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# The impact of farmers' implementation decisions on environmental effectiveness in the Rural Environment Protection Scheme (REPS)

by

Geraldine Murphy BA (Mod), MSc (Agr)

A thesis submitted in fulfilment of the degree of Doctor of Philosophy

J.E. Cairnes School of Business and Economics,

National University of Ireland, Galway

Rural Economy and Development Programme (REDP),

Teagasc, Galway

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# Abstract

The primary objective of this thesis is to investigate the impact of farmers' implementation decisions on the effectiveness of the Rural Environment Protection Scheme (REPS). Three separate empirical papers are used to achieve this objective. The first two papers focus on the impact of farmers' participation decisions on effectiveness, while the final paper addresses whether allowing farmers a role in how scheme measures were implemented into their individual farm management plans impacted on the effectiveness of the scheme. This thesis makes a significant contribution to evaluation literature for voluntary agri-environmental schemes (AESs). In doing so, it provides imperative information for policymakers involved in the design of future AESs, particularly in relation to the Irish context.

REPS had broad environmental objectives that covered both pollution abatement and biodiversity conservation. Therefore, it would have been effective if, firstly, the type of farmer who joined had to reduce pollution outputs to participate in the scheme and, secondly, if a wide variety of habitat types were found in the scheme. The first paper in this thesis aims to investigate whether the type of farmer who participated in REPS from 1995 to 2010 met these criteria. There were four separate phases of REPS. Contracts for all the phases were similar, although a few changes were made in attempts to increase participation rates over time. In particular, payment rates increased and restrictions on organic nitrogen production were reduced. Given these changes, the second objective of the first paper in this thesis is to assess whether the type of farmer who joined REPS improved in terms of the scheme's pollution abatement and biodiversity conservation objectives across the four phases.

The first objective of the first paper is met by using a random effects logit model applied to National Farm Survey (NFS) data to look at the type of farmer who joined REPS from 1995 to 2010, inclusive. To achieve the second objective, the type of farmer who was most likely to participate in REPS is estimated for four separate years using NFS data. Each chosen year represents a different REPS phase (REPS I, II, III and IV). Results show that the type of farmer who was most likely to participate in REPS over time had, *ceteris paribus*, lower income levels and chemical usage than non-REPS farmer. However, the type of farmer in each phase differed substantially. Increases in payment rates from earlier to later phases of the scheme did not appear to improve scheme effectiveness with regard to the type of farmer who

joined the latter phases of the scheme, whereas the removal of restrictions on organic nitrogen production did.

A difficulty associated with the estimation of AES participation decisions using data for actual participants and non-participants is that the final model suffers from sample selection bias. The first objective of the second paper in this thesis is to address the problem of sample selection bias by estimating farmers' participation functions using actual and counterfactual choice data for all Irish farmers from 1995 to 2010. REPS was universally available to every farmer in Ireland from 1994 to 2009. To be deemed effective, REPS should have ideally attracted as many farmers as possible to the scheme by offering them sufficient, but not too generous, compensation rates for the perceived opportunity costs of joining.

A phenomenon in Irish agriculture is that many individuals continue to farm despite their farms being commercially non-viable (Hynes and Hennessy, 2012). Given the difference between viable and non-viable farmers, they are expected to view the REPS participation decision differently. The second objective of the second paper in this thesis is to estimate separate REPS participation functions for viable and non-viable Irish farmers to investigate whether they perceived the choice in the same way. These objectives are met using conditional logit models. The REPS participation functions estimated in the second paper are in agreement with economic theory. Results show that viable and non-viable farmers perceived the REPS participation decision differently. This implies that by attempting to appeal to a heterogeneous population using just one contract, the effectiveness of REPS was reduced.

Each participant in REPS was given an individual farm management plan, meaning farmers' input into how scheme measures were implemented on their holdings was permitted. The final paper of the thesis investigates how this impacted on the likelihood that farm habitats were assigned to the correct management options, called biodiversity undertakings (BUs), on their farms. To achieve this goal, habitat types are, firstly, assigned to their ideal BUs with the help of ecological experts. Secondly, two multinomial logits are used to estimate how farmers actually assigned the habitats on their farms to BUs. The first model looks at farmers' BU decisions conditional on their joining REPS while the second includes an Inverse Mills Ratio (IMR) to capture the effect of participation on BU choice.

The modelling of the relationship between farm habitat and BU assignment under REPS in the third paper is made possible with the use of new data on farmland habitats, which are geo-linked to NFS data for 2007. Use was also made of an additional survey taken at this time on the BU choices made by REPS farmers in the NFS. Finally, a comparison between the optimal choices farmers should have made and their actual choices is carried out. The main finding of this study is that farmers did not make optimal choices for the habitats on their farms although, interestingly, the appropriateness of their choices varies across habitats. Consequently, the findings from this paper show that allowing farmers (and their advisors) a role in how scheme measures were implemented on their farms resulted in a decrease in the effectiveness of the scheme.

## Personal acknowledgements

The extent to which others helped with the production of the three papers in this thesis is acknowledged in later pages. However, the help I received from others during the PhD process extended further than the yielding of academic outputs. On this page, I wish to thank those who gave me the necessary support, encouragement and perspective to get me through my five-year journey.

Thank you, Dr Dr Stephen Hynes, for being “very” honest, dependable and pragmatic. It was a pleasure working with you. Thank you, Dr Cathal O’Donoghue, for your positivity and ingenuity.

Thank you to all the academic and administrative staff at the J.E. Cairns School of Business and Economics, NUIG, and the REDP, Teagasc, Athenry. The friendly, helpful atmospheres at both workplaces provided great comfort for a girl from the big shmoke.

Thank you to my friends from the academic community, whose support and empathy were invaluable throughout the years. Thank you, Sinéad, for the daily constitutionals. Thank you to my friends from outside the academic community. Your deliverance of reality and perspective kept me sane.

I have a wonderful family, who I love dearly. This process would have been near impossible without their help. Thank you, Elizabeth, for the proof reading and “the chats”. Finally, thank you, Da, for being so supportive, generous and caring.

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## Abbreviations

| | |
|---|---|
| **AEOS**: | Agri-Environmental Options Schemes |
| **AES**: | Agri-Environmental Scheme |
| **BU**: | Biodiversity Undertaking |
| **CAP**: | Common Agricultural Policy |
| **CDF**: | Cumulative Distribution Function |
| **CE**: | Choice Experiment |
| **CPI**: | Consumer Price Index |
| **CV**: | Contingent Valuation |
| **DAFF**: | Department of Agriculture, Fisheries and Food |
| **DAFM**: | Department of Agriculture, Food and Marine |
| **DC**: | Direct Cost |
| **EAGGF**: | European Agricultural Guidance and Guarantee Fund |
| **EC**: | European Community |
| **EEC**: | European Economic Community |
| **EPA**: | Environmental Protection Agency |
| **ESA**: | Environmentally Sensitive Area |
| **EU**: | European Union |
| **FADN**: | Farm Accountancy Network Data |
| **GAEC**: | Good Agricultural and Environmental Condition |
| **GO**: | Gross Output |
| **GIS**: | Geographic Information Systems |
| **IFA**: | Irish Farmers' Association |
| **IGM**: | Income Generation Model |
| **IID**: | Independently and Identically Distributed |
| **IMR**: | Inverse Mills' ratio |

| | |
|---|---|
| **NFS**: | National Farm Survey |
| **NHA**: | Natural Heritage Area |
| **REDP**: | Rural Economy and Development Programme |
| **REPS**: | Rural Environment Protection Scheme |
| **RP**: | Revealed Preference |
| **SAC**: | Special Area of Conservation |
| **SE**: | Standard Error |
| **SEA**: | Strategic Environmental Assessment |
| **SFP**: | Single Farm Payment Scheme |
| **SMA**: | Supplementary Measure A |
| **SMILE:** | Simulation Model for the Irish Local Economy |
| **SMR**: | Statutory Management Requirements |
| **SP**: | Stated Preference |
| **SPA**: | Special Protection Area |
| **UAA**: | Utilisable Agricultural Land |
| **VIF**: | Variance Inflation Factor |
| **WTA**: | Willingness To Accept |
| **WTP**: | Willingness To Pay |

# 1. Introduction

The primary objective of this thesis is to investigate the impact of farmers' implementation behaviour on the effectiveness of the Rural Environment Protection Scheme (REPS). This chapter is concerned with providing justification for the work carried out herein and outlining how this objective has been achieved. It is divided into four sections. Section 1.1 provides context for the main research objective of the thesis. Section 1.2 describes how the main objective has been achieved using three separate empirical papers. An outline of the structure of the thesis is provided in Section 1.3. Finally, outputs from the thesis, including papers and work presented, are detailed in Section 1.4.

## *1. 1. Context of thesis*

Regulation 2078/92 from the European Economic Community (EEC) called for the implementation of agri-environmental aid schemes across all member states. Governments were given the autonomy to design programmes that best fit the agricultural and environmental status of their countries. Approval at EEC level meant that the design would be partially funded by the European Agricultural Guidance and Guarantee Fund (EAGGF). In Ireland, the resulting agri-environmental scheme (AES) was the Rural Environment Protection Scheme (REPS), which was first implemented in June 1994. Evaluation of the performance of REPS as an AES is justified for three main reasons. The first is Regulation 746/96, which was introduced by the European Community (EC) to ensure that the funding being provided to member states was being spent wisely. It 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 *et al.*, 2005).

Secondly, 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 (DAFF, 2010). Of these, approximately 61% were paid by the State, with the remainder being financed by the European Union (EU) (DECLG, 2013a). Any scheme that incurred such high costs to the National Exchequer needs to be evaluated for the benefit of the Irish taxpayer.

The third justification for evaluating REPS comes from the fact that it 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 a new scheme, the Agri-Environmental Options Scheme (AEOS). The Common Agricultural Policy (CAP), which intends to introduce further AESs across member states in the near future, acknowledges that the success of current and future AESs is dependent upon what can be learned from the successes and failures of past schemes (DAFM, 2012b). In the Irish case, the majority of the required information must therefore come from an evaluation of REPS.

The aspect of REPS that is being evaluated by this thesis is the impact of farmers' implementation behaviour on its environmental effectiveness. This is an important aspect to evaluate for two reasons. Firstly, participation in REPS was available to every farmer in the country on an entirely voluntary basis. Hence any improvements that occurred to the environment as a consequence of its existence were conditional on farmers' decision to participate in the scheme. Secondly, famers had a role to play in how scheme measures were implemented in their farm management plans. This means that the effectiveness of REPS at meeting its environmental objectives was also conditional on the appropriateness of the outcome of adopters' decision-making processes.

## *1. 2. Overview of research objectives and contributions of the thesis*

The principal research objective of this thesis is to provide an understanding of the impact of farmers' implementation behaviour on the effectiveness of REPS. Within this wider context, the research has three main goals, which are addressed in three separate empirical papers. Each paper addresses important gaps in the AES literature and intends to produce results that are beneficial to policymakers, especially with regard to the design of future Irish AESs. These papers are contained in Chapters 4, 5 and 6 and address the following research questions:

Chapter 4: *Was the type of farmer who participated in REPS capable of effectively meeting the broad environmental objectives of the scheme?*

- Estimation of the type of farmer who was most likely to participate in REPS from 1995 to 2010.
- Review of whether the type of farmer participating in each phase of REPS was capable of producing effects under both its pollution abatement and biodiversity conservation objectives.
- Discussion of whether changes to the contract across the four phases improved the effectiveness of the type of farmer who joined REPS.

This paper adds to work by Hynes and Garvey (2009), who looked at the type of farmer who participated in REPS from 1996 to 2005. It does so by expanding the study period from 1995 to 2010 to include data on farmers for the latter two phases of the scheme in the analysis. The study is novel because the impact of contractual changes on farmers' participation behaviour has never before been addressed in the AES literature.

Outputs from this paper will inform policymakers about what types of farmers are likely to join future Irish AESs if they continue with schemes similar to REPS. This chapter helps to establish whether the same type of farmer was capable of meeting both the pollution abatement and biodiversity conservation objectives of REPS and therefore whether including broad environmental objectives in a single contract was an effective aspect of the REPS policy design. In addition, results from this chapter will provide information on which contractual features are likely to attract the most appropriate type of farmer to future voluntary AES schemes.

Chapter 5: *Was the use of one scheme to attract farmers from a heterogeneous population effective?*

- Estimation of the REPS participation decisions of Irish farmers using actual and counterfactual choice data.
- Review of whether any differences in the participation functions of viable and non-viable farmers can be used to show whether REPS effectively targeted the participation of both groups.

The method used to estimate farmers' participation decisions in this paper has never before been applied to the AES literature. By comparing farmers' actual participation choice with their counterfactual participation choice this paper uses a revealed preference (RP) technique to estimate farmers' preferences for participation without suffering from the problem of sample selection bias that is associated with studies that compare participants with non-participants.

Outputs from this paper will inform policymakers about the processes underlying farmers' participation decision in REPS by providing information on which attributes of the choice are most likely to influence their actual participation outcome. They can use this information to inform future AESs. It will also provide policymakers with information about whether using one scheme to attract a variety of farmers from a heterogeneous population was an effective aspect of the policy's design.

Chapter 6: *Was the use of individual farm-management plans effective?*

- Assignment of ideal BU choices for different farm habitats.
- Estimation of models showing how farmers actually assigned farm habitats to BUs and a discussion of whether the choices they made were appropriate for the environmental needs of these habitats.

The data on habitat types and BU assignment used in this paper are new and have never before been used in the AES literature. In addition, farmers' preferences for BUs have not been modelled in previous studies.

Outputs from this paper will inform policymakers about whether allowing farmers (and their REPS advisors) a role in the implementation of biodiversity measures on their farms was an effective aspect of the policy's design.

## *1. 3. Structure of thesis*

Chapter 2 describes a number of policies and policy changes that occurred from the early 1990s to 2010 that are relevant to subsequent discussions in this thesis. The importance of these policies to the context of this thesis lies in the fact that they all impacted on Irish agriculture, Irish farmers and/or the Irish environment in some way. Chapter 2 commences with an overview of Irish farming. In doing so, it outlines how, despite the fact that Ireland is not a large country, there is significant heterogeneity with regard to agriculture throughout the island. Section 2.2 presents details of the REPS contract from 1994 to 2010 and describes how it differed in terms of scheme targets, measures and payment rates across its four phases. REPS was closed to all new applicants in 2009. Therefore, Section 2.3 provides details of the current AES available to Irish farmers: the AEOS. Reviews of how agricultural, and environmental, policies changed from 1994 to 2010 are provided in Section 2.4, and Section 2.5, respectively. Section 2.6 describes the NFS, which is the dataset used to assess farmers' implementation decisions in this thesis. Finally Chapter 2 concludes with a brief summary.

Chapter 3 provides information on how AESs have been evaluated in the past. Section 3.1 introduces a number of factors used to assess the environmental effectiveness of AESs and describes how REPS has performed according to these criteria, which may be categorised as scheme-level or farm-level factors, in the related literature. Section 3.2 looks at issues associated with the evaluation of REPS at farm level. These include problems with the identification of what farmers were expected to produce in return for their REPS payments and issues with the measurement of externalities from production. Two important issues that need to be considered when evaluating the environmental effectiveness of REPS by looking at farmer participation behaviour are described in Section 3.3. These are the impact of other policies on farmer behaviour and adverse selection bias. Section 3.4 presents literature identifying the main factors influencing farmers' participation decisions in AESs. These factors are divided into farm-specific and individual-specific factors. Chapter 3 concludes with a brief summary.

The first empirical paper from this thesis is contained in Chapter 4 and proceeds with an introductory section (Section 4.1). Section 4.2 outlines how the changes in agricultural and environmental policies from 1994 to 2010 (described in Chapter 2), and the marginal impact of various factors on farmers participation decisions (described in Chapter 3) are expected to have changed across the four phases of REPS. Section 4.3 describes the economic theory underlying farmers' participation decisions in REPS and provides details on the econometric models used to identify the types of farmer who participated in REPS overtime and, uniquely, for each phase. The NFS data for the analysis in Chapter 4 are discussed briefly in Section 4.4, which includes summary statistics for NFS farms over time and for each of the four phases of REPS. Section 4.5 presents and discusses the findings from a random effects logit on REPS participation from 1995 to 2010 and for four binary logits on REPS participation in a representative year for each phase of the scheme from REPS I to REPS IV. The type of farmer who participated in each phase of the scheme is reviewed in terms of how they are expected to have met the biodiversity conservation and pollution abatement objectives of the scheme. In addition, a discussion of whether the institutional changes that took place across each of the four phases improved the capacity of farmers to meet these objectives is provided. Finally, Section 4.6 provides concluding remarks.

The second paper from this thesis is contained in Chapter 5 and, again, proceeds with an introductory section (Section 5.1). Section 5.2 provides a description of the farm household model. It outlines how viable and non-viable farmers are expected to respond differently to the REPS participation decision given their dissimilar levels of consumption and leisure. Section 5.3 provides details on the conditional logit model that is used to estimate the REPS participation decision in Chapter 5. It also outlines how counterfactual data are created to represent farmers' hypothetical alternative participation outcomes, with the aim of using them in the REPS participation function models. Section 5.4 introduces the data used for the analysis – showing values for the attributes of the participation decision for viable and non-viable farmers separately. Section 5.5 provides values for the counterfactual attributes. Results showing the participation function for all Irish farmers and for viable farmers and non-viable farmers are shown, and discussed, separately. Section 5.6 provides concluding remarks for Chapter 5.

The third, and final, paper from this thesis is contained in Chapter 6. It proceeds with an introductory section (Section 6.1). Section 6.2 introduces the data used in the chapter. It describes how data on habitat types are grouped according to their management requirements and how the BUs chosen by farmers are categorised by the type of habitat management they provide. Section 6.3 describes the multinomial logit and Heckman two stage models that are used to estimate the likelihood that habitat types were assigned to the appropriate BUs in terms of their management requirements. Section 6.4 presents the results from these models and discusses how the actual assignment of habitats to BUs compared with how ecological experts believe they should have been assigned. Finally section 6.5 concludes with a discussion of the implication of the results from the chapter.

Chapter 7 is the ultimate chapter of this thesis. It begins by outlining how the main objectives of the three empirical papers were achieved in Chapters 4, 5 and 6. Limitations of these studies are reviewed in Section 7.2. Of particular interest to this thesis is how findings from the research contained within may help to advise policymakers with the design of future Irish AESs. This issue is discussed in Section 7.3. Finally, Section 7.4 concludes with an overview of potential future research arising from the findings of this thesis.

## 1. 4. Thesis outputs

There has been a number of outputs from the research undertaken for this thesis to date. These are listed below and include a publication in *Ecological Economics* and presentations at both international and national conferences.

### *1. 4. 1. Work published*

Murphy, G., Hynes, S., O'Donoghue, C. Murphy, E., (Review and re-submit). An investigation into the type of farmer who chose to participate in REPS and the role of institutional change in influencing scheme effectiveness. *Land Use Policy*.

Murphy, G., Clancy, D., O'Donoghue, C., Quinlan, G. & Thorne, F., In Press. Trends in the tillage sector. *In* C. O'Donoghue, A. Kinsella & L. Connolly (eds.), *Current Economic Issues in Irish Agriculture.* Co. Cork: Oak Tree Press.

Murphy, G., Hynes, S., Murphy, E., O'Donoghue, C. & Green, S., 2011. Assessing the compatibility of farmland biodiversity and habitats to the specifications of an agri-environmental scheme using a multinomial logit approach. *Ecological Economics,* 71, 111-121.

Murphy, G., Hynes, S., Murphy, E., O'Donoghue, C. & Green, S., 2011. Do farmers in agri-environmental schemes make appropriate ecological choices for the habitats on their farms? Modelling the Biodiversity Undertakings chosen within the Irish Rural Environment Protection Scheme. *National University of Ireland Department of Economics Working Paper,* No. 0175.

### *1. 4. 2. Work presented*

2013 "An investigation of the participation decision in the Rural Environment Protection Scheme (REPS): a conditional logit approach using simulated counterfactual data for farmers". 87$^{th}$ Agricultural Economics Society, Warwick.

2012 "The effect of the participation choice in the Rural Environment Protection Scheme (REPS) on Irish farms: simulating counterfactual outcomes for farms." European

Meeting of the International Microsimulation Association, Teasgasc, Ashtown, Dublin.

2012 "Detailing the types of farmer who were most likely to participate in the Rural Environment Protection Scheme (REPS)." Brownbag series, Department of Economics, National University of Ireland, Galway.

2011 "Using georeferenced habitat data to investigate farmers' management decisions in the Rural Environment Protection Scheme." Regional Science Association International – British and Irish Section, Cardiff, Wales.

2011 "The effect of the voluntary aspect of REPS on its success as an agri-environmental scheme." Teagasc Presentation Series, Rural Economy Development Programme, Galway.

2010 "The extent of active participation behaviour in the Rural Environment Protection Scheme (REPS)." Agricultural Economics Society Annual Conference, University of Edinburgh, Scotland.

2010 "Farmer participation behaviour in the Rural Environment Protection Scheme (REPS) – what habitats are being protected?" Brownbag series, Department of Economics, National University of Ireland, Galway.

2010 "Farmer participation behaviour in REPS – what habitats are being protected?" Teagasc Presentation Series, Rural Economy Research Centre, Galway.

2009 "Farmer participation in the Rural Environment Protection Scheme (REPS)." Agricultural Economics Society of Ireland Student Day, University of Limerick.

2009 "Farmer participation in the Rural Environment Protection Scheme (REPS)." Irish Society of New Economists, Teagasc, Galway.

2009 "Farmer participation in the Rural Environment Protection Scheme (REPS)." Inaugural Irish Rural Studies Symposium, Teagasc, Galway.

### *1. 4. 3. Other contributors to the thesis*

The work undertaken in this thesis was aided by a number of other people. For the first empirical paper, the random effects panel data logit was an extension of previous work carried out by Dr Stephen Hynes and Dr Eoghan Garvey. Given his experience with this work, Stephen provided guidance on the best methods for modelling farmer participation in REPS over time. Chapter 5 was written with the help of Dr Cathal O'Donoghue. He provided help with the method used and expert input on the production, labour supply and cost functions used to describe how the REPS participation decision influenced on-farm choices.

The supplementary survey used in the third empirical paper in this thesis (Chapter 6) was collected under Stephen's direction and the habitat data used were made available by Dr Stuart Green. Ecological advice was provided by Dr Catherine Keena. Throughout the course of the PhD, Stephen provided guidance on how the thesis should be structured and he and Cathal discussed likely outputs from the PhD. Input from staff in REPS advisory at Teagasc was invaluable. Mark Gibbs and Damian Costellos' knowledge proved useful at all times. Finally, Stephen, Cathal and Dr Eithne Murphy all provided guidance on the writing style used throughout the thesis.

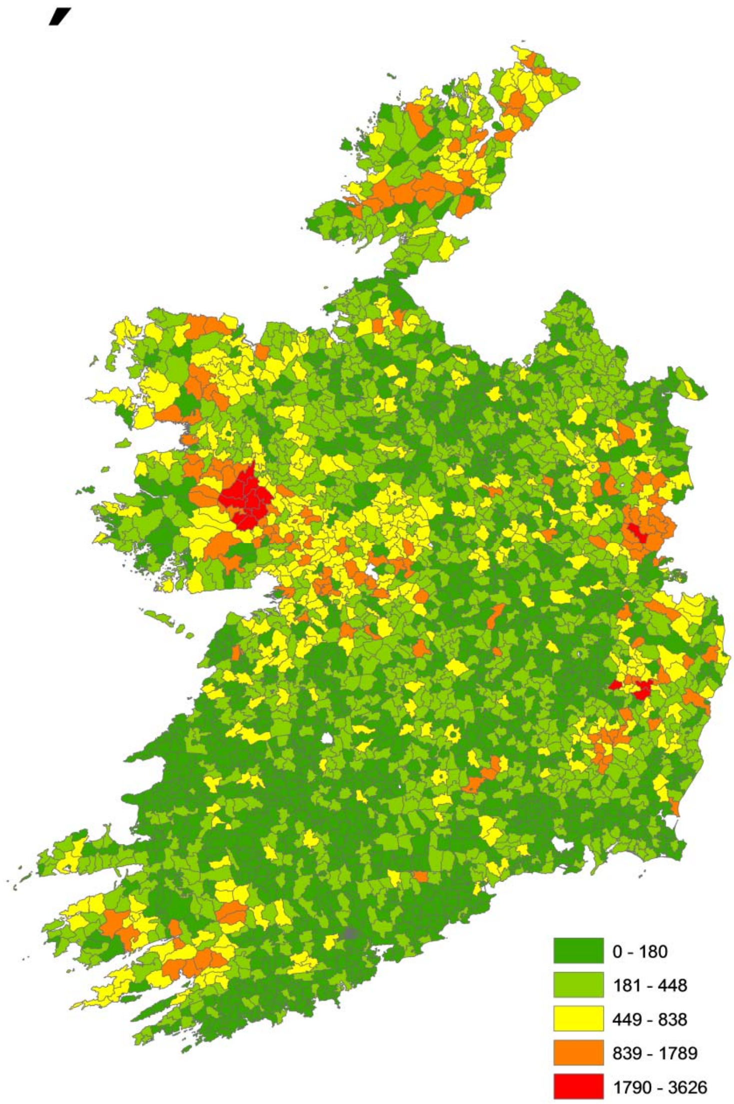
# 2. Policy background

This chapter is concerned with reviewing a number of policies and policy changes that occurred from the early 1990s to 2010 that are relevant to subsequent discussions in this thesis. These policies matter because they impacted on Irish agriculture, Irish farmers and/or the Irish environment in some way. The chapter begins with an overview of Irish farming in general. Section 2.2 presents details of the REPS contract from 1994 to 2010 and describes how it differed in terms of scheme targets, measures and payment rates. Section 2.3 provides details of the current AES (AEOS) available to Irish farmers. Sections 2.4 and 2.5 review how agricultural and environmental policies, outside of REPS, changed from 1994 to 2010. Section 2.6 describes the NFS, which is the dataset used to assess farmers' implementation decisions in this thesis. The chapter concludes with a brief summary.

## *2. 1. Heterogeneity in Irish farming*

Irish farming is essentially comprised of mixed livestock production, which is based on grass with some arable cropping. However, there are distinct spatial patterns across the country in terms of weather and soil type. Land in the northwest and west of the country tends to be peatier, largely as a consequence of the topology of the landscape and the high rainfall. Conversely, the east and southeast are sunnier and have more productive soils than elsewhere (Feehan and O'Connor, 2009). These spatial patterns influence the types of habitats found on Irish farms.

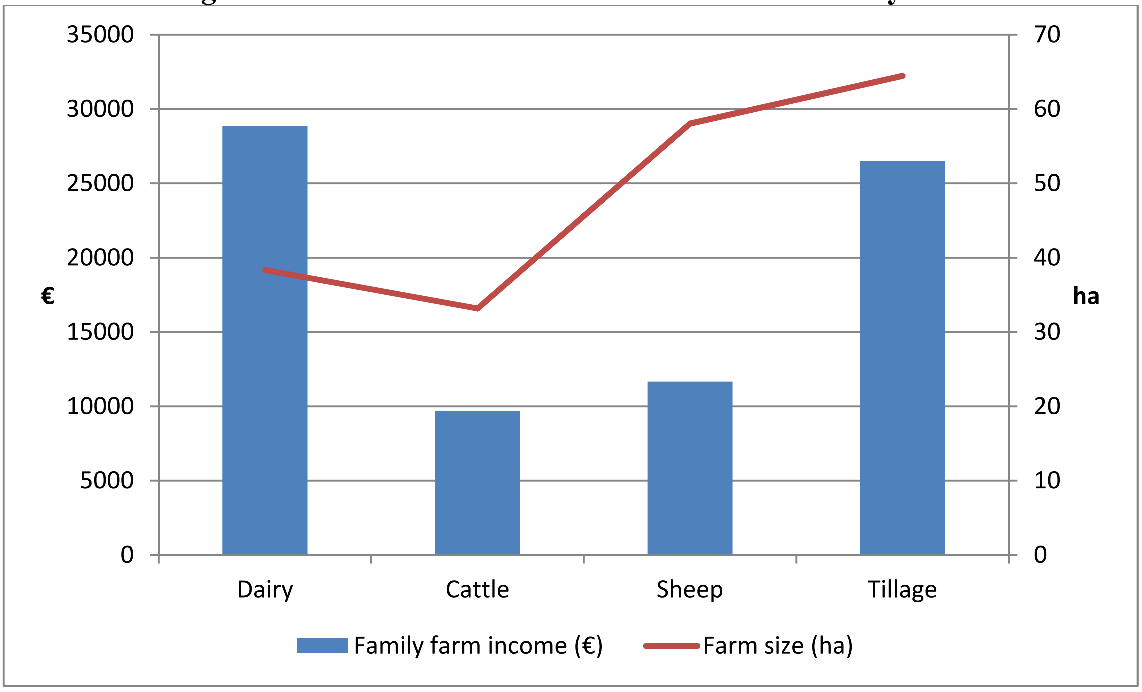
**Figure 2.1: Average sheep numbers per electoral district (livestock units)**




Source: NFS 1994 to 2010. Created in Simulation Model for the Irish Local Economy (SMILE) O'Donoghue *et al*. (2013)

Distinct weather and soil spatial patterns also influence the type of farming, or system type, that occurs throughout Ireland. Dairy farms are located in the south and southwest of Ireland and arable farms tend to be located in the east and southeast. Farms that rely on sheep and cattle production are most commonly found in the west and northwest of the country (Emerson and Gillmor, 1999). For example, Figure 2.3 shows that the majority of farms with between 839 and 3,626 sheep are located in Galway, Mayo and Sligo.

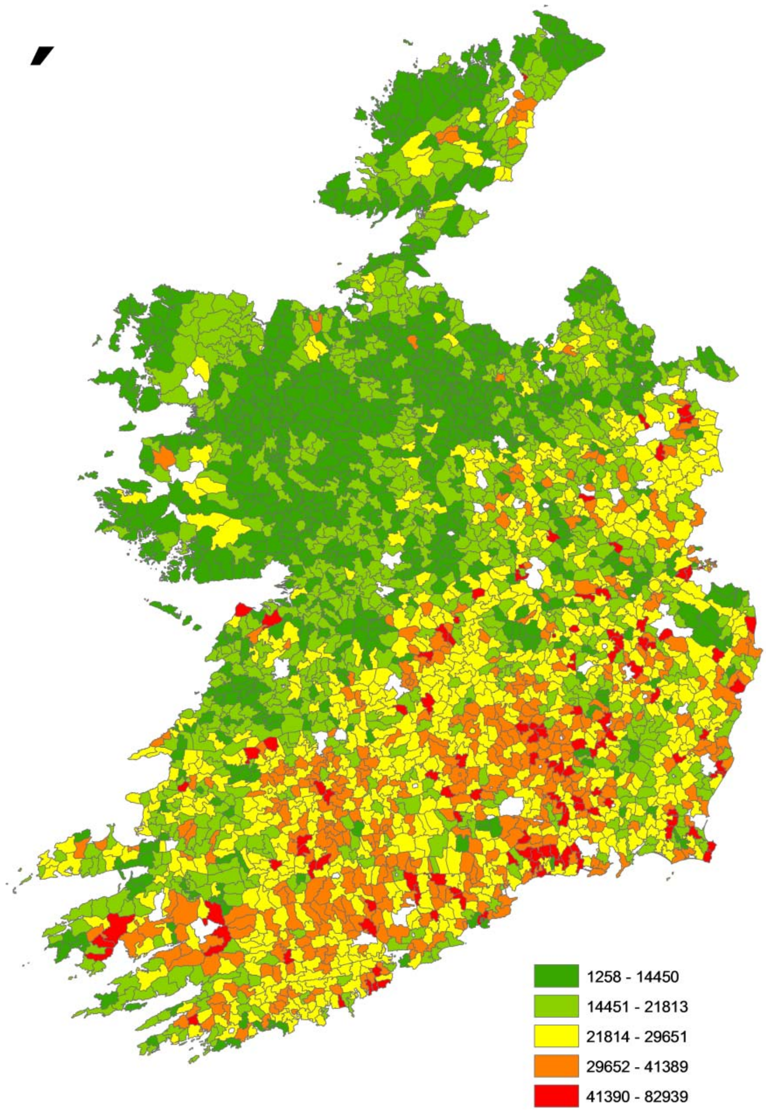
**Figure 2.2: Farm size and total farm income across system**




Source NFS: 1994 to 2010
Total farm income includes all income from on-farm sources: production-based earnings, direct payments and REPS payments. Monetary values have been adjusted by the year 2000 using the Consumer Price Index (CPI).

Figure 2.2 shows how various system types vary according to size and income. The system types with the highest total farm incomes are dairy and tillage, followed by cattle and sheep. The red line in Figure 2.2 shows that the largest farm sizes are tillage and sheep farmers, followed by dairy and cattle. Hence, the most profitable farm system type in Ireland (in terms of total farm income per hectare) is dairy and the least profitable is sheep. This is because dairy farms are generally the most intensive farms types in the country, whereas sheep farms are, on average, extensive systems.

**Figure 2.3: Average total farm income per electoral district (€)**




Source: NFS 1994 to 2010. Created in SMILE O'Donoghue *et al*. (2013)

Figure 2.3 shows how average farm income reflects the regional variation throughout the country. Average farm incomes are generally lower in the west of Ireland and increase towards the south and east of the country. It shows that the majority of Irish farms in the two lowest total farm income brackets (€1,298 to €14,450 and €14,451 to €21,813) are in western electoral districts whereas individuals in the two highest total farm income brackets (€29,652 to €41,389 and €41,390 to €82,939) are more likely to be located in the south and southeast of the country.

## *2. 2. REPS*

REPS was created in response to 2078/92/EEC, which called for the implementation of AESs across all European member states. It was the first ever Irish AES and is co-financed by the EAGGF 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). Those who chose to join were obliged to enter all of their land into the scheme. The overall aim of REPS was to enhance the environmental standard of the Irish countryside by improving agricultural practices at farm level. There were four phases of the scheme[1], which were introduced in 1994, 2000, 2004 and 2007 respectively. Objectives for the first three phases of REPS are given as:

- establishing farming practices and production methods, which reflect the need for environmental conservation and protection;
- protecting wildlife habitats and endangered species of flora and fauna;
- producing quality food in an extensive and environmentally friendly manner (Emerson and Gillmor, 1999, DAFRD, 2000, DAFF, 2004).

[1] Henceforth referred to as REPS I, REPS II, REPS III and REPS IV respectively.

In REPS IV, scheme objectives were listed as aiming to promote:

- ways of using agricultural land which are compatible with the protection and improvement of the environment, biodiversity, the landscape and its features, climate change, natural resources, water quality, the soil and genetic diversity;
- environmentally favourable farming systems;
- the conservation of high nature-value farmed environments which are under threat;
- the upkeep of historical features on agricultural land;
- the use of environmental planning in farming practice.

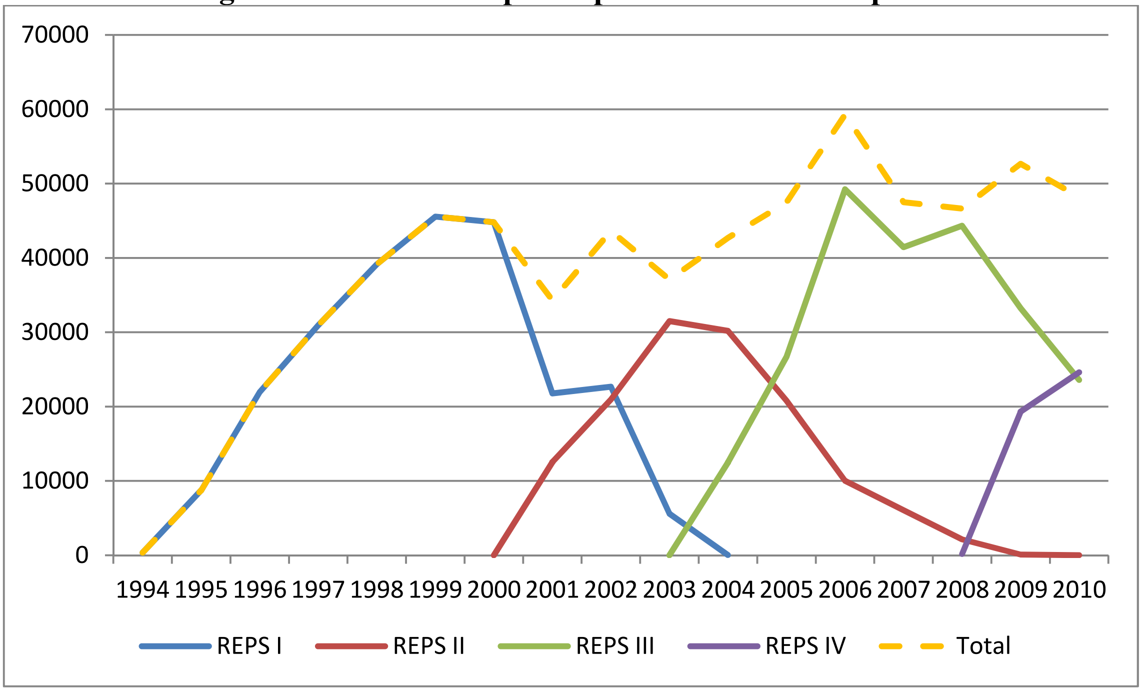
In addition, the REPS IV contract aimed:

- to protect against land abandonment;
- to sustain the social fabric in rural communities;
- to contribute to positive environmental management of farmed designated sites (DAFF, 2007).

### *2. 2. 1. Scheme targets*

No quantitative targets were set for REPS in terms of the production of specific environmental outputs. As it was a voluntary scheme, targets were instead defined in terms of target uptake rates or the desired extent of participation throughout the country.

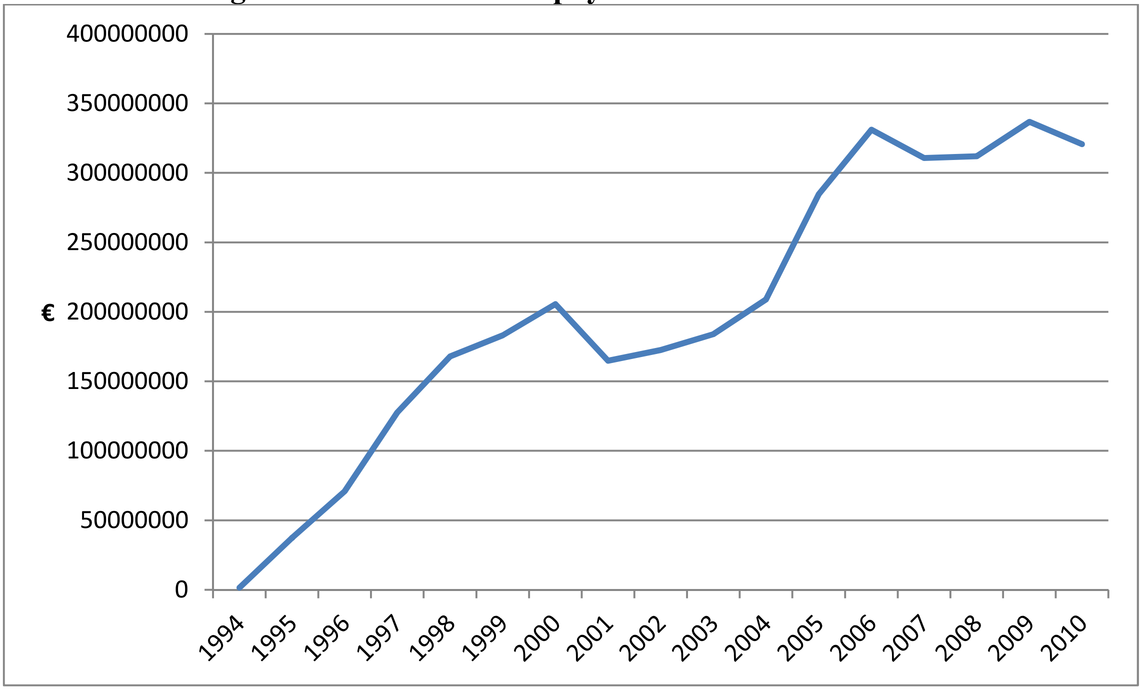
**Figure 2.4: Number of participants in each REPS phase**




Source: DAFF (2010a)

The target-uptake rates for REPS I and REPS II were set at 45,000 and 70,000 participants, respectively (Emerson and Gillmor, 1999, Rath, 2002). Figure 2.3 shows the number of participants in each of the four REPS phases from 1994 to 2010. Uptake rates in the first two years of REPS were low. However, the pace of participation increased in the following years and the total number of participants in REPS I by 1999 was 45,553, meaning REPS I was effective in terms of uptake rates. However, the number of individuals who joined REPS II peaked in 2003 at only 31,687, meaning the second phase was not as successful as the first.

**Figure 2.5: Cost of REPS payments from 1994 to 2010**




Source: DAFF (2010a)

Target uptake rates were not set for the latter two phases of REPS. Instead scheme targets were discussed in relation to the amount of money that was paid out to improve the Irish environment. For example, 2006 was considered a successful year because €279.8 million was paid out to REPS III farmers. This was an increase of 41.64% on the amount paid out under REPS III in the previous year (DAFF, 2010). In addition, when the opening of REPS IV was announced in 2007, proposed expenditure of €400 million per year in REPS IV payments was discussed in a manner similar to a target (DAFM, 2013b).

### *2. 2. 2. Scheme measures*

All participating holdings had individual farm management plans drawn up as part of a REPS contract, which incorporated the 11 measures listed in Table 2.1 below into the running of their farms. The farm management plans were discussed with participants and created by REPS advisors. Farmers paid for the service provided by the advisor, who either worked for the semi-state agency Teagasc or a private company (Emerson and Gillmor, 1999).

**Table 2.1: Measures contained in REPS contracts**

| **Basic measures** | **Biodiversity Undertaking (BU) options** | |
|---|---|---|
| | *BU description* | *Available in REPS Phase* |
| 1. Nutrient management | No BUs were listed for this measure | Neither |
| 2. Grassland and soil management | Traditional hay meadows<br>Species rich grassland<br>Use of clover in grassland swards<br>Use of trailing shoe technology<br>Control of invasive species | III & IV<br>III & IV<br>IV<br>IV<br>IV |
| 3. Protect and maintain watercourses and wells | Increase watercourse margin<br>Exclude all bovine access to watercourses<br>Use of planted buffer zones | III & IV<br>III & IV<br>IV |
| 4. Retain wildlife habitats | Creation of a new habitat<br>Broadleaved tree planting<br>Nature corridors<br>Farm woodland establishment | III & IV<br>III & IV<br>III & IV<br>IV |
| 5. Maintain farm and field boundaries | Hedgerow coppicing<br>Hedgerow laying<br>New hedgerow establishment<br>Additional stonewall maintenance | III & IV<br>III & IV<br>III & IV<br>III & IV |
| 6. Restricted use of pesticides and fertilisers | No BUs were listed for this measure | Neither |
| 7. Biodiversity buffer strips around archaeological sites | Increase in archaeological and historical buffer margins<br>Management of publically accessible archaeological sites | III & IV<br>III |
| 8. Maintain and improve visual appearance of farm and farmyard | Traditional Irish orchards<br>Install bird and/or bat boxes | IV<br>IV |
| 9. Produce tillage crops respecting environmental principals | Green cover establishment | III & IV |
| | Environmental management of setaside<br>Increased arable margins<br>Low input spring cereals<br>Minimum-tillage | III & IV<br>III & IV<br>IV<br>IV |
| 10. Training in environmentally friendly farming practices | No BUs were listed for this measure | Neither |
| 11. Maintenance of farm and environmental records | Provide landscaping around the farm | III |

Sources: DAFF (2004); DAFF (2007)

Unlike many zonal EU AESs that focus on a small number of environmental problems, the measures contained in REPS cover a list of broad and comprehensive environmental issues. These may be broadly classified into those that aim to maintain archaeological sites, to ensure transparency on farms through the keeping of farm records, to educate farmers about farm environments, to achieve pollution abatement and to encourage biodiversity conservation. This thesis is concerned with assessing measures that fall into the latter two categories. This includes (at least in part) all measures except 7, 10 and 11.

