INTERNATIONAL CONFERENCE OF AGRICULTURAL ECONOMISTS
ICAE
29th | Milan Italy 2015
UNIVERSITÀ DEGLI STUDI DI MILANO AUGUST 8 - 14
AGRICULTURE IN AN INTERCONNECTED WORLD

Modelling the Participation Decision in Agri-Environmental Schemes

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Understanding what influences farmers' decisions to participate in a voluntary agri-environmental scheme (AES) is essential for gauging scheme success. The Rural Environment Protection Scheme (REPS) was a voluntary AES that was available to all Irish farmers from 1994 to 2009. This paper models the participation decision of Irish farmers in REPS using a 15-year panel dataset. The approach taken is novel: actual values for gross outputs, direct costs and working hours are compared to simulated counterfactual values using a conditional logit framework. Model results show that Irish farmers behave rationally by maximising utility from both consumption and leisure but that their preferences differ by region and over time. In addition, the participation functions of viable and non-viable farmers are dissimilar in a number of ways. Policy makers may therefore need to target both groups of farmers using separate schemes in the future.

JEL: *C33: Multiple or Simultaneous Equation Models, Models with Panel Data; Q: Agricultural and Natural Resource Economics, Environmental and Ecological Economics*

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1 Introduction

Since the MacSharry reforms in 1992, the Common Agricultural Policy has focused on achieving environmental outcomes. The use of voluntary Agri-Environmental schemes (AESs) has been an integral part of this strategy. Gaining an understanding of what influences farmers' decisions to join an AES (or not) is imperative for the evaluation of these schemes because their entire success is dependent on farmer participation. Hence, the aim of this paper is to estimate a participation function for farmers who were given the option to participate in an Irish AES.

The AES being investigated in this study is the Rural Environment Protection Scheme (REPS), which was created in response to EU Regulation 2078/92. It was the first ever Irish AES and was co-financed by the European Agricultural Guidance and Guarantee Fund and the Irish government. The scheme was available to every farmer in the country on a voluntary basis from 1994 to 2009 provided they had more than three hectares of utilisable agricultural land (UAA) that they actively farmed for the entire calendar year (DAFF, 2004). The objectives of REPS were broad, with the scheme attempting to address the majority of environmental issues that arise on Irish farms under one scheme. Any farmer who was interested in joining applied for an individual farm management plan to be drawn up by a REPS adviser. The farm management plans outlined how individuals would be required to incorporate a total of 11 measures on their entire holdings for five years if they decided to participate in REPS. The 11 measures can be loosely categorised into those that aimed to abate pollution, e.g. nutrient management, to protect farmland biodiversity, e.g. retain wildlife habitats, and to hold farmers more accountable for the environmental status of their farms, e.g. maintenance of farm and environmental records (Emerson & Gillmor, 1999).

From an Irish context, there are three important reasons why an evaluation of REPS is necessary. The first is Regulation 746/96, which states that all member states must monitor and evaluate the programmes created under Regulation 2078/92 in terms of their environmental, agricultural and socio-economic impact (Finn, Kavanagh, & Flynn, 2005). Secondly, REPS incurred high costs to the National Exchequer and needs to be evaluated for the benefit of the Irish taxpayer. For example, figures from the Department of Agriculture, Fisheries and Food (DAFF) in Ireland show that by 2010, just under €3.5 billion had been paid out to REPS farmers by the Irish government, 61% of which were paid by the State (DAFF, 2010; DECLG, 2013). Finally, REPS was the first and, until its closure to new applicants in 2009, only AES ever executed in Ireland. Since its closure, REPS has been replaced by the Agri-Environmental Options Scheme and a new scheme, GLAS, is due to be launched in the coming months. To estimate the potential effectiveness of these newer schemes, the Common Agricultural Policy recognises that we need to learn from the successes and failures of past schemes (DAFM, 2012).

There is a significant degree of variation in the objectives, institutional details, and target population of voluntary AESs throughout the EU. The primary application of the results from this study to policymaking in other countries relates to the issue of target populations. In a review by Finn (2009) of nine EU AESs, REPS had the poorest performance of all in terms of targeting specific individuals for participation. Instead, it was made universally available to (almost) every farmer in the country. Hence, a review of Irish farmers' behaviour towards REPS can be seen as a study of who is likely to join a scheme if there are little or no constraints on participation.

This study uses data from the National Farm Survey (NFS), which is a nationally representative sample of Irish farmers. It has been collected annually since 1972 by the agriculture and food development authority, Teagasc. The NFS provides information on a wide range of economic, demographic and environmental factors for Irish farms. Having a dataset that is rich in information on farm-specific variables, e.g. inputs and outputs, in addition to individual-specific variables, e.g. farmers' age or marital status, permits an estimation of the impact of REPS participation on isolated farm variables. Understanding how REPS participation impacted on isolated farm variables allows us to estimate what the value of the variables would have been if non-participants did participate in REPS and if participants did not. In other words, it allows us to create data that represent counterfactual alternatives for individuals in the NFS. Actual and counterfactual data may then be used to empirically estimate the participation decision of Irish farmers in REPS in a manner previously unused in the agricultural economics literature.

