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Seasonality and Costs of Production on Irish dairy farms from 2000-2007

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Abstract

This paper examines the relationship between calving date and production costs on Irish dairy farms from 2000-2007. Using data from the National Farm Survey, the median calving dates of 400 dairy farms are studied each year using econometric analysis to determine the relationship between calving date and production costs. Farms are divided into five categories according to their median calving date. These categories are imputed into a panel dataset as dummy variables. Unobservable individual effects are controlled for using a fixed effect model; examples of such effects are land quality and managerial ability, Results suggest that when scale and those unobserved effects are controlled for, there was no significant difference in total cost of production per litre according to median calving date.

Key Words: Seasonality, Fixed effect and Calving date

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Introduction

Milk production in Ireland is primarily a grass-based low-cost system resulting in highly seasonal milk supply. Crosse et al (2000) calculate that 85% of milk in Ireland is produced from a spring calving summer grazing system between March and October. Ireland is favoured by a climate that has complimentary grass growth between April and October and hence the availability of a grass based diet. This emphasis on a spring calving system is to take advantage of this grass growth and leads to high seasonality in Irish milk supply. Downey (2005) states that milk production in Ireland is production rather than market led, i.e. milk is supplied at the lowest cost time rather than at the highest demand time. Ireland is relatively unique in that the small population base relative to the large production base means that only 10% of milk produced is destined for the fluid milk market. The majority of milk is used for the production of lower value commodity products, such as powders and butter. Due to the non-perishable nature of these goods, the production of milk can take place at any time of the year, and the processed product can be stored. Typically in Ireland almost 80% of the milk is supplied for processing in the April to September period, thus placing considerable pressure on processing capacity of the plants. As Ireland will be entering a no quota situation in 2015, most likely resulting in an increase in the national milk supply and if it continues to follow this seasonal pattern, it would result in over processing capacity problems in the peak months. The Prospective report (2003) details that seasonality must be reduced to remain competitive with our European counterparts.

The objective of this paper is to explore the costs associated with milk production in different calving seasons in Ireland. The paper begins with a background section exploring previous research conducted on the seasonality of milk. 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.

Background

Seasonality is defined as a regular pattern of peaks and troughs within each successive year in the supply, or demand for a product, Keane (1980). Seasonality is measured using a ratio of a peak month (May) to a trough month (January) in milk deliveries each year. Ireland's seasonality has remained high over the last two decades compared to our European competitors such as Denmark and the Netherlands who have reduced it over the same time period, Prospectus (2003).

There are many problems associated with a very seasonal supply pattern. Use of capital on dairy farms is stretched at peak supply months but under utilised in low supply months. Groover (2000) shows that spring producers compress large workloads into short periods while year round producers can spread the use of inputs and facilities over the whole year. Facilities such as bulk tanks, calving facilities and breeding programmes can be spread year round as apposed to having a peak demand at one time of the year. Another added cost to spring calving operations is the strategy to have all cows calving in a specific period in spring and the culling of those cows that calve outside this period. Year round producers have less critical constraints on their calving patterns and incur fewer costs from premature culling. Such a high demand on labour and capital on spring calving farms could lead to increased costs of production. On the other hand, spring calving systems can increase profitability by maximising the use of pasture and reducing the reliance on stored forages; Groover (2000). This system has emerged as the dominant system in Ireland as the majority of farms take advantage of the large availability of grass in spring and summer months as well as storing excess grass for winter forage.

The processing sector also faces difficulties from the seasonal supply pattern such as capacity issues during those peak months but a large idle capacity during the trough months. Oltenacu et al (1989) determine that high seasonality makes it necessary for processors to have higher plant processing and transport capacity than if the peak to trough ratio was lower which inevitably adds cost to processing resulting in a lower milk price. With such a large volume of milk in summer, the product mix that can be produced is less perishable leading to increased storage costs and ultimately lower prices for milk. Seasonality in milk production also creates late lactation milk, which is of lower quality due to high somatic cell count, bacteria and free fatty acids, Hennessy and Roosen (2003), which may also lead to a lower milk price.

