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Analysing the Economic Performance of Irish Dairy Farmers 1998-2006

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Abstract

This paper reviews the economic performance of Irish dairy farms over the period 1998 to 2006. Econometric techniques are employed to examine the variation in cost structures and to identify the factors affecting farm profitability. The overall objective of the paper is to establish the long term sustainability of dairy farming in Ireland and to explore the ability of farmers to cope with the potential price volatility that may arise out of a WTO agreement or reforms to the EU milk quota regime. National Farm Survey data from Ireland are used to analyse production costs. Average cost curves are shown for the Irish dairy industry and are compared to the results of similar analysis conducted for England and Wales.

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1. Introduction

European policy agreements of the last number of years, such as Agenda 2000 and the Mid Term Review of the Common Agricultural Policy, have resulted in a downward trend for milk price, albeit with some recent spikes, brining European prices closer to the world market level. This increased exposure to world markets, in conjunction with an erosion of world stocks of dairy products, means that European dairy farmers will increasingly be more exposed to price volatility in the future. Increased price risk necessitates that dairy farmers must be prepared to cope with possible cost price squeezes and that cost efficiency will be key to future sustainability. The objective of this paper is to explore the cost structure of dairy farmers in Ireland with a view to determining their ability to cope with price risk.

The paper begins with a background section exploring research conducted into the Irish dairy sector as well as studies conducted elsewhere examining cost structures. Following this the methodology section outlines the empirical approach adopted and describes the dataset. The final two sections of the paper present the key results of the analysis and discuss the implications for the future of dairy farming.

2. Background

Recent studies of dairy production around the EU have highlighted the cost efficiencies achieved at farm level. For example, Colman and Zhuang (2005) estimated that the English and Welsh dairy farming sector achieved on average a 1.5 percent reduction per annum in total costs of production in the period 1996 to 2003. Pierani and Rizzi (2003) conducted an economic analysis of Italian specialist dairy farms and concluded that cost savings of 3.5 percent per annum were realised in the period 1980 to 1992. The costs of production on dairy farms in Ireland have been compiled for many years by Fingleton (2004). The analysis conducted by Fingleton showed that cost efficiencies were achieved by the dairy farming sector in general from the late 1990s to the early 2000s but that a large variation in costs between farms continued throughout the time period.

The results of Fingleton's analysis show that the difference in costs of production between the best 20 percent of farms and the poorest 20 percent was 11 cent per litre in 2000, which is a cost difference of €27,500 for the average quota size of 250,000 litres. To date relatively little analysis has been conducted in Ireland on the factors affecting cost structures and the reasons for such large variation in costs between farms. The objective of this paper is to draw on research conducted elsewhere to develop empirical models that explain cost structures.

The seminal paper by Burton (1995) developed a cost function for dairy farms in England. A cost function specifies efficient use of resources, using the least cost combination of inputs to produce an output. Kadlec (1965) states that cost curves can be interpreted to indicate optimum size under present technology. Burton's cost function is as follows:

$$C_i = \beta_0 + \beta_1 X_i + u_i$$

Where C=Total cost and X=output.

Colman and Zhuang (2005) used the specification of Burton's cost function to compute a cost function for the English and Welsh dairy farming sector for 1996 and 2003. Their analysis showed that all the explanatory variables were U shaped, meaning that costs of production (economies of scale) were achieved as curve decreased to the minimum point and costs increased thereafter (diseconomies of scale). Colman and Zhuang (2005) also demonstrated the average and marginal cost curves for England and Wales for 1996 and 2003. The results show that herd sizes up to 174 cows have reduced costs from 1996 to 2003.

The average cost function provides some insight into the factors affecting the variation in farm cost efficiency. It is also interesting to consider the variation in individual farms' costs through time. The Center for International Studies and Co-operation (CECI) (2007) cites mobility of cost, or the ability of farmers' to decrease their own costs, as a major determinant in the profitability of cotton farms. Phimister et al (2004) used survival analysis to investigate the farm income mobility of Scottish farms.

Phimister et al disaggregated the farm population into quintiles on the basis of income. Using hazard and survival analysis the study shows that identifying the characteristics of farmers that move positively between quintiles, i.e. increase their farm profit, provides important information about the dynamics of farm profit. Employing the methodology of Phimister et al (2004) to costs of production on Irish dairy farms may provide insight into the factors affecting farmers' ability to manage their own costs.