### *2. 2. 3. Payment rates*

For implementing all 11 measures contained in Table 2.1, REPS farmers received payments that were designated on a per hectare basis. These rates decreased in value with the number of hectares enrolled in the scheme. Payment rates for each of the four phases are listed in Table 2.2 below.

**Table 2.2: Payment rates for each phase of REPS**

| REPS Phase | General REPS Programme | Non-Natura 2000 commonage and NHA Land | Non REPS with designated sites | Supplementary Measure A/Natura 2000 |
|---|---|---|---|---|
| I | €151/ha for3 - 40 ha | | | €242/ha for 0 - 40 ha |
| II | €165/ha for 3 - 20 ha | | €242/ha for 0 - 10 ha | €242/ha for 0 - 40 ha |
| | €151/ha for 21 - 40 ha | | | €24/ha for 41 - 80 ha |
| | | | | €18/ha for 81 - 120 ha |
| III | €200/ha for 3 - 20 ha | | €242/ha for 0 - 10 ha | €242/ha for 0 - 40 ha |
| | €175/ha for 21 - 40 ha | | | €24/ha for 41 - 80 ha |
| | €70/ha for 41 - 55ha | | | €18/ha for 81 - 120 ha |
| | €10/ha for 55+ ha | | | €5/ha for 120+ ha |
| IV | €234/ha for 3 - 20 ha | €282/ha for 0 - 40 ha | | No change from General Payment rates |
| | €205/ha for 21 - 40 ha | €29/ha for 41 - 80 ha | | |
| | €82/ha for 41 - 55 ha | €22/ha for 81 - 120 ha | | |
| | €10/ha for 55+ ha | €5/ha for 121+ ha | | |

Sources: DAFF (2004); DAFF (2007); DAFRD (2000); Emerson and Gillmor (1999)
Natura 2000 sites are a network of protected areas that came into existence in 2000. These have been identified by a number of national and international environmental policies (see Section 2.5). Commonage refers to land on which two or more farmers have grazing rights (Lafferty *et al.*, 1999)

### *2. 2. 4. Changes across phases*

As previously mentioned, targets for REPS were set in terms of uptake rates and target payout levels. For this reason, many of the changes that were made to the REPS contract overtime were concerned with attracting a greater number of farmers to the scheme. Changes that were made with this intention in mind occurred in one of two ways. Firstly, unpopular features of the contract were removed or tamed if they were viewed as deterrents to participation. For example, in REPS I, the use of growth regulators on crops was not permitted under Measure 6. This restriction was revoked for all subsequent phases because it was a contentious issue for cereal farmers.

The main issue that was contested throughout the lifetime of REPS, however, was restrictions on the production of organic nitrogen contained in Measure 1, which were viewed as unattractive for intensive farmers. In the first three phases of REPS, Measure 1 stipulated that participants were not permitted to produce more than 170 kg of organic nitrogen per hectare on their farms (Van Rensburg *et al.*, 2009). While discussing conditions of the REPS III contract at EU level, Irish politicians attempted to negotiate for clemency with regard to this restriction. They intended to introduce a two-tiered payment system for REPS III, whereby farmers who produced 210 kg of organic nitrogen per hectare were permitted to join the scheme, but received lower basic payment rates (Regan, 2003). EU policymakers were disinclined to accept this proposal, however, meaning the 170 kg/ha restriction remained in place for REPS III. In REPS IV, farmers who produced levels of organic nitrogen in excess of 170 kg per hectare were permitted to apply for a derogation under the Nitrates Directive (EEC 91/676). Those that held derogations received the same level of payment as extensive farmers but were obliged to undertake extra measures on their farms to compensate for the fact that they produced higher quantities of negative externalities.

The second way that policymakers attempted to increase participation rates in the scheme over time was by increasing payment rates. The cut off in payments for additional hectares on farms with more than 40 hectares in REPS I and REPS II (Table 2.2) was unattractive to larger farmers, especially because participants were obliged to enter all of their land into the scheme[2]. In fact, this cut off in payments was given much of the blame for the failure of REPS II to meet its target-uptake rates (Rath, 2002). In response, policymakers produced REPS III, which could be thought of as an amendment to REPS II rather than a phase in its own right. Policymakers increased payment rates for participants in REPS III for the first 40 hectares of their land and added two additional tiers to the payment structure, ensuring that farmers received additional pay for every extra hectare entered into the scheme.

In response to the increasing costs of REPS to the taxpayer (Figure 2.5), policymakers were also obliged to make changes to the REPS contract that increased the effectiveness of the scheme measures in Table 2.1. In particular, the level of effort required from farmers in terms of biodiversity conservation increased over time (Rath, 2001). REPS I and REPS II attempted to conserve biodiversity by maintaining habitats where they already existed or by creating setaside on farms that lacked habitats. This approach was criticised at EU level for not effectively addressing the issue of biodiversity conservation (Sinnott, 1999).

Improved effectiveness of scheme measures was incorporated into the latter two phases of the scheme through the introduction of BUs in REPS III (Table 2.1). Participants were obliged to incorporate BUs into their individual farm plans in addition to the 11 basic measures from the first two phases. In REPS III, farmers chose two BUs from a list of 16. In REPS IV, participants were provided with a wider variety of BUs to choose among (24) and, under certain circumstances, were obliged to undertake more than two BUs on their holdings (DAFF, 2004, DAFF, 2007). In a manner similar to the basic REPS measures, BUs improve on-farm biodiversity levels in one of two ways: the creation of habitats where they do not currently exist or the maintenance of habitats where they do exist. However, creating habitats can involve planting new species where they previously were not located in addition to taking an area of land out of production as “setaside”. Similarly, maintaining habitats may require that farmers actively promote the improvement of existing habitats as oppose to merely maintaining the status quo in terms of farm management.

This increase in emphasis on biodiversity conservation subtly altered the focus of REPS over time. Namely, whilst pollution abatement and biodiversity conservation were both important

[2] This meant that even though they only received payment under the scheme for the first 40 hectares, management options had to be carried out as specified in the REPS farm management plan across the entire holding.

objectives of the scheme from 1994 to 2010, the amount spent on biodiversity protection increased from 57% to 79% of payments in REPS I and REPS IV, respectively (Finn and O hUallachain, 2012).

The role that REPS played in the conservation of protected areas[3] also changed across phases. In REPS I, participants with protected areas, as defined by other environmental legislation, on their holdings were obliged to participate in one of two supplementary measures. These supplementary measures were created to ensure that the habitats contained in the sites were managed according to their ecological requirements. In the final year of REPS I, these measures were replaced with Supplementary Measure A (SMA). The objective of SMA was to provide a comprehensive approach to the conservation and/or regeneration of designated protected areas. SMA was also mandatory for all participating farmers with protected land listed in REPS II and REPS III. However, in these two phases, there is a payment rate for farmers who did not wish to participate in REPS but who had designated protected sites on their holdings (Table 2.2). For the fourth phase, the protection of designed areas was combined with the REPS IV contract, meaning farmers with protected areas on their holdings were obliged to participate in the scheme if they wished to receive any payments for the land (NPWS, 2010).

[3] Protected areas are those that have been identified by one (or more) of a number of environmental policies introduced in Ireland from 1979 onwards (see Section 2.5)

## *2. 3. Agri-Environmental Option Schemes (AEOS)*

The AEOS was introduced in Ireland in 2009 to replace REPS and its third phase, AEOS 3, began in October 2013 (DAFM, 2012c). It is jointly funded by the EU and the National Exchequer. The AEOS comprises of a number of small schemes that farmers may volunteer to join. Participants are not required to enter their entire farm into the scheme – just identified areas – and the duration of an AEOS contract is (at least) five years

The number of farmers admitted to the scheme is determined by the funding available. (The maximum overall funding ceiling for AEOS 3 was set at €20 million per full calendar year.) Every farmer in the country is permitted to apply but priority is given to applicants in the following order: individuals with at least 0.5 hectares of utilisable agricultural Natura land; individuals with at least 0.5 hectares of utilisable agricultural commonage land, individuals who previously participated in REPS, smaller farms and, finally, those in less favoured areas[4]. Individuals who fall outside of these categories are referred to as Category 2 applicants.

The objectives of the AEOS are given as:

- promoting biodiversity, encouraging water management/quality and combatting climate change;
- contributing to positive environmental management of farmed Natura 2000 sites and river catchments in the implementation of the Birds Directive, Habitats Directive and Water Framework Directive (DAFM, 2012c).

[4] Less favoured areas are those that have been identified under Articles 3.4 and 3.5 of 75/268/EEC as having a disadvantage that impacts on their ability to produce agricultural goods. Examples include that an area may suffer from wind or water erosion or may be required for the purposes of tourism, thereby preventing farmers from fully utilising their land. At present, 0.4% of the total land area in Ireland is classed as less favoured (DAFM, 2013)

**Table 2.3: Schemes contained in the AEOS**

| Specifications for the 2012 AEOS |
|---|
| Additional new hedgerow establishment |
| Alternative water source for bovines |
| Arable margins |
| Broadleaved tree planting |
| Conservation of animal genetic resources |
| Coppicing of hedgerows |
| Establishment and maintenance of habitats |
| Green cover establishment from a sown crop |
| Laying of hedgerows |
| Minimum tillage |
| Riparian margins |
| Slurry spreading (Use of new technologies) |
| Species-rich grassland |
| Traditional dry stone wall maintenance |
| Traditional hay meadow |
| Wild bird cover |

Source: DAFM (2012c)

The objectives listed above are intended to be met using the 16 individual schemes (or specifications) of the AEOS contained in Table 2.3. It is clear from the headings for these specifications that they overlap significantly with the measures contained in REPS, especially the BUs (see Table 2.1). Hence, the AEOS is similar to REPS for a number of reasons. Firstly, every farmer in the country is permitted to apply to the scheme. Secondly, participation is voluntary and thirdly, many of the measures used to address environmental issues in both schemes are the same. Hence, any information gleaned regarding the implementation behaviour of REPS farmers will also provide important information for the success of this subsequent scheme.

## *2. 4. Agricultural policies*

From 1994 to 2010, Irish farmers received their on-farm earnings from two sources: the market and direct payments. However, the conditions of receipt of both sources of money altered significantly during this period. At the beginning of 1992, farmers' market earnings and direct payments both depended on the quantity of goods they produced. This is because CAP awarded direct payments based on headage and yield. However, the link between production and direct payments led to overproduction, which had detrimental consequences for the environment (Buckley *et al.*, 2009). A number of agricultural policies were introduced during this period to decouple direct payments from production in an attempt to halt the deterioration of agricultural environments.

A second important reason for decoupling direct payments from production during this period was the need to remove price-support mechanisms that gave First World countries trading advantages over others. It was suggested at the World Trade Organisation's Uruguay Round Agreement on Agriculture in 1994 that this problem could be addressed using decoupled Green Box payments. Specifically, Green Box payments are decoupled from current production. Instead they are defined by a fixed, historical base period and are financed by the government (taxpayers) rather than by consumers (Hennessy and Thorne, 2006).

The first decoupled payments introduced in Ireland were brought in under the MacSharry reforms (EEC 2078/92) in an attempt to halt environmental degradation in specific areas such as the Irish uplands (Buckley *et al.*, 2009). Agenda 2000 (EC 1257/99) changed the emphasis of CAP from one that prioritised the production of commodities to one that also rewarded farmers for producing environmental goods. It involved the introduction of a second pillar for

CAP called rural development and the establishment of extra measures and sources of decoupled payments for farmers. Examples of these measures include diversification and support for young farmers (Matthews, 2002b). In addition, the Less Favoured Areas scheme was changed in 1995 and 1996 to include designations for Less Severely Handicapped and More Severely Handicapped areas, which meant a greater number of disadvantaged farmers received decoupled supplemental income from the government than before (DAFM, 2013a).

Full decoupling was not established in Ireland until 2005 with the Single Farm Payment (SFP) scheme. The SFP resulted from the Luxembourg reform of 2003 and awarded Irish farmers based on historical production from the reference years 2000 to 2002. Receipt of payments under the SFP is provisional on individuals meeting the terms of full conditionality. This means they must adhere to environmental and agricultural standards set out under statutory management requirements (SMRs) (Legg, 2007). There are 18 SMRs, covering issues such as pesticide use and the protection of groundwater and control of nitrates from farms. The Farm Waste Management Scheme was introduced in 2006 to provide grant aid to farmers for the infrastructure required under these latter SMRs. In particular, it helped farmers to invest in storage facilities for silage and agricultural wastes, as well as animal housing and equipment for the application of farm waste to land. Receipt of the SFP is also conditional on farmers maintaining their land in *good agricultural and environmental condition* (GAEC). One of the stipulations of the GAEC is that farmers must maintain landscape features such as hedgerows, ditches and open drains in good environmental condition (DAFM, 2012a).

Following on from the decoupling of payments from production, the single Common Market Organisation was introduced in 2007 to simplify European agricultural policy, making it more accessible to traders outside the EU (Vollenweider *et al.*, 2011). In fact, a review of CAP plans issued in 2009 (DAFM, 2012b) stated that the commission believed in the continued gradual dismantling of market-support measures for EU members. Taking this stance means that future policies are likely to open farmers' market-based earnings to greater levels of volatility from the worldwide market.

These changes in agricultural policy from 1994 to 2010 mean that, for certain farmers during this period, the relative importance of the production of traditional agricultural commodities will have decreased. This is because they no longer received direct payments based on current production levels. In addition, the market earnings they gained became increasingly subject to price fluctuations. Consequently, certain farmers may have chosen to expand their farms in areas other than the production of traditional agricultural commodities to ones that increased their earnings from other sources such as AES payments.

## *2. 5. Environmental policies*

Changes that were made to Irish environmental policy from 1994 to 2010 can be broadly defined as those that attempted to abate pollution and those that aimed to conserve biodiversity. In Ireland, pollution abatement strategies began with the establishment of the Environmental Protection Agency (EPA) in 1992. The purpose of the EPA is to protect the Irish environment through licensing, enforcement and monitoring activities. Therefore, in 1992 a process was put in place for evaluating the levels of negative externalities produced by farms (EPA, 2010).

The Nitrates Directive was ratified in Ireland in 2006 (despite being drafted at EU level in 1991), when it was incorporated into the SMRs of the SFP. The Nitrates Directive plays an essential role in the reduction of pollution from agricultural sources. It is specifically concerned with the protection of water against chemicals from farms, and has firm mandatory restrictions in terms of fertiliser use on agricultural holdings. Both the establishment of the EPA and the drafting of the Nitrates Directive increased farmers’ accountability for the level of negative externalities that they produced as a consequence of agricultural production.

At the beginning of this study period, legislation for the protection of biodiversity was mainly concerned with conserving designated protected habitats or species of high ecological importance. Special Protection Areas (SPAs) existed as a consequence of the Birds Directive (EEC 79/409), which aimed to protect endangered birds, migratory birds and their habitats, such as wetlands. The Habitats Directive (EEC 92/43) resulted in the creation of Special Areas of Conservation (SACs) to protect habitats and species of European importance. The Water Framework Directive (EC 60) in 2000 added to the list of designated habitats by identifying waterways of importance. In Ireland, SPAs, SACs, waterways of importance and Natural Heritage Areas (NHAs), which are identified by the Irish Wildlife (Amendment) Act of 2000, were combined to form a network of protected areas called Natura 2000 in 2000. Natura 2000 sites are protected and managed by the National Parks and Wildlife Service (NPWS, 2010).

The Water Framework Directive achieved more than merely adding to a network of protected areas. It is an innovative policy that recognises the need to protect biodiversity outside of protected areas. It takes a holistic approach towards water management, prioritising the needs of the entire river basin above anthropogenic agendas. For example, the Water Framework Directive calls for the creation of water management units based on the geographic location of river basins rather than country boundaries (Hanley *et al.*, 2006).

Another policy of importance for the protection of biodiversity is the Irish National Biodiversity Plan, which was published in April 2002. This report outlined a series of measures to reduce species' and habitat loss in Ireland by integrating conservation of biodiversity into all relevant sectors including agriculture. It was followed up with the introduction of a 2010 Convention on Biological Diversity Target in 2005 (NPWS, 2011). The combined effect of the Water Framework Directive, the Biodiversity Plan and the Biological Diversity Target was an increase in awareness of the importance of agriculture for maintaining important Irish habitats, both inside and outside of Natura sites. In effect, these policies highlighted the role that farmers play as custodians of the Irish environment (Feehan and O'Connor, 2009).

## *2. 6. The NFS*

The data used for the analysis of REPS policies in this thesis are taken from the NFS. The NFS was set up in 1972 and has been published annually by Teagasc since. The objectives of the NFS, according to Connolly *et al*. (2008), are to determine the financial situation on Irish farms by measuring levels of gross output, costs, income, investment and indebtedness across the spectrum of farming systems and sizes; to provide data on Irish farm output, costs and incomes to the EU Commission in Brussels (FADN); to measure the current levels of, and variation in, farm performance for use as standards for farm management purposes and to provide a database for economic and rural development research and policy analysis.

A sample of approximately 1,100 Irish farmers, representing 115,000 farms nationally, is taken every year. Farmers are visited by NFS surveyors three times in a year. Up to 150 farmers leave the NFS annually, so there is a substantial amount of turnover in the sample. Some sectors of the sample have only a small number of representative individuals, so the NFS incorporates a weighting factor, which is applied to each observation, to ensure that farming is representative of the national population of farmers. The classification system that is used to identify farm enterprises in the NFS is based on the EU FADN typology set out within Commission Decision 78/463. They indicate what the main enterprise on a farm in a year is. Farm systems in the sample include cattle, which is divided into suckler and rearing; dairy, which is divided into specifically dairy and dairy with other enterprises; sheep and tillage (Connolly *et al.*, 2010).

The large amount of information contained in the NFS allows it to be used to investigate trends in farm inputs and outputs, as well as providing details on farmer demographics for the entire country over time. In addition, individual farmcodes in the NFS are geo-referenced, meaning data on farm level variables can be linked to environmental data if necessary. Overall, this means the NFS provides an enormous amount of information on Irish farmers, which may be used to investigate REPS implementation decisions.

## *2. 7. Summary*

The aim of this chapter was to provide background information on Irish farming, relevant agricultural and environmental policies and the NFS, all of which are necessary for an understanding of the subsequent chapters in this thesis. It showed that spatial patterns in Irish agriculture are well established for a small country and heterogeneity in farming systems is widespread. All Irish farmers could choose to join REPS at any time from 1994 to 2009 provided they had more than three hectares of UAA that they actively farmed for the entire calendar year. Broadly speaking, the objectives of REPS did not change during this period and targets were defined in terms of uptake and expenditure rates. Participants were obliged to adhere to 11 measures as part of their individual farm management plans. These measures attempted to achieve a broad variety of environmental objectives, including pollution abatement and biodiversity conservation.

There were four distinct phases of REPS that were introduced in 1994, 2000, 2003 and 2007, respectively. Generally, the contracts for all four phases were similar; however, some changes were made to the scheme over time. These included changes to payment rates, to contentious restrictions contained in the measures to payment rates and, finally, a strengthening of the emphasis on biodiversity conservation.

REPS was replaced by a different AES – the AEOS – in 2009. There are a number of similarities between the schemes. Both are voluntary and a number of the measures that are used to address environmental issues in the AEOS are the same as those contained in REPS. Consequently, a review of farmer implementation behaviour in REPS can help to advise policy makers involved in the AEOS.

The main impacts of changes in CAP policies from 1994 to 2010 were that prices received for market-based earnings became increasingly volatile and direct payments became increasingly decoupled from production. Changes in environmental policies highlighted the fact that farmers were held increasingly accountable for the negative externalities they produced as a consequence of production. However, they were also given greater praise for the role that they play as custodians of the environment.

The final section of this chapter described the data used to assess the impact of REPS policy changes in this thesis. They come from the NFS, which is published annually by Teagasc. It provides a large variety of information on farm and farmer characteristics for a nationally representative sample of Irish farmers from 1995 to 2010[5].

[5] Data on farmers' participation status for REPS were not gathered by the NFS in 1994.

# 3. Evaluation of REPS

This chapter looks at how AESs have been evaluated in related literature. It has four distinct sections. Section 3.1 describes a number of factors used to assess the environmental effectiveness of AESs, which can be categorised as scheme-level or farm-level factors, and details the literature evaluating each for REPS. Section 3.2 looks at issues associated with the evaluation of REPS at farm level. Section 3.3 identifies two important issues that need to be considered when evaluating the environmental effectiveness of REPS using farmer participation behaviour. These are the impact of other policies on farmer behaviour and adverse selection bias. Section 3.4 presents literature identifying the main factors influencing farmers' participation decisions in AESs. These factors are divided into farm-specific and individual-specific factors. The chapter concludes with a brief summary.

## *3. 1. Factors influencing the effectiveness of AES*

In a paper that aims to clarify the many ways of evaluating the *ex post* environmental effectiveness of AESs, Finn *et al*. (2007) distinguish between environmental effectiveness from AESs attained at scheme-level and at farm-level. Effectiveness at scheme level is determined by three factors, the first of which is the participation rate. Participation in REPS was voluntary, meaning the participation rate was entirely determined by farmers.

The second scheme-level factor for determining environmental effectiveness is targeting. By targeting, Finn *et al*. (2007) refer to how well the design of a scheme ensures that the spatial distribution of participation matches the spatial distribution of the local or regional agri-environmental issues. REPS was universally available to every farmer in the country, meaning there was little targeting in the scheme. In fact, in a review by Finn (2009) of the effectiveness of nine EU AESs using multi-criteria analysis (MCA), REPS had the poorest performance of all in terms of targeting.

Finally, scheme-level environmental effectiveness is determined by farm-level environmental effectiveness. It is important to note, however, that this relationship is not additive. Namely, having 20 individuals perform effectively at farm-level does not necessarily produce 20 times more environmental change at scheme-level than 1 effective farmer (even if they all have equal sized farms). This is because effectiveness at scheme level is dependent on many aspects of the landscape such as habitat connectivity, variability, diversity and spatial scale

(Waldhardt, 2003, Weibull *et al.*, 2003, Hendrickx *et al.*, 2007). The design of REPS assumed that the relationship between scheme-level and farm-level effectiveness is additive. In other words, it assumed that effectiveness could be gauged by the quantity, rather than the quality, of participants. Whelan and Fry (2011) provide evidence that this assumption resulted in a great loss of potential effectiveness in the scheme.

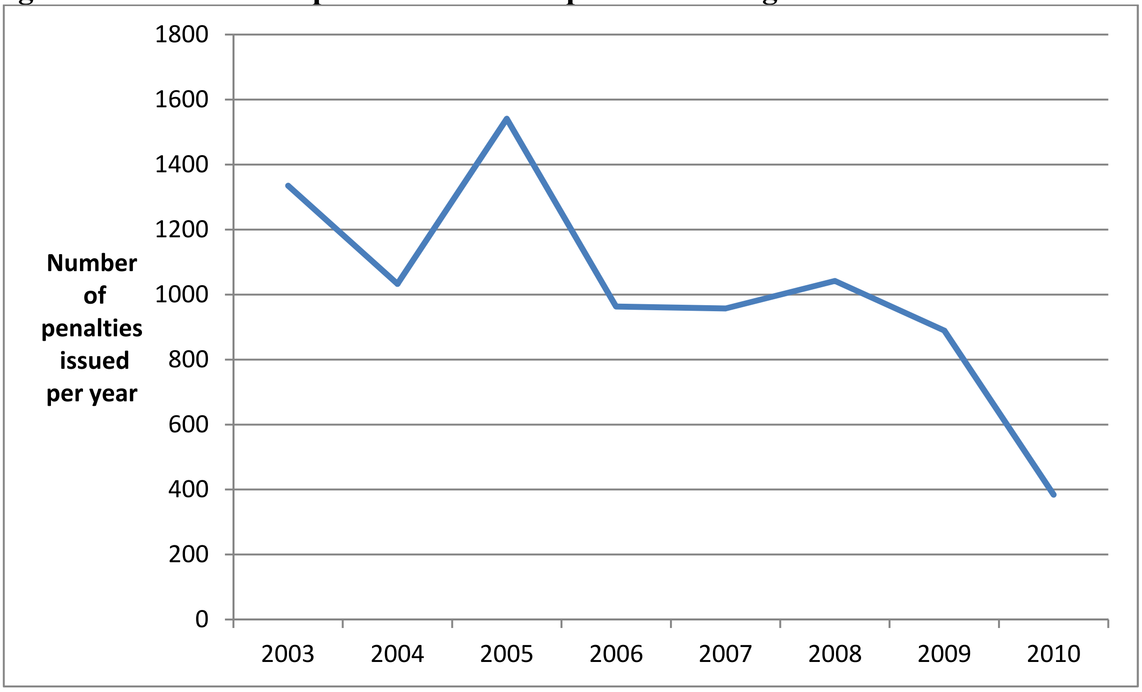
### *3. 1. 1. Farm-level environmental effectiveness*

Environmental effectiveness at farm level is determined by two factors. The first is cause and effect, which relates to whether there is scientific evidence supporting the claim that changes made on participating AES farms actually cause environmental improvements. In other words, these studies look at whether the implementation of AES measures on farms leads to an increase in the quantity or quality of environmental outputs produced by agricultural landscapes. Feehan *et al*. (2005) compared REPS farms with non-REPS farms to investigate whether participation caused a positive effect on general species' richness and abundance levels of both field-margin flora and Carabidae (ground beetles) at farm level. The results from this study were inconclusive. Similarly, Copland and O'Halloran (2010) found that management changes on REPS farms had little positive impact on bird density and abundance on lowland farms.

Results from cause-and-effect studies described above show that changes made on REPS farms were assumed, rather than proven, to cause positive changes in the Irish environment. The design of the scheme reflects this assumption; namely, all of the scheme's objectives are defined in terms of changes to farm-level input use rather than changes in environmental outputs (Chapter 2). Consequently, most *ex post* evaluations of REPS involve an examination of inputs rather than outputs from the scheme. For example, all but the advanced tier *ex post* quantitative indicators identified by Finn *et al*. (2005) for evaluating REPS effectiveness are measurements of farm-level inputs.

The second factor impacting on farm-level environmental effectiveness is farmer behaviour, which may be divided into the impact of compliance and the impact of implementation. Moral hazard occurs as a consequence of the undersupply of environmental goods when farmers do not fully comply with the terms of their AES contract (Moxey *et al.*, 1999). The amount that a scheme suffers from moral hazard is believed to be inversely proportional to the level of monitoring that occurs in the scheme, i.e., if farmers believe the risk of being caught cheating is high, they are more likely to comply with the terms of their contract (Ozanne *et al.*, 2001).

**Figure 3.1: Penalties imposed for non-compliance relating to environmental measures**




Source: DAFF, 2010[6]

Figure 3.1 shows the number of penalties issued to REPS farmers for misdemeanours from 2003 onwards. It clearly shows that, despite on-going increases in participation numbers over time (Figure 2.3), the number of penalties bestowed on farmers decreased across the four phases. This may be because farmers became more compliant over time. It is more likely, however, that the extent of monitoring that occurred on REPS farms declined between 2003 and 2010.

Information from the DAFF (2010) also states that the value of non-compliance penalties over time decreased. For example, from 2003 to 2006 inclusive, the most commonly received penalty was for not undertaking changes in respect to the farmyard as planned. The fine for

[6] It is difficult to ascertain data relating to compliancy in REPS I, although Emerson and Gillmor (1999) comment that over 600 penalties were reported for the phase and that verification of compliance with some of the specifications was difficult.

this penalty was 20%, 10% and 1-3% of farmers' payments in REPS II, REPS III and REPS IV, respectively. Over time, therefore, the risk of non-compliance for REPS farmers decreased as a consequence of reduced monitoring and reduced fines. These findings imply that the effectiveness of REPS in terms of compliance is likely to have lessened over time.

The second aspect of farmer behaviour that impacts on farm-level environmental effectiveness is implementation[7], and this is the main focus of this thesis. In REPS, scheme implementation impacts on scheme effectiveness in two ways. The first is farmers' actual participation decision, which influences scheme effectiveness because a voluntary scheme has no effect unless individuals choose to join. The second is how farmers choose to implement scheme measures into their individual farm plans. If the choices made by farmers are inappropriate for the environmental needs of their farms, it will result in a loss of effectiveness for the scheme.

## 3. 2. Evaluating REPS at farm level

Evaluating whether individual farmers met REPS requirements is not a simple affair. Estimating whether individuals made the required changes under their contract in return for their REPS payments is complicated by two important issues. These are, firstly, difficulties with the identification of what farmers were being paid to achieve on their farms under REPS and, secondly, issues with the evaluation of changes made by farmers under REPS.

### *3. 2. 1. Expectations of farmers in REPS*

When REPS was introduced in 1994, the model used to justify paying farmers for the production of environmental goods was the management agreement model. This model assumes that farmers have implicit property rights as land managers and can carry out the most profit-maximising activity on their land, irrespective of the external costs and benefits of doing so (Hanley *et al.*, 1999). Under this model, justification for providing farmers with

[7] Interestingly, a relationship also exists between the effects of compliance and implementation on scheme effectiveness because the threat of high levels of monitoring or penalisation can lead to lower uptake rates in a scheme (Steele, 2010). In fact, the high occurrence and values of penalties in REPS II is cited as one of the main reasons for the low uptake rates in REPS II (Rath, 2002). In other words, in an attempt to achieve high levels of effectiveness from compliancy, policymakers produced a scheme that was ineffective in terms of implementation.

AES payments comes from the fact that they should be compensated for losses incurred as a consequence of changing how they managed their farms to meet the requirements of the scheme. Another way of looking at this is that, under the management agreement model, farmers were expected to make changes to how they farmed to earn their payments.

REPS was incorporated into Pillar 2 (rural development) of the CAP under 1257/99/EC. Hence the policy justification underlying REPS changed at this time, although the scheme itself remained relatively unaltered. The introduction of Pillar 2 meant that justification for paying farmers to produce environmental goods moved away from the management agreement model to one that acknowledged that environmental goods are valued outputs of production from farmers. This way of thinking culminated in the addition of minimum stocking rates to the REPS IV contract. Justification for this comes from the fact that many farm habitats revert to scrub if farming practices cease (Gwyn *et al.*, 2003). Under this new model, farmers do not necessarily have to alter their agricultural practices to justify receiving their scheme payments but, in certain cases, earn payments for maintaining the status quo on their land.

In the cases where farmers did alter their management practices to meet REPS requirements, the alterations made potentially fell into one of two categories. Firstly, farmers may have changed their agricultural practices in an effort to reduce the amount of negative externalities produced by their enterprises. Negative externalities occur when the public costs of agricultural production are greater than the private costs and include problems such as soil and water pollution (Pretty *et al.*, 2001). Secondly, farmers could make changes that resulted in an increase in the level of positive externalities, or situations where the public costs of production are lower than the private costs, from their holdings. In the case of REPS, this could mean, say, the creation of additional biodiversity rich areas on a farm.

This aspect of the REPS contract complicates the matter of scheme evaluation because decreasing negative externalities and increasing positive externalities are two distinct and unconnected environmental, and economic, issues. Unsurprisingly, attempting to evaluate both issues using one framework is complicated.

### *3. 2. 1. Evaluating externalities from agriculture*

Negative externalities can take the form of point source or non-point source pollution. Non-point source pollution comes from many diffuse areas. For example, rainfall may pick up on either human or man-made pollutants and deposit them to waterways (Ribaudo, 2004). By definition, therefore, non-point source pollution is difficult to assign to individual farmers. Improvements made under REPS to levels of negative externalities can be calculated as improvements in point source pollution emitted by individuals only.

The positive externalities produced by agricultural landscapes are provisioning, regulatory, cultural and supporting goods and services. Provisioning, regulatory and cultural goods and services provide humans with use values. Supporting services are not directly used by humans but they, nonetheless, provide us with utility and are therefore assigned non-use values (UKNEA, 2011). The manner by which positive externalities with use values are evaluated depends on whether the good or service is a private or public good. On the private-public scale, an absolute private good is described as being both excludable and rival, where excludable means that it is possible to stop those who pay a zero price from consuming it and rival suggests that one individual's use of the good or service in some sense precludes or prevents another individual from using it (Young, 2005). The majority of provisioning goods are more private than public. Regulatory and cultural goods and services tend to be public in nature. Due to the fact that they provide us with non-use values, supporting services are, by definition, neither public nor private goods (Hanley and Barbier, 2009).

### *3. 2. 2. Stated preference techniques*

Values for provisional (private) goods produced by Irish landscapes may be realised through conventional market prices (Indecon, 2003). The two main methods used for evaluating public goods are stated preference (SP) and RP techniques. Broadly speaking, SPs are survey-based techniques used to investigate the trade-offs that people are prepared to make between different goods or policies (Alberini *et al.*, 2006). They are concerned with generating a hypothetical market for ecosystem goods and services and asking respondents how much they are WTP for an improvement (or willing to accept for a decline) in its supply. The two most popular SP methods used are contingent valuation (CV) and choice experiments (CE) studies.

In Ireland, Buckley *et al.* (2009) used a CV to estimate the amount that members of the public were WTP for public access and trail improvements on commonage farmland. Mean WTP for formal access with improved trail infrastructure was given as €9.08 and €12.22 per annum for upland and lowland sites, respectively. CEs have been used to estimate members of the publics' preferences for landscape improvements under REPS (Campbell, 2007). Findings showed that the highest WTP values were associated with REPS measures that protected stonewalls and mountain land. Mean values from a random parameter logit put these values at €26.68, and €33.23, per annum respectively.

### *3. 2. 3. Revealed preference techniques*

Due to the fact that SPs use hypothetical markets to estimate values for public goods, an advantage they have over RPs is that they are capable of eliciting non-use values for supporting ecosystem services. However, the fact that they use hypothetical markets and stated preferences means that they do not infer values from real human behaviour, meaning implications of SP results to policy need to be considered with caution. In fact, Hynes *et al.* (2011a) have shown that using CVs and CEs to estimate the value of positive externalities produced by REPS farmers resulted in the generation of significantly different non-market values.

An interesting factor relating to the evaluation of AESs that arises in many SPs studies is that taxpayers' opinions of which positive externalities farmers should be paid for can differ greatly. In the study by Campbell (2007), there was significant heterogeneity in individual preferences for improvements made to Irish landscapes under different REPS measures. These preferences can vary over time because favoured agricultural landscapes are dependent on the current set of endogenous and exogenous influences on the utility of respondents (Hynes and Campbell, 2011a). Doherty *et al.* (2012) have also shown that the costs associated with the management of different landscape types vary greatly across the Irish population.

RPs are concerned with estimating prices for use values produced by ecosystem goods or services using either conventional or proxy markets (Boyle, 2003). For example, Bullock *et al.* (2008) used pollination weightings as a proxy market to estimate the value of biodiversity to Irish agriculture at €53 million in 2005. Hynes *et al.* (2009) used a travel cost model to estimate the value of a 25% improvement in water quality on the river Shannon (which would be influenced by farming practices) to kayakers at between €0.14 and €0.22 per hour.

Unfortunately the use of RPs to evaluate positive externalities produced by REPS farmers is limited by the availability of utilisable data.

Results from studies above show that it is difficult to assign certain values to the various externalities produced as a consequence of agricultural activities. This problem can be somewhat overcome by using RP data to look at whether REPS payments compensated farmers for the total opportunity costs of implementing the scheme on their farms[8]. For example, rather than attempting to evaluate the amount of point or non-point sources of pollution emitted by farmers, an evaluation of farmers' input use can be used to identify the likelihood that individuals emitted pollutants. In Ireland, Hynes *et al.* (2008b) found that the production of organic nitrogen, potassium and phosphorous, as well as methane emissions, per hectare significantly decreased due to the existence of REPS in both 1996 and 2005.

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). Gaining an understanding of farmers' AES participation functions therefore plays an important role in the evaluation of scheme effectiveness at farm-level. 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 *et al.*, 1999). To date, SP techniques have not been used to estimate the opportunity costs of participating in REPS, although the participation functions of Irish farmers have been estimated by comparing REPS farmers with non-REPS farmers (Hynes and Garvey, 2009).

## *3. 3. Using farmer implementation behaviour to estimate the environmental effectiveness of REPS*

Two important issues need to be detailed at this point regarding the use of farmer implementation behaviour as a gauge for the effectiveness of REPS. Firstly, farmers' implementation of REPS on their holding is not presumed to be the only factor that

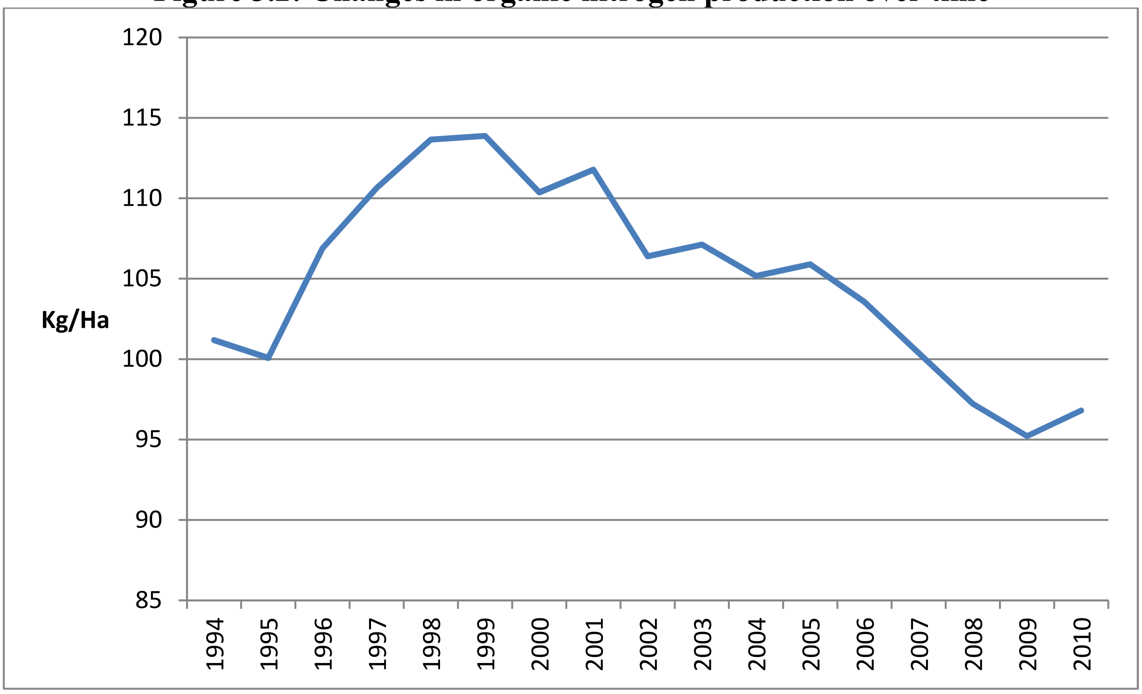
[8] In doing so the research question being asked is no longer whether the total value of externalities produced by farmers at scheme-level compensates for the total cost of the scheme to the exchequer but whether the total opportunity costs of the scheme to the farmer compensates for the value of the individual REPS payment.

influenced their levels of input usage from 1994 to 2010. Secondly, a number of farmers are expected to have met REPS criteria before they even joined the scheme, which means REPS suffered from adverse selection bias. This section provides further details of these issues because they need to be considered for the remainder of the thesis.

### *3. 3. 1. Exogenous impacts on farmers' input use*

Figure 3.2 below shows how average organic nitrogen production on all Irish farms changed from 1994 to 2010. It shows that production increased substantially from 1995 to 1998 and began to dip only in 2002. In fact, values began to reach pre-1994 levels only from 2005 onwards.

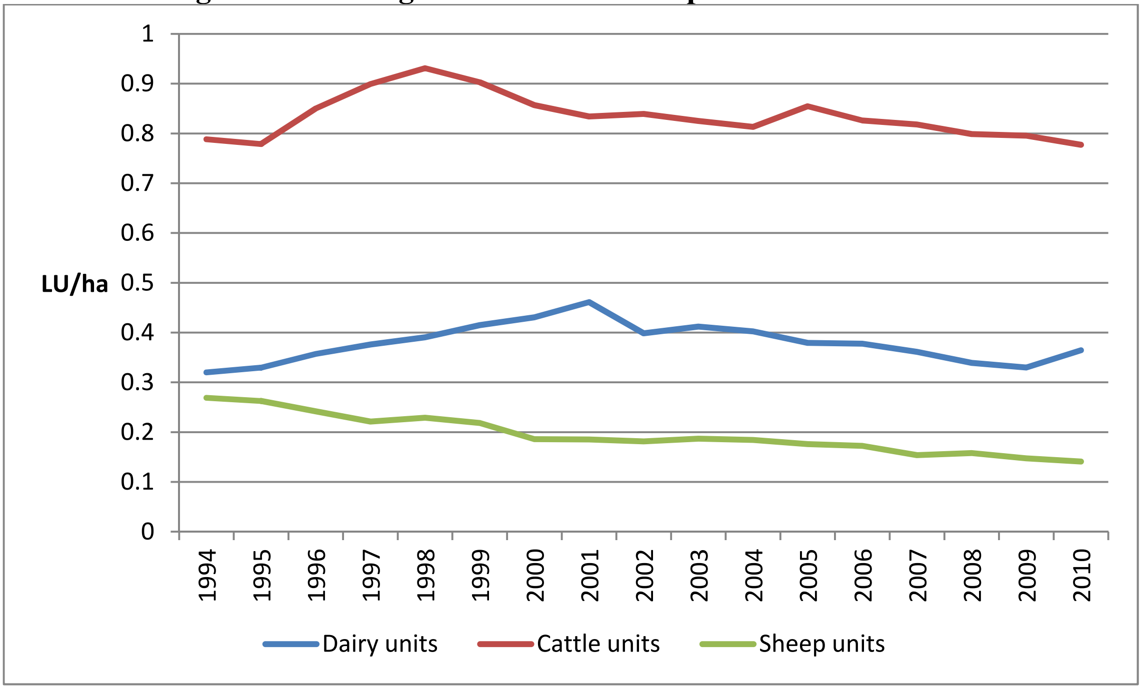
**Figure 3.2: Changes in organic nitrogen production over time**




Source: NFS 1994 to 2010

REPS had restrictions regarding organic nitrogen production so these changes could be a consequence of the introduction of REPS III in 2003, followed by REPS IV in 2007. They could also, however, be due to changes introduced under Agenda 2000 followed by the SFP in 2005.

**Figure 3.3: Changes in livestock units per hectare over time**




Source: NFS 1994 to 2010

Figure 3.3 shows the average amount of livestock units found on Irish farms from 1994 to 2010. The number of cattle units per hectare peak in 1998 and in 2005 but decrease from then onwards. Dairy units peak in 2001 and 2010. The only livestock units that show obvious and steady declines in number are sheep. Again, REPS had restrictions on the number of livestock units that farmers were permitted to have per hectare. Findings for sheep could be a consequence of the introduction of REPS or a result of other changes in agricultural policy, which began with the introduction of the MacSharry reforms in 1992 (see Chapter 2).