Groover (2000) states that farms in the United States receive the lowest milk price in the six months following spring and conversely the largest price during the winter months. A similar trend characterises the dairy market in Ireland too due to the large supply of milk in this period. He also points out that farmers are discouraged from switching to winter production on the premise that the extra price gained will be eroded by the extra costs incurred.

Shalloo and Horan (2008) studied the optimum calving date for dairy farm production costs from four possible calving dates. Using the Moorepark Dairy Systems Model, profitability was determined from total costs at different levels of milk output depending on the calving date. The four calving dates were 31st January, 14th February, 1st March and 15th March. Their results show that an average calving date of the 15th March returns the lowest total costs of all four scenarios. This study only investigated dates associated with spring calving systems. Furthermore, this analysis was carried out by varying the calving date on the same hypothetical farm. It did not explore the effect of other factors that may affect production costs such as the farmers' management abilities and so forth.

Valencia and Anderson (2000) investigated optimal milk production systems in Northern Ireland and compared spring and autumn based systems. They show that in a quota system, which is in place at the moment, a spring calving herd of medium genetic potential cows and a long grazing season are favoured. Their research also found that in a no quota situation, autumn calving, high genetic cow and higher quality silage along with a long grazing season was the optimal production system.

Hennessy and Roosen (2003) state that farmers account for various economic factors such as the abundance of low cost feed in the summer months and the seasonality of milk prices when deciding on a specific calving pattern. Keane (1980) says considerations of alternative milk supplies should involve a detailed cost-benefit analysis. This means that the calving system adopted must result in a net benefit overall and ultimately represent an increased return directly or indirectly to the farmer. Ultimately farmers will decide the system that is most profitable for them to produce. Hence, the payment of a premium may be necessary to provide an incentive for farmers to produce milk in seasons other than spring. Liquid (fluid) milk producers in Ireland are paid a premium during the winter months to encourage the production of milk during the winter months.

The use of a price premium to reduce seasonality was trialed in the state of Florida from 1993-1995. Washington et al (2003) determine that ultimately the plan was discontinued but the results shows a reduction in the seasonality of 20% of the milk supplied on those farms participating in the trial. Kaiser et al (1988) showed that a price premium of up to 3 times the present price differential could be required to change farmer’s seasonal production patterns. The study also demonstrates that those farmers with better managerial skills are able to reduce their seasonal cost significantly lower than those farmers with less skill. Sun et al (1995) also determine that price premiums can reduce seasonality substantially; critically this research was based on actual farmer behaviour rather than farmer perception of the former study from Kaiser et al (1988).

This paper will establish if there is any difference in cost associated with seasonal supply in the dairy sector in Ireland. The next section of the paper begins by describing the dataset used; following this the methodology adopted in the paper 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 2000 to 2007 was used in the course of this study to compile and analyse production costs on dairy farms. The NFS is collected as part of the Farm Accountancy Data Network (FADN) for the provision of

Irish data to the EU commission and surveys approximately 1200 farms annually. These farms are assigned a weighting factor that enables an aggregation process to represent the full farming population of approximately 115,000 farms. The data is unbalanced allowing farms to enter and exit the sample over the eight-year period. For the purposes of this study only the data collected on dairy farms is used, this is a sample of approximately 400 farms in each year giving rise to 3588 observations in total.

This sample includes specialist[2] and mixed dairy enterprises and only those costs accruing from the use of the dairy enterprise are analysed in the course of this research. Hence, 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 enterprises; see Connolly et al (2006). However fixed and overhead costs are not assigned to individual enterprises on each farm, this can be problematic when looking at mixed enterprise farms. Hence fixed and overhead costs are allotted from the calculation of total farm gross output originating from the dairy enterprise. The costs of hired casual labour are included in direct costs while permanent hired labour is included in overhead costs. Unpaid family labour is not included in the calculation of total costs.

As all of the above cost items will vary according to farm size and milk production, a comparison tool is needed. Production costs per litre of milk produced are used for comparative purposes. All costs are expressed in euros and the calculations of these costs include monetary costs only and no opportunity costs. Table 1 below summarises some of the key statistics from the data. It shows that average herd size,

[2] A specialist dairy farm receives 66% or more of their gross output from dairying

farm size and yield per cow have increased demonstrating an increasing of scale over the course of the sample.