3. Methodology

A two step empirical approach is adopted in this paper. First cost structures are described using a number of statistical techniques and following this a number of models are developed to explain the factors affecting cost structure. The following sections of the paper describe the dataset employed in the analysis and the empirical approach.

3.1. Data

Irish national farm survey data (NFS) from 1998 to 2006 was used in the course of this study to compile and analyse production costs on dairy farms. The NFS is a member of the Farm Accountancy Data Network of Europe and surveys approximately 1200 farms annually. These farms are assigned a weighting factor which enables an aggregation process to represent the full farming population of approximately 115,000 farms. For the purposes of this study only the data collected on dairy farms is used, this is a sample of approximately 340 farms in each year. Some manipulation of this data is required to calculate total costs of production.

The NFS data collection process allocates direct costs of production to specific farm businesses; see Connolly and Kinsella (2006). This facilitates the calculation of direct costs of production per unit of output. However, overhead or fixed costs are not assigned to individual enterprises. In this paper the fixed costs associated with the dairy enterprise are calculated by estimating the proportion of total farm gross output emanating from the dairy enterprise and allocating an equivalent amount of fixed costs to the dairy enterprise. For 2005 and 2006 overhead cost calculation, the Single Farm Payment was taken the out of the farm gross output variable. Furthermore, all references to total costs in this paper include cash costs only. The cost of the farmer's own labour and land are not included in this analysis. Previous studies of cost efficiency have attempted to impute owned labour and land costs, see for example Franks (2001). Due to the heterogeneity of land and labour and the consequent difficulty of sourcing appropriate valuations for both resources the calculations of costs in this paper includes cash costs only. The difficulty of imputing owned labour costs is further compounded by the fact that only total labour on the farm is recorded and not the labour allocated to individual enterprises. Therefore, it would be necessary to assign particular shares of the total labour recorded to the dairy enterprise before the cost of owned labour could be estimated.

This analysis considers specialist dairy farms only. A specialist dairy farm is defined as a farm which derives more than 66% of total farm gross output from the dairy enterprise. The dataset employed in the analysis also excludes dairy farms with herds of 10 cows or less and includes only farms producing manufacturing milk, i.e. farms with contracts to supply liquid milk are excluded. There are approximately 3000 observations, about 340 farms each year. The table below summarises some of the key statistics from the data.

Table 1. Summary Statistics for Specialist Dairy Farms

Year	**1998**	**2001**	**2004**	**2006**
Herd Size (Cows)	38	44	45	50
Farm Size (Ha)	38	43	44	47
Age (Years)	47	47	49	51
Yield (Litres)	4369	4880	4944	5028
Cow per Ha	1.12	1.08	1.05	1.02
Family Farm Income (€'s)	24242	34426	34421	36221

3.2 Empirical Approach

3.2.1 – Describing cost structures

Once the dataset has been compiled cost structures are described. First year to year efficiency is described by developing annual cumulative cost curves. The NFS data can be used to calculate the cumulative total cost function for the Irish dairy farming industry which provides an indication of the proportion of milk nationally produced at different prices, Colman and Zhuang (2005). Producers are ranked in ascending order of cost per litre of production and the cumulative amount or percentage of milk produced below any particular cost is calculated and plotted. Cumulative cost curves are derived for a number of years allowing us to determine whether total sectoral efficiency is increasing or decreasing.

As well as considering cost variation across time, variation between farms is also considered using a quintile analysis. The dataset is grouped into 5 groups on the basis of costs of production. The variation across farms is measured and the characteristics of low cost farms are identified.

3.2.1 – Explaining cost structures

A number of empirical models are developed to explain the factors affecting cost structures. Drawing from the literature review the ad-hoc average cost function used by Colman and Zhuang (2005) is employed as the average cost function in this research as per equation 1. An ordinary least squared regression is implemented to determine which of the independent variable are statistically significant in affecting cost.