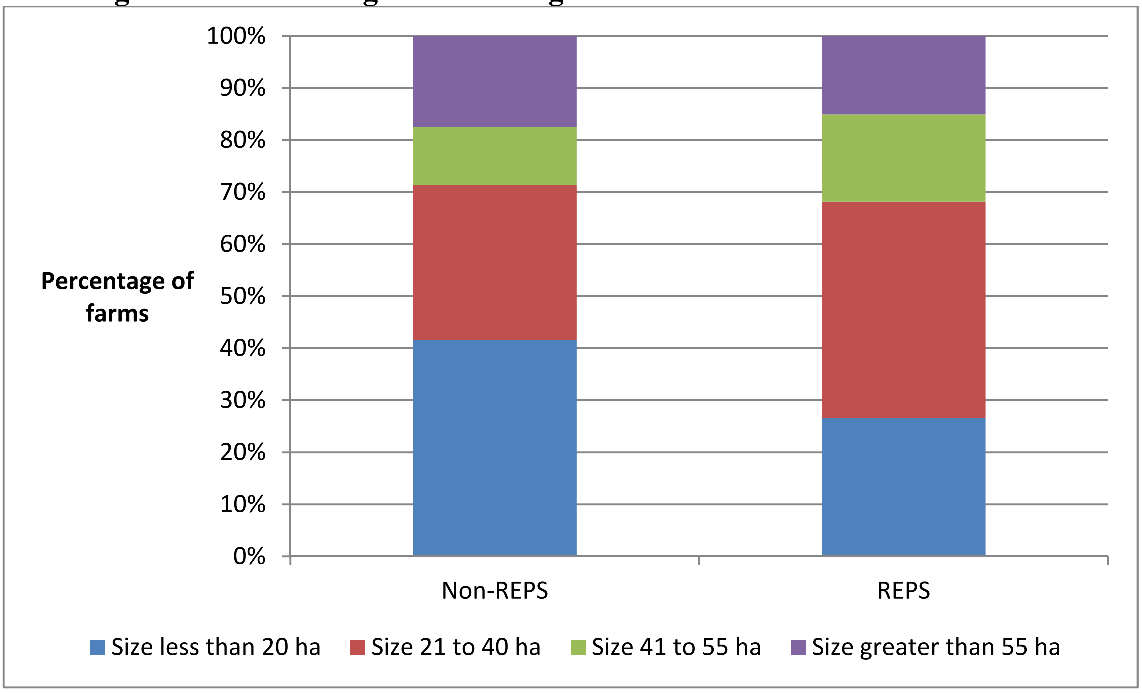
The examples of organic nitrogen production and livestock units described above highlight the fact that isolating out the impact of changes to farm management procedures as a consequence of the introduction of REPS versus other agricultural policies can be difficult. This problem needs to be noted in any evaluation of the environmental effectiveness of REPS.

### *3. 3. 1. Adverse selection bias*

No ecological baseline data were collected for REPS. Hence evaluations of scheme effectiveness usually involve comparing participating farms with non-participating farms.

Comparing changes on REPS farms with non-REPS farms has its own problem: namely, REPS farms and non-REPS farms were often fundamentally different prior to even joining the scheme. For example, although the REPS contract did not require participants to change the size of their farms in any way, the average sizes of REPS and non-REPS farms are substantially different. This is evident from Figure 3.4 below, which compares the size categories of REPS and non-REPS farms from 1994 to 2010. It shows that a greater number of REPS farms fall into the middle-size categories (21 to 40 hectares and 41 to 55 hectares) than non-REPS farms.

**Figure 3.4: Percentage of size categories in REPS and non-REPS farms**




Source: NFS 1994 to 2010

The reasons for these size differences are, doubtless, linked to the payment structure used by the REPS contracts (see Chapter 2). They show that aspects of the scheme contract can bias what type of farmer is most likely to participate in the scheme. This phenomenon is referred to as adverse selection bias. Adverse selection bias means that differences in the management of REPS and non-REPS farms may not have occurred as a consequence of the existence of the scheme. These differences may have, in fact, existed before the scheme was introduced on a farm but may nonetheless be accidently considered evidence of scheme effectiveness.

## 3. 4. Factors influencing farmers' participation in AESs

A number of studies have identified factors that influence farmers' participation decisions in AESs. These factors are assumed to influence both aspects of the implementation decision in REPS: namely the participation decision and how farmers choose to implement scheme measures into their individual farm plans. These factors, which have been identified in related literature, can be categorised into farm-specific characteristics and individual-specific characteristics.

### 3. 4. 1. Farm-specific characteristics

Farm-specific characteristics affect farmers' participation decisions because they influence how well the scheme "fits" with aspects of the AES contract (Wynn *et al.*, 2001). For example, farms with low productivity potential have lower opportunity costs associated with extensifying productivity (which is often required from an AES contract) than farms with high productivity potential. For this reason, low productivity potential (Dupraz *et al.*, 2003), low livestock density (Defrancesco *et al.*, 2008) and poor soils (Hynes and Garvey, 2009) are all associated with an increase in the likelihood that a farmer will participate in an AES.

Certain authors have also found that farm size is positively (Wilson, 1997, Lynch and Lovell, 2003) associated with the likelihood of participating in a scheme, whereas others have found its influence is inconclusive (Wynn *et al.*, 2001, Dupraz *et al.*, 2003, Wossink and van Wenum, 2003). These results are often linked to whether the AES being studied pays farmers per hectare or not and whether there are limits on the number of hectares that farmers are permitted to enter into the scheme. Consequently, findings for farm size also reflect how well the scheme fits with the specifics of the farm.

### *3. 4. 2. Individual-specific characteristics*

Individual-specific factors are more concerned with farmers' opinions of AESs and the role that they play in the management of their holdings. A number of authors have attempted to group farmers according to what motivates them to join an AES. Morris and Potter (1995) and Wilson (1996) speculated that there is a spectrum of participation in AESs, with four categories of farmer. These are called resistant non-adopters, conditional non-adopters, passive adopters and active adopters.

Resistant non-adopters refuse to participate in AESs under any circumstance. Reasons cited for their determined resistance include distrust of governments (Wilson, 2000) or a strong dislike of changing their farming practices (Ma *et al.*, 2012). Another reason for farmers' lack of motivation to join AESs, suggested by Willcock (1999), is that they view farming first and foremost as a business that produces traditional agricultural commodities as opposed to environmental goods. When Defrancesco *et al*. (2008) estimated a separate participation function for the participation decision of resistant non-adopters in an Italian AES, they found they were more likely to be market-orientated farmers with plans to invest in the future of their holdings than any other group of farmers.

Active adopters prioritise utility from environmental gain over financial gain and are likely to participate in and comply fully with the terms of the AES contract. Willcock (1999) suggested that many individuals view farming as a way of life rather than as a business. Again, Defrancesco *et al*. (2008) showed that active adopters' normative beliefs towards environmental protection, as well as the beliefs of their neighbours, had a stronger influence on their participation decision than it did for any other farmer type.

Conditional non-adopters and passive adopters will join an AES only if the value of the payments fully compensates them for the utility change associated with joining. The only difference between these two groups is that conditional non-adopters do not view the payments as being enough, whereas passive adopters do. In other words, both conditional non-adopters and passive adopters do not have strongly positive or negative opinions on the role that AES participation plays in the management of their farms.

Wossink and van Wenum (2003) also compared how conditional non-adopters and passive adopters perceived participation in an AES in the Netherlands by empirically estimating factors affecting actual participation and contingent participation in the scheme. A significant factor in determining conditional non-adopters' decision not to join the scheme was the risk associated with loss in on-farm earnings as a consequence of extensification under the scheme. Interestingly, risk aversion may also lead some farmers to join an AES. For example, risk-averse farmers may view AES payments positively when compared with the uncertainty associated with volatile market prices (Matthews, 2010).

A number of demographic variables are significantly associated with the likelihood that famers participate in an AES. Often, these demographic variables are acting as proxies for other individual-specific influences on the choice. For example, education levels are believed to capture the impact of normative beliefs towards environmental protection on farmers' participation decision. This is despite the fact that a review of 31 international papers on farmer participation behaviour in conservation tillage programmes showed that the effect of education on participation was mixed (Knowler and Bradshaw, 2007). This may be because the variable being investigated by Knowler and Bradshaw was unspecified education. The impact of environmental education, however, is almost always positively associated with participation, as is access to environmental information (Dupraz *et al.*, 2003, Zbinden and Lee, 2005).

Another demographic variable often included in participation studies is farmers' age. It is usually negatively associated with scheme adoption meaning younger farmers are more likely to join than older farmers (Wilson, 1997, Wynn *et al.*, 2001). This is believed to be because younger farmers are more keen to try new management strategies on their farms and are more sympathetic towards the needs of the environment than older farmers (Vanslembrouck *et al.*, 2002, Van Rensburg *et al.*, 2009).

A number of studies show that the effect of having children on the likelihood of participating in AESs may be negative (Potter and Lobley, 1992), positive (Wilson, 1996, Lynch and Lovell, 2003) or inconclusive (Wossink and van Wenum, 2003). This finding for the effect of having children is usually associated with whether a farm owner has a successor or not. Therefore, it is picking up on whether farmers perceive the choice to participate in AESs as something that is beneficial for the long-term success of the farm.

Although it is not a demographic variable, the presence of environmental features, such as habitat types, on farms is also expected to act as a proxy for other individual-specific characteristics that influence farmers' participation decisions. In a study of farmer-participation behaviour in the Cambrian Mountain Environmental Sensitive Areas (ESA) scheme in the UK, Wilson (1996) found that farmers with broadleaved woodlands were primarily driven to join because they believed these habitats needed protection. Herzon and Mikk (2007) found that both Finnish and Estonian farmers displayed a similar desire to those in the UK to conserve tree groups and that the desire to conserve habitats extends to semi-natural grasslands for Estonian farmers. This latter finding is not true for Finnish farmers. These findings show that farmers may perceive agricultural landscapes in many ways according to historical and cultural opinions of farm habitats, both of which may vary geographically (Burgess *et al.*, 2009). The impact of habitats on Irish farmers' participation decision may be seen through the opinions identified by Aughney and Gormally (2002), who found that REPS farmers believed that only non-productive areas of their farms, such as scrub, had any conservation value. In addition, areas of peatland have historically been viewed by landowners as wastelands with little ecological value (IPCC, 2010).

## 3. 5. *Summary*

This chapter has shown that farmer behaviour needs to be investigated to fully understand how environmentally effective REPS was as an AES for two reasons. Firstly, with regard to scheme-level effectiveness, REPS had little targeting and participation was entirely voluntary. Consequently, the decision whether any field in Ireland was covered by the scheme was made by farmers. Secondly, farmers' behaviour with regard to REPS needs to be investigated to understand its effectiveness at farm level. This is because, at farm level, the effect of REPS on any changes in input use was dictated by whether a farmer chose to join REPS and by how he implemented the scheme on his farm.

The evaluation of whether individual farmers met REPS requirements is not simple. Difficulties with its assessment stem from a two key issues. Firstly, it is not clear what farmers were being awarded for under the REPS scheme. They may have been receiving payments for altering, or for maintaining status quo, management on their farms. Similarly, their payments were intended to compensate them for both an increase in the production of externalities and for a decrease in the production of positive externalities on their farms. These are two isolated environmental problems. Secondly, there are a number of difficulties associated with the evaluation of both negative and positive externalities and assigning them to changes made on individual farms. This further complicates the issue of evaluating REPS' success.

Two issues with the use of farmer implementation behaviour to assess REPS effectiveness need to be acknowledged. Firstly, other policies, besides REPS, influenced farmers' behaviour. Secondly, as with most voluntary AESs, REPS is expected to have suffered from adverse selection bias. To investigate what effects farmers' AES implementation decisions requires an understanding of the factors that influence their choice. These factors can be divided into farm-specific and individual-specific characteristics. Analyses of farmers' implementation behaviour towards REPS should incorporate the impact of as many of these factors on behaviour as possible.

# 4. An investigation into the type of farmer who chose to participate in REPS and the role of institutional change in influencing scheme effectiveness

## *4. 1. Introduction*

The aim of this chapter is to examine the type of farmer who chose to participate in REPS over time, to assess how changes in policy design had an impact on this participation decision and how this, in turn, influenced scheme effectiveness. Changes to the policy design occurred across the four phases of REPS, which were introduced in 1994, 2000, 2003 and 2007, respectively. The scheme had broad environmental objectives, which can be divided into those that tackled issues relating to biodiversity conservation and those that were aimed at pollution abatement. In the first two phases of REPS, biodiversity conservation objectives were intended to be met in two ways. On participating farms that already had habitats, biodiversity-rich areas were retained, whereas on farms that had no habitats, areas of agricultural land were taken out of production to generate habitat-rich areas referred to as “setaside”. The introduction of biodiversity undertakings (BUs) in the latter two phases of the scheme (REPS III and REPS IV) called for adopters to make a greater effort on their farms with regard to biodiversity conservation. Those with existing habitats were occasionally required to make input changes to actively enhance existing habitats. Similarly those with no habitats were occasionally obliged to actively create habitats on their holdings.

Pollution abatement strategies in REPS were primarily concerned with reducing the quantity of chemicals used, or produced, on participating farms by imposing application, or output, limits for chemicals on participating farms. Pollution abatement was then achieved in one of two ways. For farmers who used or produced quantities of chemicals that were below the threshold limit, maintenance of the status quo was required. For farmers whose levels of use or production were above the threshold limit, adoption meant they were obliged to reduce their level of chemical use or production if they wished to participate in REPS (Emerson and Gillmor, 1999, DAFF, 2004, DAFF, 2007).

As it was a voluntary scheme, the effectiveness of REPS was largely assessed by the number of farmers who chose to join it. Consequently, scheme targets were often defined in terms of uptake rates (Rath, 2002). However, the effectiveness of REPS was also dependent on the correct type of farmer choosing to join the scheme. Given the high degree of heterogeneity in Irish farming, the level of improvement to the Irish environment that occurred as a consequence of an individual's choice to participate in REPS varied greatly. Ideally, the type of farmer who joined REPS should be someone whose participation resulted in the greatest per-farm improvement for the Irish environment.

In terms of the biodiversity conservation objectives of the scheme, REPS needed to attract all types of Irish farmers. This is because having a heterogeneous array of Irish farmers in the scheme ensured there was a high likelihood that a wide variety of habitats would be covered by the scheme. On the other hand, the ideal type of farmer one would prefer to see joining REPS for it to effectively meet its pollution abatement objectives were those whose chemical use and production levels were above the threshold limits imposed by the scheme. This would ensure that the existence of REPS produced change with regard to the amount of chemicals dispersed into the environment because participants would have reduced their use and production levels on joining rather than maintaining status quo levels, which would have been the case for individuals whose use and production levels were below the threshold limits. For these reasons, the first aim of this chapter is to assess what type of farmer was most likely to participate in REPS from 1995 to 2010, inclusive, and whether this type of farmer was capable of effectively meeting both of the scheme's objectives.

The second aim of the chapter is to investigate whether changes to the REPS contract across the four phases resulted in an improvement in the type of farmer who participated in REPS over time. The objectives of REPS were applied at farm level through 11 measures. While the topics of these 11 measures did not change across phases, certain institutional details regarding how they were to be applied on individual farms did (see Chapter 2). Two groups of institutional changes are investigated by this chapter. These are changes to the payment rates (the majority of which were increases) and changes to the threshold limits for organic nitrogen production across phases. Both groups of changes were intended to improve scheme effectiveness by attracting a greater number, and different type, of farmer(s) to the scheme. This chapter investigates whether the effectiveness of the type of farmer in each phase of REPS improved as a consequence of these institutional changes. To achieve this aim, the type of farmer found in each phase is, again, reviewed with regard to whether they were the ideal participant in REPS to effectively meet the scheme's biodiversity conservation and pollution abatement objectives.

Regarding the second group of changes in the REPS contract (the restrictions in organic nitrogen production on participating farms), Hynes and Garvey (2009) have already shown that, from 1995 to 2005 (mainly REPS I and REPS II), REPS farmers were significantly more likely to be sheep farmers, followed by cattle farmers, than any other system type. The authors believed that this finding was a consequence of the restriction on organic nitrogen production in REPS because, traditionally in Ireland, cattle and sheep farms are extensive (those who generate more than 170 Kg/ha), whereas dairy and tillage are intensive (Emerson and Gillmor, 1999). This result indicates that earlier phases of REPS suffered from "adverse selection bias" (see Chapter 3) with regard to this particular restriction: namely, those whose participation was most likely to result in the greatest output changes with regard to pollution abatement were disinclined to join. For this reason, this chapter specifically looks at whether changes in the restriction levels for organic nitrogen production across the REPS phases – in particular, the introduction of derogations for intensive farmers in REPS IV – helped to overcome the adverse selection bias that was evident during the earlier phases of the scheme, thereby improving the type of farmer who participated in REPS over time.

REPS provides an interesting case study for an investigation into the impacts of contractual changes on participation behaviour in an AES for two reasons. Firstly, REPS was universally available to all Irish farmers and, secondly, during the period that it existed, no other AES was available to Irish farmers. Consequently, there were few restrictions on who could join and, unlike the review of institutional effects on participation behaviour carried out by Peerlings and Polman (2009), there is no need to account for the impact of competing schemes on farmers' preferences. With this in mind, the outputs from this chapter should help to inform future international agri-environmental policy, in addition to Irish policy.

Section 4.2 below provides a discussion of how other agricultural and environmental policies, as well as factors identified by related literature and specific to this chapter, are expected to have influenced farmers' REPS participation decisions in each of the four REPS phases. Section 4.3 describes the economic theory underlying farmers' participation decisions in REPS. It also shows the logit models that are used in this chapter to look at the types of farmer who are most likely to participate in the scheme. The NFS data used in this chapter are introduced in Section 2.6 but are discussed briefly in Section 4.4, which includes summary statistics for NFS farms over time and for each of the four phases of REPS. Section 4.5 presents and discusses the findings from a random effects logit on REPS participation from 1994 to 2010 and for four binary logits on REPS participation in a representative year for each phase of the scheme from REPS I to REPS IV. These results are discussed in relation to the type of farmer participating and how institutional changes influenced who joined each REPS phase. The effectiveness of REPS at meeting its biodiversity conservation and pollution abatement objectives, given the type of farmer who joined, is also outlined. Finally, Section 4.6 provides concluding remarks.

## 4. 2. Literature and Policy Background

The effect of farm- and individual-specific factors on participation in AESs in general was provided in Chapter 3. Section 4.2.1 below identifies how the two institutional changes investigated in this chapter are expected to have influenced Irish farmers' REPS participation decisions from 1994 to 2010. Section 4.2.2 describes how the general perception of the four REPS phases varied at the time of their introduction. Finally, Section 4.2.3 expands on the information provided in Chapter 3 on how other agricultural and environmental policies evolved from 1994 to 2010 by highlighting how these changes are expected to have influenced the REPS participation decision for each phase.

### 4. 2. 1. Institutional effects on REPS participation

The impact of two groups of institutional changes on farmers' participation in REPS is being investigated in this chapter. These are changes to the threshold limit for organic nitrogen production and changes to payment rates across the four phases. The amount of organic nitrogen that a farm produces per hectare is calculated from the density of livestock units found on the farm. The density of livestock units on a farm provides an indication of the productivity levels of the farm which, as was previously mentioned in Chapter 3, is almost always negatively correlated with participation in an AES. Examples of gauges of productivity used in the AES participation literature include individuals' reliance on on-farm income for household support (Defrancesco *et al.*, 2008), high productivity potential (Dupraz *et al.*, 2003) and productive soil types (Hynes and Garvey, 2009). This negative relationship is assumed to exist because many AESs, including REPS, require some degree of extensification from farmers, the aim of which is to create habitats or reduce pollution. Thus, the opportunity costs of extensification for those who are intensive are, clearly, higher than the opportunity costs for extensive farmers. Wynn *et al*. (2001) describe it as the fit of the farm to the scheme.

In the case of REPS, the restriction on organic nitrogen is expected to have resulted in higher opportunity costs of participation for more intensive farmers than extensive farmers. In fact, this restriction is believed to have greatly reduced the likelihood that intensive farmers joined REPS I and REPS II (Hynes and Garvey, 2009). It is assumed that the softening of the threshold limit in REPS IV will result in a greater likelihood that intensive farmers joined the final phase of the scheme than the former three phases of REPS.

As mentioned in Chapter 2, farm size can be positively (Morris and Potter, 1995, Lynch and Lovell, 2003), negatively (Hynes and Garvey, 2009) and inconclusively (Wynn *et al.*, 2001, Wossink and van Wenum, 2003, Hynes and Garvey, 2009) associated with the likelihood that farmers will participate in an AES. Findings are usually related to the payment structure utilised by the scheme. REPS payments were awarded to participants on a per-hectare basis for each of the four phases. This suggests that farm size should be positively associated with participation in REPS. However, the per hectare value of payments decreased with increasing farm size and, in the former two phases of REPS, was capped at 40 hectares. This, combined with the fact that participants were obliged to manage all of their land according to their REPS contract, suggests that the effect of farm size on farmers' participation decision in REPS may be complex.

The impact of farm size on farmers' participation decision may be confounded by the effect of individual-specific factors on participation. For example, Morris *et al*. (2000) find "a fear of loss of control" is a major deterrent to participation for a number of potential AES participants. This fear may have a greater impact on farmers with larger holdings because they are obligated to enter ever larger tracts of land into the scheme for increasingly lower rates.

Related to the effects of farm size on participation is a finding by Peerlings and Polman (2009) who evaluated five competing land-allocation contracts across Europe and found that contract length is a particularly contentious issue for potential AES participants. This effect cannot be estimated for REPS because the duration of the contract was five years for all four phases. However, duration effects of participation on farmers' decision to join REPS can be accounted for. Duration effects refer to whether farmers have previous experiences with an AES. Wossink and van Wenum (2003) have shown that if farmers have previously participated in an AES, they are more likely to join a contemporary scheme than those who have not. This may be because they no longer fear the loss of control and are comfortable with the concept of participating. It may also be a cyclical effect whereby the fit of their farms to a new AES is better as a consequence of participating in an earlier one. Whatever the reasons, it seems reasonable to assume that if a farmer participated in a previous REPS phase, he or she will be more likely to participate in subsequent REPS phases than not.

### *4. 2. 2. The four phases of REPS*

This section provides details on the general opinions that farmers had of the four phases of the scheme, which have been gleaned from contemporary literature and newspaper reports. The introduction of REPS I in 1994 was a relatively low-key event. At the time, neither Irish policy makers nor farmers had any previous experience with AESs. Uptake was slow to begin with and initially followed trends that mirrored that of new technology adoption in Ireland: namely, farmers who are more inclined towards making risky decisions were the first to opt to join the scheme (Emerson and Gillmor, 1999). However, rates of enrolment gradually accelerated and, by 1999, REPS I had acquired its target of 45,000 adopters (Rath, 2002).

Contemporary newspaper reports show that REPS II was not well received by the farming community. Reasons given for its unpopularity include that payment and inspection rates were, respectively, too low and too high (Maguire, 2003). One report highlighted farmers' concerns that a lack of scientific evidence showing REPS was successfully protecting biodiversity at farm level was creating concerns about future funding from Brussels (Maguire, 2002). Target uptake rates for the second phase were set at 70,000 but by 2002, they still had not been met (Rath, 2000, Rath, 2002).

Conversely, contemporary newspaper reports wrote positively about the third phase of REPS, which was endorsed by the Irish Farmers' Association (IFA) before it was even introduced (McDonagh, 2003). In fact, articles relay a sense of urgency with regard to REPS III participation, advising farmers to join the scheme before it is too late (Farragher, 2004) and culminating in a rush to enrol when the deadline for applications was announced in

September 2006 (Kerryman, 2006). Target uptake rates for REPS III were more than met and it was deemed a success.

REPS IV was opened in 2007. The introduction of 8 new BUs, the merging of REPS IV with Natura 2000 sites and the use of nitrates' derogations meant that the REPS IV participation decision was more complicated for farmers than the participation decisions for the previous three phases (DAFF, 2007). The main point of interest about REPS IV, however, is that the sudden closure in the summer of 2009 of REPS IV to all new participants led to a surge in applications for the scheme. Farmers had already suffered substantial losses in earnings from agricultural commodities in 2008 and 2009 as a consequence of extreme weather patterns and were concerned with the loss of other income sources (Connolly *et al.*, 2010).

### *1.2.3. Impact of changes to Irish agriculture on the REPS participation decision*

Changes to other agricultural and environmental policies in Ireland from 1994 to 2010 are expected to have influenced farmers' perceptions of the REPS participation decision in a number of ways. To begin with, the introduction of decoupled payments is expected to have altered the structure of Irish farm earnings in a manner that reduced the opportunity costs of joining REPS for farmers over time. For example, as the number of decoupled direct payments being offered to farmers grew, the pressure on farmers to overproduce lessened, meaning the opportunity costs associated with the extensification required from REPS contracts also decreased. The introduction of obligatory SMRs in order to receive SFP is expected to have had a similar impact on the opportunity costs of reducing nitrates and pesticide use, as well as maintaining landscape features, which are other issues addressed by the REPS contract.

Farmers' main source of on-farm income, market prices, became increasingly volatile during this study period (1994 to 2010) as a consequence of the removal of price support mechanisms and simplification of the European agricultural policy (O'Neill and Hanrahan, 2012). In contrast, REPS payments were a stable source of income, meaning their attractiveness to farmers, particularly those who were risk averse, may have augmented over time.

Changes in environmental policies that are expected to influence farmers' perceptions of the REPS participation decision include the introduction of the Nitrates Directive in 2006, which held farmers more accountable for the negative externalities they created as a consequence of production (DAFM, 2013b). In addition, the combined effect of the Water Framework Directive, the Biodiversity Plan and the Biological Diversity Target was to highlight a paradigm shift towards environmentally friendly farming that occurred during the 1990s and 2000s. Before then, the predominant view towards agriculture was that it primarily existed to produce commodity based goods.

However, this productionist viewpoint was gradually overtaken by the opinion that agriculture plays a more multifunctional role in rural landscapes. For example, farmers and farming were increasingly seen as being important players in the maintenance of rural viability and working landscapes (Feehan and O'Connor, 2009). This paradigm shift may have influenced farmers' perceptions of REPS and the role it might play on their farms, thereby influencing their participation behaviour.

### 4. 3. Estimation model and framework

The theoretical framework used to interpret the results of this estimation exercise is a standard neoclassical one. When farmers make the REPS participation decision, they are assumed to compare the amount of utility that they expect to gain from non- participation, $U_N$, with the amount from participation, $U_R$, which are represented in the following two equations:

$$U_N(N_{it}, 0; Z_{it}) \tag{4.1a}$$

$$U_R(P_{it} + N_{it} - C_{it}, \bar{E}_{it}; Z_{it}) \tag{4.1b}$$

At any given time *t*, by not participating in REPS, farmer $i$ will gain utility from farm income, $N_{it}$, outputs from which are conditional on a vector of farm and farmer characteristics, $Z_{it}$. Elements of $Z_{it}$ may also directly impact on farmers' utility levels (Equation 4.1a). If farmer *i* does participate in REPS at time *t*, he will gain utility from REPS payments, $P_{it}$ as well as $N_{it}$ but may also face opportunity costs, $C_{it}$, of revenue lost when farmland is altered under the REPS contract (Equation 4.1b). $\bar{E}_{it}$ is the effort associated with participating in REPS. Total income $(P_{it} + N_{it} - C_{it})$ and $\bar{E}_{it}$ are both conditional on the contents of $Z_{it}$ in Equation 4.1b. Farmers are expected to associate higher income and lower effort levels with additional utility. The decision function for farmer *i* at time *t* can be given as (Chambers and Foster, 1983):

$$Y_{it} = U_N(N_{it}, 0; Z_{it}) - U_R(P_{it} + N_{it} - C_{it}, \bar{E}_{it}; Z_{it}) \tag{4.2}$$

Although the value of $Y_{it}$ is not directly observed, a discrete participation indicator is given by:

$$Y^*_{it} = \{0, if\ Y_{it} > 0; 1, otherwise\} \tag{4.3}$$

where 1 represents participation in REPS and 0 indicates non-participation. The decision function that the farmer evaluates when contemplating joining the scheme can be rewritten as:

$$Y^*_{it} = U_N(N_{it}, 0; Z_{it}) - U_R(P_{it} + N_{it} - C_{it}, \bar{E}_{it}; Z_{it}) = X_{it}\beta + \varepsilon_{it} \tag{4.4}$$

where $X_{it}$ is a vector that gathers observed determinants of $Y_{it}$, $\beta$ is a parameter vector and $\varepsilon_{it}$ is a random component. A binary logit can be used to look at what influences farmers' decisions to participate in REPS, meaning the probability that farmer *i* chooses to participate in REPS at time *t*, or of the dependent variable being equal to 1, is given as (Hensher *et al.*, 2006):

$$Pr(Y_{it} = 1) = \frac{1}{1 + exp(-\beta X_{it})} \tag{4.5}$$

However, in this form, any interpretation of $\beta$ is cumbersome. By adjusting Equation 4.5 to read as the log of the odds of participating in REPS divided by the odds of not participating in REPS, the dependent variable reduces to a simple linear function of the explanatory variables:

$$log\left(\frac{Pr(Y_{it} = 1)}{1 - Pr(Y_{it} = 1)}\right) = \beta' X_{it} \tag{4.6}$$

The $exp(\beta')$ represents a change in the probability of being in REPS relative to the probability of not being in REPS associated with a unit change in the independent variable. In this scenario, $exp(\beta')$ is called an odds ratio. The coefficients in the next section are expressed in this way. An estimated coefficient greater (less) than 1, indicates that farmers are more (less) likely to participate in REPS when there is a positive change in the explanatory variable than not. So, for example, if a coefficient is equal to 3, that means that farmers are three times as likely to participate in REPS than not, but if it is equal to 0.33, then they are only a third as likely.

Two aspects of the REPS participation decision are addressed in this chapter using two specifications of the binary logit model. The first is what type of farmer is most likely to be found in REPS for the duration of the scheme for which a random effects logit is used.[9] This model accounts for the existence of unobserved individual effects, which exist as a consequence of individuals' unique decision-making processes and therefore do not change across the multiple observations for each individual. A downside to using this model is that it does not allow for the existence of fixed effects, or correlations between individual effects and $X_{it}$. To compensate for this model flaw, fixed effects are accounted for in this chapter by including a variable for average farm income across the entire period in the model. This is a version of a Mundlak-Chamberlain random effect model (Mundlak, 1978) similar to that used by Hynes and Garvey (2009). It is given as:

$$Y^*_{it} = \alpha_i + \beta' \mathrm{X_{it}} + \varepsilon_{it} \tag{4.7a}$$

where

[9] A likelihood test was used on the pooled dataset and confirmed that duration effects, or correlation between farmers' participation decisions in time *t* and *t-1*, exist. Use of a fixed effects model to account for correlations between unobserved individual effects and $X_{it}$ was too restrictive for the unbalanced 16-year dataset and resulted in the loss of important information. This is due to the fact that many of the explanatory variables vary little across the panel for individual farmers, meaning these variables drop out of the model if a fixed effects specification is employed.

$$\alpha_i = \bar{I}_i\delta + \nu_{it} \tag{4.7b}$$

In Equation 4.7a, $Y^*{}_{it}$ is the indicator variable denoting whether farmer $i$ participates in REPS at time $t$, $\alpha_i$ is the individual farmer effect, $X_{it}$ is a vector of explanatory variables and $\varepsilon_{it}$ is a vector of unobservable factors affecting whether farmer $i$ decides to participate in REPS at time $t$ or not. Equation 4.7b shows that $\alpha_i$ is represented by mean income, $\bar{I}$, and other unobserved influences, $\nu_{it}$. For this reason, a variable for $\bar{I}$ is included in $X_{it}$.

Path dependence, or duration effects, are accounted for by including lagged variables in $X_{it}$, indicating whether farmer $i$ participated in REPS in the previous year or in the previous phase. In addition, $X_{it}$ contains variables indicating which REPS phase farmers were participating in at time *t* to allow for variations in the REPS contract across phases.

To compare with the panel model above, and to gain a deeper understanding of participation in each phase of the scheme, the REPS participation decision is also examined using four individual logits on NFS cross-sectional datasets from 1999, 2003, 2006 and 2010, representing REPS I, REPS II, REPS III and REPS IV, respectively. Of particular interest to this study is whether the farm sizes most likely to participate change to complement the different per-hectare payment rates in each phase. For this reason, farm size is represented as farm size categories in the four cross-sectional logit models (in the panel model, farm size is continuous). The estimated models also allow us to examine whether restrictions on organic nitrogen production were particularly strong deterrents to participation (thereby leading to adverse selection bias) across the different phases. To investigate this question in greater detail, kernel density plots of organic nitrogen production on non-REPS farms are produced and discussed in the results section.

## 4. 4. Data

NFS data is used in this chapter to look at the impact of a number of economic, labour, demographic and farm level variables, as well as duration effects, on farmers' participation decisions in REPS. To begin with, NFS datasets from 1995 to 2010, inclusive, are used to investigate farmers' participation decisions for the entire period. Then, NFS datasets for the individual years of 1999, 2003, 2006 and 2010 are used to estimate the likelihood of finding different farmers in REPS I, II, III and IV, respectively[10]. According to the DAFF, these are the years with the highest percentage of the representative phases among the REPS participants during the study period.

The NFS data include information on individuals' farm level, demographic and duration characteristics. Included under the farm level characteristics heading are variables for soil type farm size, organic nitrogen production and system type. The soil types are designated by Teagasc. Each farm in the NFS is classified into one of three major soil groups according to their use range (Hennessy *et al.*, 2011)[11]. Farm size is given as utilisable agricultural area. The variable for organic nitrogen production is created from the density of livestock found on each farm. This variable is included in the model to investigate whether REPS farms produced lower levels of organic nitrogen per hectare than non-REPS farms, thereby suggesting that the scheme may have gone some way to meeting its pollution abatement objectives.

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[10] The year 1999 represents a year where REPS I dominated in the NFS dataset; in 2003, REPS II dominated; in 2006, REPS III dominated and in 2010, REPS IV dominated in the NFS dataset.

[11] Soil type 1 has the widest use range and soil type 3 contains farms with limited use range.

System type is based on the community typology of agricultural classification[12] and refers to the dominant enterprise on each representative farm. System types discussed in this chapter are dairy, cattle, sheep and tillage[13]. All system types provide an indication of whether a heterogeneous group of farm types is found in REPS. If so, it would imply that REPS may have attracted the ideal type of farmer for meeting its biodiversity conservation objectives. This is because a strong link exists between farming systems and habitat types in agricultural landscapes (Baudry *et al.*, 2000). Hence, variation in system types provides an indirect indication of the degree of variation in the habitat types found on REPS farms.

[12] This is a uniform classification of holding used throughout the EU.

[13] Using reductions in the production of organic nitrogen as an indicator for the achievement of pollution abatement objectives on tillage farms is admittedly not ideal. This is because tillage farmers in the NFS from 1995 to 2010 used an average of 87.46 Kg/ha of synthetic nitrogen on their farms, which is significantly more than the average amount used by all other farm systems (3.17 Kg/ha). However, only 6% of these NFS farms are classified as tillage (Table 1) and each one has livestock units on their farms. Hence, whilst the reduction in organic nitrogen production under the REPS scheme is not assumed to be a primary concern for tillage farmers, it did apply to them.

**Table 4.1: Summary statistics for the entire study period (1995 to 2010)**

| Variable | NFS All | NFS REPS |
|---|---|---|
| | *n = 19,306* | *n = 5,871* |
| *Economic* | | |
| Farm income (€1,000s) (excl. REPS payment) | 15.56 | 12.23 |
| Gross outputs[a] per ha (€/ha) | 1,304 | 1,271 |
| *Labour* | | |
| Annual on-farm hours | 1,856 | 1,776 |
| *Demographic* | | |
| Farmer's age (years) | 53.03 | 52.67 |
| Children (%) | 0.42 | 0.46 |
| Married (%) | 0.67 | 0.74 |
| *Farm level* | | |
| Soil 1 (%) | 0.47 | 0.44 |
| Soil 2 (%) | 0.41 | 0.42 |
| Soil 3 (%) | 0.12 | 0.14 |
| Farm size (ha) | 36.02 | 36.57 |
| Farm size less than 20 ha (%) | 0.37 | 0.26 |
| Farm size 21 to 40 ha (%) | 0.33 | 0.41 |
| Farm size 41 to 55 ha (%) | 0.13 | 0.17 |
| Farm size greater than 55 ha (%) | 0.17 | 0.15 |
| Organic N (Kg/ha) | 102.52 | 90.82 |
| Dairy (%) | 0.31 | 0.19 |
| Cattle (%) | 0.46 | 0.50 |
| Tillage (%) | 0.06 | 0.07 |
| Sheep (%) | 0.15 | 0.23 |
| *Duration* | | |
| REPS previous phase | 0.15 | 0.40 |
| REPS previous year | 0.30 | 0.77 |

Source: NFS 1995 to 2010. Monetary values have been adjusted to the year 2000 using the CPI. Soil type variables sum to 1, farm size categories variables sum to 1 and system type variables sum to 1. [a]: Market based gross outputs only.

Table 4.1 shows how values for the variables used in this study differed between REPS farmers and Irish farmers in general for the entire study period. Average farm income (all sources of on-farm income except REPS payments) and productivity levels (estimated as gross outputs per hectare) for REPS farmers were lower from 1995 to 2010 on REPS farms than they were for the farming population generally. REPS farmers worked 80.36 hours less per year (or just over 1.5 hours per week) on their farms than Irish farmers in general.

The statistics for demographic variables in both samples in Table 4.1 are similar. The average age for all NFS farmers is marginally higher than that of REPS farmers alone. REPS farmers are slightly more likely to be married (74%) and to have children (46%) than all Irish farmers from 1995 to 2010 (67% and 42% of the entire sample are married and have children respectively). Consequently, in terms of the demographic variables considered in this paper, REPS farmers more strongly adhere to the profile of a farmer who is more likely to consider long-term goals in their decision making than not (Hennessy and Rehman, 2007).

Average farm size for REPS farms differs little from that for all NFS farms (36.57 hectares versus 36.02 hectares). However, the dummy variables indicating farm-size distributions show that a greater number of REPS farms were from the mid-ranges of size categories than the smallest (less than 20 hectares) or the largest (greater than 55 hectares) size ranges. Organic nitrogen production was lower on REPS farms, and the most likely type of farms found in the scheme are cattle and sheep, respectively, the values of which are substantially higher than for the entire sample.

**Table 4.2: Summary statistics for all NFS variables in the years representing the four phases of REPS**

| Variable | 1999 | 2003 | 2006 | 2010 |
|---|---|---|---|---|
| | *n = 1,061* | *n = 1,207* | *n = 1,141* | *n = 994* |
| REPS participation | 0.32 | 0.27 | 0.48 | 0.45 |
| *Economic* | | | | |
| Farm income (€1,000s) (excl. REPS payment) | 12.00 | 15.93 | 16.27 | 18.32 |
| Gross outputs[a] per ha (€/ha) | 1,095 | 1,267 | 1,383 | 1,473 |
| *Labour* | | | | |
| Annual on-farm hours | 1,924 | 1,849 | 1,745 | 1,725 |
| *Demographic* | | | | |
| Farmer's age (years) | 51.81 | 53.08 | 54.40 | 54.80 |
| Children (%) | 0.50 | 0.45 | 0.40 | 0.34 |
| Married (%) | 0.69 | 0.67 | 0.68 | 0.71 |
| *Farm level* | | | | |
| Soil 1 (%) | 0.48 | 0.45 | 0.49 | 0.50 |
| Soil 2 (%) | 0.42 | 0.40 | 0.40 | 0.39 |
| Soil 3 (%) | 0.10 | 0.14 | 0.11 | 0.11 |
| Farm size (ha) | 35.64 | 38.83 | 37.36 | 40.32 |
| Farm size less than 20 ha (%) | 0.37 | 0.33 | 0.34 | 0.30 |
| Farm size 21 to 40 ha (%) | 0.35 | 0.33 | 0.33 | 0.35 |
| Farm size 41 to 55 ha (%) | 0.12 | 0.15 | 0.14 | 0.14 |
| Farm size greater than 55 ha (%) | 0.16 | 0.19 | 0.19 | 0.21 |
| Organic N (Kg/ha) | 108.85 | 102.38 | 97.73 | 91.99 |
| Dairy (%) | 0.33 | 0.28 | 0.24 | 0.22 |
| Cattle (%) | 0.47 | 0.48 | 0.50 | 0.53 |
| Tillage (%) | 0.06 | 0.06 | 0.07 | 0.07 |
| Sheep (%) | 0.15 | 0.18 | 0.19 | 0.17 |
| *Duration* | | | | |
| REPS previous phase | --- | 0.29 | 0.30 | 0.46 |
| REPS previous year | 0.29 | 0.29 | 0.39 | 0.49 |
| Other sectors' earnings (€1,000s)[b] | 24.94 | 31.04 | 33.53 | 28.47 |

Sources: CSO, 2012; NFS, 1999; 2003; 2006; 2010. Monetary values have been adjusted to the year 2000 using the CPI. Soil type variables sum to 1, farm size categories variables sum to 1 and system type variables sum to 1. [a]: Market based gross outputs only. [b]: Average wage earned by Irish employees not in agriculture, forestry or fishing. Includes industrial earnings; distribution and business services; banking, insurance and building societies; public sector and construction.

Table 4.2 shows average values for the variables used in this study for all Irish farms in 1999, 2003, 2006 and 2010 (these are the years representing REPS I, REPS II, REPS III and REPS IV respectively). Participation in REPS decreases from 32% to 27% from 1999 to 2003 but increases to 48% and 45% in 2006 and 2010, respectively. These numbers are expected given that target uptake rates for REPS I were the lowest of all four phases at 45,000 adopters, and that REPS II was an unpopular phase that only succeeded in attracting 31,687 when its target uptake rate was 70,000 (Maguire, 2003). REPS III and REPS IV were considered more attractive phases than REPS II. They succeeded in drawing a greater number of farmers to the scheme for reasons that included a reduction in opportunity costs associated with joining resulting from the introduction of other agricultural and environmental policies between 2003 and 2006. In addition, these phases offered farmers higher payment rates for participation than the former two phases.

The final row of Table 4.2 shows values for earnings received by other sectors in the economy in each year. The amount farmers earned working on-farm was lower than that of people working in other sectors in every instance displayed in Table 4.2. However, whereas average farm income and productivity increased from sample year to sample year, the average value of other sectors' wages decreased from 2006 to 2010 (CSO, 2012). These statistics imply that, for the former three sample years, the farming sector did not benefit from the prosperity that affected the country in general. However, unlike other sectors, 2010 was a relatively successful year for Irish farming (Connolly *et al.*, 2010). Related to this is the fact that average on-farm hours dropped substantially from 1999 to 2003 and again from 2004 to 2006. This is likely due to the fact that farmers were supplementing their on-farm income by working off the farm for significantly higher wages during a period when the demand for manual workers, particularly in the construction industry, was high.

The size of Irish farms in the NFS generally increased over the reference time period. In particular, the number of farms in the smallest size category fell from 37% of the sample in 1999 to 30% in 2010[14]. Conversely, organic nitrogen production decreases for each sample year. Another way of viewing this is that the average number of livestock units per hectare on Irish farms fell during this study period (CSO, 2013)[15]. This reduction in livestock density is presumed to have been largely caused by the decoupling of payments from production over time (O'Donoghue and Howley, 2012). The decrease in organic nitrogen production may also be a consequence of a reduction in the number of dairy farms in Irish agriculture across phases (from 33% of the NFS in 1999 to 22% in 2010). This reduction was largely driven by the establishment of higher yielding cows, combined with the introduction of production constraints from milk quotas, over time (Dillon *et al.*, 2008).

[14] The number of individuals in the smallest size category was 161 in 1999, 156 in 2003, 154 in 2006 and 104 in 2010.

[15] Statistics from the Central Statistics Office show that total cattle numbers (beef and dairy) fell from approximately 6.8 to 5.8 million units and sheep fell from 5.1 to 3.2 million units in Ireland between December 1999 and December 2009.