Table 1. Summary Statistics for all Dairy Farms in selected years

Year	2002	2004	2006	2007
Herd Size (Cows)	39	42	46	47
Farm Size (Ha)	45	46	49	49
Age (Years)	48	49	50	51
Yield (Litres)	4644	4870	4979	4939
Family Farm Income (€'s)	27900	33050	36250	50525

Source. National Farm Survey.

Table 1a. Total cost of Production on all Irish Dairy farms

Year	2002	2004	2006	2007
Total costs	19.85	19.46	20.7	23.8
Concentrates Cost	4.0	3.6	3.8	4.4
Pasture & Forage Cost	3.3	3.6	3.7	4.8
Other direct costs	3.4	3.3	3.2	3.7
Overhead Cost	8.8	9.3	9.0	11.1
Net margin	9.4	10.7	6.4	9.3

Source: National Farm Survey. All figures in cent per litre

Table 1a outlines total cost of production for selected years of the sample from 2000-2007. The results are representative of all Irish dairy farms and show total costs increasing marginally up until 2007. Costs rose substantially in 2007 and initial results from 2008 suggest costs remained high in that year also. Investigating the breakdown of total costs in table 1b shows that increases in 2007 were seen in all costs but pasture and forage costs demonstrate a larger increase than other sub categories. This is due to increased fertilizer costs. Overhead costs also increased substantially in 2007, these costs include rent, electricity, fuel and building and machinery maintenance.

Results from table 1a and 1b give an illustration of the dairy sector before focusing on the issue of seasonality and the costs associated with it. Further investigation is applied using calving date as the main focus. Data on actual calving date is not available from the NFS but the number of calves born each month is recorded. From this variable the predominant season for calving on the farm can be determined. The median calving month was calculated and each farm was subsequently divided into five groups. The median calving date identifies which month the middle calf of the herd was born into and placed in one of the five groups. These groups are February, March, April, summer and autumn/winter. Initially the research focused on the four categories but due to the large number of spring calving herds, it was separated into different months. These five categories are chosen as they represent different calving season patterns. Summer includes May, June, July and August while autumn/winter include September, October, November, December and January. January was included in the autumn/winter category, as the majority of milk production in this month would take place indoors. All median months in the analysis are compared to the March median date. March was chosen, as it is the most popular median calving date, but also it allows for the contrast of difference in costs in the other categories away from the traditional month of calving.

Table 2 shows the summary statistics for the five dummy variable categories using all years in the sample. It illustrates that scale is larger on those farms with autumn and winter median calving dates while also returning highest yields per cow. In contrast, March and April median calving date return the lowest yields and smallest herd and farm size.

Table 2. Summary Statistics for all Dairy Farms in the median calving categories

Year	February	March	April	Summer	Autumn/Winter	All
Herd Size (Cows)	47	41	39	56	58	43
Farm Size (Hectares)	48	45	46	58	58	47
Yield (Litres)	5076	4753	4689	5032	5741	4855
Sample Size	740	1964	523	226	135	3588

Source. National Farm Survey.

Some anomalies may lie within the five categories chosen; for instance, the spread of the calving season is not taken into account in the variable. This means that some herds may have a large proportion of their calves born in the spring, but may the majority of calves in the autumn and thus they are placed in the autumn/winter category

Table 2 demonstrates that herds are larger on autumn/winter herds than March or April herds. This could also be a problem in this analysis due to higher percentage of large farms in the autumn/winter category than on the spring categories. Smyth et al (2009) found increasing scale decreased total costs per litre and hence more efficient farms may be in autumn/winter category. The issue of scale can be addressed with inclusion of variables such as herd size and forage hectares in the regression. The sample size of the five categories could also be an issue as there are fewer farms with summer and autumn/winter calving dates.

To determine if there is any noticeable differences in costs between the five categories table 3 and 4 are introduced. Table 3 shows the relationship between total cost of production and the five season dummy variables chosen. The outliers in the graph can possibly be explained by a depopulation of a dairy herd due to disease or other factors and hence having a low total milk production for that year but still having fixed costs. These outliers were subsequently dropped from the analysis as they could cause differences in the results which are not necessary correct.

