PASTORAL DAIRY FARMING SYSTEMS AND INTENSIFICATION, CHALLENGES IN INTERPRETATION

Sub theme: Knowledge and Information

Nicola Shadbolt, Muhammed Imran Siddique and Nicola Hammand

Massey University, Palmerston North, New Zealand

Abstract:

The response of many New Zealand farmers to increasing and volatile global milk prices has been to intensify their farming systems. This has generated much debate both within NZ and globally with justification for and against the changes ranging from competitive advantage to profitability to environmental footprint. Analysing nine years of farmer data provides evidence that metrics can mislead; while profit per hectare increases and operating expenses per KgMS can increase as systems intensify the metrics that reflect resources employed, operating return on dairy assets and cost of production show no significant difference between systems. After allowing for inflation the cost of production differences between the lowest and the highest milk price years also disappear apart for the more intensive systems 4 and 5. With no significant difference between the profitability or cost of production of systems as they intensify, industry research and extension would be better employed identifying best practice within each system than between systems.

Keywords: *dairy farming systems, benchmarking, profitability, cost of production*

Introduction

The response of many but not all New Zealand dairy farmers to increasing and volatile global milk prices since 2006/07 has been to intensify their farming systems producing more milk per hectare (Figure 1) and per cow (LIC & DairyNZ, 2016). Increased production has resulted from an increase in the use of imported feed and the development of irrigation based pastoral systems, especially in the South Island. The resulting increase in total feed supply enabled the mean stocking rate to rise from 2.77 cows/ha in 2006/07 to 2.85 cows/ha in 2015/16 (LIC & DairyNZ, 2016).This has generated much debate both within NZ and globally, with justification for and against the changes from the perspectives of competitive advantage (Shadbolt, 2012), profitability (Roche and Newman, 2008; Taylor, 2014) and environmental footprint (Parliamentary Commissioner for the Environment, 2015).