**Table 4.3: Summary statistics for REPS farms in the years representing the four REPS phases**

| Variable | 1999 (REPS I) | 2003 (REPS II) | 2006 (REPS III) | 2010 (REPS IV) |
|---|---|---|---|---|
| | *n = 335* | *n = 335* | *n = 550* | *n = 458* |
| *Economic* | | | | |
| Farm income (€1,000s) (excl. REPS payment) | 7.46 | 10.35 | 12.95 | 16.52 |
| Gross outputs[a] per ha (€/ha) | 1,046 | 1,202 | 1,333 | 1,552 |
| *Labour* | | | | |
| Annual on-farm hours | 1,841 | 1,758 | 1,693 | 1,755 |
| *Demographic* | | | | |
| Farmer's age (years) | 50.51 | 53.03 | 53.11 | 54.52 |
| Children | 0.56 | 0.49 | 0.48 | 0.36 |
| Married | 0.75 | 0.72 | 0.73 | 0.72 |
| *Farm level* | | | | |
| Soil 1 (%) | 0.43 | 0.44 | 0.45 | 0.48 |
| Soil 2 (%) | 0.43 | 0.41 | 0.43 | 0.36 |
| Soil 3 (%) | 0.14 | 0.15 | 0.12 | 0.16 |
| Farm size (ha) | 33.79 | 34.53 | 37.36 | 39.72 |
| Farm size less than 20 ha (%) | 0.30 | 0.24 | 0.25 | 0.26 |
| Farm size 21 to 40 ha (%) | 0.44 | 0.46 | 0.40 | 0.37 |
| Farm size 41 to 55 ha (%) | 0.15 | 0.18 | 0.19 | 0.17 |
| Farm size greater than 55 ha (%) | 0.12 | 0.13 | 0.16 | 0.19 |
| Organic N (Kg/ha) | 98.84 | 88.07 | 88.86 | 89.81 |
| Dairy (%) | 0.20 | 0.18 | 0.17 | 0.21 |
| Cattle (%) | 0.48 | 0.51 | 0.51 | 0.50 |
| Tillage (%) | 0.06 | 0.06 | 0.07 | 0.07 |
| Sheep (%) | 0.25 | 0.25 | 0.25 | 0.22 |
| *Duration* | | | | |
| REPS previous phase | ... | 0.81 | 0.57 | 0.71 |
| REPS previous year | 0.78 | 0.79 | 0.75 | 0.81 |

Sources: NFS, 1999; 2003; 2006; 2010. Monetary values have been adjusted to the year 2000 using the CPI.
Soil type variables sum to 1, farm size categories variables sum to 1 and system type variables sum to 1.
[a]: Market based gross outputs only

Table 4.3 shows that the highest percentage of REPS farmers who participated in the previous phase of REPS was for the 2003 (REPS II) sample (81%), followed closely by 2010 (REPS IV) sample (71%). The likelihood of being in REPS in the previous year is almost constant across the samples, which is expected given that all four phases lasted for five years. The likelihood of being in the previous phase is higher than the previous year for REPS II because a number of farmers in the sample did not go directly into REPS II from REPS I, meaning they were non-REPS farmers in 2002.

Average farm income for REPS farms was only 62.17% of the average farm income for all farms in 1999 (7,460/12,000). Similarly, it was 64.77% of the total NFS dataset (10,350/15,930) in 2003. However, in 1999 and 2003, gross outputs from market based earnings were 95.93% (1,046/1,095) and 94.87% (1,202/1,267) of the national average, respectively. The substantial differences in farm income may, therefore, be explained by the size differences between REPS farms (Table 4.3) and the entire NFS (Table 4.2). REPS I farms are smaller than the country's average size in 1999 (33.79 hectares in Table 4.3 versus 35.64 hectares in Table 4.2). This is largely due to the high number of REPS participants in the 21 to 40 hectare category, rather than the less than 20 hectare category. Similarly, the percentage of REPS II farmers in the 21 to 40 hectare category is the highest of all size groups across all phases in Table 4.3 at 46%.

In 2003 farm incomes on REPS farms increased to 79.59% (12,950/16,270) of the entire sample. Gross outputs per hectare on REPS III farms in Table 4.3 are 96.38% of the national average (Table 4.2). The increase in farm income from previous REPS phases is likely to be due to this increase in gross outputs per hectare (when compared to the national average) in 2003, as well as the increase in average REPS farm size. In particular, more REPS III farmers belong to the largest size category (greater than 55 hectares) than REPS I or REPS II. It is also worth noting that the amount of time that REPS participants spent working on farm is lowest for REPS III, which is the year with the highest value for other sectors' earnings (Table 4.2). This may indicate that REPS farmers took greater advantage of off-farm earnings during the more prosperous years than other Irish farmers.

In REPS IV, farm incomes increased to 90.17% (16,520/18,320) of the entire sample. Gross outputs per hectare were marginally higher than those for the national average (1,552/1,473). The average size of REPS IV farms in Table 4.3 is almost the same as the national average in

Table 4.2 (39.72 hectares versus 40.32 hectares). In addition, REPS IV farmers worked longer hours on their farms than the entire sample and the difference in organic nitrogen production (89.81 kg/ha) is only slightly smaller than that of the whole 2010 sample (91.99 kg/ha). Altogether, these findings suggest that, in 2010, REPS farms were only marginally more extensive (if even) than Irish farms in general.

Average organic nitrogen production on REPS farms fell across the four phases and is lower for REPS farms than the NFS average in each case. Differences between the REPS averages and the NFS averages may be due to the organic nitrogen restrictions in the REPS contract. They may also be caused by the large number of sheep farmers participating in REPS, which remained at 25% of the sample for REPS I, REPS II and REPS III and dipped only slightly to 22% for REPS IV. A comparison of the variable for organic nitrogen production in Table 4.2 and Table 4.3 reveals that, whilst the average amount of organic nitrogen produced on all Irish farms decreased from 108.85 to 91.99 Kg/ha in 1999 and 2010 respectively, the quantities on REPS farms marginally increased from 88.07 Kg/ha in 2003 to 89.81 Kg/ha in 2010. This finding shows that Irish farms became less intensive (on average), or that REPS became more attractive to increasingly intensive farmers, over time. The extent to which this change came about because farmers changed their farm management practices to enable participation in REPS is examined in the next section.

## *4. 5. Results and Discussion*

The results of a random effects logit model on farmer-participation behaviour in REPS from 1995 to 2010 are displayed in Table 4.4 below. The first thing to note is that the significance of the variable for average farm income indicates that an individual-level effect existed across time periods in the Mundlak-Chamberlain model.

**Table 4.4: Results from a random effects logit on REPS participation from 1995 to 2010**

| Variable | Odds ratio | SE |
|---|---|---|
| *Duration* | | |
| REPS previous phase | 0.735 | (0.115)*** |
| REPS previous year | 10.848 | (0.071)*** |
| *Economic* | | |
| Average income (€1,000s) | 0.974 | (0.005)*** |
| Farm income (€1,000s) (excl. REPS payment) | 0.958 | (0.004)*** |
| Gross outputs per ha (€/ha) | 1.002 | (0.001)*** |
| *Labour* | | |
| Annual time working on farm (hours) | 1.001 | (0.001)*** |
| *Demographic* | | |
| Farmer's age (years) | 0.980 | (0.004)*** |
| Children | 1.119 | (0.096) |
| Married | 2.421 | (0.131)*** |
| Farm level | | |
| Soil 1^ | 0.729 | (0.215) |
| Soil 2^ | 0.936 | (0.209) |
| Farm size (ha) | 1.010 | (0.002)*** |
| Organic N (Kg/ha) | 0.978 | (0.002)*** |
| Dairy^^ | 0.263 | (0.176)*** |
| Cattle^^ | 0.853 | (0.154) |
| Tillage^^ | 0.217 | (0.245)*** |
| *Phase* | | |
| REPS II^ | 1.687 | (0.098)*** |
| REPS III^ | 3.725 | (0.118)*** |
| REPS IV^ | 2.048 | (0.173)*** |
| | | |
| *Log likelihood* | | -5631 |
| *Mean VIF* | | 2.64 |

Source: NFS 1995 to 2010. N = 16,867. Monetary values have been adjusted to the year 2000 using the CPI. Standard errors (SEs) in parentheses. ^: base REPS phase is REPS I;^^: base soil type is soil 3 (least productive); ^^^: base system type is sheep. ***: p<0.01; **: p<0.05;*: p<0.1.

Given the five-year duration of all REPS contracts and the number of similarities among the four phases, the high and significant values for participation in the previous year as well as the previous phase displayed in Table 4.4 are unsurprising. It can also be seen that REPS farmers have, *ceteris paribus*, lower farm income (excluding REPS payments), work longer hours on farm and have higher productivity levels than non-REPS farmers. These findings suggest that REPS payments are supplementing lower farm incomes. They also imply that farmers are being reimbursed for the extra effort taken to employ new management regimes on their farms as part of the scheme (such as the establishment of hedgerows or maintenance of stonewalls on their holdings) more so than for reductions in production that occur as a consequence of implementing the scheme on their farms. The fact that this model shows REPS farmers had, *ceteris paribus*, marginally higher gross outputs per hectare than non-REPS farmers may be explained by the actions of extensive farmers whose land has limited production potential. The logical option for business-minded, extensive farmers who wish to optimise profits from their holdings is to maximise production on their farms (which is unlikely to breach REPS stipulations) in addition to joining REPS. This behaviour has been witnessed in Irish farmers in relation to the SFP, whereby individuals continue to produce higher than expected levels of commodities despite the fact that the SFP is decoupled from production (Hennessy and Thorne, 2006, O'Donoghue and Howley, 2012).

Demographic variables in Table 4.4 indicate that REPS farmers are more likely to be young and to be married than non-participants. This profile of farmer has been linked with the type of individual who is more actively involved in AES participation than not (Wilson, 1996, Defrancesco *et al.*, 2008). Consequently, the type of farmers who actually joined REPS may be more likely to actively engage in AES implementation on their farms than those who did not choose to join.

While the random effects model in Table 4.4 describes the type of famer who participated in REPS from 1995 to 2010, it does not help to decipher how this type of famer changed across the four phases. The high significance of the dummy variables for the REPS phases in Table 4.4 indicate that there was, indeed, a different effect of each phase on farmers' participation decisions over time. Of particular interest to this chapter are whether changes that were made to payment rates and permissible levels of organic nitrogen production across the four phases impacted on the type of farmer in each phase. In Table 4.4 the sign for farm size is positive. Hynes and Garvey (2009) ran a similar model to look at farmer participation behaviour in

REPS from 1995 to 2005 and found that farm size was negatively associated with participation. The differences in the findings from these two studies suggest that there was significant heterogeneity with respect to the influence of farm size on participation over time. Table 4.4 also shows that, while REPS farmers have higher productivity levels than their non-REPS counterparts, they are likely to produce less organic nitrogen than non-participants. This finding may be a consequence of adverse selection bias brought about by the restrictions on organic nitrogen included in the scheme. These issues are investigated using the models described below.

### *4. 5. 1. Changes across phases*

In order to examine some of the heterogeneity of variable influence on participation across the different phases of REPS, separate models for each of the four phases were ran (one for a reference year in each phase). Table 4.5 below shows the results of four logit models on cross-sectional data representing each phase of the scheme[16]. The combined direction and significance of the variables in the four logit models are each unique. This implies that the type of farmer who chose to join each of the four phases was different.

[16] The NFS weighting system is used for the cross-sectional logits (and kernel density functions) but not the panel data model because the relative weights for individual farms change over time.

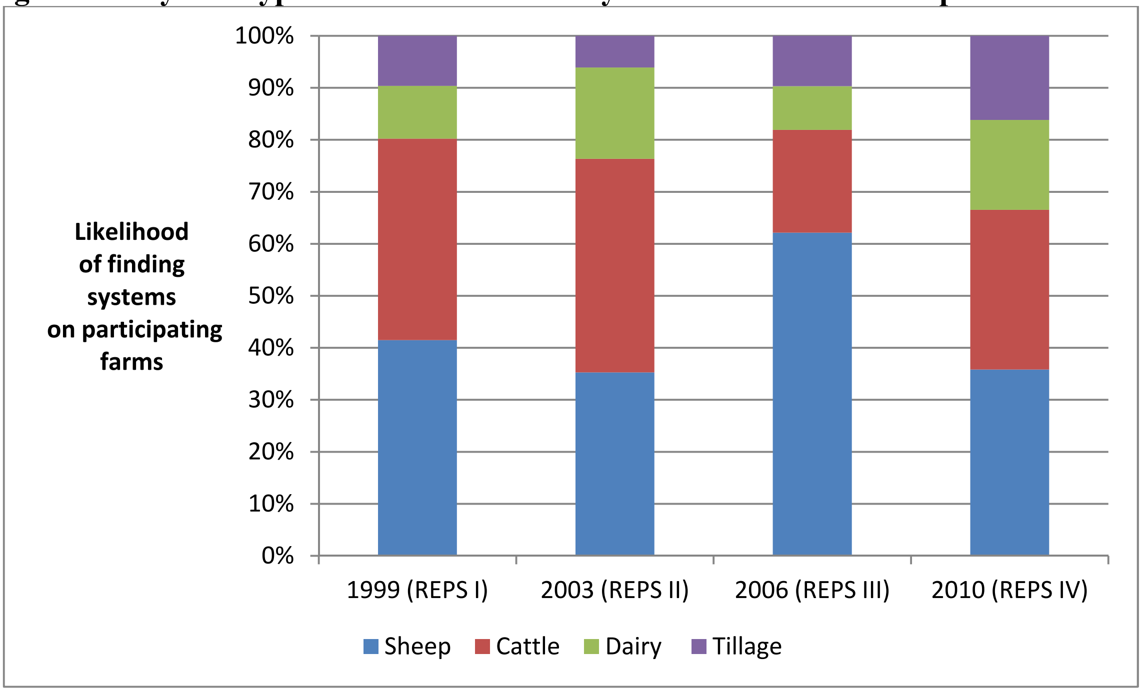
**Table 4.5: Results of the binary logits on farmer participation for the four REPS phases**

| Variable | 1999 (REPS I) | 2003 (REPS II) | 2006 (REPS III) | 2010 (REPS IV) |
|---|---|---|---|---|
| | *Odds ratio (SE)* | *Odds ratio (SE)* | *Odds ratio (SE)* | *Odds ratio (SE)* |
| *Duration* | | | | |
| REPS previous phase | ... | 9.954 (0.026)*** | 3.421 (0.032)*** | 1.896 (0.020)*** |
| REPS previous year | 40.977 (0.021)*** | 5.155 (0.025)*** | 27.058 (0.027)*** | 11.728 (0.020)*** |
| *Economic* | | | | |
| Farm income (€1,000s) (excl. REPS) | 0.920 (0.001)*** | 0.935 (0.001)*** | 0.973 (0.001)*** | 0.987 (0.001)*** |
| Gross outputs per ha (€/ha) | 1.002 (0.001)*** | 1.002 (0.001)*** | 1.001 (0.001)*** | 1.001 (0.001)*** |
| *Labour* | | | | |
| Annual time working on farm (hrs) | 0.999 (0.001)*** | 1.001 (0.001)*** | 1.001 (0.001) | 1.001 (0.001)*** |
| *Demographic* | | | | |
| Farmer's age (years) | 0.980 (0.001)*** | 0.999 (0.001) | 0.982 (0.001)*** | 0.990 (0.001)*** |
| Children | 1.044 (0.026) | 1.027 (0.026) | 1.536 (0.025)*** | 0.860 (0.023)*** |
| Married | 1.130 (0.028)*** | 1.718 (0.027)*** | 1.438 (0.024)*** | 1.111 (0.023)*** |
| *Farm level* | | | | |
| Soil 1^ | 0.725 (0.036)*** | 3.680 (0.034)*** | 2.423 (0.036)*** | 0.293 (0.033)*** |
| Soil 2^ | 0.670 (0.035)*** | 1.642 (0.032)*** | 2.296 (0.035)*** | 0.257 (0.032)*** |
| Farm size 21 to 40 ha | 2.032 (0.025)*** | 5.089 (0.028)*** | 1.701 (0.025)*** | 1.239 (0.024)*** |
| Farm size 41 to 55 ha | 5.109 (0.037)*** | 4.831 (0.037)*** | 2.901 (0.035)*** | 1.602 (0.033)*** |
| Farm size greater than 55 ha | 5.409 (0.041)*** | 3.677 (0.044)*** | 2.179 (0.039)*** | 1.275 (0.035)*** |
| Organic N (Kg/ha) | 0.988 (0.001)*** | 0.975 (0.001)*** | 0.988 (0.001)*** | 0.992 (0.001)*** |
| Dairy^^ | 0.252 (0.038)*** | 0.530 (0.036)*** | 0.176 (0.037)*** | 0.484 (0.036)*** |
| Cattle^^ | 0.862 (0.028)*** | 1.158 (0.028)*** | 0.365 (0.027)*** | 0.838 (0.025)*** |
| Tillage^^ | 0.235 (0.053)*** | 0.194 (0.057)*** | 0.191 (0.051)*** | 0.479 (0.048)*** |
| *Pseudo R2* | 0.49 | 0.48 | 0.5 | 0.33 |
| *Log likelihood* | -35369 | -33950 | -36985 | -40825 |
| *Mean VIF* | 2.50 | 2.55 | 2.56 | 2.80 |

Sources : NFS, 1999; 2003; 2006; 2010. N = 109,396 in 1999; 105,994 in 2003; 106,058 in 2006; 88,560 in 2010 (NFS frequency weights used). Monetary values have been adjusted to the year 2000 using the CPI. SEs in parentheses. ^: base REPS phase is REPS I;^^: base soil type is soil 3 (least productive); ^^^: base system type is sheep.***: p<0.01,;**: p<0.05; *: p<0.1

To understand whether the findings displayed in Table 4.5 show a change in the effectiveness of the type of farmer who chose to participate in REPS over time requires further information on the likelihood that farmers in each REPS phase were likely to have met the biodiversity conservation and pollution abatement objectives of the scheme. Figures 4.1 and 4.2 below provide this information. Hence, findings from Table 4.5 are discussed in tandem with the results shown in Figures 4.1 and 4.2. Firstly, a brief introduction to both figures is provided.

**Figure 4.1: System types which are most likely to be found in the four phases of REPS**

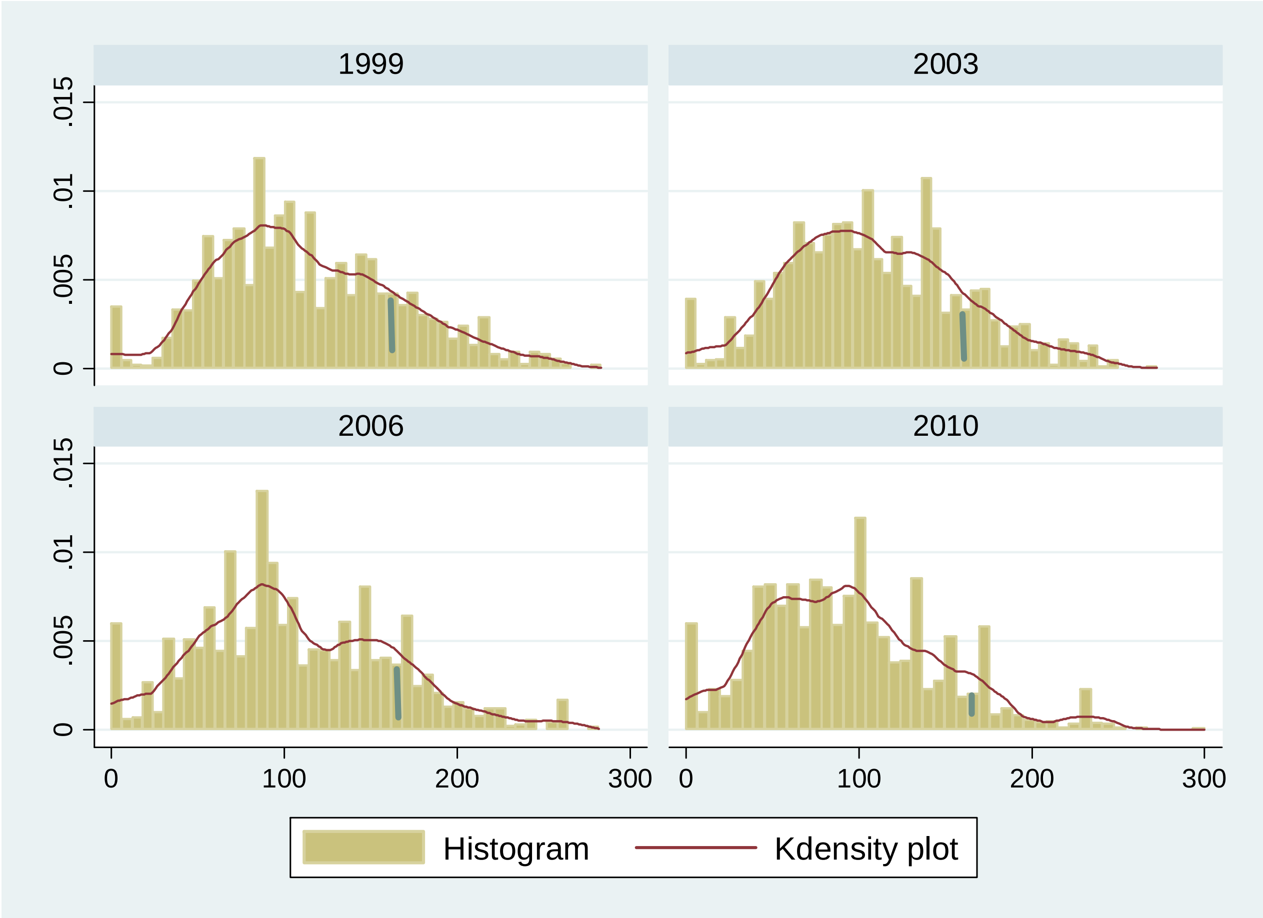



Source: NFS 1999, 2003, 2006, 2010.

Figure 4.1 has been used to graphically represent the *ceteris paribus* likelihood of finding different system enterprises on REPS farms for each of the four phases based on the results of Table 4.5. Due to the strong link between system type and habitat type on Irish farms, the variation in system type shown in Figure 4.1 is being used as an indirect indicator of variation in potential habitat types on REPS farms. Ideally, it should show that there is an equal likelihood of finding all system types on REPS farms.

As discussed previously, the two institutional effects studied in this chapter are the impact of payment rates and organic nitrogen restrictions on scheme uptake. The impact of payment rates can be seen from the coefficients on the farm-size categories in Table 4.5. The coefficients for organic nitrogen production in Table 4.5 tell only half the story of the impact of organic nitrogen production on participation. This is because negative coefficients on this variable may indicate that REPS farmers reduced their organic nitrogen production levels to meet the requirements of the scheme or they may be a consequence of endogeneity in the model. This means that participation in REPS is as much a consequence of having lower levels of organic nitrogen as having lower levels of organic nitrogen is a consequence of participation in REPS.

**Figure 4.2: Histograms and kernel density plots of organic nitrogen production on non-REPS farms for the four phases**

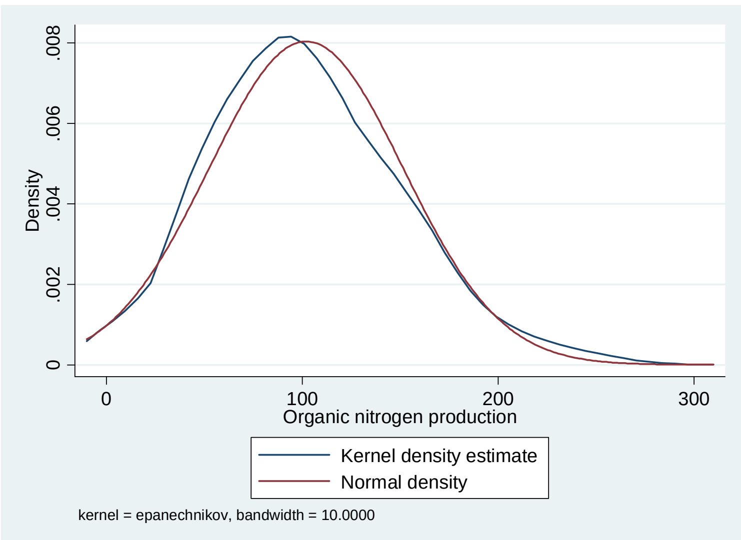



Source: NFS 1999, 2003, 2006, 2010.
Blue line in histogram shows the bin for 170 Kg/Ha organic nitrogen production levels

To establish whether farmers actually altered their levels of organic nitrogen production in response to joining REPS, Figure 4.2 shows histrogams and kernel density plots for organic nitrogen production on non-REPS farms for the four phases of the scheme[17]. The highlighted bin on the histograms indicates the restriction level for the production of organic nitrogen on REPS farms (170 Kg/ha). Ideally, the kernel density plots showing organic nitrogen production levels on non-REPS farms should be normally distributed. This would indicate that non-REPS farmers with all levels of organic nitrogen production are as likely to join the scheme as the entire sample[18]. If, however, the 170 Kg/ha threshold level specifically impacted on the likelihood that farmers participated in REPS, there will be an obvious impact of the restriction on the distributions in Figure 4.2. In particular, if farmers who produce higher levels of organic nitrogen are less likely to join REPS because they do not want to reduce their inputs to meet the requirements of the scheme, there will be a decrease in the percentage of non-REPS farmers in the area of the kernel density plot below the threshold level of 170 kg/ha and an increase in numbers after the threshold in Figure 4.2. Such a kink in

[17] Kernel density plots are modifications of histograms. They are smoothed plots that show, for each selected point, the proportion of the sample that is near it. Nearness is defined by a weighting function called the kernel function, which has the characteristic that the further a sample observation is from a selected point, the smaller its received weight (Hensher *et al*., 2006). Specifically, the kernel density function that is used to show organic nitrogen production on non-REPS farms above is of an Epanechnikov form. The bandwidth used in Figure 4.2 is 10Kg/ha.

[18] Organic nitrogen use for all NFS farms from 1995 to 2010 is almost perfectly normally distributed, as the figure below demonstrates. In it, the kdensity plot for all farms in the NFS from 1995 to 2010 is compared to a normal distribution plot.



the distribution of non-REPS farmers indicates that the organic nitrogen restriction led to adverse selection bias in the scheme.

Table 4.5 shows that the type of farmer who participated in REPS I had lower farm income, worked shorter hours on farm and had poorer soils than their non-REPS counterparts. These combined findings imply that REPS I neither compensated farmers for reducing their production levels nor for the extra effort that REPS measures required of them on their farms. In fact, a major role that REPS I played when it first appeared in Irish agriculture was as income support for disadvantaged farmers (McEvoy, 1999). REPS I farmers were far more likely to be sheep or cattle farmers than dairy or tillage farmers. The lack of variation in system type found in REPS I is obvious from Figure 4.1. This finding indicates that a wide variety of farm habitat types were not covered by the first REPS phase, which means it will have fallen short on meeting its biodiversity conservation objectives.

Neither of the two groups of institutional changes reviewed in this chapter (changes to payment rates and the limit on organic nitrogen production) appears to have a strong impact on REPS I participation. Firstly, despite the fact that individuals did not get paid for any additional hectares above 40, the most likely farm-size categories found in this phase are greater than 55 hectares followed by 41 to 55 hectares. This result may be partially explained by the cost of livestock housing required under the nutrient-management plan in REPS, which was considered excessive for particularly small farmers (Emerson and Gillmor, 1999). However, the seemingly total disregard for the payment structure of the scheme is most probably due to the need for an alternative to production-based payments among disadvantaged farmers. Secondly, the kernel density plot for non-REPS I farmers in Figure 4.2 shows that, although the graph is skewed to the right, there is only a minimal threshold effect (kink) around the 170kg/ha point for REPS I farmers. This implies that, although the farmers who joined the first phase owned predominantly extensive farm types, the threshold itself was not a main deterrent to participation in 1999.

Table 4.5 shows that REPS II farmers were 9.954 times more likely to have been REPS I farmers than not. Therefore, a large number of REPS I farmers participated in REPS II. Policymakers set target uptake rates at 70,000 farmers in the second phase, which was 25,000 more than for REPS I. For this, policymakers provided few additional incentives to entice farmers to join. Payment rates under REPS II had not kept pace with inflation rates at the time and one of the primary incentives for joining REPS I had disappeared by 2003: namely, disadvantaged farms were now in receipt of new payments as a consequence of changes made to the Less Favoured Areas Scheme in 1995 and 1996, meaning they were no longer reliant on REPS payments for income support.

The type of farmer who was likely to participate in REPS II had lower farm income (excluding REPS payments) but higher gross outputs per hectare and on-farm hours than their non-REPS counterparts. They also had better soil types. The likelihood of finding dairy farmers, who generally operate in more productive areas than, say, sheep farmers, in REPS II was higher than in REPS I. In fact, Figure 4.1 shows that there is substantially greater variation in system type in REPS II than in REPS I. This is a positive finding for REPS II in terms of its biodiversity-conservation objectives. The relatively greater numbers of dairy and cattle farmers in this phase is almost certainly a consequence of an outbreak of foot-and-mouth disease in 2001 (Connolly *et al.*, 2002). Less profitable bovine famers would have appreciated definite sources of income from REPS payments given the losses in production incurred as a consequence of the disease outbreak. These findings all suggest that REPS II farmers were using REPS as part of a whole-farm strategy – optimising production but minimising risk – in a manner similar to findings from O'Donoghue and Howley (2012), which describes farmers' use of SFP to maximise their total farm income.

Participants in REPS II appear to be more cognisant of the payment rates and organic nitrogen restrictions than those in REPS I. Increases in payment rates for this phase ended at 40 hectares and the most likely farm-size category found in REPS II is 21 to 40 hectares. The odds ratio for organic nitrogen production in REPS II is negative and there is a strong threshold effect (kink) in Figure 4.2. These findings suggest that the negative impact of the odds ratio for organic nitrogen production in Table 4.5 is due to extensive, rather than intensive, farmers joining the scheme and reducing their chemical use. Therefore, despite the fact that a greater variety of farm types were found in the second phase of REPS, it appears as though those who joined were not the ideal type of farmer for meeting pollution abatement objectives.

A total of 48% of those in the NFS dataset in 2006 are REPS participants (Table 4.2), so this phase of the scheme had the potential to make the greatest amount of environmental change of all four phases. They have the highest odds ratio values for the marriage and children variables of the four logits, meaning they are the most likely participants of the REPS phases to have successor influences, and they are also younger than their non-REPS counterparts. This profile of REPS III farmers suggests that they may be the type of farmer who views the decision to participate in REPS as some sort of long-term plan for the farm (Hennessy and Rehman, 2007). This is an ideal type of farmer to choose to participate in REPS from the point of view that most of the measures included in the REPS contract should be maintained for longer than the five-year duration to have long-term positive impacts on the Irish environment.

Payment rates in REPS III were not only greater than those for the previous two phases but two tiers were added for additional per hectare rates above 40 hectares. The findings for the farm-size categories in the REPS III logit reflect these changes, with the most likely farm-size category being 41 to 55 hectares followed by greater than 55 hectares. In addition, the magnitudes of the odds ratios for farm-size categories in this logit are lower than those of the REPS I and REPS II logits. This means that not only did this phase of the scheme attract a greater number of larger-sized farms to the scheme, but it had greater variability in its farm-size categories than the previous phases.

Despite this heterogeneity in farm-size categories in REPS III, the likelihood of finding a variety of habitat and system types in REPS III is the lowest of all four phases of the scheme – Figure 4.1 shows that the largest majority of sheep farms were found in REPS III. These findings indicate that the increase in payment rates in REPS III did not improve the type of farmer who was most likely to join REPS. Instead, similar to REPS I, those who joined were predominately extensive. They merely had larger holdings. Similarly, changes to the payment rates in REPS III did not overcome adverse selection bias as a consequence of the existence of the organic nitrogen restriction. The threshold effect in Figure 4.2 is the strongest of all four REPS phases, meaning the larger farms that joined REPS were not reducing their production of organic nitrogen to meet the requirements of the scheme, but were maintaining them at pre-participation levels.

Combined, these findings suggest that the type of farmer who participated in REPS III was not ideally suited to meeting either the pollution abatement or biodiversity conservation objectives of the scheme. In fact, given the high participation rates in REPS III (see Chapter 2), it is likely that the strong adverse selection bias in this phase that resulted from the restriction on organic nitrogen production actually played a role in the (lack of) variety in habitat types displayed in Figure 4.1. Ergo restrictions that existed to meet the scheme's pollution abatement objectives reduced the likelihood that the type of farmer found in REPS III was capable of meeting the scheme's biodiversity conservation objectives.

The type of farmer who was most likely to participate in REPS IV had the smallest farm income difference from their non-REPS counterparts of all four phases. The two most likely farm-size categories found on REPS IV farms are 41 to 55 hectares followed by greater than 55 hectares, which is presumably a consequence of the payment structures for the fourth phase of the scheme. The values of the odds ratios for the farm-size variables in the 2010 logit are lower than those in the REPS III logit, meaning variability in farm size was even greater for REPS farms in 2010 than in 2006. Figure 4.1 shows that there is also a substantial amount of variability in the type of system found in REPS IV. In addition, the kernel density plot in Figure 4.2 has only a small kink in its smoothness surrounding the 170 kg/ha bin, whereas other years had a more substantial threshold effect. This latter finding suggests that the removal of the 170Kg/ha restriction for individuals with derogations in REPS IV resulted in a change in the type of farmer who joined the fourth phase that did not happen in previous phases when payment rates were changed.

The improved variability in system types in REPS IV shown in Figure 4.1 is likely to have been, at least partially, caused by the removal of the organic nitrogen restriction in this phase. Therefore adverse selection bias, which existed as a consequence of stipulations in organic nitrogen production, may have impacted on the effectiveness of earlier phases of REPS at meeting its biodiversity conservation objectives in addition to its pollution abatement objectives.

## 4. 6. Conclusions

The CAP intends to introduce further AESs in the near future (DAFM, 2012b). The success of current and future AESs is dependent upon what can be learned from the successes and failures of past schemes. In the Irish case, all the required information must therefore come from an evaluation of REPS. Results from this chapter show that the type of farmer who was most likely to participate in REPS over time had an extensive farm system, low income and spent more hours working on-farm than their non-REPS counterparts. They were also younger, more likely to be married, had poorer soil types and produced lower levels of organic nitrogen than their non-REPS counterparts. The type of farmer who participated in each of the four phases of REPS was uniquely different to this type of farmer in some way. This means farmers responded to contractual changes in the scheme over time.

REPS I participants were primarily disadvantaged farmers in need of income support. Their choice to participate in the scheme is not expected to have produced optimal outcomes in terms of pollution abatement or biodiversity conservation. In REPS II, participants may have been using payments as a form of risk aversion after an outbreak of foot-and-mouth disease resulted in them being concerned about future farm incomes. Nonetheless, this phase of the scheme failed to entice the required number of farmers to join, meaning it failed to meet even the basic objective of required uptake rates. There is evidence of adverse selection bias with regard to organic nitrogen production in REPS III, which can be attributed to the 170 kg/ha restriction contained in the contract. It is likely that this bias heavily influenced the low level of variability in system types joining this phase. Adverse selection bias is almost absent from REPS IV and the findings for organic nitrogen production and system variation in 2010 were both conducive to the scheme being capable of producing effective environmental results.

Overall, these findings show that the number of farmers who joined REPS, and the size of farms participating in the scheme, increased in response to larger payment rates in the latter phases. However, the type of farmer who responded to the changes in payment rates may not have been the ideal type of farmer for meeting either the pollution abatement or the biodiversity conservation objectives of the scheme. This is an important consideration given that the value of REPS payments to farmers totalled €3.3 million in 2006 alone (DAFF, 2009).

An alternative to increasing payment rates is to make institutional changes that result in a decrease in the opportunity costs of participation in the scheme for farmers. Findings from this chapter indicate that removing restrictions on organic nitrogen production had a superior effect on improving the type of farmer who joined REPS across phases than changing payment rates. However, this conclusion must be considered with caution because, in this case, increasing scheme effectiveness by improving the type of farmer who joined REPS came as a consequence of reducing the effectiveness of a scheme measure.

Pollution abatement requires the reduction of negative externalities from agriculture. Biodiversity conservation requires the production of positive externalities from agriculture. Biodiversity can be both private and public goods, which may have both use and non-use values. The likelihood of one scheme attracting the type of farmer who can produce the many goods and services required of both the pollution abatement and biodiversity conservation objectives of REPS is low. In fact, results from this chapter show that adverse selection bias that occurs as a consequence of one restriction in an AES contract may potentially impact on a scheme's ability to meet other environmental objectives: namely, the high likelihood of finding extensive farm types in REPS III is likely to have been in part due to the organic nitrogen restrictions in the scheme. This result suggests that future AESs in Ireland should tackle pollution abatement and biodiversity conservation issues using different contracts rather than attempting to meet broad objectives using just a single scheme.

As georeferenced habitat data become increasingly more available to researchers, the methods used in this paper could be used to evaluate in greater detail what type of farmer participated in REPS by habitat types on the farms. The results from this chapter would also be greatly enhanced by using qualitative research to ask farmers why they behaved in the way they did with regard to REPS. By isolating the motivations behind the decisions made by farmers in relation to REPS participation, a deeper understanding of the factors driving involvement in an AES by landowners may be gleaned. This information would be useful in the design of any new AESs for European agriculture.

# 5. Using simulated counterfactual data to empirically estimate the REPS participation decision

## *5. 1. Introduction*

Ideally, voluntary AESs should exactly compensate farmers for the opportunity costs of implementing scheme measures on their farms. The REPS contract took a top-down approach to price setting, which implies that farmers were price acceptors rather than price setters in the scheme. Farmers are not expected to have participated in REPS if the payment rates provided by policymakers did not sufficiently compensate them for the perceived opportunity costs of joining the scheme. If this was the case, REPS suffered a loss in effectiveness because offers of insufficient payments diminished uptake rates and potentially biased the type of farmer who chose to participate in the scheme. Conversely, if REPS payments were overcompensating farmers for the perceived opportunity costs of implementing the scheme on their farms, it indicates a lack of efficiency in the scheme. This is because the level of environmental improvement achieved per Euro as a consequence of the existence of REPS was not optimal. It also indicates that REPS suffered in terms of effectiveness because funds could have been allocated to the achievement of other environmental gains (Moxey *et al.*, 1999).

Certain authors have used SP techniques to estimate farmers' WTA compensation for the implementation of AESs on their farms (Bateman *et al.*, 1994, Espinosa-Goded *et al.*, 2010, Beharry-Borg *et al.*, 2013). Whilst this is a useful method for estimating 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 (Bateman *et al.*, 2002). In contrast, the RP method used in this chapter involves the creation of counterfactual choice data for each individual in the NFS indicating what values certain farm-specific variables would have taken had they chosen the alternative REPS participation decision in any given year from 1995 to 2010. Using counterfactual data in this way is a novel approach for estimating the opportunity costs of participating in an AES.

As previously discussed (see Chapter 3), the participation decision of farmers in voluntary AESs has been empirically estimated by a number of authors (Defrancesco *et al.*, 2008, Hynes and Garvey, 2009, Ma *et al.*, 2012). All of these studies compare individual- and farm-specific variables on adopters' farms with individual-specific variables on non-adopters' farms. 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 independent variables used to describe the decision. The use of actual and counterfactual data in this chapter overcomes the problem of sample selection bias because individuals are being compared with counterfactual versions of themselves who differ from them only with regard to their REPS participation status. Hence, adopters, who are often fundamentally different to non-adopters regardless of their REPS participation status, are no longer being compared with non-adopters. The first objective of this chapter is therefore to empirically estimate the REPS participation functions of Irish farmers using actual and counterfactual choice data.

Of particular interest to this chapter 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, the second objective of this chapter is to investigate whether the REPS participation function of non-viable farmers is the same as the REPS participation function of viable farmers.

This chapter 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 5.3 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 5.4 introduces the data used for the analysis. Section 5.5 shows values for the counterfactual data, showing farmers' hypothetical alternative participation decision, that are used for the analysis in the chapter. 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 5.6 provides concluding remarks.

## 5. 2. *Theoretical model*

The aim of REPS was to use monetary incentives to change farmers' behaviour. As highlighted in the previous chapter, in return for receiving REPS payments, participation is expected to have incurred opportunity costs and effort for the farmer. In this chapter, individuals are expected to have viewed the choice to participate in REPS (or not) as a time-allocation decision, as described by Becker (1993). Becker's economic approach assumes that all family decisions are reached through weighing the advantages and disadvantages of alternative actions. It assumes that households maximise their utility as they see it, whether they are selfish, altruistic, spiteful or masochistic. It is based on three related assumptions: maximising behaviour, market equilibrium and stable preferences[19]. The behaviour of family members is assumed to be forward thinking, reflected by an altruistic family head and consistent over time. Actions are constrained by a number of limited resources, the most important of which is time (Becker, 1965).

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 (El-Osta *et al.*, 2004, Kimhi, 2004, Ahearn *et al.*, 2006) and the impacts of decoupled payments (Weber and Key, 2012) and setaside programmes (Chang and Boisvert, 2009) on farmer utility. To date, farmers' utility levels associated with the choice to participate in a voluntary AES have not been estimated.

[19] The assumption of stable preferences is later dropped.

The farm household model states that, as rational beings, farmers will always choose management options that provide them with the highest level of utility subject to constraints. Neoclassical economic theory states that utility can be derived from one of two goods: income (and the resulting ability to consume) and leisure:

$$U_i = U(Y_i, T_i; Z_i) \tag{5.1}$$

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. They may also impact on utility levels indirectly through current consumption and leisure decisions. Farmers maximise their utility subject to constraints on time, income and farm production:

$$T = T_i + T_f + T_{of} \tag{5.2}$$

$$P_m Y_i = P_f Y_f - RX + W_{of} T_{of} + V \tag{5.3}$$

$$Y_f = f\left(T_f, M; Z_f, H_f\right) \tag{5.4}$$

Equation 5.2 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 5.3 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 5.4 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.

The REPS participation decision potentially influenced farmers' utility through changes in all the components of Equation 5.1. It impacted on farmers' ability to purchase goods, $Y_i$, in two ways. Firstly, REPS payments increased farmers' capacity to consume goods overall. Secondly, reductions in on-farm production imposed by the REPS contract decreased farmers' earnings from on-farm production and, consequently, their ability to consume.

The amount of leisure time available to farmers was determined by the number of hours they spent working on- and off-farm (Equation 5.2). The impact of the REPS participation decision on farmers' available leisure time is complex. To begin with, the effect of joining REPS on on-farm hours is mixed. This is because, on the one hand, there was a certain amount of effort associated with joining REPS that was not required on non-participating farms. Therefore, the choice to participate in REPS may have resulted in a marginal increase in the amount of time farmers spent at REPS-related on-farm work. On the other hand, the reduction in productivity resulting from joining REPS may have resulted in a marginal decrease in farmers' production-related on-farm hours.

The effect of joining REPS on off-farm hours is also complex. If the net impact of joining REPS was a reduction in on-farm hours, farmers may have used the time for either off-farm work or leisure. This decision is presumed to be dependent on whether the participation decision resulted in an overall increase or decrease in net earnings. In the latter scenario, farmers may need to earn extra income from off-farm employment, which would result in an increase in the number of off-farm hours worked. Conversely, if joining REPS increased the amount of time that farmers were required to spend working on their farms, they may have reduced their off-farm hours or their leisure time to compensate for the increase. Overall, therefore, the impact of the REPS participation decision on farmers' leisure time is not expected to be straightforward but dictated by the complex relationships between participation and both on- and off-farm hours.

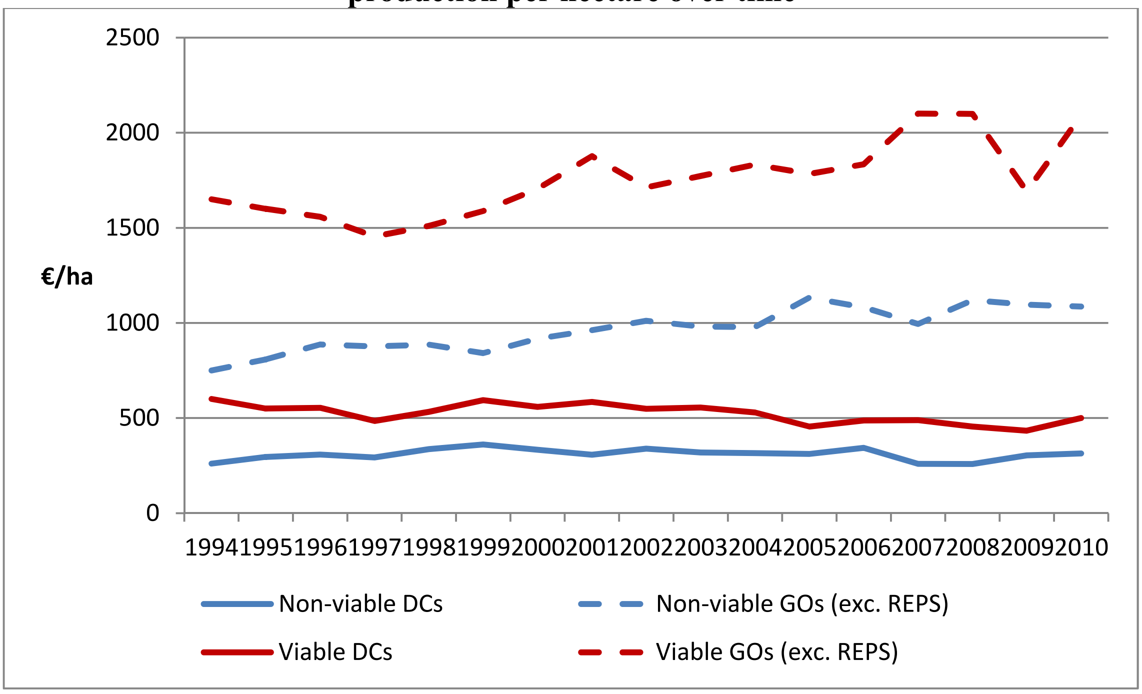
The farm-specific characteristics contained in $Z_i$ are expected to indirectly provide farmers with utility through income or leisure time. In other words, certain farm-specific characteristics are associated with higher or lower income levels or leisure times. For example, farmers' with productive 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.

