managing habitats for birds. With this in mind three alternative policy scenarios have been constructed and compared to scenario 1 which represents the continuation of the current policy.

Attribute	Scenario 1:	Scenario 2:	Scenario 3:	Scenario 4:
Modulation	10% decrease	30% decrease	30% decrease	10% decrease
RSS per unit payment	£100	£250	£250	£150
Use of In-bye grassland	1st July	15th June	15th June	15th June
Duration of scheme	5 years	1 year	3 years	5 years
No scheme modulation	30% decrease	30% decrease	30% decrease	30% decrease

Table 4: Attribute levels for the simulation policy scenarios

Scenario 2 is the most ambitious reform of the RSS, increasing the severity of modulation to a 30% decrease. Although the model can be improved by increasing this further it seems unrealistic that the response would remain small so I have kept the scenario within the most realistic ranges. It also increases the RSS payment per unit to encourage participation and cuts both the duration of the scheme and the restrictions on in-bye grassland to remove barriers to entry¹⁹. The result is an increase in participation of 10 households contributing a total of 95 extra units to the scheme; Lochaber households represent 60% of the increase in participation. Almost all of the additional households have alternative employment. The main cost saving in this model comes from the increased severity of modulation which facilitates the introduction of higher RSS payments, with the outcome being a saving of £642.15 per unit put into the scheme (this accounts for all single farm payments made to households in and out of the scheme). Not only does this scenario boost participation and cut the cost per unit in the scheme, it also reduces the overall burden of subsidies

¹⁹ Restrictions on in-bye grassland are kept at 1.5 months to ensure that environmental goals can still be met.

and encourages a shift towards agri-environmental management which matches the proposed objectives of the authorities.

Scenario 2 presents a nice contrast to the scenario 1 however it is an extreme policy and may be limited by administrative costs and political pressure, to take this into account scenario 3 illustrates a policy in which administrative costs force the duration of the scheme to be 3 years at a minimum. This has a small effect on participation reducing the number of Lochaber households in the scheme by 2 (18 units), neither household was engaged in alternative employment. The overall cost saving per unit falls by £63.46 per unit but the total costs still remain lower than scenario 1 despite the increase in participation.

Scenario 4 is the most moderate of the reforms, it assumes that duration must remain at 5 years due to administrative rigidity and reluctance to incur additional administrative costs and also assumes that political pressure limits modulation to a 10% decrease. This policy increases participation by one household (contributing 20 units) over scenario 1, however the composition of participants has been altered leading to a rise in participation amongst households with alternative employment and a reduction in the number of participants without. The saving per unit is £104.11 - as the RSS payment is increased savings are less than this until it reaches £270 and at £280 the savings are maximized at £219.81 as participation increases, however this represents an increase in the total burden of the scheme.

A Separating Scheme

The results discussed in section 5 support hypotheses 1-3 which imply that households may be divided into two taxonomies which respond differently to scheme attributes. A fifth simulation introducing a two tier scheme was designed to create a separating equilibrium based on household heterogeneity. The attribute levels for the two tiers do not represent the optimum levels but were arrived at through empirical iteration.²⁰

²⁰ To solve for the optimum attribute levels the policy maker must solve the problem:

$$\max_{t \in T} \frac{\sum (P_{t1} + P_{t2})n_t}{c_1 + c_2}$$

(P represents the number of units submitted to the scheme, t is the type of household, n is the size of the population of t, c_i represents the costs of scheme i)

This is beyond the computational capacity of this study, but the simulation provided demonstrates the potential gains adequately.

Attribute	Tier 1:	Tier 2:
Modulation	30% decrease	50% decrease
RSS per unit payment	£100	£150
Use of In-bye grassland	15th June	15th June
Duration of scheme	1 years	4 year
No scheme modulation	30% decrease	30% decrease

Table 5: Attribute levels under simulation scenario 5

Tier 1 is a one year commitment, the RSP is £100 per unit and the single farm payment is modulated by 30%. Tier 2 is a four year scheme with an RSP of £150 per unit and modulation of the single farm payment is 50%, under both schemes restrictions on in-bye grassland last for 1.5 months. Tier 1 is designed to appeal to constrained households and tier 2 to unconstrained households. Compared to scenario 1, participation increases by 4 households contributing an additional 57 units. The two tier scheme reduces the total costs and the cost per unit by £822.69.

Scenario 5 demonstrates the scope for potential savings encompassed in RSS reforms in line with an understanding of household heterogeneity. The two tier scheme separates household types. Households with alternative employment and those located in Lochaber, characterising the unconstrained, opt mainly for tier 2. Participation under the two tier scheme is increased amongst households both with and without alternative employment, and both locations, demonstrating the ability of the scheme to cater simultaneously to constrained and unconstrained households.

7. Conclusions and Implications

This paper set out to explore the scope for household heterogeneity in creating efficiency gains in redesigned agri-environmental schemes and has approached this through the Rural Stewardship Scheme. Choice sets administered in Orkney and Lochaber provided stated preference data which was used to test the predictions of the theory.

The resulting estimated utility equations performed well at reproducing the stated choices and returned coefficient estimates for the main effects which were consistent with the underlying theory and expectations of the model. In addition to this, the model highlighted an aversion to increases in scheme duration and payments received under the scheme for households without alternative employment who had not previously participated in agri-environmental schemes.

Interaction effects facilitated the testing of predictions made with regards to additional constraints and household characteristics. The results confirmed that households with alternative employment were more responsive to changes in the payment level. The results are also consistent with previous findings that participation in voluntary schemes is lower amongst older and retired households. The results suggested that there is scope to increase participation and reduce costs by altering the attribute levels of the RSS.

Further work could make additional effort to obtain information on the perceived or actual costs of scheme compliance and the labour changes. This would facilitate a more complete understanding of the marginal prices of attributes and consumer surplus under reformed versions of the scheme. Additionally, the performance of the model could be improved through the application of more advanced techniques such as latent class or switching regression models, allowing for the inclusion of unobserved elements of household constraints.

The simulations, based on the responses to the choice sets, showed that there exists substantial potential for efficient reform of the Rural Stewardship Scheme. This paper demonstrates the value of using contingent participation models as a tool for reviewing and improving the efficiency of policy design. In particular, the ability of choice experiments to account for multiple policy attributes enables the researcher to conduct policy simulations and search through a variety of policy structures for optimal policies. An interesting future line of enquiry would be an assessment of the scale of the additional administrative burden that a separating policy would entail.

More fundamentally the paper demonstrates the value of using contingent participation models as a tool for reviewing and improving the efficiency of policy design. In particular, the ability of choice experiments to account for multiple policy attributes enables the researcher to search for optimal policies through simulations.

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