Table 3 Seasonal dummies versus total cost of production per litre

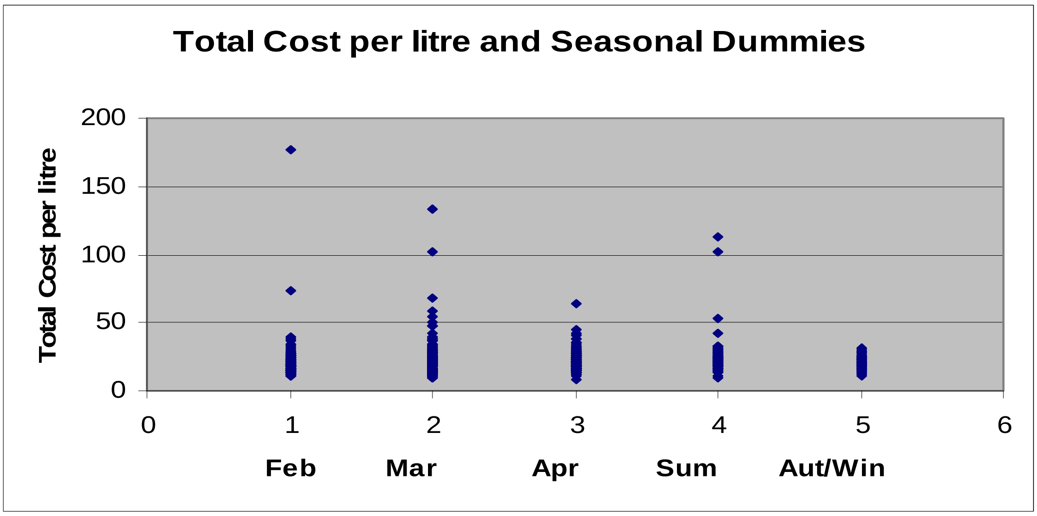


Table 4 details the weighted average of total costs of production in the five median calving date categories. The results show those farms in the summer category record the highest costs of production for three of the five years selected. This is not unusual, as traditional thinking would suggest that lowest costs are associated with spring production. However the autumn/winter category demonstrates quite low costs compared to their spring counterparts in four of the five years. A small sample size in autumn/winter category could be leading to the derision of this result. The farms in this category are larger which tend be more efficient and hence lead to lower costs of production. To determine if there is any significant difference in these results an econometric model is required.

Table 4. Production Costs according to Median Calving Period

	February	March	April	Summer	Autumn/Winter	All
2000	18.02	19.74	18.86	21.25	17.85	19.27
2002	18.20	19.44	21.62	22.64	19.23	19.84
2004	22.52	18.98	20.79	21.44	19.29	20.14
2006	19.30	20.07	23.62	23.88	22.73	20.73
2007	20.50	22.95	25.45	23.30	22.17	22.78

Source: National Farm Survey Data, all figures in cent per litre

Total costs of production for 2007 are disaggregated in Table 5 between the different median calving dates to demonstrate the main drivers behind total cost of production for that year. Intuitively, concentrate costs per litre are higher in the Autumn/winter category as they are in milk production in winter with no grass pasture available. But pasture and forage costs are lower on these herds, this may be due to higher fertilizer prices and greater quantities being purchased to maintain grass pasture in the very early and very late parts of the growing season.