Usually the participation decision of farmers in voluntary AESs is empirically estimated by comparing individual- and farm-specific variables on participants' farms with individual-specific variables on non-participants' farms(Defrancesco, Gatto, Runge, & Trestini, 2008; Hynes & Garvey, 2009; Ma, Swinton, Lupi, & Jolejole-Foreman, 2012). These models provide important information regarding the type of farmer found in an AES but their resulting participation functions suffer from sample selection bias. Sample selection bias occurs because a loop of causality exists between the choice to participate and the individual- and farm-specific dependent variables used to describe the decision. For example, Murphy, Hynes, O'Donoghue, and Murphy (2014) show that farmers who produce low levels of organic Nitrogen are more likely to be REPS participants than not. This finding may indicate that farmers with lower organic Nitrogen levels are more likely to join the scheme than those with higher levels. It may also indicate that individuals reduce the amount of organic Nitrogen they produce as a consequence of joining the scheme. In other words, these models do not account for the fact that, oftentimes, there are fundamental differences between the sample of participants and the sample of non-participants in the study. The use of actual and counterfactual data in this paper overcomes the problem of sample selection bias because individuals are being compared with counterfactual versions of themselves, meaning the two samples only differ from each other with regard to their REPS participation status.

Evaluating AESs at farm level is not always easy because in reality farmers, not policymakers, know the true opportunity costs associated with participation (Ferraro, 2008; Steele, 2010). This is particularly true for a scheme like REPS, where payment rates were set from the top down, meaning policymakers cannot be sure if they offered farmers too much or too little compensation to entice them to join the scheme (Moxey, White, & Ozanne, 1999). Some of the existing literature has used State Preferences (SP) techniques to estimate farmers' Willingness to Accept compensation for the implementation of AESs on their farms (I. J. Bateman, Willis, & Garrod, 1994; Beharry-Borg, Smart, Termansen, & Hubacek, 2013; Espinosa-Goded, Barreiro-Hurle, & Ruto, 2010). Whilst this is a useful method for gauging the opportunity costs of participation in an AES, estimates gleaned using SP techniques suffer from the fact that they are based on individuals' perceived values for environmental goods in a hypothetical market (I. Bateman et al., 2002). In contrast, Revealed Preference (RP) methods relate behavioural models to actual choices that individuals make and as a result allow for a more realistic valuation of the opportunity costs associated with scheme implementation. In this paper we utilise a RP methodology based upon observed choice attributes in relation to choices actually made and simulated choice attributes and therefore overcome the hypothetical issue associated with SPs.

Of particular interest to this paper is a phenomenon of Irish agriculture whereby many farmers continue to farm despite the fact that they are commercially non-viable. The mere fact that non-viable farmers continue to farm suggests that they may have different opinions of farming, and therefore the role of AESs in farming, to viable farmers. If various members of the heterogeneous Irish farming community have different REPS participation functions, the likelihood that REPS exactly compensated all farmers for the opportunity costs of implementing scheme measures on their farms is low. Hence, for this paper, the REPS participation decisions of non-viable farmers and viable farmers are estimated separately.

This paper proceeds with a description of the farm household model and a discussion of how viable and non-viable farmers are expected to respond to the REPS participation decision given the components of the model. Section 3 describes the econometric model that is used to estimate the REPS participation decision and outlines how counterfactual data are created to be used in the models showing farmers' REPS participation functions. Section 4 introduces the data used for the analysis. Section 5 shows values for the counterfactual data, showing farmers' hypothetical alternative participation decision, that are used for the analysis in the paper. It also displays results from a conditional logit showing the participation function for all Irish farmers and separate participation functions for viable and non-viable farmers as well as providing a discussion of results. Section 6 provides concluding remarks.

2 Theoretical model

The aim of REPS was to use monetary incentives to change farmers' behaviour; in return for receiving REPS payments, participation incurs opportunity costs and effort for the farmer. In this paper, individuals are expected to have viewed the choice to participate in REPS (or not) as a time-allocation decision, as described by Becker (1993), which assumes that family decisions are reached through weighing the advantages and disadvantages of alternative actions. The farm household model, which assumes the farm household decisions are derived from maximising utility over consumption and leisure, has been used to look at farmers' off-farm employment decisions (Ahearn, El-Osta, & Dewbre, 2006; El-Osta, Mishra, & Ahearn, 2004; Kimhi, 2004) and the impacts of decoupled payments (Weber & Key, 2012) and setaside programmes (Chang & Boisvert, 2009) on farmer utility. To date, it has not been applied to the time-allocation decision of farmers' choices to participate in an AES or not.

