Comparison of Different Studies to Analyse Adaptation on Dairy Farms

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COMPARISON OF DIFFERENT STUDIES TO ANALYSE ADAPTATION ON DAIRY FARMS

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Abstract

This paper compares and contrasts a number of farm-level modelling studies published in the academic literature. All of the studies examined adaptation on EU dairy farms in response to developments in agricultural policy and/or environmental legislation. The studies are compared on the basis of their respective aims, model structure, results and conclusions. Having reviewed the models and their application, the discussion section of the paper considers strengths and weaknesses of the studies and following from that it considers possible future developments in farm-level response modelling. The relevance and application of such developments in the context of an analytical study of adaptation in Irish dairy farms is discussed.

Introduction

Irish dairy farmers find themselves in a sector which continues to adapt and evolve in a world of constant change and dynamics. Recent decades have seen both the demise and growth of many of Irelands dairy farmers. Irish dairy farming utilises about 0.25 of the agricultural land and provides the main income for almost 28,000 farm households in the country. Average income for these full-time farmers in 1999 was €25,239 (Teagasc, 1999). Dairy farming is exposed to both internal and external forces of change and how the individual farm system responds to such pressure is system specific, site specific and ultimately farmer specific.

The pertinent question in Irish dairy farming at the moment is the implication of the implementation of proposed environmental regulations. The Nitrates Directive, Council Directive 91/676/EEC is the current most topical one. The Nitrate Directive concerns the protection of water against pollution caused by nitrates from agricultural sources (EEC, 1991). Though this directive is in place since 1991, Ireland is now the only EU member state which has not implemented it. Irish farmers face tighter environmental standards and recent initiatives by the EU necessitate that Ireland will have to comply with tight environmental directives that limit pollution and conform to the Code of Good Agricultural Practice. Modelling is required to determine the effect of changing policies on farm systems. Modelling will identify optimal ways to adapt to change. While positive or normative modelling methods may be applied, in this paper we concentrate on normative methods as positive methods are constrained to history and therefore of little relevance when examining adaptation to new policy measures.

The aim of this paper is to compare and contrast a number of farm-level modelling studies published in the academic literature in order to provide a basis for a farm level model of Irish dairy farming. All of the studies examined adaptation on EU dairy farms in response to developments in agricultural policy and/or environmental legislation.

Basic conceptual issues in modelling dairy farmer response

A model may be defined as 'an imperfect representation of reality. It is a logical and consistent abstraction that can be used as a laboratory for testing ideas and political proposals', (Hazell and Norton, 1986). Hazell and Norton explain that 'to be useful, a model has to be well grounded in theory but it also has to fulfil many practical requirements. It has to be appropriate to the problem at hand and to the available framework and the economics must be expressed in the model in an appropriate and interpretable way'. For a model to work successfully, it must be well planned, researched and have a strong conceptual framework behind it which clearly shows the relationships, links and flows within the model. The model must be clear in its purpose. It must be clearly stated for whom is the message and output from the model important. Will the model aid and inform farmers on how they should react to forces of change such as the imposition of environmental policy or will it provide government with information on available options to create a more environmentally friendly, competitive agriculture. While some features desirable in a model are difficult to judge e.g. strength of the conceptual framework, credibility, other facets are clear and easy to show. These facets allow us to compare and contrast the model structures employed in the studies. By doing such comparison and examining previous models, we can learn from their individual methods and approaches. The facets for comparison include:

Optimisation or Simulation. An optimisation model determines the optimum solution given the objective function and restrictions whereas a simulation model calculates the outcome of predefined sets of variables (Van Dyne and Abramsky, 1975). Simulation in general is to pretend that one deals with a real thing while really working with an imitation. While simulation programs model the flow and movement of entities, they never identify the optimum result. This is where optimisation has its advantage over simulation as it will identify the optimum adaptation required.

Static or Dynamic. A static model is stationary and does not include time as a variable whereas a dynamic model does account for time and its influence on farmer response (France and Thornley, 1984). To include time in a model which analyses adaptation is a vitally important feature as many farm investment decisions have gestation periods extending beyond a single agricultural year and their costs and returns are not uniformly distributed over their life. Such consideration is needed for accurate model building.

Stochastic or deterministic. A deterministic model makes definite predictions for variables while stochastic models contain probability distributions and/or random elements to deal with uncertainty in the behaviour of a system (France and Thornley, 1984). Deterministic models are those not specifically designed to cater for risk aversion.