$AverageCost_t = f($ Cows, Cows², Concentrate per cow, Concentrate per cow², Yield per cow, Yield per cow², Cow per Ha, Fair soil, Good soil and Farm size)

Equation 1

Where,
Average Cost = Total costs/ total milk quantity
Cow= Herd size
Cows² = Herd size squared
Concentrate per cow = 50kg of concentrates per cow
Concentrate per cow² = 50kg of concentrates per cow squared
Yield per cow = Yield per cow in litres
Yield per cow² = Yield per cow in litres squared
Good soil = Soil quality
Fair soil = Soil quality
Farm size = Farm size in hectares

As per the Colman and Zhuang (2005) study, the coefficients of the regression analysis are also used to plot economies of scale.

The cost mobility of farms is also considered using the quintile analysis. This allows us to investigate if low cost farms are always low cost or if there is some mobility between the cost groups. Survival and hazard analysis are used to investigate cost mobility.

Consider time t as the entry point for a farm into the survey (this may be in different years depending on when the farmer entered the survey), this farm is in a given quintile from quintile 1(low costs) to quintile 5 (high costs) according to cost in relation to all other farms. If j measures the duration (in years) of a particular farm in a quintile, a survival S_j and hazard h_j function can then be derived.

The survival function is the probability that a duration in a quintile lasts beyond year j. The other important concept in survival analysis is the hazard rate. The hazard function is the probability that a farm exits out of the quintile between the year j-1 and j, i.e. the probability that the farm improves or disimproves costs. A Weibull proportional hazard model is used to test if there was a relationship between farm characteristics and the probability of improvement. To examine the link between farm characteristics and spells in high (low) costs a proportional hazard model is used,

$$h_j(x_i) = h_{j0} \exp(x_i \beta)$$

where h_{j0} is the baseline exit hazard and x_i is the vector of covariates assumed to influence the hazard (Phimister et al. 2004).

Using 1998 as the base year, each farm is examined to determine if they improved, regressed or stayed in the same cost quintile from year to year. Farms are assigned a value of one if they improve from year to year. The survival analysis is then conducted to establish the probability of improving cost structure in a given year and the Weibull proportional hazard model is used to identify the characteristics of those farms that did not regress cost quintiles.

4.1. Production Costs

Table 2 provides a snapshot of all farms in the period; it gives a weighted mean of approximately eighteen thousand dairy farmers every year. All data in the table below are in nominal terms; inflation over the period was not taken into consideration but stood at 31 percent over the period in the macro economy (CSO). From this table it can be seen that total production costs increased by 6 percent from 1998 to 2002 but decreased from 2002 to 2005 by 7 percent. There was an increase of 14 percent from 2005 to 2006, which can be explained partly by an extremely dry summer. Gross output declined over the nine-year sample, with the exception of 2001. Net margin demonstrated an 11 percent decrease in the first eight years, but fell sharply from 10.1 c.p.l in 2005 to 6.6 c.p.l in 2006, a 33 percent decrease.

Table 2. Production Costs, Margins and Output Results 1998-2006

Cent per Litre

	Gross Output	Total Dairy Costs	Dairy Net Margin
1998	0.296	0.182	0.114
1999	0.279	0.180	0.099
2000	0.299	0.185	0.114
2001	0.313	0.183	0.130
2002	0.295	0.195	0.101
2003	0.287	0.181	0.106
2004	0.301	0.186	0.115
2005	0.282	0.180	0.102
2006	0.272	0.206	0.066

Source: National Farm Survey Data

A cumulative cost curve of milk production was derived for 2000, 2003 and 2006. Producers were ranked in ascending order of cost per litre and the cumulative percentage of milk produced for a range of costs was calculated and plotted. The cost curve was aggregated for each year to measure the efficiency change of the sector as a whole.