The farm household model assumes that farmers will choose management options that provide them with the highest level of utility subject to constraints, where utility is derived from income and leisure:

$$U_i = U(Y_i, T_i; Z_i) \tag{1}$$

where farmer *i* gains utility, U_i, from purchased goods, Y_i, and leisure time, T_i. Farm- and individual-specific characteristics, Z_i, may influence utility directly. Farmers maximise their utility subject to constraints on time, income and farm production:

$$T = T_i + T_f + T_{of} \tag{2}$$

$$P_m Y_i = P_f Y_f - RX + W_{of} T_{of} + V \quad (3)$$

$$Y_f = f(T_f, M; Z_f, H_f) \quad (4)$$

Equation 2 shows the time constraint. Household members have a fixed amount of time, *T*, which can be allocated to home time, T_i, time spent on farm work, T_f, or time spent at off-farm work, T_{of}. The budget constraint in Equation 3 shows that the consumption of market goods, Y_i, at the price P_m is limited by the amount of available income earned from farm profits, off-farm wages and other exogenous household income. Farm profit is equal to the price of farm output, P_f, multiplied by output, Y_f, less variable cost, which is the input price vector, *R*, multiplied by the quantity of inputs used, *X*. Off farm income is the product of the hours worked off farm, T_{of}, and the wage rate, W_{of}. *V* contains information on other exogenous household income such as decoupled payments. Finally, the farm production constraint in Equation 4 represents the technology available to produce farm output, Y_f, where $f(.)$ is a concave production function that relates time spent doing on-farm work and the quantity of inputs used, *M*, to output. Exogenous farm-specific characteristics, Z_f, and human capital stock variables, H_f, both directly, and indirectly (through T_f and *M*), influence output production.

Previous work has shown that those most likely to participate in REPS from 1995 to 2010 had more extensive farms (lower production levels) and were more likely to fall into lower gross margin per hectare farming activities than non-participants (Murphy et al., 2014). Figure 1 (below) has been created to depict the difference between how lower and higher earning farmers may view the choice to participate in REPS. It shows the expected budget constraints and preferences of lower, and higher, income farmers in relation to the REPS participation decision in Figures 1(a), and 1(b), respectively.

(Figure 1)

The budget constraints in Figure 1 are represented by solid lines with participating farmers in green and non-participants in red. The downward slopes show how farmers are expected to view the choice to participate in REPS (or not) as a time-allocation decision, as described by Becker (1993), whereby farm household decisions are derived by maximising utility over consumption and leisure. The vertical drop in income in the budget constraints indicate where farmers are not in receipt of the Single Farm Payment (SFP), the absence of which results in a decrease in income for no additional leisure. The budget constraints also show that certain farmers have zero or negative incomes.

The left side of Figures 1(a) and (b) show that individuals with higher earnings may face a drop in income if they choose to join REPS. This is because certain requirements of the scheme demand that farmers extensify their farms, which often leads to a reduction in the amount of commodities produced by the farm. The impact of obligatory extensification is expected to be larger for higher earning farmers (Figure 1(b)) because they will need to reduce productivity further than lower earning farmers (Figure 1(a)) to meet the extensification targets of the scheme. Moving down the budget constraint, the difference between the utility gained from non-participation and non-participation lessens. Point X shows where REPS payments perfectly compensate farmers for the opportunity costs of participating in the scheme. To the right of point X, the net amount of income from participating in REPS is higher than from non-participation. It is important to note that Figure 1 shows that participating in REPS never provides farmers with as much leisure time as non-participation. This is a consequence of the additional effort required to implement scheme measures on farm holdings.

A main point of interest in Figure 1 is that the preference curves (dashed lines) for lower and higher earning farmers are at different ends of the budget constraint. Namely, the gap in utility levels for lower and higher earning farmers is greatest on the right, and left, side of the curve, respectively. This implies that the choice to participate in REPS may have either a positive or negative influence on farmers' utility levels depending on an individual's income levels. Figure 1 therefore goes a long way to explaining why lower earning farmers were more likely to participate in REPS than higher earning farmers.

In reality, there is significant variation in farmers' preferences towards REPS participation throughout the heterogeneous population of Irish farmers. For example, farm-and individual-specific characteristics (Z_i in Equation 1) are expected to influence farmers' preferences towards AES participation. Farm-specific characteristics would have indirectly provided farmers with utility through income or leisure time because certain farm-specific characteristics are associated with higher or lower income levels or leisure times. For example, farmers' with productive soil types are presumed to get, *ceteris paribus*, a greater amount of utility from income (and therefore consumption) than those who do not have productive soil types. Similarly, individual-specific characteristics in Z_i are expected to influence farmers' utility levels indirectly through income or leisure. For example, younger farmers may associate an increase in on-farm income with higher utility levels than older farmers because they have a young family to provide for, whereas older farmers may place a higher value on utility from leisure. Individual-specific characteristics may also directly impact on farmers' utility levels. Certain individuals may, for example, gain utility directly from on-farm work as a consequence of producing goods or of working in the outdoors. The manner by which this paper creates counterfactual data accounts for personal preferences by ensuring that individuals' actual choice (the red or green line in Figure 1) is compared with their counterfactual choice (the green or red line in Figure 1). Hence, the impact of personal preferences across observations is held constant.

3 Statistical model

The REPS participation decision is a discrete choice made by farmers. Discrete choice models are based on random utility theory, or the assumption that utility contains a deterministic element, *V,* and a random element, *ε*. *V* and *ε* are assumed to be additive. In discrete choice models, *V* is usually specified to be linear in its parameters (σ) for a vector of observed attributes, X_i, relating to Y_i and T_i (Equation 1), for individual *i*. In other words, $V_i = \sigma' X_i$ (Train, 2003).

