EXPLAINING THE VARIABILITY IN THE ECONOMIC PERFORMANCE OF IRISH DAIRY FARMERS 1998-2006

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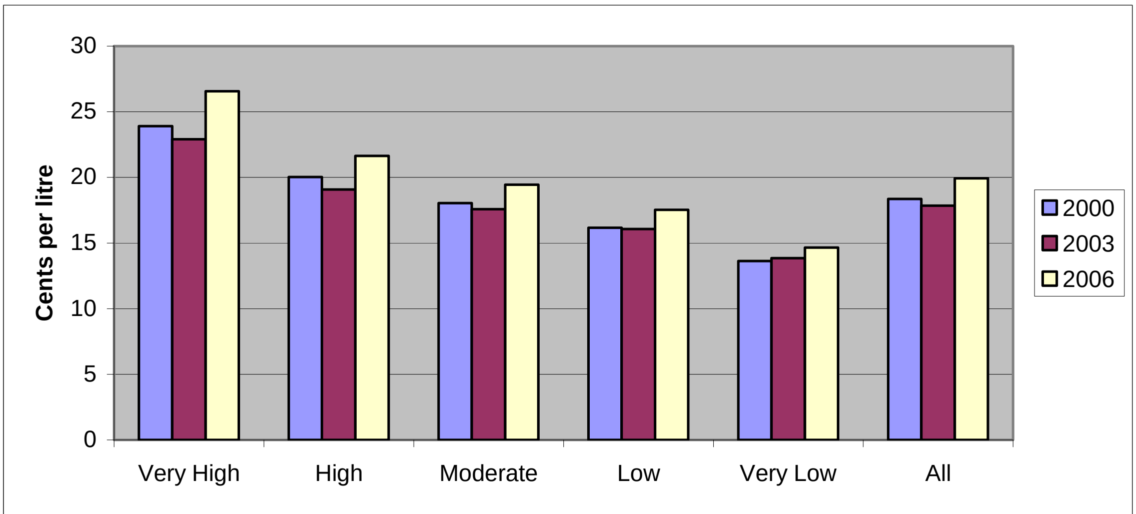
Abstract

This paper reviews the economic performance of Irish dairy farms over the period 1998 to 2006 with the objective of identifying the factors influencing cost structure. Initial analysis reveals a large variation in cost structure in the Irish dairy farming sector, and that this has increased over time. Econometric techniques are employed to examine the variation in cost structures and to identify the factors affecting farm profitability. National Farm Survey data from Ireland is 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. The results show that increasing yield per cow and stocking rate decreases costs implying that scale and improving efficiency is key to reducing costs. An analysis of cost mobility showed that cost structure was quite sticky, and that relative cost management improved little over the period, with the majority of high cost farmers remaining high cost.

Introduction

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. Thorne and Fingleton (2006) have shown that Ireland was consistently one of the lowest cost producers of milk in the EU between 1996 and 2004. Further analysis conducted by Fingleton (2004) showed that cost efficiencies were achieved by the Irish dairy farming sector from the late 1990s to the early 2000s but that a large variation in costs between farms continued throughout the time period. Fingleton's analysis shows that the difference in costs of production between the best performing 20 percent of farms and the poorest 20 percent was 11 cents per litre in 2000, which is a cost difference of €27,500 for the average quota size of 250,000 litres. Such a large variation in cost structure is surprising in a small homogenous country like Ireland.

Figure 1 presents Irish National Farm Survey data on production costs on specialist milk producers 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 costs between the lowest and highest quintiles was 10 cents per litre (cpl) in 2000, and increased to 12 cpl in 2006, thus showing that the variation between producers is increasing. The quintile analysis also reveals the varying degree to which farmers can cope with cost inflation or adverse weather conditions. As can be seen, the very high cost farms increased total production costs by 16 percent from 2003 to 2006 while costs on very low cost farms only increased by 5 percent over the same period. Over this period gross output was also declining suggesting that even with lower output prices, higher expenditure was being incurred by all farms but low cost farms were better able to manage these increases in costs.



Source: Irish National Farm Survey

Figure 1: Mean Total Cost of Production per litre on Specialist Irish Dairy Farms.