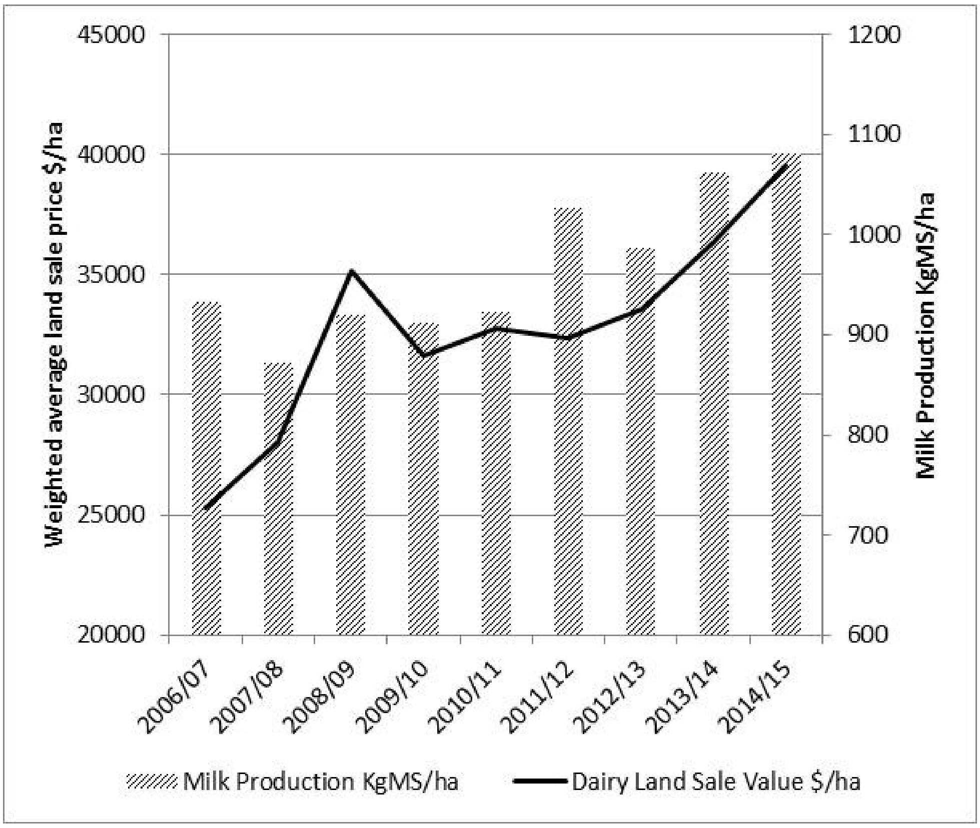

Figure 1: Milk Production (KgMS/ha) and Weighted Average Dairy Land Sale Prices ($/ha) from 2006/07 to 2014/15: Source LIC & DairyNZ (2016)

The increase in average milk price was capitalised into land values (Figure 1) quite quickly leaving farmers vulnerable to the low price years as debt levels increased in tandem with land values. Closing debt to asset percentages for owner operators increased from 34.7% to 45.8% over those 9 years (DairyNZ, 2016). Fortuitously interest rates fell so the debt servicing capacity (defined in Appendix) over the same period fell from 24.3% to 21.5% but ranged from 15.5% to 30.4% depending on milk price and production levels.

The intensification of farming systems that began in the early 2000s (Holmes and Mathews, 2001), has resulted in an increased volume of imported feed used (Roche and Newman, 2008). There are five production systems defined by DairyNZ, a farmer funded research and extension entity, based on the quantity and time of year that imported feed is used, they progress from the 'low input' of system one to the 'high input' of system five. Pastoral dairy farming systems in New Zealand are typified by a 'milking platform', the effective milking area of the farm, on which the cows are grazed; it surrounds and is in walking distance from the milking shed. As seasonal production pastoral systems the aim is to match cow feed demand as closely as possible with the pasture feed supply curve. Imported feed for the system includes feed brought onto the milking platform to supplement the pasture, as well as feed provided as grazing or supplement for cows removed from the milking platform. All systems assume that young stock, cow replacements, are grazed off the milking platform.

The systems, as outlined in Shadbolt (2012) are as follows:

System 1. *Self contained – no imported feed*
No supplement fed, except supplement harvested off the effective milking area and no grazing off the effective milking area by dry cows

System 2. *4 – 14% of total feed imported*
Feed imported, either as supplements to milking cows or grazing and supplements for dry cows

System 3. *10 – 20% of total feed imported*
Feed imported, both as supplements to extend lactation (typically autumn feed) and grazing and supplements for dry cows

System 4. *20 – 30% of total feed imported*
Feed imported, both as supplements used at both ends of lactation and grazing and supplements for dry cows

System 5. *More than 30% total feed imported*

Feed imported for use all year, both supplements used throughout lactation and grazing and supplements for dry cows. Split calving is common in this system

There has been a change in the proportion of farms in each system as a result of intensification with system 1 diminishing and the systems 3-5 increasing (Sinclair, 2011; DairyNZ, 2016). The higher milk price has enabled farmers to afford the cost of purchasing supplementary feed not only to increase production but also to reduce production variability due to climatic events such as drought that decrease pasture growth (Hammond, 2016). As summarised by Jensen *et al.* (2005), farmers have transitioned from low input systems to higher input systems where:

- Returns from extra milk production are greater than the cost of extra feed
- They allow more profitable use of existing land, cows, plant, and labour
- Farmers wish to avoid the risk and cost associated with buying more land or are unable to find suitable land to purchase
- Farmers wish to reduce production variation between seasons

While moving to a higher input system reduces the risk associated with climate, the production risk, it does increase its exposure to market risk (feed prices, milk payout) and, if more debt is involved, financial risk (interest rates). Imported supplements can increase milk production, but the effect that their use has on profit varies depending on the milk solids response to the extra feed and the costs incurred to produce the extra milk (Ho *et al.* 2013; Hedley and Kolver, 2006), marginal costs may exceed marginal returns. Essentially a change in dairy production system shifts the type of risk a farm business is exposed to (Shadbolt, 2012; Taylor, 2014). As explained by Taylor (2014) low input systems are more at risk of having low cow condition than a high input system, but a low input system's profitability is not dependent on the price of feed (Taylor, 2014). Therefore, the intensity of the production system that a farmer chooses to run relates to what kind of risk they prefer to be exposed to, their goals and their available resources (Ho *et al,* 2013). When farmed to best practice, all systems can be profitable (Hedley and Kolver, 2006).