From 1994 to 2010, Irish farmers had two alternatives to choose between regarding the REPS participation decision (*j* = 0, 1), which were contained in the set *C*. The level of utility that farmer *i* gets from choosing alternative *j* can be viewed indirectly using:

$$U_{ij} = U(X_{ij}, \varepsilon_{ij}) = V_{ij} + \varepsilon_{ij} = \sigma' X_{ij} + \varepsilon_{ij} \quad (5)$$

The level of utility that farmers assign to each alternative *j* and *k* are not witnessed but the discrete choice outcome made by farmers are, so that:

$$Pr(Y_{ij} = 1|C) = Pr(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}) \quad (6)$$

Equation 6 contains information in the random terms that is unobservable to the researcher. To account for this lack of knowledge, random utility models are based on the random utility maximisation rule. Equation 6 can be rearranged to reflect:

$$Pr(Y_{ij} = 1|C) = Pr(\varepsilon_{ik} - \varepsilon_{ij} < V_{ij} - V_{ik}) = Pr(\varepsilon_{ik} - \varepsilon_{ij} < \sigma' X_{ij} - \sigma' X_{ik}) \quad (7)$$

As a result, *V* can now be linked with a statistical model of human behaviour. The resulting conditional logit models assumes that the random terms for each alternative are independently and identically distributed (IID). Secondly, the error terms, ε_{ij} and ε_{ik}, are assumed to be Gumbel (or Extreme Value Type 1) distributed. As the difference between two Gumbel distributed variables is the logistic distribution, this latter assumption creates a conditional logit:

$$Pr(Y_{ij} = 1|C) = \frac{1}{1 + exp(\lambda \sigma' X_{ij})} \quad (8)$$

where λ is a scale parameter, which is inversely proportional to the variance of the random term and is commonly normalised to 1 for any one dataset (Hanley, Wright, & Alvarez-Farizo, 2006a). The REPS participation decisions of Irish farmers are modelled using a maximum likelihood estimation procedure.

Two conditional logit models are used to look at farmer participation behaviour for the entire population of Irish farmers:

- Restricted: Four attributes of the alternatives on choice; farm income, REPS payments, on-farm hours and off-farm hours.
- Unrestricted model: Better describes the participation function of Irish farmers by accounting for the influence of farm- and individual-specific characteristics on farmers' utility from income and leisure. Variables representing farm- and individual- specific characteristics are included in X_{ij} by interacting them with the choice attributes. Hence, the attribute is shifted by the characteristic (Borooah, 2001).

3.1 Counterfactual alternatives

To estimate elasticities for each of the attributes contained in V_{ij} (Equation 6), which are expected to influence farmers' participation decision, this paper requires the creation of counterfactual values for each of these attributes. These counterfactual values are used to represent farmers' alternative REPS participation outcomes so that they may be compared with their actual participation outcomes. Specifically, information on the levels of farm income, REPS payments and on- and off-farm hours associated with farmers' alternative participation outcomes are generated for this study.

The modelling framework used to achieve this goal has not, to date, been applied to answering questions in the environmental or Agricultural economics literature. The method was, however, introduced in the labour supply literature in 1995 by van Soest (1995) and has become well-established since e.g. (Blundell & Macurdy, 1999; Creedy & Guyonne, 2005).

Counterfactual variables are created using Teagasc's Income Generation Model (IGM); a complex system of equations that was created to understand and describe the distribution of farm income and its components in the NFS (O'Donoghue & Lennon, Forthcoming). This paper is particularly concerned with how the IGM estimates the impact of the REPS participation decision on livestock units per hectare from dairy, cattle and sheep; gross outputs per livestock unit from dairy, cattle and sheep; gross outputs per hectare from cereals; costs per hectare for the 10 cost variables in Table 1 and on- and off-farm hours worked per year.

4 Data

All the data for this paper are derived from NFS datasets for the years 1994 to 2010. A total of 20,459 actual NFS observations are used in this study. Table 1 below shows summary statistics for REPS and non-REPS farmers in the NFS during this period. They are shown for the entire sample and are also divided into viable and non-viable groups.

The first 18 lines of Table 1 show average values for gross outputs, decoupled subsidies and costs (in italics) on Irish farms from 1994 to 2010. Gross outputs are sources of income gained as a consequence of production. Decoupled subsidies include direct payments that were not awarded to farmers based on their production levels (they do not include REPS payments). Costs include all expenditure on farm-related business during the study period. Values for these variables are displayed separately for REPS farms and for non-REPS farms. As well as displaying the values for the entire sample of REPS and non-REPS farms (columns 2 and 5), Table 1 shows average gross outputs, decoupled subsidies and costs for viable and non-viable REPS farms (columns 3 and 4) and for viable and non-viable non-REPS farms (columns 6 and 7).

The four most important gross outputs for Irish farmers are dairy, cattle, sheep and cereals, which is why they are displayed separately in Table 1. Table 1 shows that gross outputs from cattle, dairy, tillage, all costs (aside from one exception mentioned below), and on-farm hours worked are higher on non-REPS farms than REPS farms for the entire sample, for viable farms and for non-viable farms. These differences may be a consequence of REPS farmers being obliged to change how they manage their farms as part of their contracts. They may also be due to sample selection bias, whereby farmers with lower production levels (and therefore lower gross outputs and inputs) and those who work shorter hours on their farms are more likely to join the scheme in the first place. This is assumed to be because joining is associated with lower opportunity costs for less productive farm types.