A key influence in model design, conception and application is the availability of sound, detailed, relevant data. The availability of such accurate data will have a major bearing on the model's ability to predict and reflect the potential responses of dairy farmers to environmental policy. It must also be decided how representative the model will be. Will it reflect the resources and capabilities of the more intensive dairy systems alone or will the model have the ability to encompass producers from various levels of the production level spectrum i.e. small, medium, large and across a range of farming efficiency.

The essential quality criteria of model building are validation, verification and credibility. The most important merit a model can have is its credibility though this is primarily established through a combination of validation and verification. Without credibility, a model is worthless and of no use to farmers, policy makers or government. When planning the model and building the conceptual framework, one must always be conscious of how elements and activities included in the model lend to its credibility.

Dairy farm models from the literature

The four studies examined in this paper are:

- Choosing optimal milk production systems in a changing economic environment, V. Valencia and D. Anderson, 2000 (Study 1)
- European environmental regulations to reduce water pollution: An analysis of their impact on UK dairy farms, Dan Rigby and Trevor Young, 1996 (Study 2)
- Manure legislation effects on income and on N, P and K losses in dairy farming, P.B.M. Berentsen, G.W.J. Giesen and S.C. Verduyn, 1992 (Study 3)
- Impacts of changing relative prices on farm level dairy production in the UK, S. Ramsden, J. Gibbons and P. Wilson, 1999 (Study 4)

<u>Aim of the study</u>

Valencia and Anderson (2000) aim to determine the optimal milk production system on a typical dairy farm in Northern Ireland, assuming a wide choice of production technologies and under a range of possible economic conditions.

The aim of Rigby and Young (1996) is to explore the economic and environmental effects on the dairy sector of various environmental regulations, determining the size of reductions in both dairy production and income from dairying.

Berentsen et al., (1992) aim to quantify the consequences of actual and proposed environmental policies on labour income and the losses of N (Nitrogen), P (Phosphorous) and K (Potassium) on grassland dairy farms situated on sandy soil. The study also aims to examine whether the Dutch governmental objectives for the year 2000 can be reached in dairy farming.

Ramsden, Gibbons and Wilson (1999) aim to evaluate the impact of changes in milk to milk-quota leasing price ratios, nitrogen fertiliser and concentrate prices on the profitability of a technically efficient UK dairy farm. The authors are concerned with establishing the optimum adjustment strategies adopted by the technically efficient farmer assuming profitability to be the primary concern .

Model Structure

Table 1 gives an overview of the main characteristics from each model studied. All of the models sought to maximise a single objective function, they were all deterministic in their approach and none of the models took time or dynamics into consideration i.e. all were static.

Table 1. Overview of characteristics from studied models (based on Jalvingh, 1992)

Model 1	**Model 2**	**Model 3**	**Model 4**	
O	**S**	**O**	**O**	**Optimisation (O) Simulation (S)**
LP	**LP with environmental sub-model**	**LP**	**LP**	**Programming Technique**
N	**Y**	**Y**	**N**	**Inclusion of Environmental Dimension Y/N**
Y	**N**	**N**	**Y**	**Inclusion of alternative Enterprises Y/N**
Y	**Y**	**Y**	**Y**	**Different intensities of Farming represented Y/N**
Single Year	**?**	**Single Year**	**Single Year**	**Time Scale in the model**
Northern Ireland	**United Kingdom**	**The**	**United Kingdom**	**Country of origin**

		Netherlands		

Model 1: Valencia and Anderson, 2000

Model 2: Rigby and Young, 1996

Model 3: Berentsen et al., 1992

Model 4: Ramsden, Gibbons and Wilson, 1999

(? = If characteristic could not be determined from literature)

Valencia and Anderson (2000) constructed a single year LP model under profit maximisation assumptions. The model was developed to take into account an average growing season of 265 days and good drainage conditions. Two hundred activities were included in the model, of which three were alternative enterprises to dairying. Six technical factors were taken into consideration in the milk production activities: calving date, level of grassland production, silage quality, genetic potential of the cow, concentrate level and length of grazing season. The model is applied to a 55 hectare (ha) farm, which corresponds to the adjusted forage area available to medium sized dairy farms in Northern Ireland. In terms of flexibility, the model allows additional land, to a maximum of 50% of total owned land, to be rented in as well as additional milk quota above the 380,190 litre owned quota. The model also allows additional labour to be hired (max 30% of family labour). Milk yield per cow is allowed to adjust in line with the optimal solutions identified under each scenario analysed. Having constructed the model, Valencia and Anderson (2000) subject the model to six alternative scenarios. The scenarios examined differ in respect of five variables (1) autumn calving milk price (p/litre), (2) spring calving milk price (p/litre), (3) concentrate price (£'s/tonne), (4) milk quota constraint, (5) dairy cow premium. For each individual scenario, the optimum milk production system is identified assuming all other factors remain constant.