Profitability is defined by Barry *et al., (*2000) as the ability of a business to use its resources to generate revenues greater than its expenses. The metric frequently used by the NZ dairy industry for profit is operating profit per hectare. However, as Johnson *et al.* (1998) explain profit is only a figure and makes no account of the resources invested in the business. To assess farm profitability, they state farm profit should be related to the resources used in the business through profitability measurements; this is to provide fair comparison between farms as all farms utilise different resources to make their profit or loss. Operating profit per hectare can be a misleading metric because not all hectares are equal in terms of capital investment and infrastructure. When comparing farm performance within a production system, operating profit per hectare cannot distinguish between the quality and the value of the hectares; there is a similar issue when comparing between systems, as operating profit does not incorporate the additional capital that is required when farms intensify (Shadbolt, 2012). This means that operating profit per hectare makes no allowance for the extra cows needed when stocking rate increases, extra co–operative shares required when milk production is enhanced and the significant investment in assets such as feed pads, herd homes and machinery. A fairer comparison of profitability could be obtained between farms by using measures such as return on assets or return on equity, as these allow for the differences in capital (Barry *et al.* 2000; James and Eberle, 2000; Kay et *al.*, 2012; Shadbolt, 2012; Moss, 2013). While Barry *et al.* (2000) state that profitability ratios can be expressed on a per unit basis (operating profit per KgMS); they suggest that the three ratios that should be used to assess profitability are return on assets (RoA), return on equity (RoE), and operating profit margin (OPM). As explained by Barry *et al.* (2000) return on assets is the rate-of-return on farm assets and provides a measure of the profitability of the business that is separate from the financing function.

Cost of production can be reported as farm working expenses or operating expenses per kilogram of milk solids, but again this is incomplete because it does not include the capital cost required to produce the milk (Shadbolt, 2012). While farm working expenses and operating expenses are commonly reported in New Zealand global comparisons of dairy farm businesses carried out by the International Farm Comparison Network (IFCN) in dairying (IFCN, 2016) include the cost of capital, both in cash terms (interest paid on debt, rent of land) and non-cash (opportunity cost of equity of 3%).

This research aimed to assess the difference between the five pastoral dairy farming systems over the nine years to determine how farmers responded to volatile but higher milk prices, by comparing both physical and financial metrics. Did low input systems outperform high input systems over that time period, and according to what metric(s) can this be best determined. This study is a combination of an honours thesis (Hammond, 2016) and subsequent further research that is one of a series of analyses in the Marginal Imperative Project funded by New Zealand dairy farmers through DairyNZ and the Ministry for Primary Industries in the Transforming the Dairy Value Chain Primary Growth Partnership programme.

Methodology

This research extracted performance of individual dairy farmers from DairyBase (www.dairybase.co.nz), a database used by farmers and professional advisors in New Zealand to analyse farm results and benchmark them with their peers. The data set included physical and financial data for nine consecutive seasons, 2006/7 to 2014/15. In addition to the DairyBase variables defined in the Appendix a cost of production metric was added to the dataset. This was the sum of the operating expenses plus a cost of capital that was calculated as 4% of the opening dairy assets for each farm. The 4% opportunity cost of capital over all assets is comparable with the IFCN approach (IFCN, 2016) of combining an equity charge of 3% with debt interest (which is typically greater than 3% in NZ).

The total number of farmers analysed varied by season and by system and included farms from throughout New Zealand. Each season was analysed separately so no attempt was made to track trends between years or exclude farms that did not have data in all nine years. Owner-operator data was extracted from the DairyBase database. Farm businesses that did not include the value of their assets or only had the physical data were removed. The farm businesses with complete record of physical and financial data or complete financial data remained in the data set. Lastly, the data was grouped according to production systems

The next step in the research process was then to run ANOVA statistics on the farms in the relative system groups to test if there was a statistically significant difference in production, cost of production and profitability in the different systems each year.