An exception to the finding for costs mentioned above is that the cost of vet and medical care is higher on non-viable REPS farms than on non-viable non-REPS farms. Certain requirements of the REPS contract may have been relatively more expensive for non-viable REPS farmers (when compared with non-viable non-REPS farmers) than for other REPS farmers. This finding for the costs of medical care may be a consequence of increases in vet bills for attending to new rare breeds introduced on farms under the supplementary measures.

(Table 1)

Gross outputs from sheep are higher on REPS farms than non-REPS farms for the entire sample, for viable farms and for non-viable farms. These findings for sheep enterprises can be explained by the fact that farmers whose specialisation was sheep production were more likely to participate in REPS over time than any other enterprise (see Paper 4).

Examples of sources of other gross outputs in Table 1 include pigs, horses or machinery hire, among other things. For the entire sample, for viable farmers and for non-viable farmers, those in REPS have higher earnings from other gross outputs, as well as higher off-farm hours, than non-REPS farmers. This is likely to be because REPS farmers need to supplement their lower incomes from conventional enterprises by diversifying their on-farm profit sources and by earning more off the farm.

The gross outputs, decoupled subsidies and costs in Table 1 are all components of farm income, which is calculated as:

$$\text{Farm Income} = \text{Gross Outputs} + \text{Decoupled Subsidies (excl. REPS)} - \text{Costs} \qquad (9)$$

The values for farm income, REPS payments, on-farm hours and off-farm hours in Table 1 (in bold) are attributes for farmers' actual participation decision in REPS. The first two attributes – farm income and REPS payments – represent farmers' actual total on-farm earnings (Y_i in Equation 1). Data on farmers' off-farm earnings for the entire period are not available from the NFS. However, as the decision to participate in REPS is an on-farm management decision, on-farm earnings are expected to capture most of the influence of income on the participation decision.

The remaining two attributes of farmers' actual REPS participation decision in Table 1 are the values for on- and off-farm working hours. They are used to capture the influence of farmers' leisure time (T_i in Equation 1) on utility.

5 Results and discussion

Table 2 below shows simulated counterfactual values for the 14 components of farm income (dairy, cattle, sheep and cereal gross outputs and all the cost variables) contained in Table 1. As mentioned above, the farm income variable has been created from these values according to Equation 9. Table 2 also shows counterfactual values for REPS payments and on- and off-farm hours. The values for farm income, REPS payments and on- and off-farm hours in Table 2 (in bold) represent attributes of the counterfactual participation outcome for farmers in the NFS from 1994 to 2010.

A comparison of the attributes of the actual participation alternative (Table 1) and the attributes of the counterfactual participation alternative (Table 2) reveals the effect of the switch from REPS to non-REPS (or vice versa) on the entire sample, on viable farmers and on non-viable farmers. The impact of switching from REPS to non-REPS on the entire sample is an increase in gross outputs from dairy and sheep and a decrease in gross outputs from cattle and cereals. REPS farmers would need to pay more for five of the 10 listed costs and less for the remaining five. They would work fewer hours both on- and off-farm. They would also go from earning €30,270.35 in combined farm income and REPS payments to just €26,443.20 in farm income. The direction of change in the value of variables for viable REPS farmers are the same as for the entire REPS sample only they would risk losing €4,286.19 by becoming non-REPS farmers. Non-viable REPS farmers risk having lower gross outputs from sheep enterprises, although the cost of purchased concentrates would be lower. For becoming non-REPS farmers, non-viable REPS farmers would lose €3,408.15 per year.

(Table 2)

Conversely, the impact of switching from being a non-REPS farmer to a REPS farmer for the entire sample would be a decrease in all four output values as well as all but three costs. Non-REPS farmers would work longer hours both on- and off-farm. For all this, they would lose €2397.30 in farm income and receive €4781.42 in REPS payments. The types of change for viable non-REPS farmers are the same as for the entire sample, only they would lose €3542.57 in farm income and gain €5224.74 in REPS payments. Non-viable non-REPS farmers would receive higher outputs from cattle and would also pay higher amounts for five of the costs listed in Table 2 if they had joined REPS. For these changes, they would lose €1318.52 in farm income but receive €4363.82 in REPS payments annually.

(Table 3)

Table 3 shows the results from a restricted model and an unrestricted model of the REPS participation decision. The restricted model contains variables for the attributes of the choice in their simplest form. Its results indicate that farmers associate additional farm income and REPS payments with utility, and additional on- and off-farm working hours with disutility. The findings for on- and off-farm hours imply that farmers choose the REPS participation alternative that provides them with greater leisure time. The final variable in the restricted model is actual participation in REPS. It is negatively associated with farmers' actual participation alternative. This implies that the choice to participate in REPS is not viewed positively by the farming community in general.

The pseudo R^2 value of the unrestricted model is higher than the pseudo R^2 value of the restricted model in Table 3. A higher pseudo R^2 value indicates that the improvement of the unrestricted model on the underlying null model at describing variation in farmers' participation decision is greater than the improvement of the restricted model on the underlying null model. A Wald test has also been used to compare the results from the unrestricted model with the restricted model. It does this by investigating the hypothesis that the additional parameters in the unrestricted model are simultaneously equal to zero. This hypothesis is firmly rejected, meaning the unrestricted model is significantly better at describing the REPS participation decision than the restricted model (Train, 2003).