To date relatively little analysis has been conducted in Ireland on the factors affecting cost structures and the reasons for such large variations in costs between farms. The objective of this paper is to draw on research conducted internationally to develop empirical models to explain cost structures in the Irish dairy sector. The paper begins by describing the dataset used; following this the methodology is outlined, while the final two sections of the paper present and discuss the key findings of the research.

Data

Irish National Farm Survey data (NFS) from 1998 to 2006 is used 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 total 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.

The NFS data collection process allocates direct costs of production to specific farm enterprises; see Connolly et al (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; this is problematic when the majority of dairy farms in Ireland are mixed enterprise farms. Fixed costs include interest payments on loans, land and building maintenance and depreciation. In this paper fixed costs are allocated on the basis of gross output. For the dairy enterprise for example, fixed costs 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.

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, these opportunity costs are not included in the paper. There are 3083 observations in the dataset, approximately 340 farms each year.

Table I. Summary Statistics for Selected years for all Specialist Dairy Farms in Ireland.

Year	**1998**	**2001**	**2004**	**2006**
Herd Size (Cows)	38	44	45	50
Farm Size (Ha)	38	43	44	47
Farmer's Age (Years)	47	47	49	51
Yield Per Cow (Litres)	4369	4880	4944	5028
Stocking Rate (Cow per Forage Ha)	1.89	1.93	1.91	1.91
Family Farm Income (€'s)	24242	34426	34421	36221

Methodology

A two step methodological approach is adopted to explore cost structures and to explain the large variation that exists in cost structures in Ireland. First the sector level cost structure is described and following this farm-level cost structures are examined.

The sector level cost structure is described by developing annual cumulative cost curves. A cumulative cost curve provides an indication of the proportion of milk produced nationally at different costs, 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. The cost curves can also be compared to those developed in other countries to provide some insight into international competitiveness.

Farm level cost structures are explained by deriving cost functions and through cost mobility analysis. A cost function specifies the efficient use of resources, using the least cost combination of inputs to produce an output. The seminal paper by Burton (1995) developed a cost function for dairy farms in England. Colman and Zhuang (2005) used Burton's specification 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 decreased to a minimum point where economies of scale were achieved and that costs increased thereafter (diseconomies of scale). Their results showed that economies of scale were achieved in herd sizes up to 174 cows.

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.

$AverageCost_t = f($ Herd Size, Herd Size^2, Concentrate Feed per cow, Concentrate per cow^2, Yield per cow, Yield per cow^2, Cow per Ha, Fair soil, Good soil and Farm size) *Equation 1*

An ordinary least squares regression is implemented to determine which of the independent variables are statistically significant in affecting cost. The coefficients of the regression analysis are also used to plot economies of scale. The average cost function should provide some insight into the factors affecting the variation in farm cost structures.

Individual farmer's cost management is also examined using a cost mobility analysis. The Centre for International Studies and Co-operation (CECI) (2006) cites mobility of cost, or farmers' ability to manage their own costs, as a major determinant of farm profitability. Techniques that have previously been applied to income mobility analysis are also appropriate for investigating the stickiness of costs. Phimister et al (2004) used survival analysis to examine the income mobility of Scottish farms. Here a similar methodology is employed to explore cost mobility.

In the analysis farms are disaggregated into cost quintiles, as per Figure 1. Survival and hazard analysis are used to investigate the mobility between quintiles. Using the following procedure, time t is considered 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 assigned to a quintile from 1(low costs) to 5 (high costs) 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 measures the probability that the duration in a quintile lasts beyond year j, while the hazard function is the probability that a farm exits out of the quintile, i.e. the probability that the farm improves or disimproves costs relative to all other farms. A Weibull proportional hazard model is then used to test if there is 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. The farm characteristics associated with cost improvement can then be identified.

Results

Table II provides a snapshot of all farms in the period. As shown total production costs have fluctuated over the period; increasing by 6 percent from 1998 to 2002, decreasing by 7 percent from 2002 to 2005 and increasing again by 14 percent from 2005 to 2006. The increase from 2005 to 2006 can be partly explained by an extremely dry summer. Gross output declined over the nine-year sample, with the exception of 2001 and 2004. Net margin demonstrated an 11 percent nominal decrease in the first eight years, but fell sharply from 10.1 cpl in 2005 to 6.6 cpl in 2006, a 33 percent decrease.