Figure 1. Cumulative Cost Curve for Irish Dairy Sector

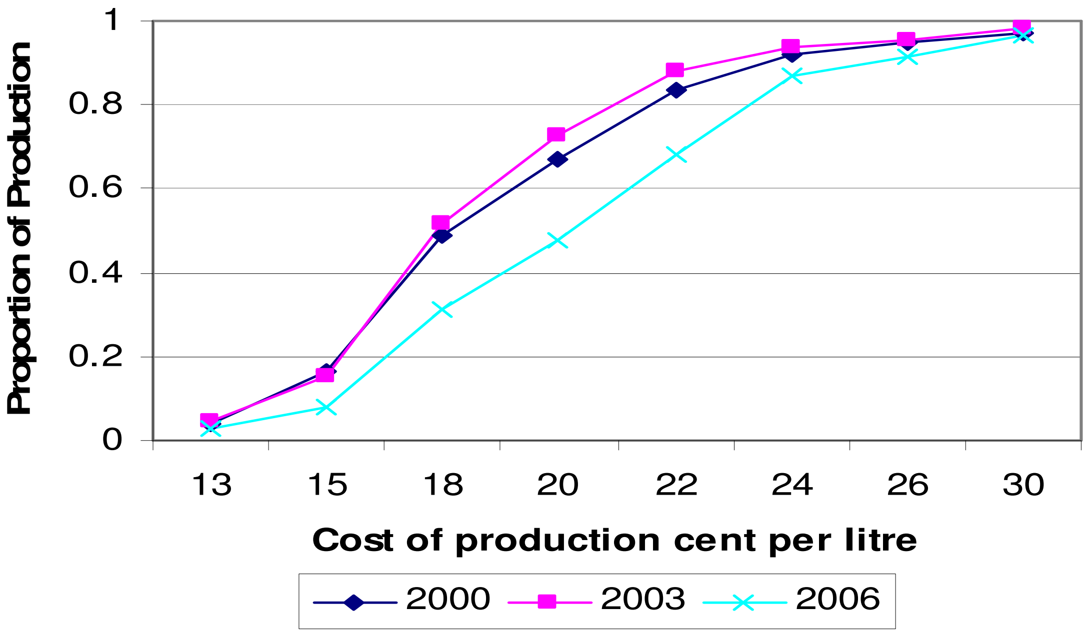
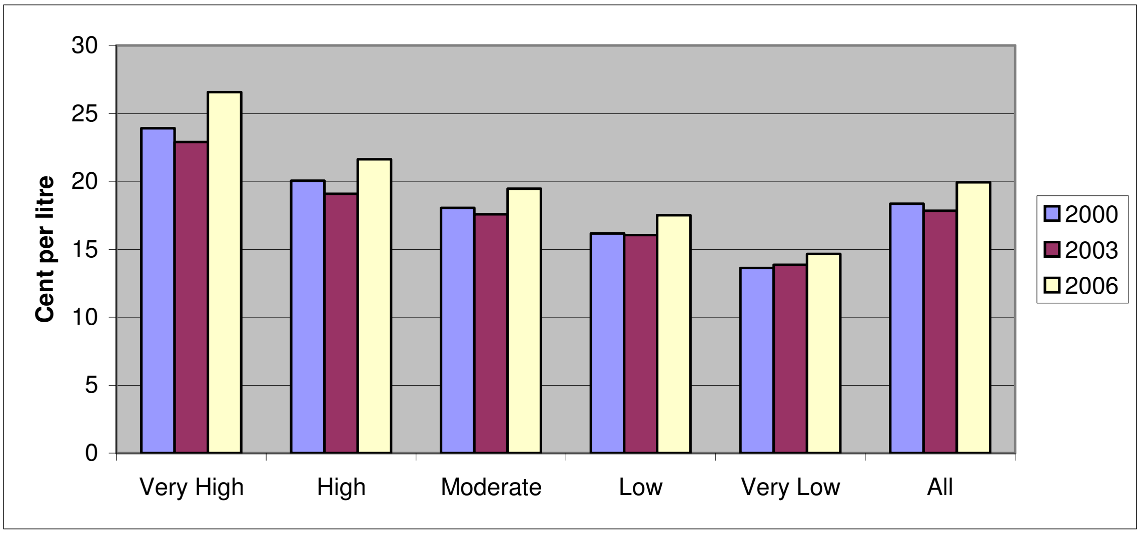


Figure 1 shows the proportion of production at various costs per litre. As can be seen some efficiency gains were made from 2000 to 2003, as the cumulative cost curve for 2003 is further to the left. In both 2000 and 2003 over fifty percent of all milk was produced at 18 cent per litre or less. In 2006 however, only thirty percent of milk was produced at 18 cent per litre or less, indicating efficiency losses. The cumulative cost curves allow us to measure the cost efficiency of the sector as a whole; however they provide little information about individual farm cost efficiency.