Rigby and Young (1996) consider specialist dairy farms in the North West of England for their study. The study uses LP farm models that include the economic relationships driving production on the farm, linked to an environmental sub-model which combines this economic information and the physical features of the farm to generate pollution information. Twenty three individual farms from the Farm Waste Handling Survey (WHS)were selected to be modelled, ordered by herd size and their response to policy imposition simulated. Five initial herd sizes were chosen ranging from 0-44 dairy cows to >112 dairy cows. Each of the 23 LP farm models was of the standard LP format, with the production process approximated using linear constraints. The objective functions for the farms were specified as a total gross margin maximisation representation, with gross margins and most non-feed costs incorporated. The model contains a replacement balance constraint which ensures that farms have enough followers to maintain the dairy herd at its present size. All farms are assumed to continue with their current practice regarding herd replacement. All dairy farms are limited in their production by their allocation of quota, which is initially set in the model at that level which would allow the farms to produce milk at the observed level. In addition, each farm is able to lease quota in or out. Included within each LP model is a Fertiliser Response Function (FRF) which relates the level of fertiliser applied to each hectare of land, to the level of total variable costs and the quantity of animals the farm can support. The methodology also involves the construction of a Risk Index. The purpose of this index is to relate the various factors on a farm that may contribute to the generation of a pollution incident to a single scale and produce a single index value to allow cross-farm comparison.

The policies simulated are all concerned with the amount of waste that agricultural producers may discharge. The farm LP models are run in terms of two individual sets of policy and their respective restrictions: (1) EU regulations; (2) Dutch regulations. (The EU guidelines regulate the quantity of nitrogen from animal waste that may be spread per hectare of farmland. The Dutch policies concern the quantities of phosphate produced by livestock). This allows the effect of regulation on gross margins to be gauged. The restrictions of 210 Kg N/ha and 170 Kg N/ha are imposed as binding limits, by adding an extra constraint to each LP model. It is therefore possible to determine the maximum herd each farm would be allowed under these regulations. This will indicate which, if any, of the twenty three farms would be affected by the policy. For those farms whose current herd exceeds that allowed by the regulation, the effect of reducing the herd accordingly can be simulated in both the LP and environmental models. In this way, the effect of the guidelines on, for example, herd sizes, total farm gross margins, BOD (Biological Oxygen Demand) per hectare and the Risk Index can all be simulated. Using provided estimates of the amount of nitrogen produced in the waste of cattle, the authors indicate the permitted herds under the 210 Kg N/ha and those permitted by the 170 Kg N/ha. They also give the actually existing herd numbers on the farms. The farms may respond to policy imposition by reducing their livestock numbers, applying inorganic fertilisers less intensively and by leasing out quota which they may no longer use to produce milk. By entering the new results from the LP models into an environmental sub-model (following the imposition of regulations), the effect of policy on pollution load and risk can also be assessed.

Berentsen et al., (1992) present a linear programming model of a typical grassland dairy farm situated on sandy soil. The model seeks to maximise labour income of the farm. In its application, the model is characterised by a cultivated area of 24 ha, a milk quota of 288 000kg and a milk production per cow per year of 6695kg. The basic element in the model is a dairy cow, calving in February. The cultivated area can be used for producing grass, maize and fodder beets. The farm has a storage capacity for two months under the slatted floor in the cowshed. In terms of flexibility the model is relatively fixed in its structure and does not allow for the leasing in or out of additional land or milk quota. Milk production per cow per year is constant at 6695kg. The study includes multiple model rows to represent different intensities of farming i.e. milk quota 8000kg/ha and 16000kg/ha. In their method, the authors identify six decision variables which they see as affecting nutrient use and nutrient losses. These variables could also be viewed essentially as potential pollutant variables: (1) the animal density on the farm, (2) the feed ration of the cows and young stock, (3) the method and length of storing slurry, (4) the method of applying slurry to the land, (5) whether the land is used for grassland or fodder crops, (6) level of nitrogen application on grassland. Losses of nutrients from runoff, leaching and denitrification are determined by subtracting the nutrients that are removed from the land with grass or with fodder crops from the nutrient input to the land. The optimum farm results for 1990 were calculated with the model. After that, the relevant policies for the years between 1990 and 2000 were incorporated in the model. For every year following a change in policy (i.e. 1991, 1995 and 2000) new optimum results were calculated. The legislation included in the model related to (1) method of applying slurry, (2) method of storing slurry, (3) P2O5 limit kg/ha, (4) Nitrogen (N) limit all crops kg/ha. The effects of policies can be determined by comparing the results of the different years.