This study also compares the operating expenses and costs of production per kilogramme of milksolids between the two years of 2006-07 and 2013-14. The two years were compared using inflation adjusted costs to remove the impact of inflation over those seven years. In order to capture the inflation impact, all nominal costs were inflated to the 2013-14 level using the producer's price index reported by Statistics New Zealand (Statistics, 2017).

The analysis was performed between groups for each of the nine seasons to identify differences between systems. In addition, t-tests were performed to test the level of significance in different categories of costs of production between 2006-07 and 2013-14. Only significant results have been reported in the study.

Results & Discussion

As dairy farm systems intensified in New Zealand they produced more milk per hectare from more cows, a higher stocking rate, and delivered a higher operating profit per hectare. There were statistical differences in these three measures between all or most systems in all or most years with the mean for the nine years depicted in Figure 2. The only year when there was no significant difference between systems for operating profit per hectare was 2007/08, the first year of high prices but when drought was also prevalent across much of the country.

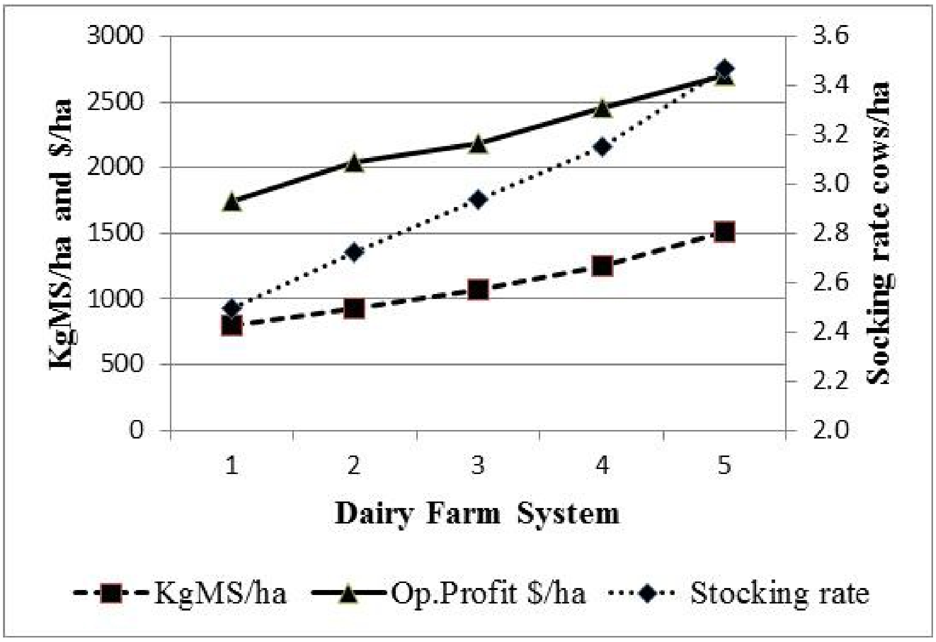

Figure 2: Mean Milk production (KgMS) per hectare, Operating Profit ($) per hectare and stocking rate (peak cows) per hectare from 2006/07 to 2014/15 for pastoral dairy farming systems (extensive=1 to intensive=5)

During this time period the proportion of farmers in the more intensive systems grew. In the data sample used system 1 farms diminished from 13% to 4%, system 2 from 38% to 20% and systems 3, 4 and 5 grew from 31%, 14% and 4% to 41%,25% and 10% respectively.

Industry puts great emphasis on operating profit per hectare, both in benchmarking (the default ranking metric in DairyBase), in farming competitions, in the annual industry economic survey report (highlighting the superiority of the top 25%) and as one of the key planks of industry strategy. Comparing operating profit per hectare within a system group does provide useful data that farmers can use to identify where they can improve their operation. Unfortunately, however, as these results show, unless these comparisons are restricted to the system, or level of intensification, ranking all farms according to this emphasis inadvertently leads to championing intensified NZ dairying.