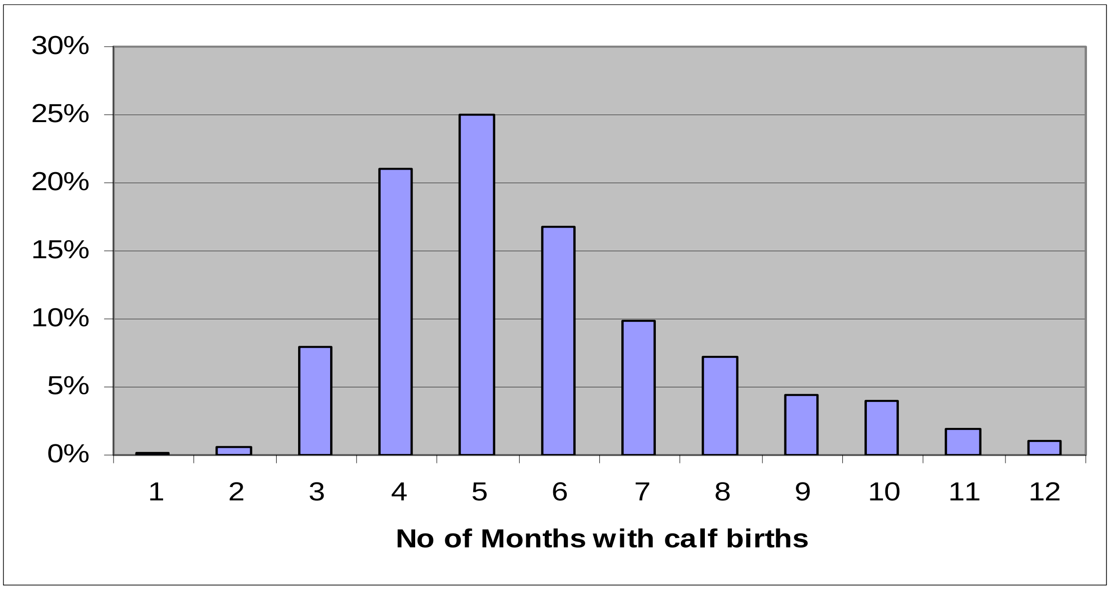
Table 5. Disaggregated Production Costs according to Median Calving Period

	February	March	April	Summer	Autumn/Winter
Concentrates	3.5	4.1	5.3	5.1	5.4
Pasture and Forage	3.3	3.5	4.1	3.5	3.1
Labour	0.6	0.4	0.6	0.5	0.9
Energy and Fuel	1.1	1.5	1.6	1.4	1.2

Source. National Farm Survey.

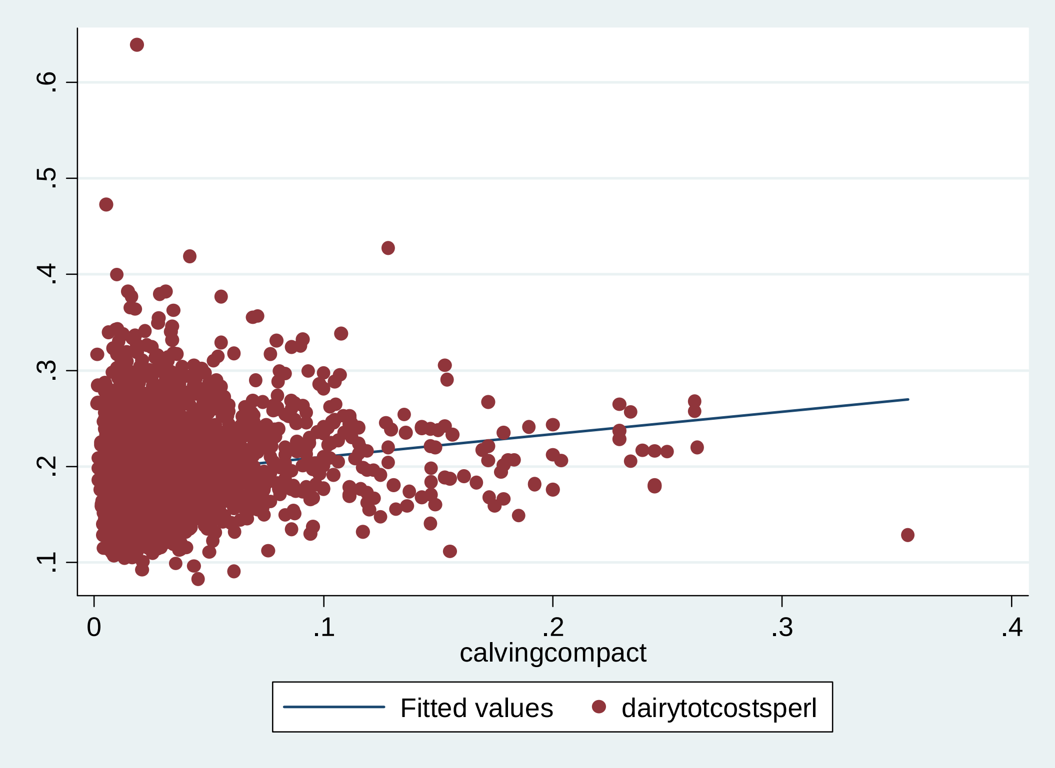
The level of calving compaction on each farm may also play a role in the significance the five variables on total cost of production. Analysis was carried out to determine if dairy farms have a compact calving season. Table 6 shows a histogram of the distribution of the number of months calves are born on all dairy farms in the sample.