In their methodology, Ramsden, Gibbons and Wilson (1999) describe an 80 ha farm divided into four 20 ha rotational blocks within which forage crops and arable crops can be grown. The model includes calves, heifers, cows and retained male calves. Two types of skilled labour are available as well as additional casual and contract labour. The model details a dairy component, beef component, feed component as well as machinery and labour costs. The objective function is the maximisation of farm net margin. The authors make reference to the fact that previous LP models of livestock systems lack the flexibility required for comprehensive adjustment strategies. In response to this, they include five alternative annual milk yields of 5000, 6000, 7000, 8000 or 9000l. The model also allows for both the leasing in and out of quota. The authors 'describe a farm level model that attempts to incorporate a fuller range of adjustment strategies available to farmers to respond to changing input/output price ratios'. Model size reflects the detailed specification of physical relationships. All production relationships are specified on a weekly basis, thus enabling changes in resource availability and use over the farming year to be fully represented. The model is initially run, analysed and subsequently exposed to changes in the milk/quota-leasing price ratio as well as variation in nitrogen and concentrate prices.

Results

Having constructed their model and subjected it to the scenarios previously described, Valencia and Anderson (2000) presented the following results. The optimum plans clearly show the changes required in production systems and management methods in response to the stresses on the system i.e. changes in price, abolition of milk quota, presence/absence dairy cow premium. The optimum plans for scenario 4,5 and 6 for example were very different from those recommended for scenarios 1, 2 and 3 as milk quota had been removed. In these scenarios, the adaptation responses shown involve conversion to autumn calving herds, the use of high genetic potential cows and the feeding of high quality silage. Consequently, milk yields increase to 8,700 litres. The paper also illustrates the consequent effect of change on farm profit, other enterprises included in the optimal plan and the marginal value of the binding constraint on dairying for each scenario, compared to the initial scenario run i.e. scenario 1. Having presented the optimum systems and detailed the changes included, Valencia and Anderson (2000) include some recommendations regarding what changes and adaptations may be required in management practices in order to realise the identified systems. They do highlight however that certain details of the optimum solution may not always be achievable and in many cases may rely upon the managerial ability of the farmer.

Having combined their LP model with an environmental sub-model and the imposition of regulations, Rigby and Young (1996) show that two farms suffered a fall in total gross margin of 7.5%, one farm suffered a decrease of 9.2% and the greatest fall of 16% was experienced by just one of the 23 farms studied. (Changes in gross margin were not shown for the remaining farms). Though the authors indicate that the environmental sub-model yields a number of pollution indicators, only one is mentioned in the paper in addition to the Risk Index. This indicator is the BOD load per hectare of farmland. Having imposed the 170kg N/ha regulation limit, its effect on the measured BOD load per hectare of each farm was discussed. The results show that some of the farms restricted by the limit have their BOD/ha level reduced whilst other farms which have a considerably higher BOD/ha (caused by factors other than N) are left unaffected. One particular farm which has the third highest level of BOD/ha is unaffected by either of the nitrogen limits. The impact of the 170kg N/ha shows that all but one of the farms which were forced to reduce their herd size experience a fall in their risk index. The results also show that none of the farms are affected by any stage of the Dutch regulations between 1987 and 1997, only one farm is restricted by the 1998 limit and only the regulation for 2000 affects more than one farm.

Berentsen et al., (1992) present the optimum farm results for 1990 and the subsequent optimum plans following the imposition of regulations. The results illustrate the effect of such policies on labour income and nutrient balances of the farm. For every nutrient, the input, the output, the losses and the efficiency at farm level are given. The results clearly depict how the dairy system responds to the imposition of legislation through variation in crops sown, areas planted and investment in fixed assets. In 1991 the farm plan does not change compared to 1990. However, an investment in an open slurry storage facility is done to meet the restrictions on the period in which manure can be applied. 1995 sees the extension of grassland and consequent cut in the area of silage maize. The costs however of purchased fertiliser decrease as a result of the lower N-level on grassland, the increased amount of slurry that is injected and enclosing the slurry storage. The only change in the model between 1995 and 2000 is a more severe P2O5 limit. This has no influence on the results because its input is already lower than the limit.