Table II. Average Production Costs, Margins and Output for all specialist dairy farms 1998-2006.

Cents per Litre (Nominal Terms)

	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

The sector level cumulative cost curve of milk production for 2000, 2003 and 2006 are presented in Figure 2. 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 50 percent of all milk was produced at 18 cents per litre or less. In 2006 however, only 30 percent of milk was produced at 18 cents per litre or less, indicating efficiency losses.

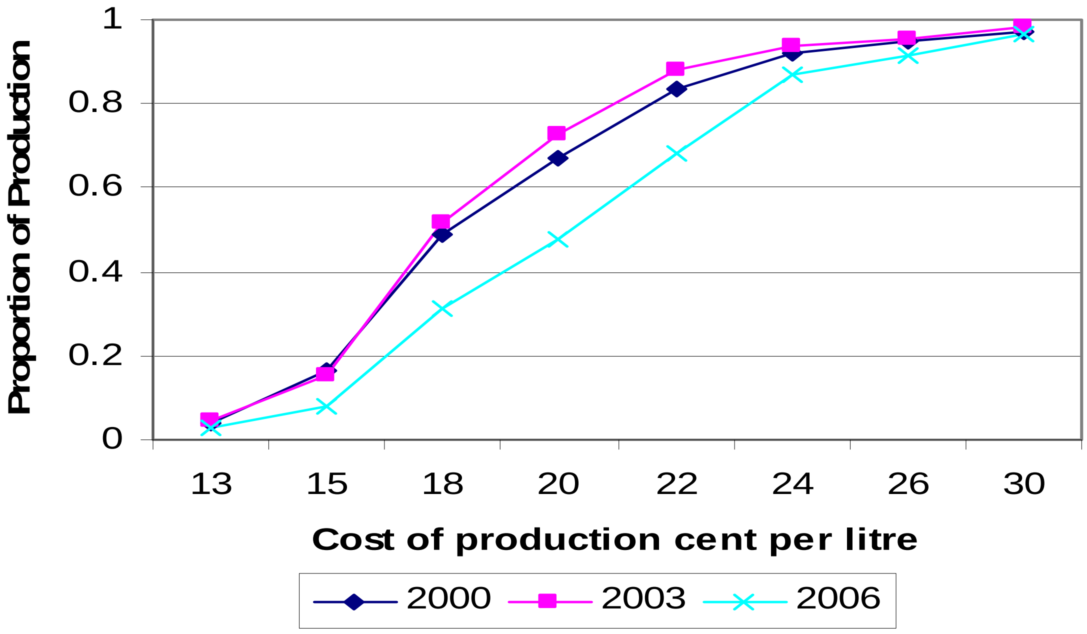


Figure 2. Cumulative Cost Curve for Irish Dairy Sector.

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. To explore costs structures at the farm level, cost functions were estimated. Table III presents the results of the average cost function regressions on the 2003 and 2006 data. The coefficients show the relationship between the independent variable and per unit cost. A negative coefficient suggests costs decrease as this variable increases and the opposite is the case for those with a positive sign.

Table III. Average Cost Function Results 2003 and 2006.

	2003		2006	
	Coefficient	**T value**	**Coefficient**	**T value**
Constant	0.4064416	13.19	.2952356	10.18
Cows	2.40E-06	-0.81	-.0006823	-2.31
Cows²	3.43E-06	1.83	3.43e-06	3.16
Yield per cow	-0.0000949	-8.12	-.0000436	-4.36
Yield per cow2	7.82E-09	6.66	2.98e-09	3.11
Fair soil	-0.0046274	-1.17	-.0000271	-0.01
Poor soil	-0.006079	-1.58	.0023193	0.51
Cow per Ha	0.0026248	0.7	-.0307578	-3.91
Farm size	0.0000754	0.68	.0001888	1.10
Concentrates per Cow	0.0031692	6.93	.0038101	6.19
Concentrates per cow2	-0.0000172	-2.33	-.0000281	-2.74

The results for the regression on the 2006 data are as expected; most of the variables are statistically significant, with the exception of farm size and soil quality, and all of the significant variables demonstrate the expected signs. For example, the effect of herd size is negative while herd size squared is positive. This suggests that costs of production decrease as herd size increases but only up to a certain point, i.e. the relationship is non-linear. In other words, economies of scale are present. It is somewhat surprising that the results for 2003 suggest that herd size is not significant.