### *5. 2. 1. Viability in Irish farming*

Returns in Irish farming are, on average, low. A method used to investigate returns is whether a farm is viable or not[20]. Based on the work of Hennessy (2011) and Frawley and Commins (2013a), non-viable farms are defined as not having (a) the capacity to remunerate family labour at the average agricultural wage and (b) the capacity to provide an additional 5% return on non-land assets.

**Figure 5.1: Viable and non-viable direct costs (DCs) and gross outputs (GOs) from production per hectare over time**



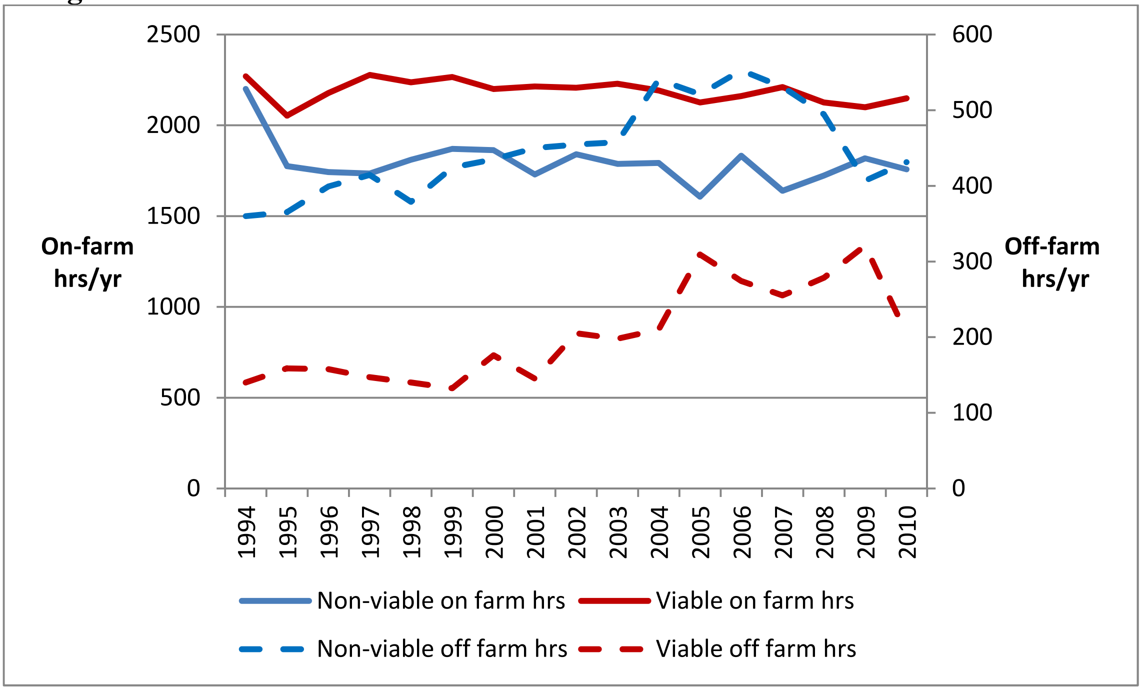

Source: NFS 1994 to 2010

Figure 5.1 shows values for gross outputs and direct costs, both of which provide an indication of on-farm income levels, for viable and non-viable farms from 1994 to 2010. Viable farmers have higher gross outputs per hectare and direct costs per hectare than non-viable farmers. Figure 5.1 also shows that the variability in gross-output values for viable

[20] It is worth noting that Irish farming is heavily reliant on farm subsidies. For example, the NFS shows that subsidies accounted for 98% of family farm income (calculated by deducting all farm costs from the value of farm gross outputs) in 2010 (Hennessy *et al.*, 2011)

farmers is greater than for non-viable farmers, which suggests that viable farming may be riskier, in terms of on-farm income accrued, than non-viable farming.

**Figure 5.2: Viable and non-viable on-farm hours and off-farm hours over time**




Source: NFS 1994 to 2010

Figure 5.2 shows the number of hours that viable and non-viable farmers worked per year both on- and off-farm. The total number of hours that viable farmers work (on-farm hours plus off-farm hours) is similar to the total number of hours that non-viable farmers work, meaning the amount of time they spend at leisure is also similar. Non-viable farmers worked on-farm, on average, for 34.05 hours per week and viable farmers worked on-farm an average of 41.98 hours per week[21]. Off-farm hours worked were 8.72 hours per week for non-viable farmers and 3.98 hours per week for viable farmers.

The differences in the structure of viable and non-viable farms displayed in Figures 5.1 and 5.2 suggest that the REPS participation decision being considered by viable and non-viable farmers may be fundamentally different because neither $Y_i$ nor $T_i$ in Equation 5.1 are the

[21] Average on-farm hours per week do not account for holidays taken.

same. For these reasons, the participation functions of viable and non-viable farmers are modelled separately in this chapter.

## 5. 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, $\varepsilon$. *V* and $\varepsilon$ are assumed to be additive. In discrete choice models, *V* is usually specified to be linear in its parameters ($\sigma$) for a vector of observed attributes, $X_i$, relating to $Y_i$ and $T_i$ (Equation 5.1), for individual $i$. In other words, $V_i = \sigma' X_i$ (Train, 2003).

From 1995 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*. These were their actual participation alternative and their counterfactual participation alternative. The level of utility that farmer *i* gets from choosing alternative *j* can be viewed indirectly using:

$$U_{ij} = U(X_{ij}, \varepsilon_{ij}) = V_{ij} + \varepsilon_{ij} = \sigma' X_{ij} + \varepsilon_{ij} \tag{5.6}$$

Farmers choose the alternative that gives them the highest level of utility, meaning farmer *i* chooses alternative *j* over *k* if and only if:

$$U_{ij} > U_{ik} \tag{5.7}$$

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. Combining equations 5.6 and 5.7 provides information on the probability that a farmer chooses his actual participation alternative:

$$Pr(Y_{ij} = 1|C) = Pr(V_{ij} + \varepsilon_{ij} > V_{ik} + \varepsilon_{ik}) \tag{5.8}$$

Equation 5.8 contains information about 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. This states that the probability of a farmer choosing his actual REPS participation alternative is equal to the probability that the difference in the unobserved source of utility of the actual alternative compared to the counterfactual alternative is less than the difference in the observed sources of utility associated with both. Equation 5.8 can be rearranged to reflect this:

$$\begin{aligned} Pr(Y_{ij} = 1|C) &= Pr(\varepsilon_{ik} - \varepsilon_{ij} < V_{ij} - V_{ik}) \\ &= Pr(\varepsilon_{ik} - \varepsilon_{ij} < \sigma' X_{ij} - \sigma' X_{ik}) \end{aligned} \tag{5.9}$$

*V* can now be linked with a statistical model of human behaviour. To make this possible, theory dictates that two assumptions must be made regarding the structure of the random terms because they are, by definition, unobservable. The assumptions are that, firstly, the random terms for each alternative are independently and identically distributed (IID). Secondly, the error terms, $\varepsilon_{ij}$ and $\varepsilon_{ik}$, 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:

$$Pr(Y_{ij} = 1|C) = \frac{1}{1 + exp(\lambda\sigma' X_{ij})} \tag{5.10}$$

where $\lambda$ 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 *et al.*, 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. The first is a restricted model, which looks at the impact of the four attributes of the alternatives on choice in isolation. These are farm income, REPS payments, on-farm hours and off-farm hours (Table 5.1). The second unrestricted model accounts for the influence of farm- and individual-specific characteristics on farmers' utility levels by including them in $X_{ij}$ as variables interacted with the choice attributes. This process captures the indirect impact of farm- and individual-specific characteristics on the REPS participation decision and is referred to as shifting the attribute by the characteristic (Borooah, 2001). Attributes are shifted by spatial and temporal variables in the second, unrestricted model to account for regional and duration effects on choice.

Finally, the unrestricted participation decision functions of viable and non-viable farmers are estimated using two separate conditional logit models.

### *5. 3. 1. Counterfactual alternatives*

To estimate the marginal effects of each of the attributes contained in $V_{ij}$ (Equation 5.6) on farmers' participation decision, this chapter 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. In other words, counterfactual values for farm income, REPS payments and on- and off-farm hours, which represent how REPS farms would be if the farmer had not chosen to join the scheme and how non-REPS farms would be if the farmer had chosen to join the scheme, need to be created.

The modelling framework used to achieve this goal has not, to date, been applied to answering questions in the environmental 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 and Macurdy, 1999, Creedy and Guyonne, 2005).

Counterfactual variables are created using Teagasc's Income Generation Model (IGM). The IGM is 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 and Lennon, Forthcoming). This chapter 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 5.1 and on- and off-farm hours worked per year. The process that underlies the generation of the counterfactual data involves four steps and is explained below using the effect of the REPS participation decision on farmers' livestock units per hectare from dairy as an example. Firstly, variables that can be used to represent a reduced form livestock units per hectare from dairy production function of the following form are identified:

$$lnY_{it} = \alpha + \beta(Q_{it})_A + \mu_i + \varepsilon_{it} \tag{5.11}$$

where $lnY_{it}$ is the natural log of livestock units per hectare from dairying for farmer $i$ at time $t$, α is a constant, $Q_{it}$ is a vector of observed characteristics used to describe variation in $lnY_{it}$ and containing a dummy variable for farmers' actual REPS participation status and $\beta$ is a parameter. The subscript A in $(Q_{it})_A$ refers to the fact that all of the variables in $Q_{it}$ represent values for farmers' actual participation status in the NFS. In Equation 5.11, the error term is made up of $\mu_{i,}$ which is an individual-specific random element that enters the equation identically for the same farmer over multiple years (referred to as a fixed effect) and $\varepsilon_{it}$, which is an observation-specific random element that differs for each observation.

The second step of the simulation process involves running a linear random effects model[22] in Stata and using the estimated values of $\beta$ to simulate a value for $lnY_{it}$ for each individual in

[22] Using a linear random effects model means the composite random element, $(\mu_i + \varepsilon_{it})$, is assumed to be uncorrelated with $Q_{it}$ (Greene, 2003)

the sample given their $(Q_{it})_A$. The simulated values are called $\widehat{\beta(Q_{it})}_A$. Estimates for the values of $\mu_i$, which are called $(\widehat{\mu_i})$, are also produced. This means that any influences on $lnY_{it}$ that are due to $\varepsilon_{it}$ can then be calculated as:

$$\widehat{(\varepsilon_{it})} = \ln Y_{it} - \alpha - \widehat{\mu_i} - \widehat{\beta(Q_{it})}_A \tag{5.12}$$

Once values for all the right hand side elements in Equation 5.12 have been stored, the third step of the simulation process is to switch the dummy for farmers' actual REPS status to zero for every farmer in the sample to give $(Q_{it})_N$. The following regression is then run:

$$lnY_{it} = \alpha + \beta(Q_{it})_N + \mu_i + \varepsilon_{it} \tag{5.13}$$

A value for $lnY_{it}$ from $\beta(Q_{it})_N$ is simulated and is called $\widehat{\beta(Q_{it})}_N$. Any differences between $\widehat{\beta(Q_{it})}_A$ and $\widehat{\beta(Q_{it})}_N$ can be accredited to the switch from 1 to 0 of the REPS participation dummy, or the observable influence of not participating in REPS for REPS farmers on (the natural log of) their livestock units per hectare from dairy. Finally, these observed effects are combined with the stored unobserved effects from Equation 5.12 to produce:

$$(Y_{it})_{\mathrm{N}} = exp\left[\widehat{(\beta Q_{it})}_N + \widehat{(\mu_i)} + \widehat{(\varepsilon_{it})}\right] \tag{5.14}$$

where $(Y_{it})_N$ contains values for farmers' livestock units per hectare from dairy if no one had participated in REPS from 1995 to 2010.

Steps 3 and 4 are repeated for all farmers in the sample but with the REPS status dummy in $Q_{it}$ set to 1. This results in the simulation of counterfactual REPS values for non-REPS farmers' livestock units per hectare from dairy. In other words, it results in the creation of a dataset containing values for farmers' livestock units per hectare from dairy if all Irish farmers had participated in REPS during the study period.

The entire process is repeated to estimate the effect of REPS participation on livestock units per hectare from cattle and sheep; gross outputs per livestock unit from dairy, cattle and sheep; gross outputs per hectare from cereals; per hectare values for the 10 cost variables in Table 5.1 and on- and off-farm hours worked per year (each represent $Y_{it}$ in Equation 5.11). For each of these variables, $Q_{it}$ always contains a dummy variable for REPS participation. It may also include variables relating to price, land, labour, stock, farm and farmer characteristics depending on whether it is representing a reduced form production function, cost function or labour supply function for output, input or time variables, respectively. (See Appendix A for outputs from these simulations.)

Counterfactual values for farmers' dairy, cattle and sheep gross outputs are calculated as the product of their counterfactual livestock units per hectare from dairy, cattle and sheep and their gross outputs per livestock unit from dairy, cattle and sheep, respectively. Counterfactual gross outputs from cereals are derived from the product of the simulated per hectare variables and the amount of land farmers actually assigned to tillage. These values are combined with farmers' actual other gross outputs to obtain a counterfactual value for their gross outputs.

Due to the fact that farmers are not awarded decoupled subsidies based on current production levels, the value of farmers' counterfactual decoupled subsidies do not alter from their actual decoupled subsidies. Counterfactual values for farmers' costs per hectare are the product of simulated costs per hectare and actual farm size. Finally, an attribute representing farmers' farm income for their alternative REPS participation choice is created for each farmer in the NFS from 1995 to 2010 by combining counterfactual gross output values, decoupled subsidies and counterfactual cost values according to Equation 5.5.

The remaining three attributes of the participation choice listed (in bold) in Table 5.1 are REPS payments, on-farm hours and off-farm hours. An attribute representing non-REPS farmers' REPS payment value for their alternative participation choice, i.e. if they had joined, is generated by estimating per hectare payments from actual participants, applying them to non-REPS farmers according to the size of their farms and adjusting them according to contemporary REPS payment rates. Attributes for farmers' alternative on- and off-farm hours worked are taken directly from the counterfactual variables described above.

## *5. 4. Data*

All the data for this chapter are derived from NFS datasets for the years 1995 to 2010. A total of 20,459 actual NFS observations are used in this study. Table 5.1 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.

**Table 5.1: 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[a] (€)** | 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 |

Source: NFS 1995 to 2010. Monetary values have been adjusted to the year 2000 using the CPI. [a]: Farm income does not include labour costs.

The first 18 lines of Table 5.1 show average values for gross outputs, decoupled subsidies and costs (in italics) on Irish farms from 1995 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 5.1 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 5.1. Table 5.1 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.

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 Chapter 4).

Examples of sources of other gross outputs in Table 5.1 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 5.1 are all components of farm income, which is calculated as:

$$\text{Farm Income} = \text{Gross Outputs} + \text{Decoupled Subsidies (excl. REPS)} - \text{Costs} \qquad (5.5)$$

The values for farm income, REPS payments, on-farm hours and off-farm hours in Table 5.1 (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 5.1). 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 5.1 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 5.1) on utility.

## 5. 5. Results and discussion

Table 5.2 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 5.1. As mentioned above, the farm income variable has been created from these values according to Equation 5.5. Table 5.2 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 5.2 (in bold) represent attributes of the counterfactual participation outcome for farmers in the NFS from 1995 to 2010.

**Table 5.2: 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[a] (€)** | 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 |

Sources: Simulated counterfactual data from NFS data (see Appendix A). Monetary values have all been adjusted to the year 2000 using CPI. [a]: farm income does not include labour costs

A comparison of the attributes of the actual participation alternative (Table 5.1) and the attributes of the counterfactual participation alternative (Table 5.2) 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.

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 5.2 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 5.3: REPS participation decision for entire population**

| **Variables** | **Restricted** | **Unrestricted** |
|---|---|---|
| | *β (S.E.)* | *β (S.E.)* |
| *Income* | | |
| 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*** |

Sources: NFS actual and counterfactual data. N = 37,298 for both models. Also included in this model are interacted terms for farm income and REPS participation. Both are shifted by dummies for all years from 1995 to 2010 and 6 national regions.^: Base soil type is soiltype 2. `: This value is too small to display.
***: p<0.01, **: p<0.05, *: p<0.1

Table 5.3 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.

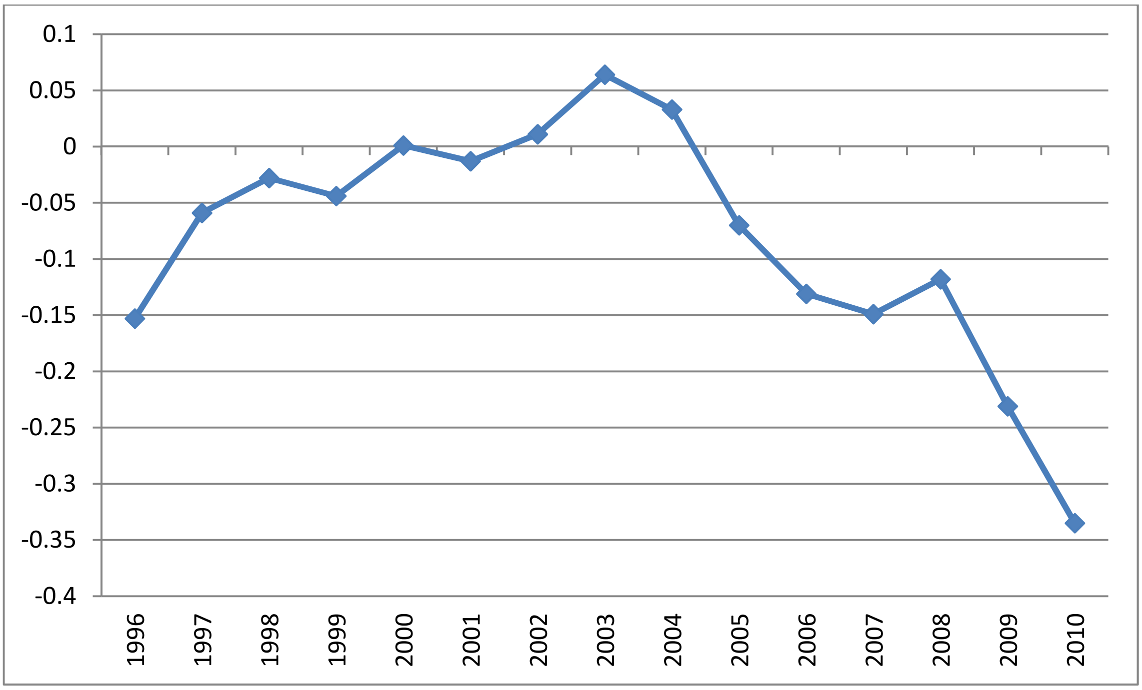
The pseudo $R^2$ value of the unrestricted model is higher than the pseudo $R^2$ value of the restricted model in Table 5.3. A higher pseudo $R^2$ value indicates that the improvement of the unrestricted model on the underlying null model at describing variation in farmers' participation decision is 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[23]. 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 5.3 contained a number of other variables besides those listed in the table[24]. 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.

[23] Correctly speaking, this should read the "log odds of the REPS participation decision" because the model used is a logit.

[24] To ease the reading of Table 5.3, dummy-shifted variables have not been included. Any findings of interest are instead included as a graph in this section.

**Figure 5.3: Coefficient values for the farm income variables shifted by year dummies in the unrestricted model in Table 5.3**




Coefficient values are multiplied by 1000. Base year is 1995.

Of particular interest to this study, however, is how the impact of farm income on farmers' utility levels over time changed. Figure 5.3 shows how the coefficients on the year-shifted farm income variables increased substantially from 1996 to 2003 and then fell from providing additional positive marginal utility from income to additional and increasing negative utility from income for every year after 2004. In other words, Figure 5.3 shows that, individuals associated every year from 2005 onwards with marginal disutility from income. This means higher farm income was less likely to influence farmers' participation decision in these years than in earlier years. The SFP was introduced in 2005 and began awarding farmers direct payments based on historical production levels. Hence, a large section of farm income was "safe" from the influence of farmers' REPS status. This explains why farm income was not as influential in farmers' participation decisions in the latter years of this study.

The marginal utility of farm income from having soil type 1 is positive and significant in Table 5.3. 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 5.3 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.

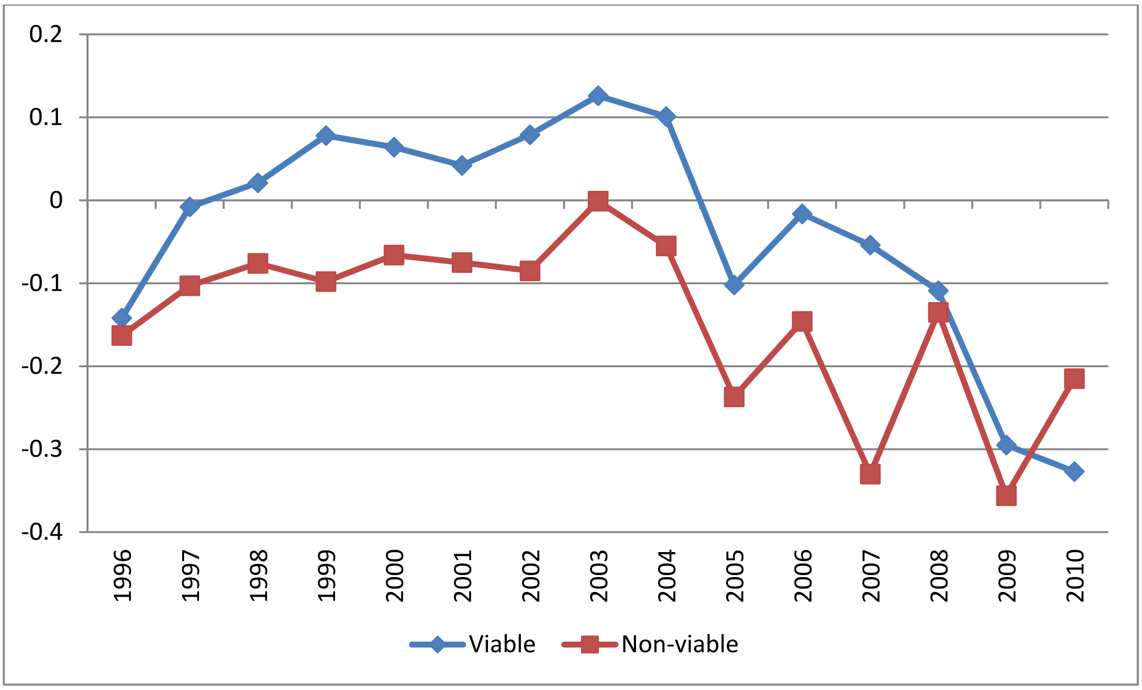
**Table 5.4: REPS participation decision for viable and non-viable farmers**

| **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 $(\text{hours})^2$ | -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 $(\text{hours})^2$ | -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 | -5.629578 (0.275478)*** | -3.57779 (0.238357)*** |
| Pseudo $R^2$ | 0.3255 | 0.1892 |
| Wald Test | 1532.20*** | 1026.65*** |

Sources: NFS actual and counterfactual data. N = 18,002 for viable model; N = 19,296 for non-viable model. Also included in these models are interacted terms for farm income and REPS participation. Both are shifted by dummies for all years from 1995 to 2010 and 6 national regions. ^: Base soil type is soiltype 2. `: This value is too small to display. ***: p<0.01, **: p<0.05, *: p<0.1

Table 5.4 shows the results of two unrestricted conditional logits for farmers' participation decisions in REPS[25]. 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. Before these differences can be discussed, however, Figure 5.4 below is used to show the trends in the coefficients for the year-shifted farm income variables in the viable and non-viable participation functions in a manner similar to Figure 5.3.

**Figure 5.4: Coefficient values for the farm income variables shifted by year dummies in the viable and no-viable models in Table 5.4**




Coefficient values are multiplied by 1000. Base year is 1995.

[25] 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.

The unshifted variable for farm income is positive and significant for viable farmers in Table 5.4. In addition, Figure 5.4 shows that marginal utility from income for viable farmers is positive for every year from 1998 to 2004 and negative for every year from 2005 to 2010, meaning they put more, and less, emphasis on the importance of earnings from on-farm income in the years before, and after, the introduction of the SFP, respectively. 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. Figure 5.4 shows that marginal utility from income for non-viable farmers fluctuates greatly and does not respond to the introduction of the SFP in 2005 to the same extent as viable farmers' utility functions do. For example, non-viable farmers' marginal utility from income is not positive for any of the years displayed in Figure 5.4. This indicates that non-viable farmers do not emphasise the importance of utility from on-farm income in their REPS participation decision in the same way viable farmers do. 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 5.4). 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 who attach more importance 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 5.3) as well as for viable and for non-viable farmers (Table 5.4). This is almost certainly due to regional variation in farm types, and farm productivity across the country (see Figure 2.1 and Figure 2.2). It implies that further variation in farmers REPS participation decision may be seen across the country as well as by viability status.

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 of life.

## 5. 6. Conclusions

The restricted model in Table 5.3 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 5.4 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.

Farmers whose perceived opportunity costs of joining REPS are higher than the set rate of REPS payments are unlikely to participate in REPS. Therefore, the use of top-down price setting in REPS is likely to be ineffective, and to produce inefficiencies, by attracting individuals' whose perceived opportunity costs of joining are likely to be lower than the payments offered by the scheme. An alternative to top-down price setting that may alleviate the problem of overcompensating farmers 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 *et al.*, 2005).

By recognising the fact that Irish farmers may be incentivised to join AESs for various reasons, policymakers will produce more efficient future schemes. This is because schemes that follow this model are more likely to adequately compensate farmers for their perceived opportunity costs of participation. In fact, a review of Irish farmers' participation behaviour in organic schemes by Lapple and Kelley (2013) shows that policy makers will greatly increase uptake if they acknowledge the impact of social and technical barriers to adoption, as well as focussing on monetary incentives.

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 chapter 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. For example, maximum and minimum agri-environmental payments can be estimated by simulating how farmers will respond to different offers. Ultimately, simulations such as these will help with the design of voluntary AESs that appeal to farmers' preferences at the lowest possible costs.

# 6. The impact of REPS farmers' decisions on the management of agricultural habitats

## *6. 1. Introduction*

With Agenda 2000 came the second pillar of the CAP and an increasing interest in the role that multifunctional production plays on European farms. In addition to being a provider of commodity based goods, the agricultural sector was being increasingly viewed as a source of non-commodity based goods, such as biodiversity and scenic landscapes (Matthews, 2002a, Feehan and O'Connor, 2009). This meant that much of the criticism of the first two phases of REPS focussed on their lack of emphasis on the promotion of agricultural practices that actively encouraged the enhancement and maintenance of commensurable biodiversity levels (Feehan *et al.*, 2002). In response to these criticisms, mandatory BUs, the primary objectives of which are to improve biodiversity levels on participating farms, were added to the 11 basic measures for the latter two phases of REPS.

In REPS III farmers have 16 BUs to choose between, whereas in REPS IV, the number of options increases to 24. Farmers must choose (at least) 2 BUs to incorporate onto their farms. Participants in REPS cannot choose the same BU twice. They receive the same level of REPS payments regardless of which BUs they chose. The amount of land on a farm holding that is required to be covered under the BUs varied according to their specifications. This chapter evaluates the BU choices of REPS farmers in terms of their ecological suitability, given the type of habitats that REPS farms contain. If it is the case that REPS farmers are making appropriate choices given the habitats found on their farms, then it points to the effectiveness of REPS in terms of its voluntary design. If it turns out that, in some instances, farmers are choosing inappropriate BUs given the habitats on their land, it points to a failure of the design of REPS, whereby allowing farmer behaviour to dictate how the scheme is implemented at farm level does not work. In addition, it prompts us to ask why farmers are making such ecologically inappropriate choices.

In both REPS III and REPS IV specific measures are provided for land that was protected under the Birds, Habitats or Water Framework Directives (79/409/EEC, 92/43/EEC and 2000/60/EC) or under the Wildlife Amendment Act (2000) – henceforth referred to as target land. The details of the management goals for target land are contained in Measure A and Measure 4 of the REPS III and REPS IV contracts, respectively. Specific management goals for target land were included in the environmental farm plans and were given precedence over BU choices whenever the target land and BU objectives were at odds. As a consequence of the independent treatment of target land under REPS contracts, this study assumes that BU choice did not impact upon how target land was managed. Therefore, the habitat types that are being evaluated in this chapter are those that are more generally found on Irish farms. The majority of the BUs in REPS strives to improve biodiversity levels on participating holdings by enhancing pre-existing habitats on extensive farms.

Of course some farms do not have habitats with high biodiversity levels to enhance, perhaps because the land has been intensively managed for agricultural production over a long period of time (Bignal, 1998). For these REPS farms there existed BUs that are specifically designed to generate biodiversity rich areas. Fore mostly, farmers are expected to choose BUs that enhance/maintain endemic habitats if they subsist on a given holding. REPS participants with farms that are absent of biodiversity rich habitats should ideally choose BUs that encourage habitat creation. This chapter is concerned with whether farmers did indeed make decisions along these lines. Firstly, using specialist ecological knowledge, the optimal ecological assignments of habitats to BUs are identified. Then, multinomial logit models of farmers' choice of BU options are used to compare the decisions farmers actually made with what experts say should be the environmentally optimal outcomes. As such this chapter presents findings on the policy performances of AESs in relation to biodiversity on the farm that to date has not been adequately dealt with in the literature.

The question of how well farmers' choices met the requirements of the habitats on their farms is addressed in this chapter using two separate models. The first investigates the probability that REPS farmers choose the correct BUs for the habitats on their farms conditional on all the other farm and farmer characteristics that are expected to influence REPS farmers' choice of BU. Answering this research question is important because it provides information on the probability that REPS farmers made the correct decisions for the biodiversity on their farms. In doing so, it assesses whether the use of individual farm management plans in the design of REPS was effective.

It is also possible to ask whether the decision to participate in REPS had any effect on the likelihood that farmers in general made the correct decisions for the habitats on their farms. Therefore, the second model used in this chapter includes a variable to correct for the effect of non-REPS farmers' participation decisions on the assignment of Irish farm habitats to BUs. Consequently, the second model demonstrates whether REPS was effective in terms of assignment of habitats to BUs in the individual farm management plans.

The use of geo-referenced landscape variables in AES assessment is growing, as is their use in participation frameworks for voluntary schemes (Lynch and Lovell, 2003, Cunningham, 2005). Regarding REPS, Hynes *et al*. (2008a) advanced earlier econometric behavioural studies of AES participation by including habitat data in a logit model of REPS participation behaviour. In doing so the authors take a step in the direction of an increased multidisciplinary approach towards the question of why farmers choose to participate in an AES because the role of habitat type in this decision making process has implications for both the farmer and the farm environment. They find that farmers are more likely to participate in REPS if they have wet grassland, shallow water, forest and scrubland, fen, blanket bogs or rocky complexes on their farms. Farmers are less likely to participate in REPS if they had dry grassland, heath, built land or cutover fen habitat types on their farms. This chapter adds to the research of Hynes *et al*. (2008a) by further investigating how farmers maximise their utility in relation to land use once they have decided to participate in REPS.

While Hynes *et al*. (2008a) are interested in the relationship between REPS participation and habitat type this chapter is concerned with the relationship between the BUs undertaken within the scheme given the habitat type on the farm. Also unlike Hynes *et al*. (2008a), the habitat data in this chapter is associated with actual farms rather than spatially simulated, representative farm types. Furthermore, this chapter combines specialist ecological knowledge with a discrete choice models of farmer utility maximising behaviour to compare the decisions farmers should have made with the decisions they actually made. As such it presents findings on the policy performances of AESs in relation to biodiversity on the farm that to date has not been adequately dealt with in the literature.

The next section introduces the data used in this chapter and elaborates on how it has been categorised and aggregated so that habitats with similar management requirements, as well as BUs providing similar types of habitat management, are grouped together. Section 6.3 describes the evaluation method used in this study and the theory that underpins it, while the following section presents the results of the estimation exercise. Finally section 6.5 concludes with a discussion of the implication of the results, including the role that they may play in informing agri-environmental policymakers in the future.

## 6. 2. Data

The 2007 NFS dataset, which consisted of a random sample of 1,151 farms representing 111,913 farms nationally, is used for the analyses undertaken in this chapter. Summary statistics for the entire sample, including REPS and non-REPS farmers, are included in Table 6.1 below.

**Table 6.1: Summary statistics for all farmers in the 2007 NFS dataset**

| Variable | Description | Mean |
|---|---|---|
| Farm income | Income from the farm (excluding REPS payments) in €1,000s | 25.24 |
| Farm size | Size of farm (ha) | 39.29 |
| Off farm job | 0: farmer has no off farm employment 1: farmer has off farm employment | 0.34 |
| Farmers' age | Age of farmer (years) | 52.53 |
| Married | 0: farmer has never been married 1: farmer is or has been married | 0.82 |
| Children | 0: no children living on the farm 1: children living on the farm | 0.51 |
| Finished school | 0: farmer did not finish secondary school 1: farmer finished secondary school | 0.60 |
| Agricultural education | 0: farmer has no agricultural training beyond REPS courses 1: farmer has agricultural training | 0.49 |
| Sheep | 0: not a specialist sheep farm enterprise 1: specialist sheep farm enterprise | 0.15 |
| Cattle | 0: not a specialist cattle rearing enterprise 1: specialist cattle rearing enterprise | 0.22 |
| Cattle other | 0: not a specialist cattle rearing and fattening enterprise 1: specialist cattle rearing and fattening enterprise | 0.23 |
| Dairy other | 0: not a specialist dairy with other enterprise 1: specialist dairy with other enterprise | 0.08 |
| Dairy | 0: not a specialist milk production enterprise 1: specialist milk production enterprise | 0.23 |
| Tillage | 0: not a tillage enterprise 1: tillage enterprise | 0.09 |
| Same option | 0: both BU options are from different groups 1: both BU options are from the same group | 0.15 |

Source: NFS (2007). N=424.

In 2007, REPS farmers who participated in the NFS were asked to fill out supplementary questions asking, amongst other things, which BUs they had chosen for their farms. Farmers are not required to complete BUs as part of the second phase of the scheme, so participants in REPS II are excluded from this study. All of the remaining observations come from REPS III and REPS IV farmers (424 participants in total). Each farmer is obliged to choose at least 2 BUs as part of their contract, meaning the resulting dataset has at least two observations for each REPS farmer in the 2007 NFS dataset.

Each of the BUs that a farmer could choose is categorised into one of five BU groupings according to the type of management changes that they incur for farmers to improve terrestrial biodiversity on their farms. The five groupings are *enhance field margins*, *maintain/enhance grazing areas*, *setaside*, *create habitats* and *maintain water quality* and are defined in Table 6.2. Two of the BUs that are only offered to REPS IV farmers –low input spring cereals and minimum tillage – were not chosen by anyone in the supplementary survey. Also, 12 of the 24 BUs are only chosen by farmers on ten or less occasions. The disparity between the number of BUs made available to REPS III and REPS IV farmers is accounted for by using this grouping system because a number of BU choices from REPS III and REPS IV are included in each grouping. As each farmer selects more than one BU, the multiple (and exclusive) choices are affected by the same farm habitats and farmer characteristics and therefore the individual's choices cannot be considered independent. To control for this dependence, a dummy variable is included in the model to indicate whether a farmer took two BUs from the same grouping. This incorporates the effect of dependence across BU into the model[26]. The resulting dataset contains 870 observations for 424 REPS farmers.

[26] Another approach to controlling for the dependence across a farmer's BU choices is the introduction of an individual fixed effect into the model (i.e. assuming a panel sample). However, this is not possible because the explanatory variables do not vary across the choices made by the farmer, thus resulting in a model that drops (or has only insignificant) coefficients.

**Table 6.2 BU groupings**

| **Enhance field margins** | **Maintain/ enhance grazing areas** | **Setaside** | **Create habitats** | **Maintain water quality** |
|---|---|---|---|---|
| *n = 238* | *n = 59* | *n = 126* | *n = 303* | *n = 144* |
| Arable margins | Traditional hay meadows | Creation of a new habitat | Broadleaved tree planting | Exclude bovines from water courses |
| Hedgerow laying | Species rich grassland | Environmental management of setaside | Farm woodland establishment | Use of clover in swards |
| Hedgerow coppicing | Control of invasive species | Planted buffer zones | Traditional Irish orchards | Use of trailing shoe technology |
| Stone wall maintenance | Nature corridors | | Landscaping around farms | Green cover establishment |
| Increase water course margins | | | Bird/bat boxes | |
| Maintaining access to archaeological sites | | | New hedgerow establishment | |
| Buffer zones around archaeological sites | | | | |

Sources: Fossitt (2000); Foss *et al*. (2001); Gwyn *et al*. (2003); NPWS (2005); Finn *et al*. (2009); IPCC (2010) as well as expert advice.

As mentioned earlier, the objectives of the BUs are to, firstly, enhance non-target habitats where they currently exist and to, secondly, promote the creation of new habitats where they do not exist. Two of the BU groupings in Table 6.2 are entirely devoted to the enhancement and maintenance of pre-existing farm habitats – *enhance field margins* and *maintain/enhance grazing areas*. In particular, they guard against the effects of land abandonment or intensification because the removal of traditional farm practices on extensively farmed areas can result in habitat deterioration. *Enhance field margins* contains three BUs that call for the maintenance of traditional style hedgerows and stone walls and four BUs that enhance the development of habitats on farm margins by stipulating that traditional grazing and strict chemical management routines are adhered to. *Maintain/enhance grazing areas* contains BUs that forbid intensification of the grazing areas on a farm yet they ensure grazing levels and nutrient cycles are maintained as they always have been.

*Setaside* and *create habitats* are both intended to generate new habitats on farmland where biodiversity levels are low. These are often intensively farmed or modified areas. The difference between the two BUs is that *setaside* involves fencing off a section of the farm and ceasing agricultural activity in the area, whereas *create habitats* stipulates that farmers must plant some new form of vegetation to improve the habitat biodiversity on the farm. BUs in the *maintain water quality* category are not primarily intended to help terrestrial biodiversity, but are aimed instead at reducing sediment and nutrient run-off into water bodies. Nonetheless, if farmers do choose these options, they will impact on farmland habitats and therefore these BUs need to be considered in this chapter.

**Table 6.3 Coverage in Ireland of the 29 habitat types identified using the spatial model**

| Habitat | Coverage (%) |
|---|---|
| Cutover fen | <0.01 |
| Bog and heath | <0.01 |
| Cutover upland blanket bog | 0.01 |
| Sand | 0.01 |
| Salt marsh | 0.01 |
| Fen | 0.03 |
| Coastal complex | 0.12 |
| Bare rock | 0.14 |
| Reclaimed fen | 0.16 |
| Karst bare rock | 0.18 |
| Bare peat and soil | 0.20 |
| Cutover/eroding lowland blanket bog | 0.47 |
| Wetland | 0.54 |
| Cutover/eroding upland blanket bog | 0.57 |
| Reclaimed upland blanket bog | 0.69 |
| Reclaimed lowland blanket bog | 1.03 |
| Cutover raised bog/fen | 1.12 |
| Built land | 1.21 |
| Intact raised bog/fen | 1.71 |
| Water | 1.94 |
| Immature woodland and scrub | 3.04 |
| Rocky complex | 3.19 |
| Intact lowland blanket bog | 3.22 |
| Intact upland blanket bog | 3.37 |
| Mature forest | 3.65 |
| Heath | 4.13 |
| Reclaimed raised bog/fen | 4.76 |
| Wet grassland | 5.74 |
| Dry grassland | 58.76 |

Source: FitzPatrick and Green, (2007).

Habitat data for this chapter come from a map that was produced to indicate the likely distribution of habitats in Ireland. The map is derived from a spatial model implemented in a geographical information system (GIS) using real data on peatlands (Hammond, 1978) and elevation, landcover and subsoils (Fealy *et al.*, 2004). The spatial model incorporates an expert rule base, which is used to perform a pixel-by-pixel analysis on these data sources and to create a final map with a minimum mapping unit of 1 ha (1 ha = 16 pixels), which identifies a total of 29 habitats (Table 6.3). This GIS land cover dataset is linked to the farms in the NFS sample to examine the relationship between habitat type on the farm and the BU options chosen.

The geo-referenced location of the farm boundaries of each observation in the 2007 NFS is not available but the geo-co-ordinates of the farmhouse for each of the sample farms is known by the NFS department. Access to the co-ordinates of these farmhouses is unavailable due to confidentiality issues. GIS data relating to the land cover within a specified radius of each farmhouse is obtainable however. Therefore, an assumption is made that each farm in the sample is located in a circle with a 0.5 km radius surrounding the farmhouse, making each farm a circle of 78.5 ha. Irish farm holdings tend not to be in a single block but can be broken up around the general area of the farm house (Aughney and Gormally, 2002). Consequently, despite the average size of a REPS farm being 39.29 ha (Table 6.1), this assumption is not unrealistic.

The habitat data are overlaid on the GIS farm data to match up land cover types to farm holdings. Dummy variables are created indicating whether each of 29 possible habitat types are present in the 78.5 ha circles representing every REPS farm in the NFS dataset (1 if the habitat is present on the farm, 0 otherwise). The 29 habitats are listed in Table 6.3. However, not all 29 are used as explanatory variables in the model. Five of the habitat types cover only 0.01 percent (or less) of the country and are not found on any of the farms in the NFS sample, so they have been excluded from the study. Dry grassland is present on all of the farms in the sample, so it is also excluded from the analysis because it is not possible to measure the marginal effect of this variable on farmers' decision making.

Built land is also removed from the study because it is irrelevant as a landcover type under an agri-environmental scheme (it mainly refers to residential and commercial units). Finally, habitats that are listed as priority habitats and that are allocated their own management plans under REPS III Measure A and REPS IV Measure 4 are not included in this analysis because contractually they should not be affected by farmers' BU choices. These include intact raised bogs, intact blanket bogs, fens and mature forests. Consequently, this analysis looks at how a total of 424 farmers assigned BUs to 15 habitat types on their farms.

**Table 6.4 Habitat groupings**

| Peatlands | Marginal Grasslands | Immature forest | Wetlands | Reclaimed peatlands |
|---|---|---|---|---|
| Cutover/eroding lowland blanket bog | Wet grassland | Scrub/ transitional woodland | Water | Reclaimed fen |
| Cutover/eroding upland blanket bog | Exposed calcareous rock | | Wetland (Springs or Swamps) | Bare peat and soil |
| Cutover raised bog/fen | Coastal Complex | | | Reclaimed upland blanket bog |
| Heath | | | | Reclaimed lowland blanket bog |
| | | | | Reclaimed raised bog/fen |

Sources: Fossitt (2000); Foss *et al*. (2001); Gwyn *et al*. (2003); NPWS (2005); Finn *et al*. (2009); IPCC (2010) as well as expert advice.