The results presented by Ramsden, Gibbons and Wilson (1999) clearly illustrate the adaptation strategies chosen as a result of changes in relative prices but it also quantifies the financial implications of failure to adapt ones dairy system by fixing the model structure and allowing it to run under the new price ratios. "There are substantial financial penalties in not adjusting yield/cow to changing relative prices, particularly for high yielding herds in a situation of falling relative milk output prices". This is a unique feature of the study as none of the other studies considered quantify the financial implication of non-adaptation. The results generated by Ramsden, Gibbons and Wilson (1999) depict the various effects on the dairy system as a result of the specific adaptation response. The incorporation of variable feed input and milk output levels, substitution between feed inputs, variation in nitrogen use and stocking rate and variable levels of labour and machinery does allow a comprehensive range of adaptation strategies to be modelled.

Conclusion

Valencia and Anderson (2000) conclude that the optimal system in all scenarios where milk quotas were in place involved spring calving herds, medium genetic potential cows, medium quality silage, high grassland production and extended grazing. In a no milk quota situation, the optimal production system changed dramatically. While grassland production and the length of the grazing season remained unchanged, the optimal system in all of the scenarios where milk output was unrestricted by quotas involved autumn calving herds, the use of high genetic potential cows and high quality silage. In addition to these changes, the concentrate and silage level increased while the grazing requirement decreased significantly. Sensitivity analysis found that the model's results were generally robust to changes in the assumptions regarding the seasonal milk price, the replacement rate for high genetic potential cows and the costs of concentrates and silage. In general, this work has illustrated the decision support role which LP farm models can play in the choice of optimal milk production system.

Rigby and Young (1996) conclude that while the results of the LP models indicated that the sampled farms posed little or no pollution threat, these results are rejected for two reasons. The first was that, given the polluting role of the type of farms modelled, such a consideration seemed inappropriate. Furthermore, the Risk Index scores generated by the farms did not support the view that they posed little or no pollution threat. They also discuss the issue of targeting policy and its importance. Finally they conclude that a farms pollution threat cannot simply be reduced to its stocking rate or nitrogen application rate.

Berentsen et al., (1992) conclude that the policies appear to be successful in decreasing the ammonia emission on the farms under consideration though the level of reduction stated by government is not realised. Taking into account the animal density on the farms, it is not strange that the P2O5- limit has no effect. The labour income per hectare decreases by Dfl. 244 (extensive farm) up to Dfl. 532 (intensive farm) due to increasing costs. The majority of these costs are the result of an investment in a closed slurry storage. The paper also concludes that the importance of the feed ration with respect to nitrogen losses is underestimated in the model.

Ramsden, Gibbons and Wilson (1999) conclude that “with cereal-based feedstuffs becoming less expensive under Agenda 2000 and reform of the EU dairy regime being postponed until 2005, technically efficient farmers in the UK will maintain profitability by continuing with strategies based on high yielding cows being fed high levels of concentrate feeds”.

Discussion and Conclusion

This paper compares and contrasts a number of farm-levelling modelling studies published in the academic literature. All of the studies examined adaptation on EU dairy farms in response to developments in agricultural policy and/or environmental policy. The ability to study and compare such responses is a fundamental learning experience which highlights the successes and limitations of different methods, the approaches and techniques which can be built upon and further developed, the weaknesses that can be learnt from, reassessed and indeed reapplied. By studying previous work, can future progress be mapped.

The use of scenario analysis and sensitivity analysis by Valencia and Anderson (2000) is a very effective method and clearly illustrates the potential implications of change to the dairy industry. The inclusion of such enterprises lends itself very readily to increasing the representativeness of the model. Their inclusion also broadens the options and scope for the farmer in his adaptation response. This dimension would merit inclusion in the Irish model. However, the movement from a spring calving, medium genetic potential herd to an autumn calving, high genetic one, following the abolition of milk quota, does merit question and further explanation as the authors fail to explain why such fundamental changes occur in the optimal systems identified.