Figure 2 presents farm production costs for 2000, 2003 and 2006. The average for the weighted population is presented and the population is also divided into quintiles on the basis of production costs. As is evident from the graph there is significant variation in production costs across farms. The range in production costs between the lowest cost 20 percent of producers and the highest cost 20 percent of producers was 10 cent per litre (cpl) in 2000, and was greater at 12 cent per litre in 2006. As well as displaying the variation in production costs, the quintile analysis provides some insight into the ability of farmers to cope with cost inflation or adverse weather conditions. Costs on very high cost farms increased by 16 percent from 2003 to 2006 while costs on very low cost farms only increased by 5 percent over the same period.

Figure 2: Mean Cost per litre of each Quintile



4.2 Average Cost Function

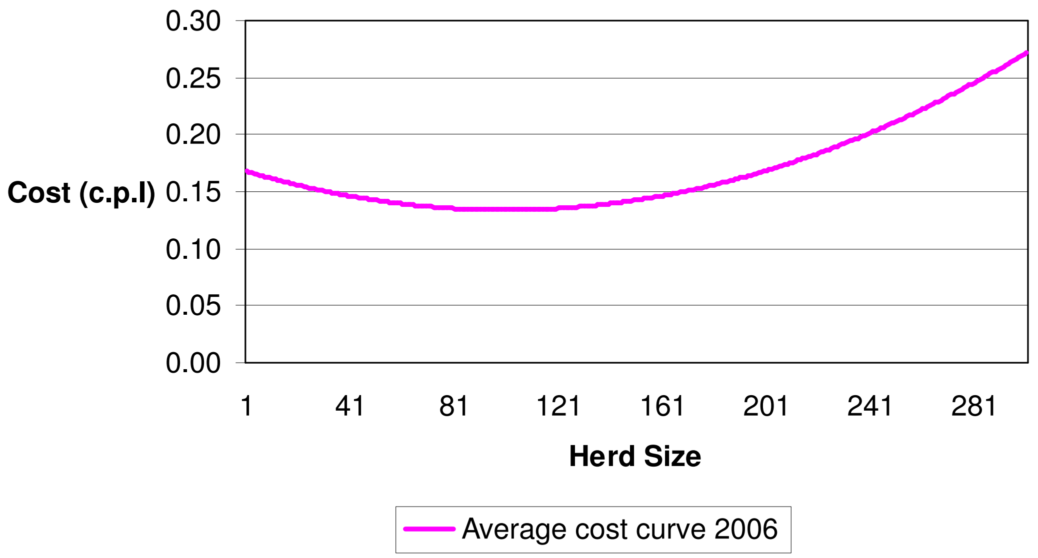
Table 3 outlines the results of the average cost function regressions on 2006 data.All variables except farm size and soil quality were significant. All significant variables express the expected sign, which indicates that economies of scale impact as the herd size increases, but diseconomies of scale set in beyond a certain point. The cow's coefficient is negative demonstrating that increasing cow numbers will decrease costs but only up until a certain number as cows² is positive implying diseconomies of scale set in beyond that certain point. This optimum herd size is calculated by plotting the average cost curve which figure 3 illustrates. Concentrates per cow increase average costs up until a certain point and then costs decrease while an increasing yield per cow decreases average until a certain point also. Soil quality and Farm size have no significant effect on average cost. The non-significance of soil quality can be explained by the selection of only specialist dairy farms in the sample, the majority of these specialist dairy farms in Ireland have a similar quality of land. Increasing cow per hectare decreases cost, which implies that many farms are restricted by farm size and increase herd size as a means of increasing scale.

Table 3. **Average Cost Function Results**

Average cost	Coefficient	T value
Constant	.2952356	10.18
Cows	-.0006823	-2.31
Cows²	3.43e-06	3.16
Yield per cow	-.0000436	-4.36
Yield per cow2	2.98e-09	3.11
Fair soil	-.0000271	-0.01
Poor soil	.0023193	0.51
Cow per Ha	-.0307578	-3.91
Farm size	.0001888	1.10
Concentrates per Cow	.0038101	6.19
Concentrates per cow2	-.0000281	-2.74

The average cost curve (ACC) for the dairy sector in 2006 was subsequently plotted from the results of the average cost function. Calculating the ACC involves plotting equation 1 by using the coefficients obtained from the regression and multiplying them by their respective average from the sample. The average cost curve is presented in Figure 3. The results show that economies of scale exist up to about 99 cows and diseconomies of scale set in thereafter. Interestingly costs increase dramatically faster as size increases over 160 cows. Labour costs become an issue as the dairy farms expand and this could explain this rise in cost. Given the constraints of milk quota, obtaining an optimal herd of 99 cows remains a challenge; the average herd size was 55 cows in Ireland in 2006.