Yield per cow is significant in both years and is negative and non-linear. This suggests that costs of production decrease as yield per cow increases but only up to a certain point and decrease thereafter. It is possible that the costs, in terms of stocking rate and purchased feed, push yields per cow beyond a certain limit that are greater than the benefits achieved in the additional supply per cow. The effect of the yield variable is also likely to be interlinked with the stocking rate and purchased feed variables. Figure 3 presents the relationship between yield and production costs graphically. The graph shows the optimal yield per cow to be somewhere around 6,000 litres per cow.

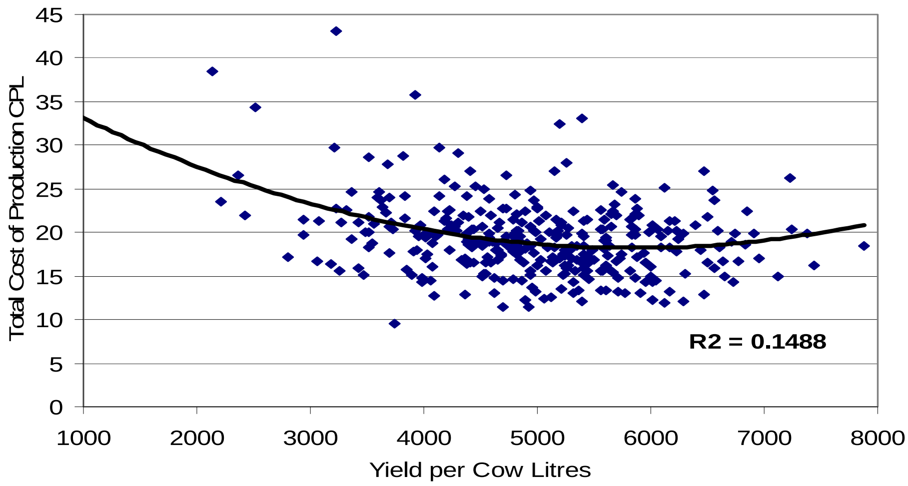


Figure 3: The Relationship between Production Costs and Yield per Cow 2006.

Soil quality and farm size have no significant effect on average cost in either 2003 or 2006. Farm size is a measure of total land area and as such there may be multicollinearity problems between herd size and stocking density, thus making this variable not significant. The non-significance of soil quality may be explained by the relatively little variability in this variable, as the vast majority of farms are on good soils.

The average cost curve (ACC) for the dairy sector in 2006 was subsequently plotted from the results of the average cost function. The 2003 data were not plotted due to the non significance of many of the variables. 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 4. 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 as family labour would not increase, the farm would have to hire additional labour which would explain the rise in costs. Given the constraints of milk quota, obtaining an optimal herd of 99 cows remains a challenge; the average herd size in Ireland was 55 cows in 2006.