Table 6. Calving Compaction on Irish dairy farms.



It demonstrates that there is a low level of compaction as only approximately 10% of the farms have a compact calving season of three months or less. Over 60% of the sample a calving season of between four and six months. These results indicate that dairy farms have a staggered calving pattern and may be imposing inefficiencies accordingly. Hence a variable for calving compaction must be added to the analysis to follow. This variable is calculated as the deviation away from the calving spread expected from the number of months they have calves born. Table 7 plots this calving spread against total cost of production. As this variable gets larger, calving date is less compact. The fitted line value shows that as calving compaction decreases costs of production increases. This suggests that efficiency in calving compaction may lead to lowering total costs of production.

Table 7. Total Cost of Production versus Compaction of Calving Season



Methodology

The following section details the methods applied to the data to determine differences in production cost according to calving date.

A panel data set contains repeated observations over the same units (firms, individuals, households), collected over a number of periods, Verbeek (2000). Basic estimators of panel data sets are the Pooled Ordinary Least Squares (OLS). Johnston & DiNardo (1997) state that the pooled OLS estimators ignore the panel structure of the data, treat observations as being serially uncorrelated for a given individual, with homoscedastic errors across individuals and time periods. A pooled OLS model is run using all eight years as a pooled sample using total costs of production per litre as the dependant variable. Colman and Zhuang (2003) utilise a similar function in the calculation of their cost function on English and Welsh dairy farms. Variables such as herd size; yields and concentrates are included in this research according to their specification. The five dummy variables are also included in the regression. The basic regression function is as follows:

$$Y_i = \beta_0 + \beta_i X_i + u_i \,. \qquad \textbf{\textit{Equation 1}}$$

If we can assume that the errors have mean zero and are independent for different *i's*, then we can use standard methods to fit this model. However, for repeated measures of the response on the same individual as in panel data, it is unlikely that the error is independent of unobserved effects *(u).* Hence the use of OLS techniques to estimate panel data is subject to unobservable heterogeneity bias. This bias arises when the error term is correlated with any one (or more) of the independent variables across time. Furthermore, even if the error term is not correlated with any of the independent variables, its presence will in general yield inefficient estimates and invalid standard errors. The OLS model is still included to determine if the results are similar to those obtained using a more robust model.

Thus, to correct for the possibility of this bias a Fixed Effects Model was used. The use of a fixed model regression makes it possible to control for all stable characteristics of an individual or farm, including those characteristics that are not observed or measured. Examples of such unobserved effects are land quality and managerial ability. The fixed effects model removes all those time invariant observations and expresses them as part of the farm constant.

The fixed effect panel data model is now introduced and the general model is estimated in the form of:

$$Y_{it} = \beta_0 + \beta_i X_{it} + u_{it}$$ ***Equation 2***

i= 1, 2….N t= 1, 2 …T

where Yit is the independent variable and Xit is a vector of explanatory variables. This means that the effect of a change in X is the same for all units for all periods, but the average level for one farm may be different to another farm. Using a fixed effect model the results can capture the individual unobservable effect.

A Hausman test was carried out to check whether the individual effects (u_i) are correlated with the regressors (X_{it}) i.e. determine if the fixed effect model is consistent and efficient. Results from the Hausman test determine that that the FE model is consistent and efficient. The model in full is shown in equation 3:

Total cost of production per litre= f(Cows, Cows², Yield per cow, Yield per cow², Stocking rate, Stocking rate², Calving spread, February, March, April, Summer and Autumn/winter) ***Equation 3***