When profitability is measured in relation to the resources (land, cows, machinery, plant and on-farm infrastructure) used to make that profit (Johnson et al, 1998, Barry et al, 2000, Shadbolt, 2012; Moss, 2013) the results tell a different story (Figure 3).

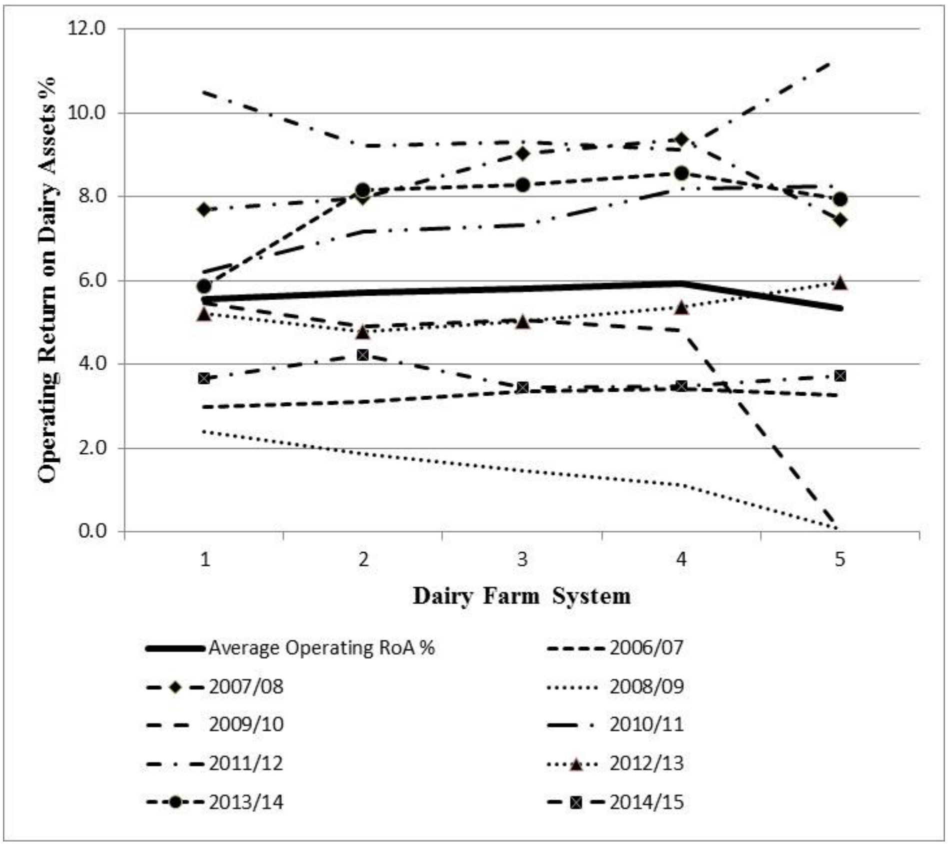

Figure 3: Operating Return on Dairy Assets % by pastoral dairy farming systems (extensive=1 to intensive=5) from 2006/07 to 2014/15 and on average.

The Operating Return on Dairy Assets (RoA) metric allows for the differences in capital invested. Throughout the nine years of analysis (Figure 3) in only one year was there a statistical difference between the systems for this metric, 2008/09. In this year, as previously reported by Shadbolt (2012) the milk price fell through the year providing limited ability to farmers in more intensive systems to pull back costs. The impact of milk price is observable, with higher RoAs in the four years of higher payout 2007/08, 2010/11, 2011/12 and 2013/14, all above the average RoA with the remaining years below the average as illustrated in Figure 3.