These 15 habitat types are re-classified, using related literature and ecological expert advice, according to the type of agricultural management that best suits their ecological needs (Table 6.4). “A guide to habitats in Ireland” (Fossitt, 2000) is a hierarchical habitat classification system for Irish biodiversity with 11 broad habitat groups, 30 habitat subgroups at level 2 and 117 subgroups at level 3. Clearly Table 6.3 does not include information relating to all the habitats contained in the level 3 subgroups under Fossitt’s classification system, so to ensure transparency a different habitat nomenclature has been used for the habitat groupings in Table 6.4, but details on how these headings relate back to Fossitt’s classification system are provided below. The purpose of this is to ensure that the results in this chapter are comparable with other literature relating to Irish habitats.

Subsequent paragraphs discuss habitat groupings and each possible BU-habitat grouping combination in terms of whether a BU is the optimal ecological choice, a good ecological choice or a damaging ecological choice for a habitat grouping. Table 6.5 contains an outline of how, in an ideal world, the BUs in REPS would be assigned to different farmland habitats in Ireland. All the groupings and categorical assignments in Table 6.2, Table 6.4 and Table 6.5 have been compiled based on a variety of literary sources and with the aid of both ecological and REPS experts[27].

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[27] The input of a number of individuals’ advice in assisting in the formation of these biodiversity groupings and on deciding the optimal BU choices across farm habitats need to be acknowledged at this point. These individuals include REPS planners from Teagasc, Mr Damian Costello and Mr. Mark Gibson and ecologist Dr. Catherine Keena.

**Table 6.5 Optimal BU choices for farm habitats**

| | **Biodiversity Undertakings (BU)** | | | | |
|---|---|---|---|---|---|
| *Habitat Group* | *Enhance field margins* | *Maintain/enhance grazing areas* | *Setaside* | *Create habitats* | *Maintain water quality* |
| Peatlands | | | | | |
| Marginal Grasslands | | | | | |
| Immature forest | | | | | |
| Wetlands | | | | | |
| Reclaimed peatlands | | | | | |

Sources: Fossitt (2000); Foss *et al*. (2001); Gwyn *et al*. (2003); NPWS (2005); Finn *et al*. (2009); IPCC (2010) as well as expert advice.

**Key**

| | |
|---|---|
| Optimal ecological choice | |
| Good choice | |
| Damaging choice | |

### *6. 2. 1. Habitat categorisation and appropriate biodiversity undertakings (BUs)*

All the habitat types in the grouped habitat variable peatlands are Fossitt's subgroup level 3 habitats except heath, which is a subgroup level 2 category because it can be further defined as siliceous, calcareous, wet or montane heath. These habitats have been grouped together because agriculture is an essential actor in both their formation and maintenance. Peatlands are not agriculturally productive habitats, so the main threats to them are the consequences that occur if they are either under or overgrazed (Foss *et al.*, 2001). So, as they are dependent on traditional grazing, *maintain/enhance grazing areas* is the optional choice for these habitats. *Setaside* excludes animals from the area and would be a poor choice because peatlands revert to scrub if left ungrazed. *Creating habitats* would also be detrimental to these habitats because this BU would fundamentally alter the structure of what are ecologically important habitats.

In marginal grasslands, exposed calcareous rock and wet grasslands are both subgroup level 3 variables but coastal complex can be further identified according to Fossitt (2000) as embryonic, marram or fixed dunes. These habitats have been grouped together because, like peatlands, they are reliant on continued extensive agricultural management. However, being more productive land than peatlands, marginal grasslands may be improved by farmers in a way that would disrupt the biodiversity in the habitats e.g. farmers may add lime to reduce the acidity of the land for agricultural reasons. So, marginal grasslands have been assigned to the BUs in the same way as peatlands because they have similar requirements in terms of farm management, but they are more threatened by intensification than peatlands.

The geo-referenced data for immature forest only identifies that the habitat is scrub/traditional woodland, which is a subgroup level 2 in Fossitt's classification system. Some types of immature woodland and scrub have high ecological value and are viewed as being precursors to important woodland habitats, but others are just seen as unmanaged grasslands – the species composition of the immature forest is the decisive factor in which type it is and the habitat data used in this study do not provide this information. Nonetheless, important woodland sites are likely to be recorded as target land on REPS farms, so immature forest is assumed to be mostly unmanaged grasslands that mainly exist because of land abandonment. In this scenario, it needs to be managed sensitively, because, as mentioned above, in the absence of grazing or mowing, immature forest has the potential to expand and replace marginal grasslands or peatlands. Therefore *maintain/enhance grazing areas* is the best option for immature forest and allowing it to grow uncontrollably as *setaside* would be problematic. Controlling immature forest by including it in *enhance field margins* is also a beneficial option and planting over it by choosing *creating habitats* would not be an issue under the assumption that it is an encroaching and uncontrolled habitat.

Wetlands contain any type of still water body, swamp or marsh and are only at the first group level in Fossitt's classifications. This low categorisation level is justified because these habitat types are found at the boundary of what can be defined as utilisable farmland (note that running water is not included in wetlands). Any part of this habitat type that is farmed would require continued grazing, so *setaside* is a damaging option and *maintain/enhance grazing areas* is a good ecological option. *Enhance field margins* could increase biodiversity in these habitats, but *maintain water quality* is the best ecological option for wetlands because nutrient run-off is a major threat to these ecosystems.

Reclaimed peatlands are defined in greater detail than Fossitt's subgroup level 3 because the expert base rule was used to identify peatland subsoils so that the habitats could be identified as reclaimed peatlands and not grasslands, which is what they appear to be to the naked eye. This distinction is important because it will impact upon both the productive and biodiversity levels found in the grasslands. In general, the biodiversity levels of reclaimed peatlands would be low because the peatland biodiversity will be removed and they will not have had time to build up biodiversity levels that exist in naturally created grasslands. Therefore none of the BUs would damage them and the optimal choices that farmers could make would be *creating habitats* or *setaside*, as these encourage the growth of new habitats on this particular type of farmland.

## *6. 3. Theoretical framework and estimation model*

The theoretical framework used to interpret the results of the estimation exercise in this chapter is a standard neoclassical one. In other words, the underlying behavioural assumption is that all farmers behave in a utility maximising way. This can be expressed as follows:

$$U_i[Y_i, \bar{E}_i; BU_i] \tag{6.1}$$

where, $Y_i$ is the income impact of implementing a BU $i$, $\bar{E}_i$ is the effort associated with adopting the particular BU and $BU_i$ contained specifics of the BU adopted. It is reasonable to assume that all BUs will require some resources and therefore lower farm income, just as all BUs will require farmer effort as an input. Neoclassical theory assumes that lower income and higher effort reduce utility, while it is assumed that the environmental good that is a product of the particular BU will contribute directly to utility. Since all BUs will have different incomes, effort and direct utility effects (depending on the preferences of the farmer) whatever the farmer chooses must be optimal for him/her. The manner in which a BU impacts on the farmer's income, effort and utility will be determined by farmer and farm characteristics, including the habitats found on the farm.

In the estimation in this chapter, the farmer chooses from 5 BU groupings. The utility associated with each BU grouping can be represented as:

$$U_i = X_i\beta_i + \varepsilon_i \tag{6.2}$$

where $X_i$ is a vector of observable farm and individual-specific variables that influence farmers' BU choice, $\beta_i$ is a vector of coefficients and $\varepsilon_i$ represents unobservable influences that effect the BU choice. The probability that a farmer chooses a particular BU group *m* from the mutually exclusive choices *j* = 1, …, M is expressed as:

$$Pr(Y_i = m) = \frac{exp(\beta'_m X_m)}{\sum_{j=1}^{M} exp(\beta'_j X_j)} \tag{6.3}$$

Because the probabilities $Pr(Y_i = j)$ sum to 1 over all BU choices, only $M-1$ of the probabilities can be determined independently. To deal with this problem, $\beta_{i1}$ is normalised to equal zero, which results in a base case, $Pr(Y_i = 1)$, being generated. In this chapter, the base case is the BU *create habitats* and the probability of it being chosen is given as:

$$Pr(Y_i = 1) = \frac{1}{1 + \sum_{j=1}^{M-1} exp(\beta'_j X_j)} \tag{6.4}$$

The remaining $M-1$ unknown probabilities are estimated as a ratio in terms of the base case in the following way:

$$Pr(Y_i = m) = \frac{exp(\beta'_m X_m)}{1 + \sum_{j=1}^{M-1} exp(\beta'_j X_j)} \tag{6.5}$$

However, if one wishes to calculate the ratio of the probability of selecting $BU_j$ relative to $BU_1$ the log of this expression reduces to a simple linear function of the explanatory variables.

$$log\left(\frac{p_j}{p_1}\right) = \beta'_j X \tag{6.6}$$

So $exp(\beta'_j)$ represents the change in the probability of being in $BU_j$ relative to the probability of being in $BU_{11}$ associated with a unit change in the independent variable. In this scenario, $\beta'_j$ is called a relative risk ratio. The coefficients in the next section are expressed in this way. An estimated coefficient greater (less) than 1, indicates that that particular BU is more (less) likely to be chosen than *create habitats* when there is a positive change in the explanatory variable. So, for example, if a coefficient associated with a BU is equal to 2, that means that it is twice as likely as the base case but if it is equal to 0.33, then it is only a third as likely.

Of particular interest to this chapter are the habitat variables and the effect that their presence on farms has on the likelihood of a farmer choosing a particular BU relative to *create habitats.* However, as habitats are not the only determining factors of a farmer's choice, we also control for the impact of other farm characteristics (such as farm size, system and profitability), individual characteristics (such as age, family status, educational attainment and off farm employment, if any) and choosing a BU from the same group twice ("same option"). The relative risk ratios estimated by the first model in this chapter are conditional on farmers adopting the scheme:

$$\left\{\frac{p_j}{p_1}\middle| REPS\ participant\right\} \tag{6.7}$$

This conditional probability is appropriate for estimating the likelihood of REPS farmers choosing different BUs based on the choices they actually made in 2007 and to evaluate them in terms of what would be considered the ecologically optimal choices.

Results from the first model cannot be extrapolated to represent how all Irish farmers are likely to assign habitats to BUs because of the effects of sample selection bias in the scheme. For this reason, the second model in this chapter is used to estimate the unconditional probability of farmers' choosing a BU:

$$\left\{\frac{p_j}{p_1}\right\} \tag{6.8}$$

To estimate a value for Equation 6.8 requires three steps. Firstly, it must be recognised that the likelihood of an Irish farmer choosing a particular BU is conditional on them first choosing to join REPS:

$$Pr(D_i = 1|Z_i) = \Phi(Z_i\gamma) \tag{6.9}$$

where:

$$D_i = \{0\ if\ Z'_i\gamma + v_i \leq 0; 1\ if\ Z'_i\gamma + v_i > 0\} \tag{6.10}$$

In Equations 6.9 and 6.10, $D_i$ indicates REPS participation for farmer $i$, $Z_i$ is a vector of farm and farmer characteristics that influence participation, Φ is the cumulative normal distribution function, γ is a vector of unknown parameters and $v_i$ are unobservable sources of variation in $D_i$. Secondly, the impact of the participation decision needs to be estimated. A probit model is used for this, where:

$$E[\varepsilon_i|Z_i, D_i = 1] = \frac{\varphi(Z'_i\gamma)}{\Phi(Z'_i\gamma)} \tag{6.11}$$

Then, an Inverse Mills Ratio (IMR), or the right side of Equation 6.11, can be estimated from the results of the probit model. In Equation 6.11, $\varphi(.)$ denotes the probability distribution function of the standard normal distribution. The IMR provides a numerical value for variation in the unobserved component in Equation 6.2 that can be assigned to the choice to participate in REPS. Finally, the relative risk ratios for farmers' BU choices can be modelled, as in Equations 6.4 and 6.5, but with the IMR included in $X_i$. For this, $\varepsilon_i$ and $\upsilon_i$ are assumed to be IID and independent of $Z_i$ (Vella, 1998).

The variables contained in vectors $Z_i$ and $X_i$ of the second model are similar but not the same. There are three differences between them. Firstly, as mentioned above, $X_i$ contains an IMR for REPS participation. Secondly, $Z_i$ contains a variable for farm income, which is not in $X_i$. This is because farmers receive the same level of payment regardless of which BU choice they make. The impact of income on farmers' choices is therefore more likely to affect their participation decision rather than their BU choices. This inclusion of an extra variable in the first step acts as an exclusion restriction and helps to avoid collinearity problems between the IMR and other independent variables in $X_i$ (Greene, 2003). Finally, $Z_i$ does not contain the *same option* variable because it is not a logical determinant of the REPS participation decision[28].

## 6. 4. Results

The parametric regression results of the multinomial logit of BU choices made by REPS farmers (weighted using the individual farm population weights provided in the NFS) are presented in Table 6.6. Likelihood ratio tests carried out on each independent variable in the model confirmed that, in each case, the effect is significant at the 1 percent level.

[28] Grouping the BUs results in the possibility that farmers may have chosen two BUs from the same grouping as part of their REPS contract. The *same option* variable is used to distinguish between farmers who chose two BUs in the same grouping from those who chose BUs in separate groupings.

**Table 6.6 Model 1: Multinomial logit on REPS farmers' choices of BUs**

| | **Enhancing field margins** | **Maintain/enhance grazing areas** | **Setaside** | **Maintaining water quality** |
|---|---|---|---|---|
| Farm income (€) | 1.003(4.08)*** | 1.001(0.81) | 0.992(-10.17)*** | 1.004(5.03)*** |
| Farm size (ha) | 0.992(-17.53)*** | 1.005(7.84)*** | 1.003(6.89)*** | 0.998(-3.19)*** |
| Off farm job | 0.777(-10.95)*** | 0.880(-3.21)*** | 1.292(9.05)*** | 1.146(4.83)*** |
| Farmers' age | 0.999(-0.58) | 0.985(-8.37)*** | 1.008(5.66)*** | 1.025(17.35)*** |
| Married | 1.033(1.11) | 0.825(-3.97)** | 0.517(-18.30)*** | 0.812(-5.82)*** |
| Children | 0.814(-8.11)*** | 0.897(-2.50)** | 1.192(5.35)*** | 1.105(3.14)*** |
| Finished school | 0.902(-4.65)*** | 0.539(-16.17)*** | 0.746(-10.27)*** | 0.548(-22.46)*** |
| Agricultural education | 0.955(-2.10)** | 1.346(7.97)*** | 1.163(5.49)*** | 1.213(7.03)*** |
| Cattle | 0.986(-0.48) | 0.683(-8.04)*** | 1.387(9.04)*** | 2.837(25.38)*** |
| Cattle other | 0.934(-2.50)** | 0.590(-12.12)*** | 0.628(-12.45)*** | 1.754(14.26)*** |
| Dairy other | 0.768(-6.51)*** | 0.521(-10.09)*** | 0.938(-1.27) | 1.940(12.72)*** |
| Dairy | 0.672(-10.04)*** | 0.086(-24.27)*** | 1.087(1.65) | 2.904(21.62)*** |
| Tillage | 0.953(-1.23) | 0.478(-10.39)*** | 2.022(14.82)*** | 1.466(6.60)*** |
| Peatlands | 3.526(31.51)*** | 0.775(-3.06)*** | 1.649(9.83)*** | 2.362(16.38)*** |
| Marginal grasslands | 1.269(10.51)*** | 0.800(-5.54)*** | 1.984(25.44)*** | 1.236(7.62)*** |
| Immature forest | 0.608(-10.98)*** | 0.988(-0.18) | 0.985(-0.30) | 0.563(-10.27)*** |
| Wetlands | 2.725(14.25)*** | 0.398(-4.11)*** | 1.521(4.71)*** | 2.875(12.96)*** |
| Reclaimed peatlands | 1.372(13.54)*** | 1.623(12.79)*** | 1.403(11.90)*** | 0.952(-1.63) |
| Same option | 0.596(-20.75)*** | 0.001(0.01) | 0.101(-40.01)*** | 0.117(-41.86)*** |
| | | | | |
| Log likelihood | | | | -103929 |
| Mean VIF | | | | 1.60 |
| Likelihood ratio test(nested model containing all common variables with Model 2) | | | | 190.88*** |

Source: NFS (2007). N = 77,104 (NFS frequency weights used). All values are in comparison with the base category of choosing *create habitats*. Values are relative risk ratios (the likelihood of a farmer choosing the given BU divided by the likelihood of him choosing the base category). Z values in parentheses.
***: p<0.01, **: p<0.05, *: p<0.1.

The results of Model 1 in Table 6.6 show that having a larger farm increases the likelihood that farmers will choose *maintain and enhance grazing* and *set aside* over the other BUs. *Set aside* is also the most attractive option for farmers with lower farm income and part time farmers. By contrast, if farmers are married *set aside* is a considerably less likely option for farmers to choose than all other BUs. Instead married farmers show a preference for *create habitats* and *enhance field margins*. The latter BUs are also more likely to be chosen if farmers have finished secondary school. Intriguingly, having an agricultural education results in farmers displaying different preferences, with *create habitats* and *enhance field margins* going from being the most likely BUs to be chosen to being the least likely, while the reverse happens for *maintain and enhance grazing*, which now becomes the most probable choice. In accordance with the literature cited earlier, one possible explanation for such divergent preferences may be that while a general education fosters more environmental awareness, an agricultural education may prioritise production and economic sustainability. The results for systems are compelling, revealing that farmers with livestock systems of cattle and dairying are much more likely than the base case of sheep farming to choose *maintain water quality* above all other BUs. Tillage farmers display a preference for *set aside*, while the most probable choice for sheep farming (base case) is *maintain and enhance grazing*.

The 'Same Option' variable (which helps account for dependence across BU choices) indicates that farmers are more likely to choose BUs from different groupings rather than from the same grouping. This variable is significant in all but the *maintain/enhance grazing areas* grouping. Only in the base case of *create habitats* are farmers more likely to choose a second options from within that BU grouping. In order to highlight the impact of habitats on BU choice, it is useful to profile the types of farmers and farms associated with each BU, independent of whether they have habitats or not on their land. The regression results indicate the following: (i) *enhance field margins* appeals to full time farmers with smaller farms while; (ii) *maintain and enhance grazing* is most attractive to sheep farmers and those with an agricultural education and bigger farms; (iii) *set aside* is more probable if one is a tillage farmer, single, with a low income, off farm job and a bigger farm; (iv) *maintain water quality* is most likely to be chosen by cattle, dairy and older farmers; (v) *create habitats* finds favour with married farmers who have completed secondary schooling.

The habitat results in Table 6.6 show that farmers with peatland on their farms are more likely to choose *enhance field margins* than any other BU. This choice is 1.5 times more likely than the next preferred option of *maintain water quality* and over 4.5 times more likely than the least favoured option of *maintain and enhance grazing areas.* The marginal grasslands habitat favours the *set aside* option, with it being 1.6 times more likely than the second most favoured choice of *enhancing field margins* and 2.5 times more likely than the least favoured option of *maintain and enhance grazing areas.*

Immature forest is most associated with *create habitats,* followed closely by *maintain/enhance grazing areas and set aside,* although it should be noted that the coefficients in the latter two instances are insignificant. Those with wetlands habitats are most likely to choose the optimal ecological choice, *maintaining water quality* followed closely by *enhancing field margins* (odds of 1.06), with the least favoured option *maintain and enhance grazing area* being highly unlikely (odds of 7.2 between most and least likely). Finally, for farmers with reclaimed peatlands, *maintain and enhance grazing area* is the most likely choice with odds of 1.2 over the second most likely choice (*setaside*) and odds of 1.7 over the least likely choice (*maintain water quality*).

**Table 6.7 Model 2: Two stage model on farmers' choices of BUs**

| | Enhancing field margins | Maintain/enhance grazing areas | Setaside | Maintaining water quality |
|---|---|---|---|---|
| Farm size (ha) | 0.992(-18.37)*** | 1.004(8.77)*** | 1.001(3.42)*** | 0.999(-0.76) |
| Off farm job | 0.700(-13.87)*** | 0.996(-0.09) | 1.543(13.84)*** | 1.097(2.98)*** |
| Farmers' age | 0.993(-5.66)*** | 0.991(-4.26)*** | 1.014(8.31)*** | 1.018(11.46)*** |
| Married | 1.279(6.31)*** | 0.619(-7.22)*** | 0.404(-18.49)*** | 0.961(-0.87) |
| Children | 0.880(-4.66)*** | 0.806(-4.54)*** | 1.133(3.58)*** | 1.177(4.78)*** |
| Finished school | 0.933(-2.90)*** | 0.468(-18.24)*** | 0.643(-14.37)*** | 0.557(-20.56)*** |
| Agricultural education | 1.125(4.31)*** | 1.100(2.01)** | 0.963(-1.07) | 1.346(8.64)*** |
| Cattle | 0.787(-5.62)*** | 1.011(0.15) | 1.892(11.94)*** | 2.422(16.59)*** |
| Cattle other | 0.818(-6.15)*** | 0.758(-4.97)*** | 0.720(-7.36)*** | 1.585(10.34)*** |
| Dairy other | 0.576(-9.60)*** | 0.877(-1.36) | 1.239(3.02)*** | 1.607(6.83)*** |
| Dairy | 0.477(-11.55)*** | 0.183(-12.46)*** | 1.413(4.22)*** | 2.455(11.85)*** |
| Tillage | 0.889(-2.91)*** | 0.582(-7.42)*** | 2.0514(14.71)*** | 1.443(6.25)*** |
| Peatlands | 3.526(31.35)*** | 0.657(-4.93)*** | 1.512(8.05)*** | 2.255(15.41)*** |
| Marginal grasslands | 1.359(12.59)*** | 0.724(-7.42)*** | 1.896(21.58)*** | 1.312(9.07)*** |
| Forest | 0.676(-8.48)*** | 0.888(-1.62) | 0.867(-2.82)*** | 0.609(-8.72)*** |
| Wetlands | 2.474(12.38)*** | 0.590(-2.31)** | 2.025(7.50)*** | 2.889(12.41)*** |
| Reclaimed peatlands | 1.509(15.70)*** | 1.456(8.84)*** | 1.337(9.09)*** | 1.042(1.26) |
| Same option | 0.636(-18.96)*** | 1.000(0.01) | 0.085(-43.20)*** | 0.131(-43.99)*** |
| IMR | 2.305(7.95)*** | 0.288(-6.33)*** | 0.408(-6.51)*** | 1.924(5.51)*** |
| | | | | |
| Log likelihood | | | | -103904 |
| Mean VIF | | | | 2.25 |
| Likelihood ratio test(nested model containing all common variables with Model 1) | | | | 241.44*** |

Source: NFS (2007). N = 77,104 (NFS frequency weights used). All values are in comparison with the base category of choosing *create habitats*. Values are relative risk ratios (the likelihood of a farmer choosing the given BU divided by the likelihood of him choosing the base category). Z values in parentheses.
***: p<0.01, **: p<0.05, *: p<0.1.

Table 6.7 shows the results of the second stage of the two-stage model on the same variables as those in Table 6.1. (See Appendix B for the results of the first stage.) Similarly to Model 1, likelihood ratio tests carried out on each independent variable in the two-stage model confirms that, in each case, the effect is significant at the 1 percent level. The IMR variable is highly significant meaning the first step – the REPS participation decision – does effect farmers' decisions regarding which BUs they choose. Farm income is included in the first stage of the process, but not the second, whilst the variable *same option* was excluded from the first stage but included in the second.

To determine whether Model 1 or Model 2 best fit the data, a likelihood ratio test was performed for each where the restricted model contained only those independent variables that they have in common. The resulting test statistics are significant for both model specifications indicating that the unrestricted models for both Model 1 and Model 2 do a superior job of describing the model than the restricted model. However, the value of the likelihood test statistic in Model 2 is higher than Model 1 (241.44 versus 190.88), meaning the observed result of the two stage model is more likely to occur than the original multinomial logit. An analysis of the VIF of both models indicates that there is a higher level of collinearity in Model 2 than Model 1 (2.25 versus 1.60); however, both are significantly below 10, indicating the levels are acceptable. Consequently, both models fit the data well. Justification for using one over the other therefore comes from whether one is interested in the impact of BU choice conditional on REPS participation or on the BU decision of farmers once they have already joined the scheme.

Profiles of the types of farmers and farms associated with each BU in Model 2, independent of whether they have habitats or not on their land, are as follows: (i) *enhance field margins* still appeals to full time farmers with smaller farms but the emphasis now is on cattle farming; (ii) *maintain and enhance grazing* is no longer the most attractive BU for sheep farmers or for those with an agricultural education but remains the most likely option for large farms; (iii) *set aside* is now the most likely option for sheep farmers with off-farm employment; (iv) *maintain water quality* remains the most likely BU to be chosen by cattle, dairy and older farmers; (v) *create habitats* continues to finds favour with those who have completed secondary schooling. The relative risk ratios indicating the likelihood of finding different habitats in the five BUs in Table 6.7 do not differ much from those in Model 1. A quick glance shows that the only obvious difference between the findings from the two models is for *reclaimed peatlands.*

**Table 6.8 Rankings for most to least likely assignment of habitats to BUs compared with ecological status of the outcomes**

| | **Biodiversity Undertakings (BU)** | | | | |
|---|---|---|---|---|---|
| *Habitat Group* | *Enhance field margins* | *Maintain/enhance grazing areas* | *Setaside* | *Create habitats* | *Maintain water quality* |
| Peatlands | 1 | 5 | 3 | 4 | 2 |
| Marginal Grasslands | 2 | 5 | 1 | 4 | 3 |
| Immature forest | 4 | 2 | 3 | 1 | 5 |
| Wetlands | 2 | 5 | 3 | 4 | 1 |
| Reclaimed peatlands | 3(1) | 1(2) | 2(3) | 4(5) | 5(4) |

Results based on habitat grouping coefficients in both the multinomial logit and the two-stage models. Numbers indicate the likelihood of farmers with the given habitat type on their farm choosing each BU where 1: most likely option to be chosen, 2: second most likely option to be chosen, 3: third most likely option to be chosen, 4: second least likely option to be chosen and 5: least likely option to be chosen. Colour Key the same as Table 5–5. Findings for both model specifications are the same except where parentheses can be seen – values outside the parentheses are from Model 1, values inside the parentheses are from Model 2.

**Key**

| | |
|---|---|
| Optimal ecological choice | |
| Good choice | |
| Damaging choice | |

Table 6.8 combines information on the choices that farmers should make (if guided by ecological considerations only) with the choices that they are likely to make according to the findings from Model 1 and Model 2. Normative considerations are represented by colour coding (as per Table 6.5), while the likely choices as revealed in Table 6.6 and Table 6.7 are shown as a ranking, with 1 being the most likely and 5 the least likely. Of those farmers that had one of the five grouped habitats on their farm, 33.6% made an optimal ecological choice, 47.2% made good ecological choices and 19.2% made damaging ecological choices. In an ideal world with a perfectly designed agri-environmental scheme, the optimal choices would also be the most likely (get a high ranking) and the damaging ecological choices would be the least likely (get a low ranking). Parentheses indicate where findings from Model 1 and Model 2 differed. The rankings outside, and inside, the parentheses are the values from Model 1 and Model 2, respectively.

Findings for peatlands are far from ideal. On the one hand, the most likely BU *enhance field margins* is an ecologically acceptable choice and much more likely than the damaging choices of *set aside* and *create habitats* (2.1 and 3.5 being the respective odds of the former with respect to the latter two BUs). However, the ecologically optimal choice would be *maintain and enhance grazing areas,* which is ranked the least likely of all BU choices for this habitat. The situation is even more serious in the case of the marginal grasslands habitat. In this instance, farmers have shown themselves to be most likely to choose the damaging option of *set aside* with it being 2.5 times more likely than the optimal choice *maintain and enhance grazing areas.* The situation with regard to immature forest is better from an ecological suitability perspective, as the two ecologically optimal choices (*create habitats* and *maintain/enhance grazing areas*) for this habitat type have been ranked 1 and 2 in Table 6.8. The results for immature forest must be interpreted with caution, however, as there is little difference in the probability between the top three most likely BUs and the coefficients are insignificant for at least one outcome in both models. Farmers' choices with regard to wetlands appear to indicate that this habitat is well protected by the choices that farmers make. The BUs ranked 1 and 2 for wetlands are the ecologically optimal *maintain water quality* and the good *enhance field margins*, respectively.

The results indicate that the marginal grasslands habitat is not well protected by the current choices of farmers and that there is considerable room for improvement where the peatlands habitat is concerned. Even where there is limited scope for further ecological damage (reclaimed peatlands), the situation could be enhanced. What needs to be examined is why farmers with marginal grassland are choosing *set aside* and why *maintain and enhance grazing areas*, which is the optimal choice for those farms with both marginal grasslands and peatlands, is such an unlikely outcome in both instances. As mentioned earlier, *set aside* appeals most to those with an off farm job, are single, have lower farm income, with bigger farm area and tillage systems. Farmers whose farms contain marginal grasslands have a mean income of €14,200, an average farm size of 50 hectares, 47% have off farm jobs and their average age is 52. In other words the only appreciable way in which they differ from the total sample of REPS farmers in this study is that they have a lower farm income, larger farms and a greater percentage have off farm jobs (see Table 6.1 for the summary statistics for the total sample). These three factors would predispose farmers to choose set aside as the BU. Possibly, the much lower attractiveness of *maintain and enhance grazing* compared to *set aside* for farmers with grassland habitats has to do with the additional effort of putting a proper grazing management plan in place for this land cover, compared to the ease of implementation of *set aside*, especially if they have off farm jobs. Alternatively, a lack of ecological knowledge may explain the appeal of *set aside.*

The case of farms with peatlands is even harder to explain since farms with peatland habitats have a higher mean area (68.75ha) and a bigger percentage of sheep systems (39.7%) than the total sample of REPS farms. According to the regression results the aforementioned characteristics should predispose farmers towards the BU choice of *maintain and enhance grazing areas* but that is not the case, which means that the low odds of this choice must be uniquely associated with the peatland habitat in some way. One potential reason for the low priority attached to *maintain and enhance grazing areas* by farmers with peatlands may be that they view this habitat as wastelands with no grazing potential (IPCC, 2010). On the other hand, the appeal of *enhance field margins* may be related to its association with stonewalls. It has been observed that Irish people attach a high value to the preservation of stonewalls, which are commonplace in peatland areas (Campbell, 2007, Hynes *et al.*, 2011b). As stone walls come under the BU *enhance field margins,* this stated preference of the public may have predisposed farmers with peatland to prioritise this visible BU over others.

There is little scope for farmers with reclaimed peatlands to make poor choices, since none of the BUs are deemed to be ecologically damaging for this type of habitat. This is because, as fundamentally altered habitats, it is assumed that many of the ecosystem processes that would have been found on the peatlands to begin with have already been irreversibly damaged. As previously mentioned, reclaimed peatlands are one of the most productive of the habitat types in this study from an agricultural point of view. This finding showing that nonparticipants' behaviour is most likely to affect it, rather than other habitat types, is not surprising given that non REPS farmers are associated with having more productive land. Allowing for the impact of nonparticipants in the estimation process reduced the likelihood of reclaimed peatlands being assigned to the optimal BU choices from a ranking of 2 to 3, and from 4 to 5, in the cases of *setaside* and *create habitats,* respectively (Table 6.8). Both *setaside* and *create habitats* require farmers' to cease farming activities on a portion of their land – a feature that nonparticipants may find particularly unsatisfactory. Overall, Table 6.8 shows that BU outcomes do not change for the better by including the effect of the participation decision for any habitat. Therefore, the likelihood of misallocation will not be reduced if more farmers in the Ireland join the scheme. The problem of misallocation of habitats to BUs being highlighted by this chapter relate to poor decision making on the part of the farmer and the planner during the formation of the individual farm management plan.

## *6. 5. Conclusions*

All REPS participants in the latter two phases were obliged to adopt 2 additional BUs from a menu of options, designed to protect and enhance biodiversity of species of fauna and flora found on farms. Their choices as to BUs were relatively unconstrained, although farmers did get advice from REPS planners as to the BU choices that were appropriate to the land cover found on their farms. How effective or otherwise this institutional modus operandi has been in protecting ecologically important habitats is what this chapter attempted to evaluate.

The novel feature of this chapter is that it combines new information on farmer choices as to BUs with data on actual habitats located on farms, and estimates the likelihood of each BU for a given habitat. This is a distinct advance on Hynes *et al*. (2008a) who examined the probability of REPS participation as a function of habitats found on simulated farms. Furthermore, in this chapter the choices that farmers are likely to make, given the habitats found on their farms, are evaluated in terms of ecological desirability (where ecological desirability was determined on the basis of discussion with experts in the field). While such an approach does not address directly the environmental impact that the scheme has had on the natural environment, it does serve to highlight whether farmer behaviour is consistent or otherwise with some of the environmental objectives of the scheme.

Two models were used to assess how well farmers assigned farmland habitats to BUs. Model 1 investigated the BU choices made by farmers conditional on other factors that are assumed to impact on the management choices they made for their farms. The second specification incorporates the effect of the REPS participation decision into the model. Findings varied little between the two. Wetlands are relatively well protected by the scheme as currently constituted, in that the likelihood of farmers adopting a damaging BU for these habitats is low. By contrast, the habitats of peatlands and marginal grasslands are not being sufficiently protected by the choices that farmers are making. In both instances, the ecologically optimal choice, which is *maintain and enhance grazing* has the lowest probability of being chosen and, in the case of marginal grasslands, the most likely choice *set aside* is actually ecologically unsuitable. So clearly, REPS IV came up short when it came to protecting all ecologically valuable habitats found on Irish farms. Inclusion of the effect of REPS participation on BU allocation in Model 2 merely confirmed the fact that these problems are not a consequence of sample selection bias – where not enough farmers with the farmland habitats are joining – but are a consequence of poor decision making at farm level.

Trying to determine why farmers sometimes make ecologically correct choices as to BUs and other times are less likely to do so is, in the absence of direct attitudinal studies, inevitably speculative. For farms with marginal grasslands, the reasons may be partly economic, especially if a lot of those farmers have off farm jobs. However, it would be incorrect to exclude genuine lack of awareness of the ecological value of maintaining grazing on farms with such habitats. Similarly, the same may be said in the case of peatlands. All the socio-economic data indicate that the optimal BU (*maintain and enhance grazing areas)* should be the most likely to be chosen, so it is not too unreasonable to assume that farmers failure to do so may have been as a result of misinformation as to what BUs are most ecologically suitable for their type of land cover. However, all this points to the need for further study to ascertain farmer motivation. Attitudinal studies could reveal not just the extent of farmer environmental awareness but also their willingness to act as genuine custodians of the environment.

The results also raise some important issues regarding the AEOS. Many of the specifications of the AEOS are similar to the BUs contained in REPS (see Chapter 2) and the individuals applying to participate in the AEOS will, being Irish farmers, be the same individuals who participated in REPS. Given these similarities, it makes sense that the DAFF could use the information gleaned from this study to identify areas where extra monitoring, or education, may be required to ensure that the maximum possible level of environmental effectiveness is obtained by this AES. In particular, this chapter has helped with the identification of key areas that need to be improved in relation to farmers' decision making processes, particularly in connection with peatlands and marginal grasslands. To avoid repeating the misallocation mistakes that occurred in REPS, policymakers should consider including ecological assessments and habitat specific educational courses in future agri-environmental policy.

# 7. Conclusions

This chapter begins by outlining how the main objectives of the three empirical papers (Chapters 4, 5 and 6) were addressed in the thesis. Section 7.2 describes limitations of these studies. Section 7.3 provides a discussion of how results from this thesis may be used to advise policymakers on the design of future Irish AESs. Finally, the chapter concludes with an overview of potential future research arising from the findings of the thesis.

## *7. 1. Key findings*

The principal research objective of this thesis was to provide an understanding of the impact of farmers' implementation behaviour on the effectiveness of REPS. Within this wider context, the research had three main goals, which were addressed in three separate empirical papers contained in Chapters 4, 5 and 6. Research questions for each of these papers were identified in Chapter 1. Here are the key findings from this thesis (with the research questions for each of the three chapters stated first).

Chapter 4: *Was the type of farmer who participated in REPS capable of effectively meeting the broad environmental objectives of the scheme?*

- Table 4.4 shows that, from 1995 to 2010, REPS farmers were more likely to have, *ceteris paribus*, lower farm incomes, lower chemical usage, longer hours on-farm and higher productivity levels than non-REPS farmers. The implications of these findings are that REPS payments appeared to have compensated Irish farmers for the additional effort required from them for implementing, but not for reducing production levels to meet, scheme requirements.
- Table 4.5 shows that the type of farmer who participated in each phase of REPS differed. It also indicates that the type of farmer who was most likely to participate in REPS I was disadvantaged and was likely to be using REPS payments as income support. Given the extensive nature of these REPS I farmers, their participation in REPS is not expected to have made large changes to the Irish environment in terms of its pollution abatement objectives. REPS II failed to meet its target uptake rates. In addition, there appears to be significant adverse selection bias with regard to the organic nitrogen restriction in this phase (Figure 4.2), meaning participants in REPS II

are likely to have used low levels of organic nitrogen prior to, and not as a consequence of, joining the scheme. Adverse selection bias in REPS III is the strongest for all four phases (Figure 4.2) and Figure 4.1 shows that there was homogeneity in the type of habitat that was most likely to be found in this phase. These findings suggest that REPS III farmers were not the optimal type of farmer for meeting the scheme's pollution abatement or biodiversity conservation objectives. In fact, it is likely that the adverse selection bias in REPS III that resulted from restriction in organic nitrogen production impacted on the (lack of) variety in habitat types in this phase. Ergo restrictions that existed to meet the scheme's pollution abatement objectives reduced the likelihood that the type of farmer found in REPS III was capable of meeting the scheme's biodiversity conservation objectives. Conversely, Figure 4.2 shows that the threshold effect for organic nitrogen use in REPS IV is small and that there was heterogeneity in the type of habitat found in this phase. These findings bode well for the likelihood that the type of farmer REPS IV was capable of meeting the pollution abatement and biodiversity conservation objectives of the scheme.

- The effects that institutional changes to the REPS contract had on the likelihood that participants could meet the objectives of the scheme were mixed. Changes to the payment rates from REPS II to REPS III did not improve the type of farmer who joined the scheme. It resulted in an increase in the size of participants' holdings but it did not attract a greater variety of farm types to the scheme: namely, participants continued to be predominantly extensive farmers. Conversely, the reduction in the restriction on organic nitrogen production from REPS III to REPS IV improved the type of farmer who joined the scheme. However, this increase in the effectiveness of the type of participant came at the cost of reducing the effectiveness of a scheme measure.

Outputs from this chapter have provided information for policymakers in a number of key areas. Firstly, they have provided an indication of what types of farmer are most likely to join future Irish AESs if they resemble REPS. The chapter has shown that scheme effectiveness in terms of the type of farmer who participated was improved in REPS by reducing restrictions contained in scheme measures and not by increasing payment rates. This finding needs to be considered with caution by policymakers, however, because reducing the stringency of a measure may produce a greater net reduction in scheme effectiveness than the increase resulting from changes in participant type. Results from this chapter also suggest that attempting to achieve broad environmental objectives using one scheme may not be effective. This is because aspects of the AES that are intended to produce improvements under one objective may deter the type of farmer required to meet other objectives.

Chapter 5: *Was the use of one scheme to attract farmers from a heterogeneous population effective?*

- The counterfactual data generated to represent farmers' alternative participation outcomes showed that the hypothetical switch from being a REPS to a non-REPS farmer, or vice versa, impacted on farmers' gross outputs, costs and on- and off- farm working hours (Tables 5.1 and 5.2). The novel REPS participation function that was produced using these data generated results in agreement with economic theory (Table 5.3).
- The impact of the switch in farmers' REPS participation outcomes, demonstrated by comparing their actual participation status with their counterfactual participation status (Tables 5.1 and 5.2,) varied somewhat for viable and non-viable farmers. In addition, results from the separate viable and non-viable participation functions show that the two groups of farmers did not put equal emphases on the importance of various attributes when they were deciding whether to join or not (Table 5.4). Specifically, viable farmers appear to fit Willcock's definition of a farmer who views agriculture primarily as a business, whereas non-viable farmers appear to view it as a way of life.

Outputs from this paper have shown policymakers that viable and non-viable farmers made their participation decisions differently. Therefore the use of one scheme, with uniform top-down allocated payment rates, to attract farmers from a heterogeneous population was an ineffective aspect of the REPS policy design. In future, different groups of farmers should be targeted using various AES contracts that suit their needs as a farm household. For example, viable farmers are likely to prefer a scheme that fits with their farm business plans, whereas non-viable farmers may prefer one that adheres to their idea of farming as a lifestyle.

Chapter 6: *Was the use of individual farm-management plans effective?*

- According to ecological experts, farmers should have ideally assigned habitats to the following BUs: peatlands to *maintain and enhance grazing areas*, marginal grasslands to *maintain and enhance grazing areas*, wetlands to *maintain water quality*, reclaimed peatlands to *create habitats* and immature forests to *maintain/enhance grazing areas* or *create habitats* (Table 6.5).
- Results show that farmers actually assigned peatlands to *enhance field margins*, marginal grasslands to *setaside*, wetlands to *maintain water quality*, reclaimed peatlands to *maintain and enhance grazing areas* and immature forests to *create habitats* (Table 6.8). These findings show that farmers did not make the optimal management choices for all the habitats on their farms, although the appropriateness of their decision-making varied by habitat type. Of particular concern is the finding for marginal grasslands because assignment to *setaside* could potentially damage these habitats.

Results from this paper have shown that farmers' actual assignment of habitats to BUs varied considerably from their ideal assignment. Future AES policy makers should note that farmers do not appear to understand the requirements of all the habitats on their farms. Ergo, they should aim to remove farmers' role in the decision-making processes when it comes to the management of on-farm habitats. Alternatively, policymakers could attempt to educate farmers further regarding the needs of the habitats on their holdings.

## *7. 2. General limitations of the research in this thesis*

There are three limitations that apply to all of the studies carried out in this thesis. Firstly, they do not account for the impact of compliance on scheme effectiveness. Arguments made for using a voluntary framework for an AES usually include that coercive strategies lead to decreases in effectiveness because farmers who are uninterested or ethically opposed to the scheme may be forced to join when they do not want to (Alberini and Segerson, 2002). If information on the rate of compliance for REPS farmers in the NFS was available, as well as information on the rate of compliance for a more coercive programme such as the SMRs in the SFP, the added benefit of farmers' implementation behaviour could be incorporated into the models used in this study.

Secondly, there are no data on farmers' attitudes towards AESs, or the agricultural environment in general, included in the models in this thesis. While the use of demographic variables is expected to have accounted for a large amount of variation in farmers' implementation decisions due to varying attitudes, the use of actual attitudinal data would be superior.

Finally, given the fact that the studies in this thesis are concerned with estimating farmers' preferences towards REPS participation, there is scope for the use of more advanced econometric modelling techniques in this work. In particular many models, such as random effects logits and latent class models, are capable of accounting for heterogeneity in individuals' preferences in choice functions.

## *7. 3. Future research arising from the findings in this thesis*

Overall, the empirical papers in this thesis provide three unique methods for investigating the ways through which farmers' implementation behaviour impacted on the effectiveness of REPS. Findings from each of these papers have led to the realisation of other interesting avenues of study in this research area.

The methods used in Chapter 4 could be further refined to look at the likelihood of finding different types of enterprises, farmers from different regions or various demographic types in REPS over time, or phase by phase. Information on farmers' participation decisions could be used to generate an SP study to further investigate their perceived opportunity costs of joining an AES and preferences for future schemes.

The participation functions estimated in Chapter 5 could be used to simulate farmers' responses to different specifications in future Irish AESs. For example, the minimum acceptable rates of payment, below which no Irish farmer would have joined the scheme, could be simulated (or maximum rates of pay).

The conditional logit models used in Chapter 5 do not capture all of the heterogeneity in farmers' preferences towards the REPS participation decision. With this in mind, a latent class model could be used to generate participation functions like those in Chapter 5. This would allow for the estimation of participation functions for groups of farmers who are similar for reasons other than viability and would provide a greater insight into the decision-making processes of Irish farmers.

As the creation of geo-referenced data becomes more commonplace, the availability of habitat data such as those in Chapter 6 to look at changes in the state of the environment over time will improve. Eventually, these data will be available to carry out panel studies on the impact of farmer behaviour on AES effectiveness over time.