The unrestricted model shows that the influence of increasing farm income on farmers' participation decision is not as simplistic as the restricted model suggests. The significance of the farm income^2 variable in the unrestricted model implies that the marginal effect of farm income on farmers' participation decision lessens as the value of farm income increases. The unrestricted model in Table 3 contained a number of other variables besides those listed in the table. It is worth noting that a number of the spatially shifted farm income variables in the unrestricted model are significant. This means that the marginal influence of farm income on the participation decision was greater or less for different locations throughout the country.

The marginal utility of farm income from having soil type 1 is positive and significant in Table 3. Soil type 1 is the most productive soil type that Irish farmers can have. This finding implies that individuals with more productive farms get greater marginal utility from income than those with poor soil types (the coefficient for farm income interacted with soil type 3 is negative) and are therefore more likely to make their REPS participation decision based on which alternative provides them with higher levels of farm income than other farmers.

Findings from the unrestricted model in Table 3 show that the effects of on- and off-farm hours on the REPS participation decision are not as simplistic as the restricted model suggests either. Farmers get greater utility from increased working hours (both on- and off-farm) to a point, after which they associate additional work hours with disutility. Therefore, they are expected to make their REPS participation decision based on the alternative that provides them with their optimal work versus leisure hours.

Use of a cubic functional form for REPS payments in the unrestricted model shows that the effect of REPS payments on farmers' participation decision is initially positive but becomes negligible as the value of the payments increases. This finding is expected given the marginal decrease in the values of payments per hectare with increasing farm size in the contract.

(Table 4)

Table 4 shows the results of two unrestricted conditional logits for farmers' participation decisions in REPS[1]. The first model displays viable farmers' participation function and the second model shows the same for non-viable farmers. There are a number of differences between the direction and significance of the coefficients for the two models.

The unshifted variable for farm income is positive and significant for viable farmers in Table 4. The impact of on-farm working hours on viable farmers' participation decision is insignificant. This implies that viable farmers choose participation options that do not alter their current on-farm practices (at least in terms of work hours). The combined findings for farm income and on-farm working hours imply that viable farmers emphasise the importance of utility from on-farm earnings over increased leisure time when making their REPS participation decision.

In contrast, the unshifted variable for farm income in the non-viable model is insignificant. Non-viable farmers' participation function is negatively associated with the number of on-farm hours they work. It is also positively influenced by off-farm hours to a point, after which extra off-farm hours are associated with additional disutility. This implies that non-viable farmers are more likely to choose the participation alternative if it means they will work fewer hours on-farm and greater hours off-farm. This is likely to be because they need off-farm income to supplement their non-viable farms. Finally, the pseudo R^2 value for the non-viable logit is substantially lower than that of viable farmers (0.1892 versus 0.3255 in Table 4). Hence, the variables included in the models explain more of the variation in viable farmers' preferences than non-viable farmers, whose participation functions need to be explained by other, unobservable influences. These descriptions of viable and non-viable farmers correspond with the two farmer types described by Willcock (1999): those who attach more importance to farming as a business and those to farming as a way of life.

Variation in the utility from joining REPS for the five regions listed differ substantially for the entire sample (Table 3) as well as for viable and for non-viable farmers (Table 4). This is almost certainly due to regional variation in farm types, and farm productivity across the country. It implies that further variation in farmers REPS participation decision may be seen across the country.

The differences in the participation functions of viable and non-viable farmers imply that by attempting to attract heterogeneous farm types to one scheme, the effectiveness of REPS was reduced. It would have been more effective if it had appealed to the preferences of the two farmer types separately. One contract could have been created for viable farmers, which appealed to the business side of farming, and a second contract could have been used to attract non-viable farmers by emphasising the importance of farming as a way for life.

[1] It is important to note that, due to the existence of scale parameters, the values of the coefficients in the viable and non-viable choice functions cannot be directly compared (Hensher *et al*., 2006). However, the signs and significance of the variables are comparable.

6 Conclusions

The restricted model in Table 3 shows Irish farmers behave rationally, maximising utility from consumption through farm income and REPS payments. Results from the unrestricted model do not alter these findings but they show that farmers' utility-maximising behaviour with regard to the REPS participation decision is complex, changing regionally and over time.

Table 4 shows that the REPS participation functions of viable and non-viable farmers differ in many ways. In particular, non-viable farmers, who continue to farm despite being unprofitable, do not maximise utility from on-farm production in a manner similar to viable farmers. Willcock (1999) suggests that many individuals do not view farming as a business but primarily as a way of life. Non-viable farmers may fall into this category. If they do, the motivations behind their on-farm management decisions are fundamentally different from those of viable farmers.

Results from this paper show that using a top-down approach to set REPS payments, with the intention of attracting both viable and non-viable farmers, reduced scheme effectiveness. This is because farmers' perceived opportunity costs of participating in REPS cannot be exactly met if the way that they value the attributes of the choice differs throughout the population. An alternative to top-down price setting that may alleviate this problem is auctioning. Auctions can be used to allow farmers to dictate the minimum possible amounts that they would be willing to accept in return for their perceived opportunity costs associated with joining the scheme (Kirwan, Lubowski, & Roberts, 2005).