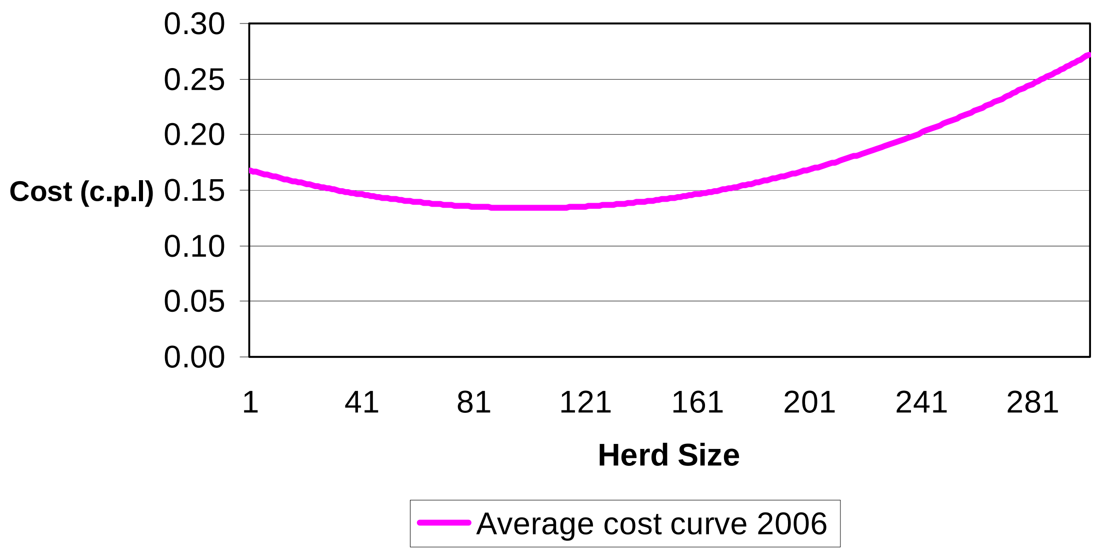


Figure 4. Average Cost Curve 2006.

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 panel of farmers who remained in the sample for the nine-year period was compiled for a transition matrix, totalling 114 sample farms. All farms in the sample were used in the survival analysis not only those that stayed in the sample for all nine years. 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 IV 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 in cost structure and the majority of the movement that occurs is to the closest quintile.

Table IV: 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%

Survival analysis is used to calculate the probability that a farm can move through the cost quintiles. Table V presents the results of the survival analysis for the sample. It shows the probability of farms improving their cost structure.

Table V. 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 the probability of improving cost structure has increased marginally from 0.24 in 1998 to 0.27 in 2006 but has also fluctuated largely over the period in question. While this information is useful, the hazard model can be used to identify the characteristics of those farms that are improving cost structure. The following results were attained from the Weilbull proportional model.

Table VI. 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. This result suggest that farming on poor soil, although the number of dairy farms in this category are quite low, is a significant disadvantage and limits the farmer's ability to improve costs. 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 is to analysis the cost efficiency of Irish dairy farms with a view to explaining why such large differences exist in cost structures. 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 the optimal herd size was 99 cows, compared to the current average of 55 thus there is ample capacity to exploit economies of scale. While economies of scale may be exploited, the presence of the milk quota regime continues to act as a major barrier to expansion. The results suggest that if milk quotas were removed or enlarged, as is likely over the next few years, Ireland would be well placed to increase production while maintaining cost efficiency. Increasing yield per cow and stocking rate also decrease costs implying that scale and improving efficiency is key to reducing costs.

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. The analysis revealed that physical endowments like soil type have a significant negative impact on the probability on improving cost structure, suggesting that even increased scale and greater technical efficiency cannot compensate for this disadvantage.

References

Burton, M. (1995). The Impact of rBST on the Structure of England and Wales Dairy Sector. Journal of Technological Forecasting and Social Change, Vol. 50, pp. 93-104.

The Centre for International Studies and Co-operation (CECI) (2006). Dehkan Farms Inside/Out: A Comparative Assessment of Cotton Growing Dehkan Farm Models in Sughd, Tajikistan.

Colman, D. and Zhuang, Y. (2005). Cost Efficiency Improvement in Milk Production: England and Wales 1997-2003. Centre for Agricultural, Food and Resource Economics, University of Manchester, UK.

Connolly, L. Kinsella, A., Quinlan, G. & Moran B. (1998-2006). Irish National Farm Survey, Teagasc, Dublin, Ireland.

Fingleton, W.A. (2004). Comparative Costs and Returns for milk production in Ireland. Paper presented of the Annual Conference of the Rural Economy Research Centre, Dublin.

Franks, J. (2001). Developments in milk marketing in England and Wales during the 1990s. British Food Journal, Vol.103, No. 9, pp. 631-643.

Phimister, E., Roberts, D. and Gilbert, A. (2004). Analysis using the Farm Accounts Survey. Journal of Agricultural Economics, Vol. 55, No. 2, pp. 197-221.

Pierani, P., and P.L. Rizzi (2003), Technology and efficiency in a panel of Italian Dairy Farmers: an SGM restricted cost function approach, Agricultural Economics, 29 (2003), 195-2009.

Thorne, F. and Fingleton, W.A. (2006). Examining the Relative Competitiveness of Milk Production: An Irish Case Study (1996 - 2004). Journal of International Farm Management, Vol. 3, No. 4.