Rigby and Young (1996) offer many interesting views in their paper. They too, identify variables which they see as key factors when considering the pollution load generated by a farm. Again, the identification of such factors offers direction and thought to the Irish study. Much of the interesting points which they raise offer considerable scope to the discussion section from an Irish perspective. The issue of actual spreading land and its effect on optimum systems and profitability, the generation of a risk index and the polluting potential of a farm and any policy which attempts to use a single variable such as stocking rate or nitrogen application rate as a proxy for potential pollution threat runs the risk of being inaccurate. This raises the question of the efficiency in targeting policy. Following the presentation of their results however, one would wonder if the authors ever did question the validity of their models or the accuracy of model structure and parameters as though the model itself indicated that the sampled farms posed little or no pollution threat, the authors rejected this finding for reasons already explained.

Berentsen et al., (1992) is an example of a modelling study which sought to answer many of the questions raised by the Dutch farming community with the threatened imposition of various environmental regulations. The paper examines in detail the issue of nutrient use and nutrient losses, an area highly topical yet lacking emphasis in an Irish content. In the paper, the authors identify the most important decision variables affecting both nutrient use and losses on the farm. The identification of such variables in very interesting and highly applicable to the Irish study as little modelling work has been conducted in this area for an Irish context. Such an approach could be applied to the Irish model. The paper examines government policies concerning environmental problems caused by agriculture. The paper highlights that the measures discussed by government are related to the application and storage of slurry and the period of applying manure and the level of nutrient use on the land. Both these measures are very applicable to the Irish study as two of the key issues in the environmental debate are the proposed ban on slurry spreading from November to March and the consequent need for greater slurry storage facilities on Irish farms.

The methodology employed in the model is also very interesting to examine. The optimum farm results for 1990 were calculated with the model followed by the incorporation of the relevant polices for the years between 1990 and 2000. For every change in policy, new optimum results were calculated. This format lends itself very well to clarity, understanding and ease of comparison for different policy amendments. The study offers very valuable results on the potential impact of proposed restrictions and regulations. To date, little such work has been conducted in an Irish content on such potential restrictions. With both farmers and farming organisations calling for answers to imperative questions governing the future viability of many of Irelands farm systems, further detailed research and study is needed. The Irish modelling study aims to contribute grounded, tested and validated knowledge to the heated debate. The Irish study aims to represent different intensities of farming. This dimension was included in the Berentsen et al., (1992) model. To gain some insight into the impact of the intensity of the farm, additional calculations were made with a milk quota of 8000 kg/ha and 16000 kg/ha. It is envisaged that the Irish study will be representative of dairy producers in Ireland and will encompass producers from various levels of the production level spectrum i.e. small, medium, large and across a range of farming efficiency.

The methods and scenarios applied by Ramsden, Gibbons and Wilson (1999) are very effective in illustrating the direct impacts on UK dairy farms of various changes in input/output price ratios. Many strengths of the model can be both applied and built upon. The method employed of varying input and output prices is very effective as it clearly identifies and quantifies the knock-on effects across the farm system. Such an approach could be utilised for the main study as various environmental regulations and limits on slurry/fertiliser application could be applied to the model and the corresponding effects observed, just as observed with changing input/output price ratios.

When looking to the future and possible developments in farm-level response modelling, the importance of dynamics in model design and construction cannot be overstated. To include time in a model which analyses adaptation is a vitally important feature as many farm investment decisions have gestation periods extending beyond a single agricultural year and their costs and returns are not uniformly distributed over their life. Such consideration is needed for accurate model building. The inclusion of time and dynamics in a model allows the farmer to clearly see the specific steps required and changes experienced each year as s/he aims to optimise. Such scope is not offered by static models.

Presently, it is envisaged that the initial model for the Irish study will employ static, single objective LP. The model will be a profit maximising model of a typical grassland dairy farm with a strong environmental dimension. The model will include basic activities such as milk production, calving pattern, grassland management and N, P and K applications. Mathematical programming farm level models have been identified as a suitable methodology for the study. It is felt that the innovative dimension to the study can be added through the inclusion of dynamic modelling and also the development of multiple goal techniques and decision strategies as in reality, a farmer has multiple objectives which s/he seeks to satisfy rather than a single objective such as profit maximisation.

'For ultimate success, one must sense the future and at times sense that future in a very uncertain world. Success comes to those who first see the threats and opportunities and react the fastest', (Denis Brosnan, 2001). The ability to identify and recognise the need for change, the willingness and readiness to adapt to such change and ultimately the ability to plan successfully into the future is a skill which dairy farmers must perfect to ensure survival in an ever changing environment. By recognising the threats and adapting to make them your opportunities can future survival and growth be achieved.

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