The manner by which farmers make their REPS participation decision varies substantially by region for the entire sample and for both viable farmers and non-viable farmers. Whilst this study was primarily concerned with examining whether viable and non-viable farmers have different REPS participation functions, further research in this area should also account for these other sources of heterogeneity in farmers' preferences. In particular, latent class models, which account for heterogeneity in preferences by assuming that individuals belong to one of a defined set of classes, could be incorporated into future work. Latent class models use sample data to estimate the probabilities of class membership for individuals and estimate different preference functions for each class identified (Greene, 2003). Thus, using a latent class model could lead to a comparison of REPS participation functions for, say, a class containing low income, mainly western sheep or cattle farmers with a class containing high income, mainly southern dairy farmers.

The models used in this paper provide a convincing description, which is supported by economic theory, of how Irish viable and non-viable farmers make their REPS participation decisions. Findings from these models can be used in future work to predict how Irish farmers will respond to alternative AESs under a variety of conditions.

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Tables

Table 1: Attributes of the REPS participation decision (actual values)

Variable	REPS			Non-REPS		
	Entire sample	*Viable*	*Non-viable*	*Entire sample*	*Viable*	*Non-viable*
	n = 5,943	*n = 2,836*	*n = 3,107*	*n = 14,516*	*n = 7,041*	*n = 7,475*
Gross Outputs (€)						
Dairy	12,160	20,393	4,645	28,571	47,065	11,152
Cattle	11,178	14,325	8,305	15,163	21,096	9,574
Sheep	2,681	3,294	2,122	2,112	2,677	1,580
Cereals	2,889	4,870	1,080	7,212	12,572	2,162
Other gross outputs	*14,562*	*18,008*	*11,417*	*7,600*	*10,432*	*4,932*
Decoupled Subsidies (excl. REPS) (€)	8,423	11,220	5,869	12,834	16,893	9,011
Costs (€)						
Purchased concentrate	4,016	5,159	2,973	6,973	10,100	4,027
Purchased bulky feed	409	492	333	667	764	576
Fertiliser	2,269	3,041	1,564	4,342	6,487	2,321
Crop protection	522	815	254	1,160	1,935	429
Purchased seed	295	455	150	631	1,028	257
Vet and med	1,440	1,793	1,118	1,693	2,320	1,102
Artificial insemination	264	343	192	661	977	364
Car, electricity, phone	1,446	1,708	1,207	1,956	2,505	1,439
Other direct costs	3,620	4,685	2,647	6,321	9,254	3,559
Other overhead costs	12,374	15,196	9,798	18,835	27,120	11,031
Farm Income (€)	25,237	38,424	13,200	30,252	48,244	13,305
REPS Payments (€)	5,033	5,766	4,364	0	0	0
On-farm (hours/year)	1,966	2,095	1,847	2,105	2,265	1,954
Off-farm (hours/year)	491	334	635	304	156	444

Table 2: Attributes of the REPS participation decision (counterfactual values)

Variable	Counterfactual Non-REPS			Counterfactual REPS		
	Entire sample	*Viable*	*Non-viable*	*Entire sample*	*Viable*	*Non-viable*
	n = 5,943	*n = 2,836*	*n = 3,107*	*n = 14,516*	*n = 7,041*	*n = 7,475*
Gross Outputs (€)						
Dairy	12,331	20,677	4,713	27,998	46,090	10,957
Cattle	11,061	14,186	8,208	15,154	21,055	9,595
Sheep	2,689	3,312	2,121	2,067	2,613	1,553
Cereals	2,839	4,789	1,060	7,094	12,344	2,149
Other gross outputs	14,562	18,008	11,417	7,600	10,432	4,932
Decoupled subsidies (excl. REPS) (€)	8,423	11,220	5,869	12,834	16,893	9,011
Costs (€)						
Purchased concentrate	3,929	5,055	2,901	7,078	10,231	4,109
Purchased bulky feed	474	572	384	572	653	497
Fertiliser	2,428	3,258	1,671	4,038	6,024	2,167
Crop protection	530	828	258	1,140	1,903	422
Purchased seed	316	487	161	589	959	240
Vet and med	1,427	1,779	1105	1,696	2,319	1,110
Artificial insemination	276	360	200	621	914	346
Car, electricity, phone	1,429	1,689	1,191	1,972	2,520	1,456
Other direct costs	3,598	4,663	2,626	6,255	9,128	3,549
Other overhead costs	11,056	13,599	8,735	20,928	30,074	12,313
Farm income (€)	26,443	39,904	14,157	27,855	44,701	11,986
REPS payments (€)	0	0	0	4,781	5,225	4,364
On-farm (hours/year)	1,944	2,062	1,836	2,140	2,304	1,985
Off-farm (hours/year)	396	268	512	385	234	527