Where,
Average Cost = Total costs/ total milk quantity
Cow= Herd size
Cows² = Herd size squared
Yield per cow = Yield per cow in litres
Yield per cow² = Yield per cow in litres squared
Stocking rate = Cows per dairy forage hectare
Stocking rate² = Cows per dairy forage hectare squared
Calving Spread = Deviation from calving spread expected from actual monthly births.
February = Dummy variable for median month caving date
March = Dummy variable for median month caving date
April = Dummy variable for median month caving date
Summer = Dummy variable for median month caving date
Autumn/Winter = Dummy variable for median month caving date

Results

Results from the pooled (OLS) regression in table 8 show that when herd size, yield, stocking rate and calving spread are controlled for, the total cost of production per litre were statistically different on all median category calving dates from March dates. Scale factors such as herd size and yield return expected results, which determine that economies of scale apply. However, stocking rate returns a positive coefficient and is not significant suggesting increasing stocking rate has no significant effect on total cost of production. Literature such as Colman and Zhuang (2003) and Smyth et al (2009) suggested increasing stocking rate plays a significant role in the reduction of costs. The pooled OLS also demonstrates that increasing calving spread decreases total cost of production. Looking at the FE model it suggests increasing calving spread increases costs. The latter would follow conventional thinking. As the use of OLS techniques to estimate panel data is subject to unobservable heterogeneity bias, this bias may be yielding inefficient estimates and invalid standard errors.

In contrast, the results produced by the FE model are more in keeping with those expected through economic theory. For example, the FE model shows that economies of scale are present, when herd size increases, the per unit cost of production decreases but at a declining rate. Similarly, increased efficiency (yield per cow) reduces per unit costs but at a declining rate and increasing stocking rate initially reduces costs but again non-linearly. Calving spread demonstrated a significant effect on costs of production showing that as calving date is less compact the total costs of production increase. The FE model suggests that there is no significant difference in total cost per litre on February, summer and autumn/winter compared to March median calving dates. It does suggest however those herds with an April median calving date demonstrate higher costs of production, which are significant. The summer variable returned a positive coefficient, which while it was not significant the result must be noted.

Hence, the FE model demonstrates that when size, efficiency and unobserved individual effects are accounted for; the median calving date for February, summer and autumn/winter herd had no significant effect on production costs compared to March herds. This would suggest that when the unobserved effects such as land quality and managerial qualities are accounted for in the model, median calving date had little effect on production costs.

Table 6. OLS and FE Model Results

Variables	OLS		FE	
	Coefficient	T value	Coefficient	T-value
Constant	0.39211	33.73	0.4796	31.62
Herd size	-0.00025	-3.43	-0.0015	-9.93
Herd size²	2.57×10^{-6}	6.48	7.55×10^{-6}	7.55
Yield	-0.000006	-13.75	-0.00006	-10.95
Yield²	5.63×10^{-9}	12.66	4.13×10^{-9}	7.66
Calving Spread	-0.00009	-5.86	0.00004	2.34
Stocking rate	0.00011	2.62	-0.0048	-15.67
Stocking rate ²	-7.82×10^{-8}	-0.74	8.88×10^{-7}	9.14
February	-0.00435	-2.57	-0.0011	-0.74
March	N/A	N/A	N/A	N/A
April	-0.121	6.17	0.0035	2.15
Summer	0.179	6.08	0.0035	1.32
Autumn/Winter	0.0151	4.21	-0.0005	-0.17
R^2	0.21		0.22	
F=	172.1		174.7	

Conclusions and Discussion

The FE model demonstrates that when size, efficiency and unobserved individual effects are accounted for; the median calving date for February, summer and autumn/winter has no significant effect on production costs. Assuming the individual effects are controlled for, this analysis suggest dairy farmers could change their median calving date from March to February, summer or autumn/winter and would show no significant change in production costs. A change in the median calving date on some farms would result in a lower in the peak to trough ratio and ultimately lower seasonality. These results suggest that production costs may not hinder the ability of the dairy sector in Ireland in reducing the seasonality of milk supply.

However, as calving spread has a significant effect on production costs, the validity of comparing different median calving seasons may come into question. That is, as most farmers have a large number of months in which they have calves being born, the analysis to compare median calving date might be inaccurate. The results also suggest that the individual effect such as managerial ability plays a significant role in production costs.

The results also go against traditional thinking so some further analysis may be needed to confirm the findings above. Caveats such as the level of spread in the median calving date categories need to be heeded and researched fully.

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