Of course, no work on human behaviour is complete without the use of attitudinal surveys to reveal exactly why individuals act the way they do. The results from this thesis would be greatly enhanced using qualitative research to ask farmers why they behaved the way they did with regard to REPS.

## *7. 1. Lessons learned from REPS for future Irish AES*

REPS was the first and, until its closure to new applicants in 2009, only AES ever executed in Ireland. Since its closure, it has been replaced by the AEOS, which has a significantly smaller budget and far less ambitious environmental goals than REPS. The CAP, which intends to introduce further AESs across member states in the near future, acknowledges that the success of current and future AESs is dependent upon what can be learned from the successes and failures of past schemes (DAFM, 2012b). In the Irish case, the majority of the required information must therefore come from an evaluation of REPS.

### *7. 1. 1. Design issues in REPS*

Chapter 3 of this thesis highlighted three imperative problems with REPS that must be amended for future AESs in Ireland. The first is that the environmental goals of the scheme were never clearly defined – either at farm level or at scheme level. At farm-level, individuals were obliged to adhere to 11 measures, all of which were intended to produce more environmentally friendly farming practices on Irish farms in general. A shift occurred from 1994 to 2009 from an adherence to the management agreement model to a model that recognised the importance of farming for maintaining rural landscapes. This meant that the identification of what constituted a successful outcome from participating farmers altered across REPS phases. Resulting difficulties associated with the evaluation of the scheme were never adequately addressed. Future AESs must clearly state what farmers are expected to produce in return for receiving scheme payments.

In addition, the environmental goals of REPS were not clearly defined at scheme-level. REPS objectives were vaguely written in terms of making environmental improvements to the Irish landscape. This resulted in the production of a scheme that attempted to achieve both pollution abatement and biodiversity conservation goals using one contract. Due to the fact that pollution abatement and biodiversity conservation goals are unique environmental issues, this is not a sound model to follow. From a farmers' point of view, the former issue is a question of reducing levels of negative externalities, and the latter issue is a question of increasing positive externalities, produced on their farms. Results from Chapter 4 provide some indication that Irish farmers viewed these two issues differently. The solution to this problem for future AESs is that different environmental issues should be addressed using separate AES contracts.

The second major problem with the design of REPS was that no cause and effect relationships between on-farm management practices and the production of environmental outputs were quantifiably identified. Instead, all objectives were written in terms of (often immeasurable) changes to farmers' practices and any resulting environmental improvements were assumed. The establishment of cause and effect relationships in future AESs must be followed up by two practical steps. The first is the identification of measurable environmental indicators for testing whether the environmental goals of the scheme have been achieved. The second is the collection of baseline ecological data. Without baseline ecological data, the true impact of the scheme on the environment cannot be estimated.

The final imperative problem with the design of REPS was that there was virtually no targeting in the scheme. If future AESs are to successfully meets their environmental objectives, policy makers need to target farmers who are capable of producing the desired environmental outcomes. Targeting needs to account for the fact that the amount an individual farmer might improve the environment by joining an AES varies across individuals and across farms. In addition, the cumulative impact of farmers joining an AES is not always additive: namely, the impact of having two adjacent participants, say, could be much greater than having two unconnected participants. Policy makers need to acknowledge the fact that, within these targeted populations, there is likely to be variation in farmers' preferences towards participation in the scheme. For example, Chapter 5 has shown that the underlying utility functions of viable and non-viable Irish farmers with regard to REPS participation were different. Hence, different farmers may require various incentives for joining the scheme. By recognising this fact, policymakers are likely to produce an effective and efficient scheme that adequately compensates farmers for their perceived opportunity costs of participation (Lapple and Kelley, 2013).

### *7. 1. 2. Suggestions for future AESs*

Currently, Irish farmers will only receive their SFPs if they meet the required SMRs and maintain their farms in GAEC. Many of these SMRs are concerned with reducing the amount of chemicals farmers use, or produce, on their farms or with the general aesthetics of the farming landscape. SMRs are therefore primarily concerned with reducing the amount of negative externalities produced by Irish farms in general. Future plans for European agriculture have recently been discussed in the Greening of the CAP. These plans suggest that all farmers will also be obliged to produce basic levels of positive externalities in return for their decoupled payments[29] (HCEFRAC, 2012).

The role that future AESs are likely to play if plans for the Greening of the CAP come to fruition is therefore going to be more targeted than REPS ever was. In this scenario, specific environmental goals are likely to be identified for areas that are sensitive to impacts from negative externalities and, separately, for areas that require targeted protection of biodiversity or other positive externalities. Results from this thesis indicate that unique contracts should be written for each environmental objective to best meet the preferences of farmers living in target areas. This approach should be akin to the Higher Level Stewardship schemes that form part of the Environmental Stewardship Scheme in the UK (ESS, 2013). The role of the Higher Level Stewardship scheme is to protect priority species and habitats, meaning much (although certainly not all) of the value associated with this type of scheme pertains to the non-use values of the supporting services of ecosystems.

Hynes and Campbell (2011b) show that the Irish publics' favoured, and least favoured, outcomes from a number of hypothetical landscape types were, respectively, *sustainable*

[29] Proposed measures include crop diversification, retention of permanent pasture and ecological focus areas.

*rural environment*, and *globally competitive farming*. This suggests that the Irish taxpayer wants more from agriculture than the production of food for consumption. Hence, farmers should be offered grants to encourage the maintenance or production of a variety of use values provided by the provisional, regulatory and cultural goods and services of the ecosystems on their farms. These grants would adhere to the ethos of Pillar 2 of CAP and should be offered to farmers in addition to the basic and higher level tiers described above. Due to the fact that these (private or public) goods are intended to be consumed by the taxpayer, SP studies by the likes of Campbell (2007) and Doherty *et al.* (2012) play an important role in identifying which goods and services farmers should be rewarded for producing. Possible examples of what farmers could be funded for include the production of angling fish or game birds, the maintenance of carbon sinks, or for the provision of walkways or cycle routes on their land.

Identification of areas that should be targeted because they are particularly vulnerable to negative externalities, because they are important in terms of non-use values or because they are hot spots for encouraging the production of use values should be carried out using SEAs throughout the country (Whelan and Fry, 2011). Final outputs from the SEAs should be made based on scientific evidence alone and should not be influenced by the preferred management options of farmers. (This statement is not suggesting that farmers should be discouraged from enhancing SEAs with their knowledge. It is merely making the point that, as highlighted in Chapter 6, outcomes from farmers' decision-making processes are not always environmentally beneficial.)

The subsidiary principle that Regulation 2078/92 promoted should then be adhered to within local areas, whereby amounts are allotted to farming communities to supply the required goods and services in a manner that best suits the local community. These subsidies should be used to promote rural viability and sustainability in conjunction with the EU Rural Development Programme (LEADER) to produce more holistic, transparent and bottom-up AESs than REPS (DECLG, 2013b). A major deterrent to adopting AES contracts for many farmers is the fear of a loss of control over how they manage their holdings (Wynn *et al.*, 2001). By giving local communities autonomy over how they are going to produce the required goods for the taxpayer, a large amount of control is being returned to landowners.

Finally, for those farmers who decide that, given the plans for their local community, they wish to participate in one (or more) of the resulting AES schemes, contracts should be awarded to them based on the outcomes of auctions (Kirwan *et al.*, 2005). This further encourages the use of bottom-up approaches for achieving identified environmental outcomes from AESs and helps to overcome the problem of asymmetric information flow that occurred with the bottom-down price setting used in REPS.

# 8. References


Ahearn, M., El-Osta, H. & Dewbre, J., 2006. The impact of coupled and decoupled government subsidies on off-farm labor participation of U.S. farm operators. *American Journal of Agricultural Economics,* 88**,** 393-408.

Alberini, A., Longo, A. & Veronesi, M., 2006. Basic statistical models for stated choice studies. In Kanninen, B. (ed.) *Valuing environmental amenities using stated choice studies.* The Netherlands: Springer.

Alberini, A. & Segerson, K., 2002. Assessing voluntary programs to improve environmental quality. *Environmental and Resource Economics,* 22**,** 157-184.

Aughney, T. & Gormally, M., 2002. The nature conservation of lowland farm habitats on REPS and non-REPS farms in County Galway and the use of traditional farm methods for habitat management under the Rural Environment Protection Scheme. *Tearmann: Irish journal of agri-environmental research,* 2**,** 1-14.

Bateman, I., Carson, R., Day, B., Hanemann, M., Hanley, N., Hett, T., Jone-Lee, M., Loomes, G., Ozdemiroglu, E., Pearce, D., Sugden, R. & Swanson, J., 2002. *Economic valuation with stated preference techniques: a manual.* Cheltenham, UK: Edward Elgar Publishing Limited.

Bateman, I.J., Willis, K. & Garrod, G., 1994. Consistency between contingent valuation estimates - a comparison of two studies of UK national parks. *Regional Studies,* 28**,** 457-74.

Baudry, J., Burel, F., Thenail, C. & Le Coeur, D., 2000. A holistic landscape ecological study of the interactions between farming activities and ecological patterns in Brittany, France. *Landscape and Urban Planning,* 50**,** 119-128.

Becker, G., 1965. A theory of time allocation. *The Economic Journal,* 75**,** 193-517.

Becker, G., 1993. Nobel lecture: the economic way of looking at behavior. *Journal of Political Economy,* 101**,** 385-409.

Beharry-Borg, N., Smart, J., Termansen, M. & Hubacek, K., 2013. Evaluating farmers' likely participation in a payment programme for water quality protection in the UK uplands. *Regional Enviromental Change,* 13**,** 633-647.

Bignal, E., 1998. Using an ecological understanding of farmland to reconcile nature conservation requirements, EU agricultural policy and world trade agreements. *Journal of Applied Ecology,* 35**,** 949-954.

Blundell, R. & Macurdy, T., 1999. Labor supply: a review of alternative approaches. In Ashenfelter, O. & Card, D. (eds.) *Handbook of labor economics.* Amsterdam: Elsevier. 1559-1698.

Borooah, V., 2001. *Logit and probit.* Quantitative applications in the social sciences series. Sage University Paper 138.

Boyle, K.J., 2003. Chapter 9: Revealed preference methods. In Champ, P., Boyle, K. & Brown, T. (eds.) *A primer on nonmarket valuation* London.

Buckley, C., Van Rensburg, T. & Hynes, S., 2009. Recreational demand for farm commonage in Ireland: a contingent valuation assessment. *Land Use Policy,* 26**,** 846-854.

Bullock, C., Kretsch, C. & Candon, E., 2008. *The economic and social aspects of biodiversity: benefits and costs of biodiversity in Ireland.* Department of Environment, Heritage and Local Government, Dublin. Available at: http://www.cbd.int/doc/case-studies/inc/cs-inc-ireland-en.pdf.

Burgess, D., Patton, M. & Georgiou, S., 2009. *Public attitudes to changing landscape: implications for biodiversity.* 11th BIOECON Conference 21st-22nd of September 2009, Venice, Italy. Available at: http://www.bioecon.ucl.ac.uk/11th_2009/Burgess.pdf.

Campbell, D., 2007. Willingness to pay for rural landscape improvements: combining mixed logit and random-effects models. *Journal of Agricultural Economics,* 58**,** 467-483.

Chambers, R. & Foster, W., 1983. Participation in the farmer-owned reserve program: a discrete choice model. *American Journal of Agricultural Economics,* 65**,** 120-124.

Chang, H. & Boisvert, R., 2009. Are farmers' decisions to work off the farm related to their decision to participate in the conservation reserve program. *Applied Economics***,** 71-85.

Connolly, L., Finnerty, E., Kinsella, A. & Quinlan, G., 2002. *National Farm Survey 2001.* Teagasc. Dublin. Available at: http://www.teagasc.ie/publications/2002/farmsurvey2001.asp.

Connolly, L., Kinsella, A., Quinlan, G. & Moran, B., 2010. *National Farm Survey 2009.* Rural Economy Research Centre (RERC) Teagasc, Dublin. Available at: http://www.agresearch.teagasc.ie/rerc/downloads/NFS/NFSReport09.pdf.

Copland, A. & O'Halloran, J., 2010. Agri-environment impacts and opportunities for summer bird communities on lowland Irish farmland. *Aspects of Applied Biology,* 100**,** 77-87.

Creedy, J. & Guyonne, K., 2005. Discrete hours labour supply modelling: specification, estimation and simulation. *Journal of Economic Surveys,* 19**,** 697-734.

CSO, 2012. *Earnings* [online]. Central Statistics Office Available at: http://www.cso.ie/en/statistics/earnings/ [Accessed: 16th of January 2012].

CSO, 2013. *Livestock survey. December 2009* [online]. Central Statistics Office. Available at: http://www.cso.ie/en/media/csoie/releasespublications/documents/agriculture/2009/livestock_dec2009.pdf [Accessed: 22nd October 2013].

Cunningham, M., 2005. A comparison of public lands and farmlands for grassland bird conservation. *The Professional Geographer,* 57**,** 51-65.

DAFF, 2004. *Terms and conditions of the Rural Environment Protection (REPS) in implementation of (EC) 1257/1999 as amended by (EC) 1783/2003.* Food, Department of Agriculture Fisheries and. Dublin. Available at: http://www.agriculture.gov.ie/farmerschemespayments/ruralenvironmentprotectionschemereps/pastruralenvironmentprotectionschemereps/reps3/.

DAFF, 2007. *Terms and conditions of the Rural Environment Protection Scheme (REPS) and Natura 2000 (1698/2005).* Food, Department of Agriculture Fisheries and. Dublin. Available at: http://www.agriculture.gov.ie/ruralenvironment/ruralenvironmentprotectionschemereps/reps4/.

DAFF, 2009. *REPS factsheet. Facts and figures 2006* [online]. Department of Agriculture Fisheries and Food. Available at: http://www.agriculture.gov.ie/farmerschemespayments/ruralenvironmentprotectionschemereps/repsfactsheets/ [Accessed: 16th of December 2009].

DAFF, 2010. *REPS factsheets* [online]. Department of Agriculture Fisheries and Food. Available at: http://www.agriculture.gov.ie/farmerschemespayments/ruralenvironmentprotectionschemereps/repsfactsheets/ [Accessed: 10th of December 2010].

DAFM, 2012a. *Cross compliance* [online]. Department of Agriculture, Food and the Marine. Available at: http://agriculture.gov.ie/farmerschemespayments/crosscompliance/ [Accessed: 13th of November 2012].

DAFM, 2012b. *The future shape of the Common Agricultural Policy* [online]. Department of Agriculture, Food and the Marine. Available at: http://www.agriculture.gov.ie/media/migration/farmingschemesandpayments/commonagriculturalpolicycap/captowards2020/Requestforsubmissionsbackgrounddocumentfinal.pdf [Accessed: 1st October 2012].

DAFM, 2012c. *Terms and conditions of the agri-environmental options scheme (AEOS) and the Natura 2000 scheme. Introduced by the Minister for Agriculture, Food and the Marine in implentation of Council Regulation (EC) No. 1698/2005.* Department of Agriculture, Food and the Marine, Dublin. Available at: http://agriculture.gov.ie/farmerschemespayments/ruralenvironmentprotectionschemereps/repsandaeosschemes/agri-environmentoptionsschemeaeos/.

DAFM, 2013a. *Categories of Disadvantaged Areas* [online]. Department of Agriculture, Food and the Marine. Available at: http://www.agriculture.gov.ie/farmerschemespayments/singlepaymentschemedisadvantagedareasschemebeefdataprogrammebdp/categoriesofdisadvantagedareas/ [Accessed: 23rd September].

DAFM, 2013b. *Nitrates information* [online]. Department of Agriculture Fisheries and Marine. Available at: http://www.agriculture.gov.ie/farmerschemespayments/crosscompliance/nitrates/ [Accessed: June 2013].

DAFRD, 2000. *Rural Environment Protection Scheme (REPS) introduced by the Minister for Agriculture, Food and Rural Development in implementation of Council Regulation (EC) No. 1257/1999.* Department of Agriculture, Food and Rural Development. Dublin. Available at: http://www.agriculture.gov.ie/farmerschemespayments/ruralenvironmentprotectionschemereps/pastruralenvironmentprotectionschemereps/reps2/.

DECLG, 2013a. *Ireland. Rural Development Programme 2007-2013. Summary of measures* [online]. Department of Environment, Community and Local Government. Available at: http://www.environ.ie/en/Publications/Community/RuralDevelopment/FileDownLoad,26522,en.pdf].

DECLG, 2013b. *Rural Development Programme (LEADER) 2007-2013* [online]. Department of Environment, Community and Local Government. Available at: http://www.environ.ie/en/Community/RuralDevelopment/EURuralDevelopment/RuralDevelopmentProgrammeLEADER2007-2013/ [Accessed: 3rd of December 2013].

Defrancesco, E., Gatto, P., Runge, F. & Trestini, S., 2008. Factors affecting farmers' participation in agri-environmental measures: a northern Italian perspective. *Journal of Agricultural Economics,* 59**,** 114-131.

Dillon, P., Hennessy, T., Shalloo, L., Thorne, F. & Horan, B., 2008. Future outlook for the Irish dairy industry: a study of international competitiveness, influence of international trade reform and requirement for change. *International Journal of Dairy Technology,* 61**,** 16-29.

Doherty, E., Campbell, D. & Hynes, S., 2012. Models of site-choice for walks in rural Ireland: exploring cost heterogeneity. *Journal of Agricultural Economics***,** doi: 10.0000/1477-9552.12002.

Dupraz, P., Vermersch, D., DeFrahan, H. & Delvaux, L., 2003. The environmental supply of farm households. *Environmental and Resource Economics,* 25**,** 171-189.

El-Osta, H., Mishra, A. & Ahearn, M., 2004. Labor supply by farm operators under "decoupled" farm program payments. *Review of Economics of the Household,* 2**,** 367-385.

Emerson, H. & Gillmor, D., 1999. The Rural Environment Protection Scheme of the Republic of Ireland. *Land Use Policy,* 16**,** 235-245.

EPA, 2010. *Environmental Protection Agency official website* [online]. http://www.epa.ie/environment/biodiversity/birdspecies/ [Accessed: 19th of February 2010].

Espinosa-Goded, M., Barreiro-Hurle, J. & Ruto, E., 2010. What do farmers want from agri-environmental scheme design? A choice experiment approach. *Journal of Agricultural Economics,* 61**,** 259-273.

ESS, 2013. *Natural England. Environmental Stewardship Higher Level Stewardship* [online]. http://www.naturalengland.org.uk/ourwork/farming/funding/es/hls/default.aspx [Accessed: 3rd of December 2013].

Farragher, F. 2004. Pressure increases on Dept. to get REPS III back into operation. *Connaught Tribune*, 1st of January 2004.

Fealy, R., Loftus, M. & Meehan, R., 2004. *EPA soil and subsoil mapping project: summary methodology descriptions for subsoils, land cover, habitat and soils mapping/modelling. Version 1.2.* Teagasc, Rural Economy Research Centre (RERC). Kinsealy, Co. Dublin. Available at: http://www.epa.ie/downloads/pubs/research/land/name,23747,en.html.

Feehan, J., Gillmor, D. & Culleton, N., 2002. The impact of the Rural Environment Protection Scheme (REPS) on plant and insect diversity. *Tearmann: Irish journal of agri-environmental research,* 2**,** 15-28.

Feehan, J., Gillmor, D. & Culleton, N., 2005. Effects of an agri-environment scheme on farmland biodiversity in Ireland. *Agriculture, Ecosystems and Environment,* 107**,** 275-286.

Feehan, J. & O'Connor, D., 2009. Agriculture and multifunctionality in Ireland. In McDonagh, J., Varley, T. & Shortall, S. (eds.) *A living countryside: the politics of sustainable development in rural Ireland.* Surrey, UK: Ashgate Publishing Ltd.

Ferraro, P., 2008. Asymmetric information and contract design for payments for environmental services. *Ecological Economics,* 65**,** 810-821.

Finn, J., Bartolini, F., Bourke, D., Kurz, I. & Viaggi, D., 2009. Ex post environmental evaluation of agri-environment schemes using experts' judgements and multicriteria analysis. *Journal of Environmental Planning and Management,* 52**,** 717-737.

Finn, J., Kavanagh, B. & Flynn, M., 2005. *Identification of environmental variables for use in monitoring for the evaluation of the Rural Environment Portection Scheme (REPS): 5190a.* Environmental Protection Agency, Teagasc, Royal College of Surgeons in Ireland. Available at: http://www.teagasc.ie/publications/view_publication.aspx?PublicationID=464.

Finn, J., Kurz, I. & Bourke, D., 2007. Multiple factors control the environmental effectiveness of agri-environmental schemes: implications for design and evaluation. *Tearmann: Irish journal of agri-environmental research,* 6**,** 45-56.

Finn, J. & O hUallachain, D., 2012. A review of evidence on the environmental impact of Ireland's Rural Environment Protection Scheme (REPS). *Biology and Environment: Proceedings of the Royal Irish Academy,* 112B.

Foss, P., O'Connell, C. & Crushell, P., 2001. *Bogs and fens of Ireland. Conservation Plan 2005. Action for Bog and Wildlife.* Irish Peatland Conservation Council, Dublin. Available at: http://www.wetlandsurveysireland.com/downloads/npws-study-of-the-extent.html.

Fossitt, J., 2000. *A guide to habitats in Ireland.* The Heritage Council, Dublin. Available at: http://www.heritagecouncil.ie/fileadmin/user_upload/Publications/Wildlife/Guide_to_Habitats.pdf.

Greene, W., 2003. *Econometric Analysis.* 5th Edition. New Jersey: Prentice Hall.

Gwyn, L., Jones, L., Bignal, E., Lysaght, L., Baldock, D. & Phelan, J., 2003. *A review of the CAP Rural Development Plan 2000-2006: implications for natural heritage.* The Heritage Council, Dublin. Available at: http://www.heritagecouncil.ie/fileadmin/user_upload/Publications/Wildlife/rural_plan.pdf.

Hammond, R., 1978. *The peatlands of Ireland.* An Foras Taluntais, Dublin. Available at: http://www.agresearch.teagasc.ie/johnstown/Soil%20maps/Peatlands%20of%20Ireland/book.pdf.

Hanley, N. & Barbier, E., 2009. *Pricing nature: cost-benefit analysis and environmental policy.* Cheltenham, UK: Edward Elgar Publishing Limited.

Hanley, N., Whitby, M. & Simpson, I., 1999. Assessing the success of agri-environmental policy in the UK. *Land Use Policy,* 16**,** 67-80.

Hanley, N., Wright, R. & Alvarez-Farizo, A., 2006. Estimating the economic value of improvements in river ecology using choice experiments: an application to the water framework directive. *Journal of Environmental Management,* 78**,** 183-193.

Hanley, N., Wright, R. & Alvarez-Farizo, B., 2006a. Estimating the economic value of improvements in river ecology using choice experiments: an application to the water framework directive. *Journal of Environmental Management,* 78**,** 183-193.

HCEFRAC, 2012. *Greening of the Common Agricultural Policy. First Report of Session 2012-13.* House of Commons. Environment, Food and Rural Affairs Committee, London, UK. Available at: http://www.publications.parliament.uk/pa/cm201213/cmselect/cmenvfru/170/170.pdf

Hendrickx, F., Maelfait, J., Van Wingerden, W., Schweiger, O., Speelmans, M., Aviron, S., Augenstein, I., Billeter, R., Bailey, D., Bukacek, R., Burel, F., Diekotter, T., Dirksen, J., Herzog, F., Liira, J., Roubalova, M., Vandomme, V. & Bugter, R., 2007. How landscape structure, land-use intensity and habitat diversity affect component of total arthropod diversity in agricultural landscapes. *Journal of Applied Ecology,* 44**,** 340-351.

Hennessy, T., Moran, B., Kinsella, A. & Quinlan, G., 2011. *National Farm Survey 2010.* Rural Economy Research Centre (RERC) Teagasc, Dublin. Available at: http://www.teagasc.ie/publications/2011/1016/NFS10.pdf.

Hennessy, T. & Rehman, T., 2007. An investigation into factors affecting the occupational choices of nominated farm heirs in Ireland. *Journal of Agricultural Economics,* 58**,** 61-75.

Hennessy, T. & Thorne, F., 2006. How decoupled are decoupled payments? The evidence from Ireland. *Eurochoices,* 4**,** 30-35.

Hensher, D., Rose, J. & Greene, W., 2006. *Applied choice analysis: a primer.* New York: Cambridge University Press.

Herzon, I. & Mikk, M., 2007. Farmers' perceptions of biodiversity and their willingness to enhance it through agri-environment schemes: A comparative study from Estonia and Finland. *Journal for Nature Conservation,* 15**,** 10-25.

Hynes, S. & Campbell, D., 2011a. Estimating the welfare impacts of agricultural landscape change in Ireland: a choice experiment. *Journal of Environmental Planning and Management,* 54**,** 1019-1039.

Hynes, S. & Campbell, D., 2011b. Estimating the welfare impacts of agricultural landscape change in Ireland: a choice experiment approach. *Journal of Environmental Planning and Management,* 54**,** 1019-1039.

Hynes, S., Campbell, D. & Howley, P., 2011a. A holistic vs. an attribute-based approach to agri-enviromental policy valuation: do welfare estimates differ? *Journal of Agricultural Economics,* 62**,** 305-329.

Hynes, S., Campbell, D. & Howley, P., 2011b. A holistic vs. an attribute-based approach to agri-environmental policy valuation: do welfare estimates differ? *Journal of Agricultural Economics,* 62**,** 305-329.

Hynes, S., Farrelly, N., Murphy, E. & O' Donoghue, C., 2008a. Modelling habitat conservation and participation in agri-environmental schemes: a spatial microsimulation approach. *Ecological Economics,* 66**,** 258-269.

Hynes, S. & Garvey, E., 2009. Modelling farmers' participation in an agri-environmental scheme using panel data. An application to the Rural Environment Protection Scheme in Ireland. *Journal of Agricultural Economics,* 60**,** 546-562.

Hynes, S., Hanley, N. & O'Donoghue, C., 2009. Alternative treatments of the cost of time in recreational demand models: an application to whitewater kayaking in Ireland. *Journal of Environmental Management,* 90**,** 1014-1021.

Hynes, S. & Hennessy, T., 2012. Agriculture, fisheries and food in the Irish economy. *The World Economy,* 35**,** 1340-1357.

Hynes, S., O' Donoghue, C., Murphy, E. & Kinsella, A., 2008b. The impact of REPS participation on farm chemical input usage and the production of negative externalities. *Tearmann: Irish journal of agri-environmental research,* 6**,** 15-28.

Indecon, 2003. *An economic/socio economic evaluation of wild salmon in Ireland.* Submitted to the Central Fisheries Board, Dublin. Available at:

IPCC, 2010. *Irish Peatlands Conservation Council. Cutover and cutaway bogs* [online]. http://www.ipcc.ie/cbdefinition.html [Accessed: 13th of February 2010].

Kerryman. 2006. No rush on REPS. *Kerryman*, 13th of September 2006.

Kimhi, A., 2004. Family composition and off-farm participation decisions in Israeli farm households. *American Journal of Agricultural Economics,* 86**,** 502-512.

Kirwan, B., Lubowski, R. & Roberts, M., 2005. How cost-effective are land retirement auctions? Estimating the difference between payments and willingness to accept in the conservation reserve program. *American Journal of Agricultural Economics,* 87**,** 1239-1247.

Knowler, D. & Bradshaw, B., 2007. Farmers' adoption of conservation agriculture: a review and synthesis of recent research. *Food Policy,* 32**,** 25-48.

Lafferty, S., Commins, P. & Walsh, A., 1999. *Irish agriculture in transition: A census atlas of agriculture in the Republic of Ireland.* Co. Kildare: Teagasc.

Lapple, D. & Kelley, H., 2013. Understanding the uptake of organic farming: accounting for heterogeneity among Irish farmers. *Ecological Economics,* 88**,** 11-19.

Legg, W., 2007. Agri-environmental programs in OECD countries. *U.S. Agricultural Policy and the 2007 Farm Bill: Promoting the Economic Resilience and Conserving the Ecological Integrity of American Farmlands,* Chapter III-4.

Lynch, L. & Lovell, S., 2003. Combining Spatial and Survey Data to Explain Participation in Agricultural Land Preservation Programs. *Land Economics,* 79**,** 259-76.

Ma, S., Swinton, S., Lupi, F. & Jolejole-Foreman, C., 2012. Farmers' willingness to participate in payment-for-environmental-services programmes. *Journal of Agricultural Economics,* 63**,** 604-626.

Maguire, D. 2002. Why farmers aren't queuing up to join REPS 2. *Irish Farmers Journal*, 2nd of November.

Maguire, D. 2003. Sweeping changes sought in REPS. *Irish Farmers Journal*, 18th of January 2003.

Matthews, A., 2002a. Future role of REPS under a changing CAP. *National REPS Conference 2002.* Teagasc.

Matthews, A., 2002b. Has agricultural policy responded to the Rio challenge? In Convery, F. & Feehan, J. (eds.) *Achievements and challenge - Rio+10.* Dublin: The Environmental Institute. 73-82.

Matthews, A., 2010. *Perspectives on addressing market instability and income risk for farmers.* 324, IIS Discussion Paper No. Institute for International Integration Studies, Trinity College, Dublin. Available at: http://ideas.repec.org/p/iis/dispap/iiisdp324.html.

McDonagh, G. 2003. The IFA view on REPS. *Irish Farmers Journal*, 28th of May 2005.

McEvoy, O., 1999. *Impact of REPS - Analysis from the 1998 Teagasc National Farm Survey.* Conference, Teagasc REPS. Teagasc, Johnstown Castle, Wexford. Available at: http://www.teagasc.ie/publications/reps1999/paper2.asp.

Morris, C. & Potter, C., 1995. Recruiting the new conservationists: farmers' adoption of agri-envrionmental schemes in the U.K. *Journal of Rural Studies,* 11**,** 51-63.

Morris, J., Mills, J. & Crawford, I.M., 2000. Promoting farmer uptake of agri-environment schemes: the Countryside Stewardship Arable Options Scheme. *Land Use Policy,* 17**,** 241-254.

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

Mundlak, Y., 1978. On the pooling of time series and cross section data. *Econometrica,* 46**,** 69-85.

NPWS, 2010. *National Parks and Wildlife Services official website* [online]. http://www.npws.ie/en/ConservationSites/SpecialAreasofConservationSACs/ [Accessed: 19th of February 2010].

NPWS, 2011. *Actions for biodiversity 2011-2016. Ireland's biodiversity plan.* National Parks and Wildlife Service. Department of Arts, Heritage and Gaeltacht, Dublin. Available at: http://www.npws.ie/media/Biodiversity%20Plan%20text%20English.pdf.

O'Donoghue, C., Farrell, N., Morrissey, K., Lennon, J., Ballas, D., Clarke, G. & Hynes, S., 2013. The SMILE model: construction and calibration. In O'Donoghue, C., Ballas, D., Clarke, G., Hynes, S. & Morrissey, K. (eds.) *Spatial microsimulation in rural policy analysis.* Berlin Heidelberg: Springer.

O'Donoghue, C. & Howley, P., 2012. The Single Farm Payment: a basic income for farmers? *Basic Income Studies,* 7**,** Article 4.

O'Donoghue, C. & Lennon, J., Forthcoming. Development of a farm level microsimulation model for a pastoral based system. *Teagasc Working Paper*.

O'Neill, S. & Hanrahan, K., 2012. Decoupling of agricultural support payments: the impact on land market participation decisions. *European Review of Agricultural Economics,* 39**,** 639-659.

Ozanne, A., Hogan, T. & Colman, D., 2001. Moral hazard, risk aversion and compliance monitoring in agri-environmental policy. *European Review of Agricultural Economics,* 28**,** 329-347.

Peerlings, J. & Polman, N., 2009. Farm choice between agri-environmental contracts in the European Union. *Journal of Environmental Planning and Management,* 52**,** 593-612.

Potter, C. & Lobley, M., 1992. The conservation status and potential of elderly farmers: results from a survey in England and Wales. *Journal of Rural Studies***,** 133-143.

Pretty, J., Brett, C., Gee, D., Hine, R., Mason, C., Morison, J., Rayment, M., Van der bijl, G. & Dobbs, T., 2001. Policy challenges and priorities for internalizing the externalities of modern agriculture. *Journal of Environmental Planning and Management,* 44**,** 263-283.

Rath, F., 2000. *The new REPS scheme 2000.* 2000, National REPS Conference. Teagasc, Dublin. Available at: http://www.teagasc.ie/publications/reps2000/reps2000_paper01.asp.

Rath, F., 2001. *REPS - situation and outlook.* 2001, National REPS Conference. Teagasc, Dublin. Available at: http://www.teagasc.ie/publications/2001/reps2/paper01.asp.

Rath, F., 2002. *REPS 2000 and beyond.* 2002, National REPS Conference. Teagasc. Available at: http://www.teagasc.ie/publications/2002/reps/reps2002.pdf.

Regan, S., 2003. New environmental requirements - meeting the challenge. *National REPS Conference 2003.* Teagasc.

Ribaudo, M., 2004. Policy explorations and implications for nonpoint source pollution control: discussion. *American Journal of Agricultural Economics,* 86**,** 1220-1221.

Sinnott, M., 1999. *REPS evaluation and its implications.* 1999, REPS Conference. Teagasc Publication, Teagasc Johnstown Castle, Wexford. Available at: www.teagasc.ie/publications/reps1999/paper1.htm.

Steele, S., 2010. An organisational discussion of incomplete contracting and transaction costs in conservation contracts. *Journal of Agricultural Economics,* 61**,** 163-174.

Train, K., 2003. *Discrete choice methods with simulation.* Cambridge, UK: Cambridge University Press.

UKNEA, 2011. *The UK National Ecosystem Assessment: Synthesis of the Key Findings.* UK National Ecosystem Assessment, UNEP-WCMC, Cambridge. Available at: http://uknea.unep-wcmc.org/Home/tabid/38/Default.aspx.

Van Rensburg, T., Murphy, E. & Rocks, P., 2009. Commonage land and farmer uptake of the rural environment protection scheme in Ireland. *Land Use Policy,* 26**,** 345-355.

Vanslembrouck, I., Van Huylenbroeck, G. & Verbeke, W., 2002. Determinants of the willingness of Belgian farmers to participate in agri-environmental measures. *Journal of Agricultural Economics,* 53**,** 489-511.

Vella, F., 1998. Estimating models with sample selection bias: a survey. *Journal of Human Resources,* 33.

Vollenweider, X., DiFalco, S. & O'Donoghue, C., 2011. Risk preference and voluntary agri environmental schemes: does risk aversion explain the uptake of the Rural Environment Protection Scheme? *Grantham Research Institute on Climate Change and the Environment. London School of Economics and Political Science,* Working paper No. 48.

Waldhardt, R., 2003. Biodiversity and landscape-summary, conclusions and perspectives. *Agriculture, Ecosystems and Environment,* 98**,** 305-309.

Weber, J. & Key, N., 2012. How much do decoupled payments affect production? An instrumental variable approach with panel data. *American Journal of Agricultural Economics,* 94**,** 52-66.

Weibull, A., Ostman, O. & Granqvist, A., 2003. Species richness in agroecosystems: the effect of landscape, habitat and farm management. *Biodiversity and Conservation,* 12**,** 1335-1355.

Whelan, J. & Fry, J., 2011. The lack of SEA to support agri-environmental objectives in Ireland's Rural Environment Protection Scheme. *Journal of Environmental Assesssment Policy and Management,* 13**,** 101-127.

Willcock, J., Deary, I., Edwards-Jones, G., Gibson, G., McGregor, M., Sutherland, A., Dent, B., Morgan, O. & Grieve, R., 1999. The role of attitudes and objectives in farmer decision making: business and environmentally-oriented behaviour in Scotland. *Journal of Agricultural Economics,* 50**,** 286-303.

Wilson, G., 1996. Farmer environmental attitudes and ESA participation. *Geoforum,* 27**,** 115-131.

Wilson, G., 1997. Factors influencing farmer participation in the Environmentally Sensitive Areas scheme. *Journal of Environmental Management,* 50**,** 67-93.

Wilson, P., 2000. Social capital, trust, and the agribusiness of economics. *Journal of Agricultural and Resource Economics,* 25**,** 1-13.

Wossink, G. & van Wenum, J., 2003. Biodiversity conservation by farmers: Analysis of actual and contingent participation. *European Review of Agricultural Economics,* 30**,** 461-485.

Wynn, G., Crabtree, B. & Potts, J., 2001. Modelling farmer entry into the Environmentally Sensitive Areas schemes in Scotland. *Journal of Agricultural Economics,* 52**,** 65-82.

Young, R.A., 2005. *Determining the economic value of water: concepts and methods.* Washington DC: Resources for the Future.

Zbinden, S. & Lee, D., 2005. Paying for environmental services: an analysis of participation in Costa Rica's PSA program. *World Development,* 33**,** 255-272.

# A. Appendix

**Table A.1: Linear random effects model showing a production function for the log of livestock units per hectare from dairy**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | -5.038** | (2.422) |
| Land value per hectare (€) | 0.0258*** | (0.00325) |
| Gross margin from dairy/ha/LU (€) | 0.188*** | (0.0361) |
| Forage area (ha) | -0.0885*** | (0.00770) |
| Farmers' age (years) | -0.00697 | (0.00740) |
| Has off farm employment | -0.0447*** | (0.00914) |
| Has forestry | 0.0123 | (0.00902) |
| Percentage land under dairy | 0.229*** | (0.0274) |
| REPSxYear | 0.00250** | (0.00121) |
| Has Teagasc advisor | -0.00436 | (0.00503) |
| Unpaid labour units | 0.0172* | (0.00915) |
| Dairy GO/LU previous year (€) | 0.00362 | (0.0167) |
| 1995 | -0.0131 | (0.0196) |
| 1996 | 0.0318 | (0.0207) |
| 1997 | 0.0447** | (0.0208) |
| 1998 | 0.0442** | (0.0199) |
| 1999 | 0.0328 | (0.0204) |
| 2000 | -0.00559 | (0.0201) |
| 2001 | 0.00447 | (0.0202) |
| 2002 | -0.0240 | (0.0208) |
| 2003 | -0.00775 | (0.0194) |
| 2004 | -0.0157 | (0.0193) |
| 2005 | -0.0331* | (0.0198) |
| 2006 | -0.0424** | (0.0198) |
| 2007 | -0.0435** | (0.0195) |
| 2008 | -0.0596*** | (0.0223) |
| 2009 | -0.0731*** | (0.0225) |
| 2010 | -0.117*** | (0.0186) |
| Soil 1 | 0.190*** | (0.0217) |
| Soil 2 | 0.112*** | (0.0202) |
| Constant | 0.607*** | (0.0402) |

Source: NFS 1994 to 2010 N = 7,488. OLS regression. SEs are in parentheses. Base year: 1994. Base soiltype: Soil 3. ***: $p<0.01$, **: $p<0.05$, *: $p<0.1$

**Table A.2: Linear random effects model showing a production function for the log of livestock units per hectare from cattle**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | 1.713 | (1.893) |
| Land value per hectare (€) | 0.0353*** | (0.00331) |
| Gross margin from cattle/ha/LU (€) | -0.000505 | (0.0138) |
| Forage area (ha) | -0.131*** | (0.00524) |
| Farmers' age (years) | -0.0158*** | (0.00594) |
| Has off farm employment | -0.0129* | (0.00681) |
| Has forestry | -0.00352 | (0.00825) |
| Percentage land under cattle | 0.181*** | (0.0245) |
| Percentage land under dairy | 0.415*** | (0.0248) |
| REPSxYear | -0.000856 | (0.000945) |
| Has Teagasc advisor | 0.0126*** | (0.00452) |
| Unpaid labour units | 0.104*** | (0.00721) |
| Cattle GO/LU previous year (€) | 0.0273** | (0.0127) |
| 1995 | -0.00390 | (0.0178) |
| 1996 | 0.0274 | (0.0178) |
| 1997 | 0.0501*** | (0.0159) |
| 1998 | 0.0647*** | (0.0156) |
| 1999 | 0.0520*** | (0.0153) |
| 2000 | 0.00235 | (0.0151) |
| 2001 | -0.00584 | (0.0160) |
| 2002 | -0.0313** | (0.0152) |
| 2003 | -0.0235 | (0.0152) |
| 2004 | -0.0479*** | (0.0151) |
| 2005 | -0.0531*** | (0.0164) |
| 2006 | -0.0837*** | (0.0168) |
| 2007 | -0.0974*** | (0.0177) |
| 2008 | -0.122*** | (0.0174) |
| 2009 | -0.149*** | (0.0191) |
| 2010 | -0.240*** | (0.0173) |
| Soil 1 | 0.227*** | (0.0162) |
| Soil 2 | 0.126*** | (0.0141) |
| Constant | 0.434*** | (0.0347) |

Source: NFS 1994 to 2010 N = 18,456. OLS regression. SEs are in parentheses. Base year: 1994. Base soiltype: Soil 3. ***: p<0.01, **: p<0.05, *: p<0.1

**Table A.3: Linear random effects model showing a production function for the log of livestock units per hectare from sheep**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | 0.00874 | (3.672) |
| Land value per hectare (€) | 0.0548*** | (0.00724) |
| Forage area (ha) | -0.135*** | (0.00659) |
| Farmers' age (years) | -0.00367 | (0.0127) |
| Has off farm employment | -0.0413*** | (0.0139) |
| Has forestry | -0.0132 | (0.0166) |
| Percentage land under sheep | 0.00920 | (0.0347) |
| REPSxYear | -9.63e-06 | (0.00183) |
| Has Teagasc advisor | 0.00827 | (0.00912) |
| Unpaid labour units | 0.118*** | (0.0148) |
| Sheep GO/LU previous year (€) | 0.0651*** | (0.0248) |
| 1995 | -0.0263 | (0.0299) |
| 1996 | -0.0103 | (0.0281) |
| 1997 | 0.00114 | (0.0324) |
| 1998 | 0.0475 | (0.0334) |
| 1999 | 0.0464 | (0.0306) |
| 2000 | -0.0328 | (0.0296) |
| 2001 | -0.0587* | (0.0315) |
| 2002 | -0.0981** | (0.0400) |
| 2003 | -0.0829** | (0.0350) |
| 2004 | -0.103*** | (0.0345) |
| 2005 | -0.116*** | (0.0354) |
| 2006 | -0.149*** | (0.0340) |
| 2007 | -0.209*** | (0.0349) |
| 2008 | -0.257*** | (0.0352) |
| 2009 | -0.323*** | (0.0368) |
| 2010 | -0.433*** | (0.0363) |
| Soil 1 | 0.349*** | (0.0270) |
| Soil 2 | 0.203*** | (0.0232) |
| Constant | 0.565*** | (0.0576) |

Source: NFS 1994 to 2010 N = 7,172. OLS regression. SEs are in parentheses. Base year: 1994. Base soiltype: Soil 3. ***: p<0.01, **: p<0.05, *: p<0.1

**Table A.4: Linear random effects model showing a production function for the log of gross outputs per livestock units from dairy**

| Variable | Coefficient (β) | Standared error (SE) |
|---|---|---|
| REPS | 1.989 | (2.559) |
| Land value per hectare (€) | 0.000783 | (0.00335) |
| Gross margin from dairy/ha/LU (€) | 0.836*** | (0.0231) |
| Forage area (ha) | 0.107*** | (0.00676) |
| Farmers' age (years) | -0.0129* | (0.00749) |
| Has off farm employment | -0.00368 | (0.00901) |
| Has forestry | -0.00730 | (0.00900) |
| Percentage land under dairy | -0.00614 | (0.0229) |
| REPSxYear | -0.000985 | (0.00128) |
| Has Teagasc advisor | 0.0246*** | (0.00520) |
| Cost of fertiliser per ha (€) | 0.0580*** | (0.00572) |
| Dairy LU/ha | -0.0124 | (0.0122) |
| Unpaid labour units | -0.0108 | (0.00872) |
| Dairy GO/LU previous year (€) | -0.0253 | (0.0180) |
| 1995 | 0.00910 | (0.0211) |
| 1996 | -0.00240 | (0.0222) |
| 1997 | -0.00659 | (0.0222) |
| 1998 | -0.0294 | (0.0212) |
| 1999 | -0.0140 | (0.0217) |
| 2000 | 0.0676*** | (0.0214) |
| 2001 | 0.0712*** | (0.0215) |
| 2002 | 0.0391* | (0.0222) |
| 2003 | 0.0642*** | (0.0207) |
| 2004 | 0.0870*** | (0.0206) |
| 2005 | 0.0497** | (0.0211) |
| 2006 | 0.0703*** | (0.0211) |
| 2007 | 0.0878*** | (0.0208) |
| 2008 | 0.0372 | (0.0240) |
| 2009 | -0.000369 | (0.0241) |
| 2010 | 0.0365* | (0.0195) |
| Soil 1 | 0.0889*** | (0.0169) |
| Soil 2 | 0.0660*** | (0.0162) |
| Constant | 6.540*** | (0.0423) |