Figure 3. Average Cost Curve 2006



Comparing the Irish average cost curve with that produced by Colman and Zhuang (2005), the optimum herd size in 2003 in England and Wales was 174 cows. The slope of Colman and Zhuang's average reduces much faster as herd size increases up to the optimum point. This implies that farms in England and Wales are attaining economies of scale quicker than Ireland as herd size increases.

4.3 Survival and Hazard Model and Cost Mobility

A balanced panel of farmers who remained in the sample for the nine-year period was compiled, totalling 114 sample farms weighted to represent approximately 6000 farms. A cost quintile analysis was conducted and a transition matrix derived to measure the movement of farms between cost quintiles from 1998 to 2006. The results in Table 4 show that over 40 percent of those in the lowest total cost quintile in 1998 are still in lowest cost quintile in 2006, while inversely for those who had the highest costs in 1998 over half of them were still in that quintile in 2006. Only 7 percent of those in the high cost quintile in 1998 were in the low cost quintile in 2006. This suggests that there is limited mobility and the majority of the movement that occurs is to the closest quintile.

Table 4: Transition matrix of cost mobility for 1998 and 2006 quintiles

		1998 Quintiles					
		1	2	3	4	5	Total
2006 Quintiles	1	41%	30%	11%	11%	7%	100%
	2	48%	26%	13%	9%	4%	100%
	3	22%	17%	39%	13%	9%	100%
	4	12%	16%	32%	28%	12%	100%
	5	0%	13%	23%	17%	47%	100%

Now that the amount of mobility is known, survival analysis is used to calculate the probability that a farm can move through the cost quintiles. Table 5 illustrates the results of the survival analysis for the sample. It shows the probability of farms improving its cost structure.

Table 5. Survival Analysis 1998-2006

Year	**Probability of Improvement**
1998	0.2390
1999	0.2814
2000	0.2580
2001	0.2871
2002	0.2805
2003	0.2816
2004	0.3438
2005	0.2547
2006	0.2736

The results show that probability of improving cost structure has increased marginally over the period. While this information is useful, the hazard model confirms the characteristics of those farms that are improving cost structure. The following results were attained from the Weilbull proportional model.

Table 6. Results of Weilbull Proportional Hazard Model

	Hazard	T-stat
Herd Size	.9966749	-1.99
Farm Size	1.003988	2.42
Cow per Ha	1.049021	0.80
Concentrates	.9858114	-3.72
Yield per Cow	.9999817	-0.53
Good Soil	1.125795	1.83
Fair Soil	1.285962	3.47

The hazard ratios identify the factors significantly affecting a farmer's probability of improving cost structure. Those with fair soil and good soil are 28 percent and 12 percent respectively more likely than those with poor soil to improve cost structure. Increasing farm size also improves the probability that a farm will improve cost structure, while the effect of stocking rate and yield per cow are not statistically significant. Increasing herd size and concentrates will decrease the probability of improving cost structure by approximately 1 percent.

5. Conclusions

The purpose of this paper was to analysis the cost efficiency of Irish dairy farms from 1998 to 2006. Various methodologies were employed to determine the factors driving costs as well as the characteristics of those farms that succeeded in maintaining low costs. Employing an average cost function like Colman and Zhuang (2005), it was determined from 2006 data that economies of scale exist up to the optimal herd size of 99 cows. Increasing yield per cow and cows per hectare also decreased costs implying that scale and improving efficiency is key to reducing cost.

While significant variation in costs exist across farms, the cost mobility analysis showed that, relative to their peers, individual farmer's cost efficiency changed very little over the period. Using a cost quintile analysis and a transition matrix, the results showed that the majority farmers stay in the same cost quintile or only move to the nearest quintile. This suggests that high cost farmers tend to remain high cost. A hazard model was used to identify the characteristics of farmers that improve their cost efficiency over time. The results yielded limited information on the drivers of cost efficiency, with farm size and soil type being the main drivers of change.

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