# Development and application of a whole farm bio-economic model for Northern Ireland dairy systems

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## Abstract

Dairy farm businesses continue to face many challenges and in future years will have to make decisions that are critical in terms of the farming systems they choose to operate alongside giving consideration to adapting systems in order to maintain profitable and sustainable businesses going forward. In this context, there is a need to develop a model to explore a range of systems from both an industry and policy perspective. Farmers will require advice and guidance in relation to which systems or adaptations to systems will be best under a range of factors. This study developed a whole farm dairy model for Northern Ireland. This paper provides an overview of the model developed and an application looking at three different dairy systems and the effect of price changes on them.

## Introduction

Dairy farming is the largest agriculture sector in Northern Ireland in terms of output and contribution to overall GDP. However, as a sector it is facing many challenges over the coming years and in this context, farm businesses will be faced with decisions associated around which farming system to adopt and/or which new technologies to implement on farm. Farmer decision-making is influenced by a range of factors; a farmer's own knowledge of scientific and technological issues, their attitudes to risk, capital and labour availability, environmental issues and the wider policy framework. At an industry level, it is important to have a method of assessing how such factors impact on farming systems within the conditions prevailing in a particular geographical region. This study aimed to develop a whole farm dairy model for Northern Ireland and provide an application of the model by looking at three different dairy systems. The model developed will provide an important framework to explore and guide decision making and resource-use at farm level.

## Methodology

The model is a whole farm, single year, static, deterministic simulation model that facilitates the technical and economic evaluation of dairy production systems. It operates with a monthly time step and was developed in Microsoft Excel. The model is empirical and uses data from production research experiments to specify coefficients and production functions (e.g. grazed grass dry matter digestibility and energy content, milk yield and the monthly proportions of grazed grass and grass silage in the diet). Where alternative production functions are available, the model structure allows these to be used. The user must define the farm land area owned and the production system choices. Dietary components consist of grazed grass, grass silage and concentrate (which is purchased when required). The model consists of four sub models namely; the farm system, animal nutrition, feed supply and financial.

Three different dairy systems were examined in this study - Low, Medium and High. In the Low system, cows calved in the Spring and produced 6,000L per lactation. In the Medium system cows calved in the Autumn and Spring and produced 8,000L per cow. In the High system cows calved all year round and produced 10,000L per cow. Farm size was assumed to be 70ha and stocking rate was set at 170kg organic N/ha. The effects of changing milk, concentrate, fertiliser and electricity prices on the profitability of the three systems was analysed.

**Results**

The High system produced the largest volume of milk, had the highest feed requirement and, therefore, carried the lowest number of cows on the fixed land base of 70ha (Table 1).

**Table 1.** Physical outputs of dairy systems studied using the AFBI Dairy Systems Model

| | **Low** | **Medium** | **High** |
|---|---|---|---|
| Area farmed (ha) | 70 | 70 | 70 |
| Stocking rate (CE/ha) | 1.77 | 1.78 | 1.79 |
| Milk yield (L/cow) | 6,058 | 8,009 | 10,031 |
| Average number cows | 101 | 98 | 95 |
| Total milk produced (L/farm) | 618,586 | 781,061 | 953,635 |
| Concentrate fed (kg/cow) | 1,032 | 2,008 | 3,313 |
| Grazed grass (kgDM/cow) | 3,603 | 2,963 | 1,261 |
| Grass silage (kgDM/cow) | 2,245 | 3,879 | 6,975 |

As shown in Table 2 the Medium system was found to have the highest net profit per farm and cow, the Low system had the smallest net profit per farm and cow. However, net profit per litre was highest for the Low system.

**Table 2.** Profitability of dairy systems using the AFBI Dairy Systems Model

| | **Low** | **Medium** | **High** |
|---|---|---|---|
| **Sales (£/farm)[1]** | 274,532 | 340,839 | 406,295 |
| Variable costs (£/farm)[2] | 125,665 | 176,763 | 246,003 |
| **Gross margin (£/farm)** | 148,867 | 164,076 | 160,293 |
| Fixed costs (£/farm)[3] | 74,895 | 76,494 | 78,007 |
| **Net profit (£/farm)** | 73,972 | 87,583 | 82,285 |
| **Net profit (£/cow)** | 732 | 894 | 866 |
| **Net profit (ppl)** | 12 | 11 | 9 |

1 Milk price 40ppl, 2 Concentrate price £400/t, Fertiliser price £650/t,

3 Electricity price £0.25/kwh

As shown in Table 3, all price changes had the biggest effect on the High system and the smallest effect on the Low system, reflecting the level of inputs and milk sales from these systems. Overall, in this analysis milk price changes had the largest effect on profitability, followed by concentrate price changes, then fertiliser price changes, with electricity price changes having the smallest effect on profit.

**Table 3.** Effects of changing milk, concentrate, fertiliser and electricity price on the net profit of dairy systems using the AFBI Dairy Systems Model

| Impact on farm net profit (£) | Low | Medium | High |
|---|---|---|---|
| Milk price (+/-5ppl) | 30,929 | 39,053 | 47,682 |
| Concentrate price (+/-£20/t) | 2,652 | 4,010 | 5,718 |
| Fertiliser price (+/-£50/t) | 2,180 | 2,570 | 2,768 |
| Electricity price (+/-5p/kwh) | 1,667 | 1,795 | 1,907 |

The range of cost and price changes included in the analysis resulted in a re-ordering of the profitability of the systems. Increasing and decreasing milk price by 5ppl, resulted in the High system becoming the most and least profitable, respectively. Furthermore, the Low system became the most profitable when milk price decreased by 10ppl. Decreasing concentrate price by £60/t, resulted in the High system becoming almost as profitable as the Medium system. However, when concentrate price increased by £60/t, the High system became the least profitable.

## Conclusion

The AFBI Dairy Systems Model has been developed which can be used to analyse how changes in physical and economic factors affect farm performance. Going forward, this will provide an important research tool informing and supporting decision-making at the farm level in Northern Ireland.

The application of the model in this study found that the Medium system (autumn/spring calving, 8,000l/cow) was the most profitable. It also remained the most profitable across most of the price changes examined. Profitability of the High system was the most sensitive to price changes and the Low system the least. Furthermore, changes in milk and concentrate price can cause re-ranking of the systems in terms of overall farm profitability.