Source: NFS 1994 to 2010 N = 7,464. OLS regression. SEs are in parentheses. Base year: 1994. Base soiltype: Soil 3. ***: p<0.01, **: p<0.05, *: p<0.1

**Table A.5: Linear random effects model showing a production function for the log of gross outputs per livestock units from cattle**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | -10.23** | (4.068) |
| Land value per hectare (€) | 0.0113* | (0.00673) |
| Gross margin from cattle/ha/LU (€) | 0.370*** | (0.0183) |
| Forage area (ha) | 0.0166** | (0.00679) |
| Farmers' age (years) | -0.0456*** | (0.0116) |
| Has off farm employment | -0.00314 | (0.0109) |
| Has forestry | 0.000909 | (0.0150) |
| Percentage land under cattle | -0.114*** | (0.0270) |
| Percentage land under dairy | 0.685*** | (0.0270) |
| REPSxYear | 0.00511** | (0.00203) |
| Has Teagasc advisor | 0.0510*** | (0.00891) |
| Cost of fertiliser per ha (€) | 0.0739*** | (0.00507) |
| Cattle LU/ha | -0.0745*** | (0.0126) |
| Unpaid labour units | 0.0498*** | (0.0112) |
| Cattle GO/LU previous year (€) | -0.0391 | (0.0296) |
| 1995 | -0.0319 | (0.0414) |
| 1996 | 0.0283 | (0.0410) |
| 1997 | 0.0820** | (0.0362) |
| 1998 | -0.0464 | (0.0354) |
| 1999 | -0.0333 | (0.0348) |
| 2000 | 0.0476 | (0.0340) |
| 2001 | 0.0756** | (0.0362) |
| 2002 | 0.0515 | (0.0341) |
| 2003 | -0.00383 | (0.0343) |
| 2004 | 0.0666** | (0.0339) |
| 2005 | 0.0518 | (0.0371) |
| 2006 | 0.0284 | (0.0380) |
| 2007 | 0.0829** | (0.0400) |
| 2008 | 0.0435 | (0.0393) |
| 2009 | 0.0364 | (0.0434) |
| 2010 | 0.0749* | (0.0389) |
| Soil 1 | 0.110*** | (0.0177) |
| Soil 2 | 0.0678*** | (0.0170) |
| Constant | 5.573*** | (0.0565) |

Source: NFS 1994 to 2010 N = 18,271. OLS regression. SEs are in parentheses. Base year: 1994. Base soiltype: Soil 3. ***: $p<0.01$, **: $p<0.05$, *: $p<0.1$

**Table A.6: Linear random effects model showing a production function for the log of gross outputs per livestock units from sheep**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | -11.32* | (6.502) |
| Land value per hectare (€) | -0.00335 | (0.0125) |
| Forage area (ha) | -0.0470*** | (0.0115) |
| Farmers' age (years) | -0.000422 | (0.0218) |
| Has off farm employment | -0.0182 | (0.0227) |
| Has forestry | -0.0446 | (0.0285) |
| Percentage land under sheep | -0.163*** | (0.0533) |
| REPSxYear | 0.00566* | (0.00325) |
| Has Teagasc advisor | 0.0491*** | (0.0158) |
| Cost of fertiliser per ha (€) | 0.0471*** | (0.00929) |
| Sheep LU/ha | -0.0674*** | (0.0211) |
| Unpaid labour units | 0.0841*** | (0.0239) |
| Sheep GO/LU previous year (€) | 0.0738* | (0.0438) |
| 1995 | 0.0399 | (0.0530) |
| 1996 | 0.0754 | (0.0495) |
| 1997 | 0.123** | (0.0571) |
| 1998 | -0.0400 | (0.0587) |
| 1999 | -0.123** | (0.0539) |
| 2000 | 0.0656 | (0.0520) |
| 2001 | 0.117** | (0.0551) |
| 2002 | 0.0192 | (0.0702) |
| 2003 | 0.0884 | (0.0614) |
| 2004 | 0.0774 | (0.0604) |
| 2005 | 0.115* | (0.0620) |
| 2006 | 0.146** | (0.0597) |
| 2007 | 0.169*** | (0.0613) |
| 2008 | 0.123** | (0.0619) |
| 2009 | 0.112* | (0.0649) |
| 2010 | 0.00685 | (0.0640) |
| Soil 1 | 0.463*** | (0.0404) |
| Soil 2 | 0.336*** | (0.0365) |
| Constant | 5.018*** | (0.102) |

Source: NFS 1994 to 2010 N = 7,039. OLS regression. SEs are in parentheses. Base year: 1994. Base soiltype: Soil 3. ***: p<0.01, **: p<0.05, *: p<0.1

**Table A.7: Linear random effects model showing a production function for the log of gross outputs per hectare from cereals**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | -22.81*** | (8.496) |
| Land value per hectare (€) | -0.0160 | (0.0144) |
| Tillage area (ha) | -0.195*** | (0.00936) |
| Farmers' age (years) | -0.00268 | (0.0229) |
| Has off farm employment | 0.0274 | (0.0287) |
| Has forestry | 0.0253 | (0.0335) |
| Percentage land under tillage | 0.0134 | (0.0107) |
| REPSxYear | 0.0114*** | (0.00424) |
| Has Teagasc advisor | 0.000890 | (0.0205) |
| Cost of fertiliser per ha (€) | 0.0749*** | (0.0188) |
| Unpaid labour units | -0.0104 | (0.0199) |
| Price of Cereal GO/ha (€)^ | 0.00445*** | (0.000937) |
| Price of Cereal GO/ha prev year (€)^ | -0.000427** | (0.000201) |
| Cereal gross margin /ha/tonne (€) | 0.682*** | (0.0228) |
| 1995 | 0.0878** | (0.0379) |
| 1996 | 0.0293 | (0.0453) |
| 1997 | -0.296*** | (0.0510) |
| 1998 | -0.198*** | (0.0435) |
| 1999 | -0.0824* | (0.0478) |
| 2000 | 0.0456 | (0.0508) |
| 2001 | -0.116*** | (0.0421) |
| 2002 | -0.286*** | (0.0438) |
| 2003 | -0.102** | (0.0416) |
| 2004 | -0.0902* | (0.0483) |
| 2005 | -0.234*** | (0.0455) |
| 2006 | -0.242*** | (0.0389) |
| 2008 | -0.244*** | (0.0416) |
| 2009 | -0.432*** | (0.0475) |
| 2010 | 0.0234 | (0.0406) |
| Soil 1 | -0.417*** | (0.0941) |
| Soil 2 | -0.396*** | (0.0937) |
| Constant | 7.120*** | (0.177) |

Source: NFS 1994 to 2010 N = 4,228. OLS regression. SEs are in parentheses. ^Source: CSO (2013). Base year: 1994. Base soiltype: Soil 3. ***: $p<0.01$, **: $p<0.05$, *: $p<0.1$

**Table A.8: Cost function for the log of costs of purchased concentrates per hectare**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | 0.0288** | (0.0127) |
| Land value per hectare (€) | 0.00245 | (0.00497) |
| Farm size (ha) | -0.0195*** | (0.000657) |
| Farm size$^2$ (ha$^2$) | 3.02e-05*** | (1.86e-06) |
| Farmers' age (years) | -0.00203*** | (0.000470) |
| Has off farm employment | -0.00695 | (0.0169) |
| Spouse has off farm employment | 0.00162 | (0.0143) |
| Percentage land under tillage | -0.00253 | (0.0118) |
| Has forestry | -0.0393* | (0.0206) |
| Percentage land under dairy | 2.246*** | (0.0576) |
| Percentage land under sheep | 0.433*** | (0.0536) |
| Sheep (LUs) | 0.00822*** | (0.000463) |
| Cattle (LUs) | 0.0136*** | (0.000384) |
| Dairy (LUs) | 0.00759*** | (0.000588) |
| Has Teagasc advisor | 0.0650*** | (0.0113) |
| Unpaid labour units | 0.0873*** | (0.0169) |
| Purchased conc prev year (€) | 0.00392 | (0.0288) |
| 1995 | 0.182*** | (0.0434) |
| 1996 | 0.0249 | (0.0443) |
| 1997 | -0.130*** | (0.0448) |
| 1998 | 0.0340 | (0.0437) |
| 1999 | 0.262*** | (0.0427) |
| 2000 | 0.207*** | (0.0428) |
| 2001 | 0.245*** | (0.0430) |
| 2002 | 0.284*** | (0.0433) |
| 2003 | 0.300*** | (0.0432) |
| 2004 | 0.224*** | (0.0431) |
| 2005 | 0.159*** | (0.0454) |
| 2006 | 0.224*** | (0.0456) |
| 2007 | 0.0701 | (0.0470) |
| 2008 | 0.132*** | (0.0502) |
| 2009 | 0.156*** | (0.0537) |
| 2010 | 0.219*** | (0.0492) |
| Louth, Leit., Sligo, Cav., Don., Mon. | -0.178*** | (0.0327) |
| Kildare, Meath, Wicklow | -0.129*** | (0.0378) |
| Laois, Longford, Offaly, Westmeath | -0.165*** | (0.0365) |
| Clare, Limerick, Tipperary N. | -0.191*** | (0.0382) |
| Carl., Kilk., Wex., Tipp S., Water. | -0.192*** | (0.0323) |
| Cork, Kerry | -0.171*** | (0.0343) |
| Galway, Mayo, Roscommon | -0.163*** | (0.0366) |
| Soil 1 | 0.157*** | (0.0382) |
| Soil 2 | 0.122*** | (0.0332) |
| Constant | 3.650*** | (0.0546) |

Source: NFS 1994 to 2010 N = 18,137. OLS regression. SEs are in parentheses. Base year: 1994. Base soiltype: Soil 3. ***: $p<0.01$, **: $p<0.05$, *: $p<0.1$

**Table A.9: Cost function for the log of costs of purchased bulky feed per hectare**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| Land value per hectare (€) | 0.0160 | (0.0109) |
| Farm size (ha) | -0.0219*** | (0.00108) |
| Farm size$^2$ (ha$^2$) | 3.20e-05*** | (2.41e-06) |
| Farmers' age (years) | -0.000282 | (0.00101) |
| Has off farm employment | 0.100** | (0.0396) |
| Spouse has off farm employment | 0.0487 | (0.0341) |
| Percentage land under tillage | -0.237 | (0.153) |
| Has forestry | -0.154*** | (0.0512) |
| Percentage land under dairy | -0.0672 | (0.122) |
| Percentage land under sheep | -0.189* | (0.105) |
| Sheep (LUs) | 0.00696*** | (0.000857) |
| Cattle (LUs) | 0.00680*** | (0.000733) |
| Dairy (LUs) | 0.00952*** | (0.00104) |
| Has Teagasc advisor | -0.0848*** | (0.0283) |
| Unpaid labour units | -0.143*** | (0.0328) |
| Purchased bulky feed prev year (€) | -0.0505 | (0.0361) |
| 1995 | -0.0600 | (0.109) |
| 1996 | -0.0344 | (0.110) |
| 1997 | -0.322*** | (0.114) |
| 1998 | -0.0979 | (0.109) |
| 1999 | 0.127 | (0.105) |
| 2000 | 0.0603 | (0.106) |
| 2001 | -0.0469 | (0.107) |
| 2002 | -0.0953 | (0.111) |
| 2003 | -0.156 | (0.110) |
| 2004 | -0.203* | (0.111) |
| 2005 | -0.136 | (0.115) |
| 2006 | 0.144 | (0.113) |
| 2007 | 0.0543 | (0.115) |
| 2008 | -0.0616 | (0.124) |
| 2009 | 0.207 | (0.133) |
| 2010 | 0.308** | (0.123) |
| Louth, Leit., Sligo, Cav., Don., Mon. | 0.0382 | (0.0781) |
| Kildare, Meath, Wicklow | 0.284*** | (0.0758) |
| Laois, Longford, Offaly, Westmeath | 0.138* | (0.0755) |
| Clare, Limerick, Tipperary N. | 0.0861 | (0.0777) |
| Carl., Kilk., Wex., Tipp S., Water. | 0.0901 | (0.0678) |
| Cork, Kerry | 0.102 | (0.0680) |
| Galway, Mayo, Roscommon | 0.126* | (0.0718) |
| Soil 1 | -0.184*** | (0.0708) |
| Soil 2 | -0.130** | (0.0654) |
| Constant | 3.231*** | (0.110) |

Source: NFS 1994 to 2010 N = 18,137. OLS regression. SEs are in parentheses. Base year: 1994. Base soiltype: Soil 3. ***: $p<0.01$, **: $p<0.05$, *: $p<0.1$

**Table A.10: Cost function for the log of costs of fertiliser per hectare**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | -0.0636*** | (0.00861) |
| Land value per hectare (€) | 0.0156*** | (0.00342) |
| Farm size (ha) | -0.00867*** | (0.000388) |
| Farm size$^2$ (ha$^2$) | 9.56e-06*** | (9.22e-07) |
| Farmers' age (years) | -0.00169*** | (0.000316) |
| Has off farm employment | 0.00644 | (0.0114) |
| Spouse has off farm employment | 0.0222** | (0.00965) |
| Percentage land under tillage | 0.0147* | (0.00791) |
| Has forestry | 0.0184 | (0.0141) |
| Percentage land under dairy | 0.755*** | (0.0401) |
| Percentage land under sheep | -0.360*** | (0.0366) |
| Sheep (LUs) | 0.00285*** | (0.000318) |
| Cattle (LUs) | 0.00569*** | (0.000253) |
| Dairy (LUs) | 0.00562*** | (0.000410) |
| Has Teagasc advisor | 0.0384*** | (0.00760) |
| Unpaid labour units | 0.0433*** | (0.0115) |
| Price of fertiliser/ha (€)^ | -0.421*** | (0.0244) |
| Price of fertiliser/ha prev year (€)^ | 0.0106 | (0.0153) |
| 1995 | 0.0945*** | (0.0262) |
| 1996 | 0.104*** | (0.0255) |
| 1997 | -0.0128 | (0.0271) |
| 1998 | -0.0109 | (0.0270) |
| 1999 | 0.0377 | (0.0264) |
| 2000 | 0.0143 | (0.0255) |
| 2001 | 0.0214 | (0.0232) |
| 2002 | -0.0161 | (0.0248) |
| 2003 | -0.000240 | (0.0239) |
| 2004 | -0.0520** | (0.0236) |
| 2005 | -0.0662*** | (0.0225) |
| 2006 | -0.0642*** | (0.0218) |
| 2007 | -0.129*** | (0.0221) |
| 2009 | -0.0830*** | (0.0229) |
| 2010 | -0.165*** | (0.0221) |
| Louth, Leit., Sligo, Cav., Don., Mon. | 0.0762*** | (0.0222) |
| Kildare, Meath, Wicklow | 0.123*** | (0.0253) |
| Laois, Longford, Offaly, Westmeath | 0.0612** | (0.0250) |
| Clare, Limerick, Tipperary N. | 0.0370 | (0.0261) |
| Carl., Kilk., Wex., Tipp S., Water. | 0.106*** | (0.0220) |
| Cork, Kerry | 0.0733*** | (0.0236) |
| Galway, Mayo, Roscommon | -0.0183 | (0.0257) |
| Soil 1 | 0.394*** | (0.0268) |
| Soil 2 | 0.212*** | (0.0234) |
| Constant | 4.180*** | (0.0469) |

Source: NFS 1994 to 2010 N = 18,956. OLS regression. SEs are in parentheses. ^Source: CSO (2013). Base year: 1994. Base soiltype: Soil 3. ***: p<0.01, **: p<0.05, *: p<0.1

**Table A.11: Cost function for the log of costs of crop protection per hectare**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | -0.0168 | (0.0252) |
| Land value per hectare (€) | 0.0154* | (0.00915) |
| Farm size (ha) | 0.0103*** | (0.000998) |
| Farm size$^2$ (ha$^2$) | -1.81e-05*** | (2.46e-06) |
| Farmers' age (years) | -0.00281*** | (0.00105) |
| Has off farm employment | 0.0141 | (0.0335) |
| Spouse has off farm employment | 0.00366 | (0.0274) |
| Percentage land under tillage | 0.176*** | (0.0240) |
| Has forestry | 0.0552 | (0.0386) |
| Percentage land under dairy | -0.412*** | (0.110) |
| Percentage land under sheep | -0.447*** | (0.0936) |
| Sheep (LUs) | -0.00193** | (0.000762) |
| Cattle (LUs) | -0.00758*** | (0.000644) |
| Dairy (LUs) | -0.00112 | (0.00101) |
| Has Teagasc advisor | 0.0288 | (0.0224) |
| Unpaid labour units | 0.0242 | (0.0308) |
| Price of crop prot/ha prev year (€)^ | -0.0206 | (0.0615) |
| 1995 | -0.0417 | (0.0871) |
| 1996 | 0.0390 | (0.0882) |
| 1997 | 0.0851 | (0.0889) |
| 1998 | 0.135 | (0.0883) |
| 1999 | 0.109 | (0.0890) |
| 2000 | 0.109 | (0.0891) |
| 2001 | 0.116 | (0.0880) |
| 2002 | 0.118 | (0.0882) |
| 2003 | 0.255*** | (0.0875) |
| 2004 | 0.175** | (0.0866) |
| 2005 | 0.166* | (0.0895) |
| 2006 | 0.0130 | (0.0903) |
| 2007 | 0.0842 | (0.0901) |
| 2008 | 0.206** | (0.0891) |
| 2009 | 0.0392 | (0.0896) |
| 2010 | -0.192** | (0.0887) |
| Louth, Leit., Sligo, Cav., Don., Mon. | 0.180*** | (0.0637) |
| Kildare, Meath, Wicklow | 0.287*** | (0.0676) |
| Laois, Longford, Offaly, Westmeath | 0.166** | (0.0691) |
| Clare, Limerick, Tipperary N. | -0.0891 | (0.0768) |
| Carl., Kilk., Wex., Tipp S., Water. | 0.202*** | (0.0600) |
| Cork, Kerry | 0.00660 | (0.0637) |
| Galway, Mayo, Roscommon | -0.216*** | (0.0703) |
| Soil 1 | 1.102*** | (0.0724) |
| Soil 2 | 0.591*** | (0.0669) |
| Constant | 1.008*** | (0.108) |

Source: NFS 1994 to 2010 N = 11,807. OLS regression. SEs are in parentheses. ^Source: CSO (2013). Base year: 1994. Base soiltype: Soil 3. ***: p<0.01, **: p<0.05, *: p<0.1

**Table A.12: Cost function for the log of costs of purchased seed per hectare**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | -0.0731** | (0.0286) |
| Land value per hectare (€) | 0.0330*** | (0.00996) |
| Farm size (ha) | 0.00817*** | (0.00103) |
| Farm size$^2$ (ha$^2$) | -1.11e-05*** | (2.63e-06) |
| Farmers' age (years) | -0.00525*** | (0.00111) |
| Has off farm employment | 0.0286 | (0.0371) |
| Spouse has off farm employment | -0.00974 | (0.0297) |
| Percentage land under tillage | 0.0980*** | (0.0216) |
| Has forestry | -0.00713 | (0.0421) |
| Percentage land under dairy | -0.368*** | (0.120) |
| Percentage land under sheep | -0.212** | (0.102) |
| Sheep (LUs) | -0.00309*** | (0.000807) |
| Cattle (LUs) | -0.00605*** | (0.000644) |
| Dairy (LUs) | -0.00107 | (0.00102) |
| Has Teagasc advisor | 0.0557** | (0.0249) |
| Unpaid labour units | -0.0690** | (0.0313) |
| Price of purch seed/ha prev year (€)^ | -0.0701 | (0.0560) |
| 1995 | -0.00286 | (0.0856) |
| 1996 | 0.0119 | (0.0886) |
| 1997 | 0.0301 | (0.0902) |
| 1998 | 0.0154 | (0.0884) |
| 1999 | -0.00290 | (0.0896) |
| 2000 | 0.0927 | (0.0905) |
| 2001 | 0.0248 | (0.0882) |
| 2002 | -0.0688 | (0.0898) |
| 2003 | 0.0572 | (0.0898) |
| 2004 | -0.0500 | (0.0930) |
| 2005 | 0.0153 | (0.0954) |
| 2006 | -0.120 | (0.0964) |
| 2007 | -0.345*** | (0.0981) |
| 2008 | -0.168* | (0.101) |
| 2009 | -0.140 | (0.105) |
| 2010 | -0.235** | (0.0975) |
| Louth, Leit., Sligo, Cav., Don., Mon. | 0.264*** | (0.0694) |
| Kildare, Meath, Wicklow | 0.260*** | (0.0713) |
| Laois, Longford, Offaly, Westmeath | 0.188*** | (0.0730) |
| Clare, Limerick, Tipperary N. | 0.0263 | (0.0823) |
| Carl., Kilk., Wex., Tipp S., Water. | 0.268*** | (0.0629) |
| Cork, Kerry | 0.142** | (0.0662) |
| Galway, Mayo, Roscommon | -0.253*** | (0.0799) |
| Soil 1 | 1.046*** | (0.0756) |
| Soil 2 | 0.597*** | (0.0722) |
| Constant | 1.519*** | (0.114) |

Source: NFS 1994 to 2010 N = 11,807. OLS regression. SEs are in parentheses. ^Source: CSO (2013). Base year: 1994. Base soiltype: Soil 3. ***: $p<0.01$, **: $p<0.05$, *: $p<0.1$

**Table A.13: Cost function for the log of costs of vet and med per hectare**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | 0.0162 | (0.00989) |
| Land value per hectare (€) | 0.0209*** | (0.00410) |
| Farm size (ha) | -0.0162*** | (0.000447) |
| Farm size$^2$ (ha$^2$) | 1.70e-05*** | (1.07e-06) |
| Farmers' age (years) | -0.00334*** | (0.000423) |
| Has off farm employment | 0.0122 | (0.0132) |
| Spouse has off farm employment | 0.0325*** | (0.0108) |
| Percentage land under tillage | -0.321*** | (0.0413) |
| Has forestry | 0.0228 | (0.0162) |
| Percentage land under dairy | 0.892*** | (0.0436) |
| Percentage land under sheep | 0.185*** | (0.0397) |
| Sheep (LUs) | 0.00823*** | (0.000354) |
| Cattle (LUs) | 0.00984*** | (0.000282) |
| Dairy (LUs) | 0.00807*** | (0.000433) |
| Has Teagasc advisor | 0.0635*** | (0.00907) |
| Unpaid labour units | 0.109*** | (0.0132) |
| Price of vet and med/ha prev year (€)^ | -0.0115 | (0.0218) |
| 1996 | -0.0302 | (0.0227) |
| 1997 | 0.0181 | (0.0218) |
| 1998 | -0.00444 | (0.0210) |
| 1999 | -0.0308 | (0.0206) |
| 2000 | 0.0244 | (0.0207) |
| 2001 | 0.0260 | (0.0195) |
| 2002 | 0.0468** | (0.0193) |
| 2003 | 0.0365* | (0.0189) |
| 2004 | 0.0720*** | (0.0185) |
| 2005 | 0.0889*** | (0.0183) |
| 2006 | 0.0179 | (0.0183) |
| 2007 | 0.0597*** | (0.0181) |
| 2008 | 0.0733*** | (0.0182) |
| 2009 | 0.0263 | (0.0184) |
| Louth, Leit., Sligo, Cav., Don., Mon. | -0.00346 | (0.0284) |
| Kildare, Meath, Wicklow | 0.0174 | (0.0307) |
| Laois, Longford, Offaly, Westmeath | -0.00704 | (0.0301) |
| Clare, Limerick, Tipperary N. | 0.00435 | (0.0293) |
| Carl., Kilk., Wex., Tipp S., Water. | 0.0263 | (0.0263) |
| Cork, Kerry | 0.0345 | (0.0267) |
| Galway, Mayo, Roscommon | -0.0330 | (0.0284) |
| Soil 1 | 0.0881*** | (0.0294) |
| Soil 2 | 0.0301 | (0.0260) |
| Constant | 3.273*** | (0.0550) |

Source: NFS 1994 to 2010 N = 16,794. OLS regression. SEs are in parentheses. ^Source: CSO (2013). Base year: 1994. Base soiltype: Soil 3. ***: p<0.01, **: p<0.05, *: p<0.1

**Table A.14: Cost function for the log of costs of AI per hectare**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | -0.0323 | (0.0234) |
| Land value per hectare (€) | -0.00303 | (0.00846) |
| Farm size (ha) | -0.0210*** | (0.00115) |
| Farm size$^2$ (ha$^2$) | 2.69e-05*** | (2.96e-06) |
| Farmers' age (years) | -0.00453*** | (0.00104) |
| Has off farm employment | 0.0135 | (0.0317) |
| Spouse has off farm employment | 0.00443 | (0.0243) |
| Percentage land under tillage | -0.321** | (0.148) |
| Has forestry | 0.0597 | (0.0373) |
| Percentage land under dairy | 0.956*** | (0.0922) |
| Percentage land under sheep | -0.231 | (0.144) |
| Sheep (LUs) | 0.000233 | (0.00141) |
| Cattle (LUs) | 0.00342*** | (0.000726) |
| Dairy (LUs) | 0.0138*** | (0.000872) |
| Has Teagasc advisor | 0.0290 | (0.0204) |
| Unpaid labour units | -0.000861 | (0.0280) |
| Price of AI/ha prev year (€)^ | 0.0259 | (0.0549) |
| 1995 | -0.123 | (0.0956) |
| 1996 | -2.456*** | (0.0894) |
| 1997 | -2.436*** | (0.0903) |
| 1998 | -2.495*** | (0.0903) |
| 1999 | -2.572*** | (0.0913) |
| 2000 | -2.461*** | (0.0922) |
| 2001 | -2.534*** | (0.0929) |
| 2002 | -2.575*** | (0.0944) |
| 2003 | -2.642*** | (0.0955) |
| 2004 | -2.681*** | (0.0970) |
| 2005 | -2.741*** | (0.0993) |
| 2006 | -2.707*** | (0.101) |
| 2007 | -2.685*** | (0.103) |
| 2008 | -2.695*** | (0.104) |
| 2009 | -2.679*** | (0.104) |
| 2010 | -2.692*** | (0.103) |
| Louth, Leit., Sligo, Cav., Don., Mon. | -0.0635 | (0.0595) |
| Kildare, Meath, Wicklow | 0.00562 | (0.0691) |
| Laois, Longford, Offaly, Westmeath | 0.0642 | (0.0639) |
| Clare, Limerick, Tipperary N. | 0.00146 | (0.0639) |
| Carl., Kilk., Wex., Tipp S., Water. | 0.110** | (0.0543) |
| Cork, Kerry | 0.0115 | (0.0555) |
| Galway, Mayo, Roscommon | 0.0634 | (0.0580) |
| Soil 1 | 0.116* | (0.0655) |
| Soil 2 | 0.0786 | (0.0601) |
| Constant | 5.034*** | (0.115) |

Source: NFS 1994 to 2010 N = 9,669. OLS regression. SEs are in parentheses. ^Source: CSO (2013). Base year: 1994. Base soiltype: Soil 3. ***: $p<0.01$, **: $p<0.05$, *: $p<0.1$

**Table A.15: Cost function for the log of costs of car, electricity and phone per hectare**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | 0.0147 | (0.00940) |
| Land value per hectare (€) | 0.0129 | (0.00366)*** |
| Farm size (ha) | -0.0156 | (0.000455)*** |
| Farm size$^2$ (ha$^2$) | 1.96E-05 | (1.08e-06)*** |
| Farmers' age (years) | 2.55e-05 | (0.000349) |
| Has off farm employment | -9.17e-05 | (0.0127) |
| Spouse has off farm employment | 0.0204 | (0.0107)* |
| Percentage land under tillage | 0.0619 | (0.0336)* |
| Has forestry | 0.0265 | (0.0153)* |
| Percentage land under dairy | 0.706 | (0.0452)*** |
| Percentage land under sheep | -0.0493 | (0.0418) |
| Sheep (LUs) | 0.00187 | (0.000353)*** |
| Cattle (LUs) | 0.000942 | (0.000288)*** |
| Dairy (LUs) | 0.00466 | (0.000475)*** |
| Has Teagasc advisor | 0.0211 | (0.00834)** |
| Unpaid labour units | 0.177 | (0.0129)*** |
| Price of car, elect, phone/ha prev year (€)^ | -0.0126 | (0.0180) |
| 1995 | 0.0991 | (0.0299)*** |
| 1996 | 0.085 | (0.0302)*** |
| 1997 | 0.0536 | (0.0303)* |
| 1998 | 0.0436 | (0.0302) |
| 1999 | 0.0515 | (0.0304)* |
| 2000 | 0.119 | (0.0306)*** |
| 2001 | 0.101 | (0.0304)*** |
| 2002 | 0.0594 | (0.0305)* |
| 2003 | -0.0322 | (0.0308) |
| 2004 | -0.0783 | (0.0322)** |
| 2005 | -0.122 | (0.0335)*** |
| 2006 | -0.154 | (0.0349)*** |
| 2007 | -0.21 | (0.0357)*** |
| 2008 | -0.218 | (0.0374)*** |
| 2009 | -0.342 | (0.0375)*** |
| 2010 | -0.324 | (0.0378)*** |
| Louth, Leit., Sligo, Cav., Don., Mon. | -0.103 | (0.0249)*** |
| Kildare, Meath, Wicklow | -0.0128 | -0.0288 |
| Laois, Longford, Offaly, Westmeath | 0.00967 | (0.0286) |
| Clare, Limerick, Tipperary N. | -0.0337 | (0.0293) |
| Carl., Kilk., Wex., Tipp S., Water. | -0.0114 | (0.0250) |
| Cork, Kerry | -0.0278 | (0.0272) |
| Galway, Mayo, Roscommon | -0.0937 | (0.0295)*** |
| Soil 1 | 0.17 | (0.0315)*** |
| Soil 3 | 0.119 | (0.0265)*** |
| Constant | 3.643 | (0.0439)*** |

Source: NFS 1994 to 2010 N = 19,412. OLS regression. SEs are in parentheses. ^Source: CSO (2013). Base year: 1994. Base soiltype: Soil 3. ***: p<0.01, **: p<0.05, *: p<0.1

**Table A.16: Cost function for the log of costs of other direct costs per hectare**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | -5.725 | (4.932) |
| Land value per hectare (€) | 0.0186*** | (0.00514) |
| Farm size (ha) | -0.00990*** | (0.000515) |
| Farm size$^2$ (ha$^2$) | 9.47e-06*** | (1.23e-06) |
| Farmers' age (years) | -0.00236*** | (0.000479) |
| Has off farm employment | -0.0243 | (0.0169) |
| Spouse has off farm employment | 0.00769 | (0.0146) |
| Percentage land under tillage | 0.00635 | (0.0122) |
| Has forestry | -0.0224 | (0.0213) |
| Percentage land under dairy | 1.081*** | (0.0554) |
| Percentage land under sheep | -0.659*** | (0.0482) |
| Sheep (LUs) | 0.00534*** | (0.000459) |
| Cattle (LUs) | 0.00524*** | (0.000346) |
| Dairy (LUs) | 0.00638*** | (0.000556) |
| Has Teagasc advisor | 0.0530*** | (0.0118) |
| Unpaid labour units | 0.0346** | (0.0167) |
| REPSxYear | 0.00286 | (0.00246) |
| 1995 | 0.0439 | (0.0328) |
| 1996 | -0.191*** | (0.0334) |
| 1997 | -0.191*** | (0.0334) |
| 1998 | -0.105*** | (0.0328) |
| 1999 | -0.178*** | (0.0330) |
| 2000 | -0.151*** | (0.0335) |
| 2001 | -0.313*** | (0.0328) |
| 2002 | -0.168*** | (0.0330) |
| 2003 | -0.258*** | (0.0330) |
| 2004 | -0.261*** | (0.0329) |
| 2005 | -0.284*** | (0.0334) |
| 2006 | -0.326*** | (0.0339) |
| 2007 | -0.354*** | (0.0342) |
| 2008 | -0.388*** | (0.0343) |
| 2009 | -0.346*** | (0.0347) |
| 2010 | -0.467*** | (0.0350) |
| Louth, Leit., Sligo, Cav., Don., Mon. | 0.0937*** | (0.0326) |
| Kildare, Meath, Wicklow | 0.0721** | (0.0357) |
| Laois, Longford, Offaly, Westmeath | -0.0346 | (0.0349) |
| Clare, Limerick, Tipperary N. | 0.0125 | (0.0361) |
| Carl., Kilk., Wex., Tipp S., Water. | 0.0739** | (0.0309) |
| Cork, Kerry | 0.0291 | (0.0322) |
| Galway, Mayo, Roscommon | -0.0204 | (0.0344) |
| Soil 1 | 0.460*** | (0.0352) |
| Soil 2 | 0.328*** | (0.0319) |
| Constant | 4.266*** | (0.0511) |

Source: NFS 1994 to 2010 N = 19,462. OLS regression. SEs are in parentheses. Base year: 1994. Base soiltype: Soil 3. ***: p<0.01, **: p<0.05, *: p<0.1

**Table A.17: Cost function for the log of costs of other overhead costs per hectare**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | 0.116*** | (0.00738) |
| Land value per hectare (€) | 0.0172*** | (0.00289) |
| Farm size (ha) | -0.00679*** | (0.000362) |
| Farm size$^2$ (ha$^2$) | 7.73e-06*** | (8.62e-07) |
| Farmers' age (years) | -0.00185*** | (0.000275) |
| Has off farm employment | 0.0150 | (0.00997) |
| Spouse has off farm employment | 0.0370*** | (0.00838) |
| Percentage land under tillage | 0.0161** | (0.00701) |
| Has forestry | 0.0218* | (0.0120) |
| Percentage land under dairy | 0.294*** | (0.0359) |
| Percentage land under sheep | -0.206*** | (0.0330) |
| Sheep (LUs) | 0.00279*** | (0.000279) |
| Cattle (LUs) | 0.00470*** | (0.000229) |
| Dairy (LUs) | 0.00677*** | (0.000381) |
| Has Teagasc advisor | 0.0568*** | (0.00654) |
| Unpaid labour units | 0.0238** | (0.0102) |
| Price of other overheads/ha prev year (€)^ | -0.00786 | (0.0157) |
| 1995 | 0.167*** | (0.0234) |
| 1996 | 0.167*** | (0.0240) |
| 1997 | 0.0827*** | (0.0240) |
| 1998 | 0.104*** | (0.0239) |
| 1999 | 0.111*** | (0.0241) |
| 2000 | 0.229*** | (0.0245) |
| 2001 | 0.188*** | (0.0248) |
| 2002 | 0.146*** | (0.0253) |
| 2003 | 0.119*** | (0.0256) |
| 2004 | 0.139*** | (0.0259) |
| 2005 | 0.103*** | (0.0267) |
| 2006 | 0.136*** | (0.0273) |
| 2007 | 0.160*** | (0.0277) |
| 2008 | 0.176*** | (0.0280) |
| 2009 | -0.00566 | (0.0287) |
| 2010 | 0.0523* | (0.0286) |
| Louth, Leit., Sligo, Cav., Don., Mon. | -0.0208 | (0.0194) |
| Kildare, Meath, Wicklow | 0.0235 | (0.0228) |
| Laois, Longford, Offaly, Westmeath | 0.0303 | (0.0225) |
| Clare, Limerick, Tipperary N. | 0.00987 | (0.0232) |
| Carl., Kilk., Wex., Tipp S., Water. | -0.0136 | (0.0197) |
| Cork, Kerry | -0.00959 | (0.0215) |
| Galway, Mayo, Roscommon | -0.0921*** | (0.0234) |
| Soil 1 | 0.207*** | (0.0250) |
| Soil 2 | 0.133*** | (0.0211) |
| Constant | 5.156*** | (0.0350) |

Source: NFS 1994 to 2010 N = 19,660. OLS regression. SEs are in parentheses. ^Source: CSO (2013). Base year: 1994. Base soiltype: Soil 3. ***: $p<0.01$, **: $p<0.05$, *: $p<0.1$

**Table A.18: Labour supply function for the log of hours spent working on-farm**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | 3.883 | (2.616) |
| Land value per hectare (€) | -0.00186 | (0.00297) |
| Farm size (ha) | -0.000276 | (0.000298) |
| Farm size$^2$ (ha$^2$) | -7.83e-07 | (7.13e-07) |
| Farmers' age (years) | -0.00750*** | (0.000374) |
| Farmers' age$^2$ (years$^2$) | 1.16e-05*** | (1.16e-06) |
| Has off farm employment | -0.274*** | (0.00953) |
| Spouse has off farm employment | 0.0278*** | (0.00799) |
| Percentage land under tillage | -0.0618** | (0.0263) |
| Has forestry | 0.00713 | (0.0115) |
| Percentage land under dairy | 0.330*** | (0.0313) |
| Percentage land under sheep | 0.0404 | (0.0282) |
| Sheep (LUs) | 0.000256 | (0.000256) |
| Cattle (LUs) | 0.00119*** | (0.000199) |
| Dairy (LUs) | -0.00167*** | (0.000310) |
| Has Teagasc advisor | 0.00824 | (0.00644) |
| Unpaid labour units | 0.420*** | (0.00952) |
| REPSxYear | -0.00192 | (0.00131) |
| 1995 | -0.00803 | (0.0142) |
| 1996 | -0.00590 | (0.0135) |
| 1997 | -0.000607 | (0.0129) |
| 1998 | -0.00263 | (0.0126) |
| 1999 | -0.0138 | (0.0123) |
| 2001 | -0.0298** | (0.0124) |
| 2002 | -0.00588 | (0.0124) |
| 2003 | -0.00745 | (0.0124) |
| 2004 | -0.0333*** | (0.0125) |
| 2005 | -0.0250* | (0.0129) |
| 2006 | -0.0198 | (0.0133) |
| 2007 | -0.0240* | (0.0136) |
| 2008 | -0.0191 | (0.0137) |
| 2009 | -0.0355** | (0.0140) |
| 2010 | -0.0343** | (0.0154) |
| Louth, Leit., Sligo, Cav., Don., Mon. | 0.00650 | (0.0196) |
| Kildare, Meath, Wicklow | 0.00135 | (0.0221) |
| Laois, Longford, Offaly, Westmeath | 0.0877*** | (0.0221) |
| Clare, Limerick, Tipperary N. | 0.0189 | (0.0219) |
| Carl., Kilk., Wex., Tipp S., Water. | -0.00362 | (0.0191) |
| Cork, Kerry | 0.0640*** | (0.0200) |
| Galway, Mayo, Roscommon | -0.00645 | (0.0220) |
| Soil 1 | -0.0986*** | (0.0199) |
| Soil 2 | -0.0859*** | (0.0175) |
| Constant | 7.407*** | (0.0233) |

Source: NFS 1994 to 2010 N = 18,232. OLS regression. SEs are in parentheses. Base year: 1994. Base soiltype: Soil 3. ***: p<0.01, **: p<0.05, *: p<0.1

**Table A.19: Labour supply function for the log of hours spent working off-farm**

| Variable | Coefficient (β) | Standard error (SE) |
|---|---|---|
| REPS | 20.06*** | (6.134) |
| Land value per hectare (€) | -0.0132* | (0.00751) |
| Farm size (ha) | -0.00101 | (0.000775) |
| Farm size$^2$ (ha$^2$) | 3.35e-06** | (1.63e-06) |
| Farmers' age (years) | 0.0146*** | (0.00288) |
| Farmers' age$^2$ (years$^2$) | -0.000236*** | (3.73e-05) |
| Has off farm employment | -0.0369** | (0.0175) |
| Percentage land under tillage | -0.0838 | (0.0690) |
| Has forestry | 0.00562 | (0.0308) |
| Percentage land under dairy | -0.267*** | (0.0894) |
| Percentage land under sheep | 0.118* | (0.0641) |
| Sheep (LUs) | -0.00497*** | (0.00114) |
| Cattle (LUs) | 0.000289 | (0.000586) |
| Dairy (LUs) | -0.00334*** | (0.00103) |
| Has Teagasc advisor | -0.0306** | (0.0154) |
| Unpaid labour units | 0.0428 | (0.0292) |
| REPSxYear | -0.0100*** | (0.00306) |
| Hours working on-farm (hrs) | -0.000374*** | (1.80e-05) |
| 1995 | 0.0389 | (0.0362) |
| 1996 | 0.00666 | (0.0333) |
| 1997 | 0.0639** | (0.0316) |
| 1999 | 0.0151 | (0.0303) |
| 2000 | 0.0674** | (0.0313) |
| 2001 | 0.0538* | (0.0313) |
| 2002 | 0.0835*** | (0.0312) |
| 2003 | 0.0996*** | (0.0313) |
| 2004 | 0.117*** | (0.0312) |
| 2005 | 0.122*** | (0.0320) |
| 2006 | 0.146*** | (0.0331) |
| 2007 | 0.155*** | (0.0343) |
| 2008 | 0.159*** | (0.0352) |
| 2009 | 0.137*** | (0.0367) |
| 2010 | 0.137*** | (0.0417) |
| Louth, Leit., Sligo, Cav., Don., Mon. | -0.142*** | (0.0469) |
| Kildare, Meath, Wicklow | -0.185*** | (0.0574) |
| Laois, Longford, Offaly, Westmeath | 0.0761 | (0.0548) |
| Clare, Limerick, Tipperary N. | 0.0641 | (0.0513) |
| Carl., Kilk., Wex., Tipp S., Water. | -0.0949* | (0.0494) |
| Cork, Kerry | -0.0589 | (0.0488) |
| Galway, Mayo, Roscommon | 0.125*** | (0.0470) |
| Soil 1 | -0.0700 | (0.0486) |
| Soil 2 | -0.0541 | (0.0410) |
| Constant | 7.514*** | (0.0636) |

Source: NFS 1994 to 2010 N = 4,491. OLS regression. SEs are in parentheses. Base year: 1994. Base soiltype: Soil 3. ***: p<0.01, **: p<0.05, *: p<0.1

# B. Appendix

**Table B.1: Probit on farmers' participation decision in REPS (first stage of the Heckman model)**

| Variable | β | SE |
|---|---|---|
| Farm income (€) | -0.00945*** | (0.000159) |
| Farm size (ha) | 0.00323*** | (0.000113) |
| Off farm job | -0.206*** | (0.00625) |
| Farmers' age | -0.0115*** | (0.000289) |
| Married | 0.403*** | (0.00705) |
| Children | 0.138*** | (0.00716) |
| Finished school | 0.183*** | (0.00594) |
| Agricultural education | 0.313*** | (0.00675) |
| Cattle | -0.507*** | (0.00846) |
| Cattle other | -0.299*** | (0.00823) |
| Dairy other | -0.553*** | (0.0114) |
| Dairy | -0.562*** | (0.0110) |
| Tillage | -0.093*** | (0.0121) |
| Peatlands | 0.0593*** | (0.00978) |
| Marginal grasslands | 0.120*** | (0.00623) |
| Forest | 0.201*** | (0.0128) |
| Wetlands | -0.325*** | (0.0158) |
| Reclaimed peatlands | 0.174*** | (0.00626) |
| Constant | 0.474*** | (0.0201) |

Source: NFS, N = 251, 942 (NFS frequency weights used). Coefficient (β) shows the log odds of participating in REPS. SEs are in parentheses. ***: $p<0.01$, **: $p<0.05$, *: $p<0.1$