Table 3: REPS participation decision for entire population

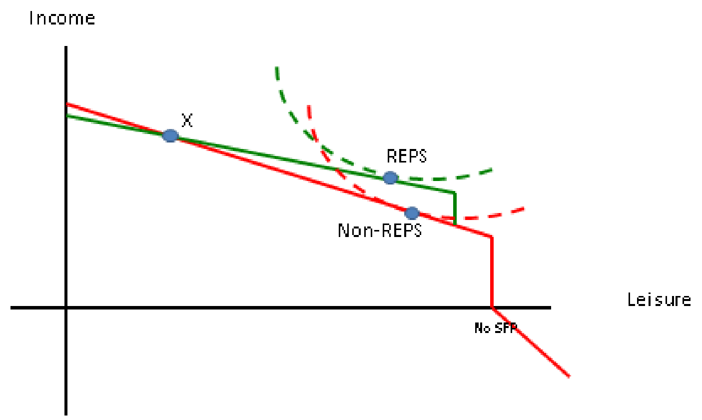
Variables	**Restricted**	**Unrestricted**
Income	*β (S.E.)*	*β (S.E.)*
Farm income (exc. REPS) (€)	0.000297 (0.000011)***	0.000095 (0.000046)**
Farm income (exc. REPS) (€)^2		0.000000` (0.000001)***
Farm income (exc. REPS) (€)*REPS payment (€)		-0.000000' (0.000001)***
Farm income (exc. REPS) (€)*Soil1^		0.000100 (0.000017)***
Farm income (exc. REPS) (€)*Soil3^		-0.000034 (0.000042)
Time		
Time spent working on farm per year (hours)	-0.000438 (0.000163)***	0.005115 (0.000915)***
Time spent working on farm per year (hours)^2		-0.000001 (0.000001)***
Time spent working off farm per year (hours)	0.000120 (0.000059)**	0.002277 (0.000300)***
Time spent working off farm per year (hours)^2		-0.000001 (0.000001)***
Time spent working on farm per year (hours)*		
Time spent working off farm per year (hours)		-0.000001 (0.000001)***
REPS Payments		
REPS payment (€)	0.000147 (0.000009)***	0.001760 (0.000102)***
REPS payment (€)^2		-0.0000001 (0.000000')***
REPS payment (€)		0.000000` (0.000000')***
REPS participation		
In REPS	-1.013532 (0.044289)***	-4.505853 (0.161170)***
Pseudo R^2	0.1489	0.2205
Wald Test	…	1852.46***

Table 4: REPS participation decision for viable and non-viable farmers

Variables	Viable	Non-Viable
	β (S.E.)	*β (S.E.)*
Income		
Farm income (exc. REPS) (€)	0.000200 (0.000059)***	0.000035 (0.000097)
Farm income (exc. REPS) (€)^2	-0.000000` (0.000001)	0.000000` (0.000001)
Farm income (exc. REPS) (€)*REPS payment (€)	-0.000000` (0.000001)***	-0.000000` (0.000001)***
Farm income (exc. REPS) (€)*Soil1^	0.000100 (0.000022)***	0.000129 (0.000031)***
Farm income (exc. REPS) (€)*Soil3^	-0.000011 (0.000058)	-0.000116 (0.000066)*
Time		
Time spent working on farm per year (hours)	0.002040 (0.001370)	-0.00889 (0.001403)
Time spent working on farm per year (hours)^2	-0.000001 (0.000001)	-0.000001 (0.000001)***
Time spent working off farm per year (hours)	0.00117 (0.000546)**	0.003130 (0.000414)***
Time spent working off farm per year (hours)^2	-0.000001 (0.000001)	-0.000001 (0.000001)***
Time spent working on farm per year (hours)*		
Time spent working off farm per year (hours)	-0.000001 (0.000001)***	-0.000001 (0.000001)
REPS Payments		
REPS payment (€)	0.003308 (0.000178)***	0.000776 (0.000151)***
REPS payment (€)^2	-0.000001 (0.000001)***	-0.000001 (0.000001)***
REPS payment (€)^3	0.000000` (0.000001)***	0.000000` (0.000000')***
REPS participation		
In REPS	-629578 (0.275478)***	-3.57779 (0.238357)***
Pseudo R^2	0.3255	0.1892
Wald Test	1532.20***	1026.65***

Figures

(a) Lower farm incomes



(b) Higher farm incomes

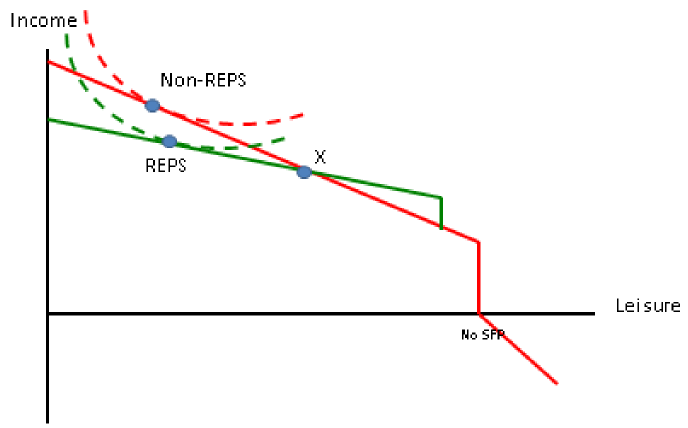


Figure 1: Budget constraints and preferences for (a) lower income farmers and (b) higher income farmers. Green lines: REPS participants; red lines: non-participants.