In 2006/07, 2007/08, 2009/10 and, 2010/11 there was no significant difference between the operating expenses ($/KgMS) of the five systems. However for the other 5 years there were significant differences with operating expenses ($/KgMS) increasing as systems intensified. When allowance is made for the cost of capital invested there was no significant difference between the costs of production of the five systems in any year except for 2006/07, the year before milk prices shifted up. The average cost of production of the five systems (Figure 4) illustrates this lack of difference between seasons. This reconfirms the outcomes noted by Shadbolt (2012) from a 3 year data set, that intensification of pastoral dairy farming systems in New Zealand does not increase their cost of production and, by inference, decrease their competitive advantage on the global stage. However this conclusion would not have been reached over half of the time if systems were compared on the basis of operating expenses ($/KgMS), which is a very commonly used industry benchmark. In five of the years analysed if highlighting 'top 25%' farms based on operating expenses per kilogramme of milksolids produced, unless comparisons are restricted to the system, or level of intensification, the low input farms would be championed. While this interpretation might be useful for those advocating low input solutions as 'more desirable' for NZ dairy farming, lack of consistency with this metric would not enable them to consistently reach this conclusion. There is further confusion caused in this debate by the fact that the terms low input and low cost are often taken as synonymous in industry commentary; these results prove that they are not, as illustrated in Figure 4.

In Figure 4 while the impact of the 5 out of 9 years of significant increases in operating expenses per KgMS as systems intensify can be seen in the average so also can the lack of difference between cost of production between systems. The gross farm revenue

(GFR) per KgMS also does not differ between systems. The difference between the GFR and the operating expenses per KgMS is the operating profit that is then available for payments of rent, interest and tax as well as discretionary payments of capital, debt and personal drawings. If these payments equate to more than the 4%, the opportunity cost of capital included in the cost of production, the farm business will run at a deficit.

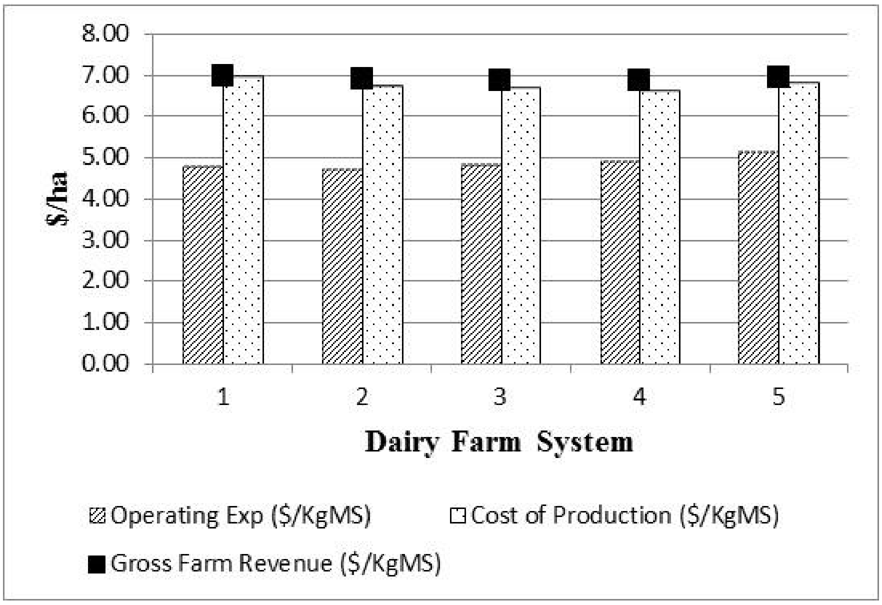

Figure 4: Mean Operating Expenses ($/KgMS) and mean Cost of Production ($/KgMS) from 2006/07 to 2014/15 of pastoral dairy farming systems (extensive=1 to intensive=5)

Of particular interest in these results is the fact that all systems increased costs from 2006/07 under higher milk prices (2007/08, 2010/11, 2012/13, 2013/14) and all also decreased them in the lower milk price years (Figure 5). In 2013/14, the highest milk price year the cost of production was exceeded by gross farm revenue per KgMS by $1.10/KgMS across all systems. However the following year, when milk prices dropped the cost of production exceeded gross from revenue by $0.30/KgMS so all systems ran at a deficit, on average, indicating costs could not be pulled back quickly enough when prices dropped. While it is easy to understand how intensive farms adjust variable costs such as feed in line with milk price to increase or decrease production, for less intensive, low input systems it is less easy to explain what costs they adjust as milk prices fluctuate.

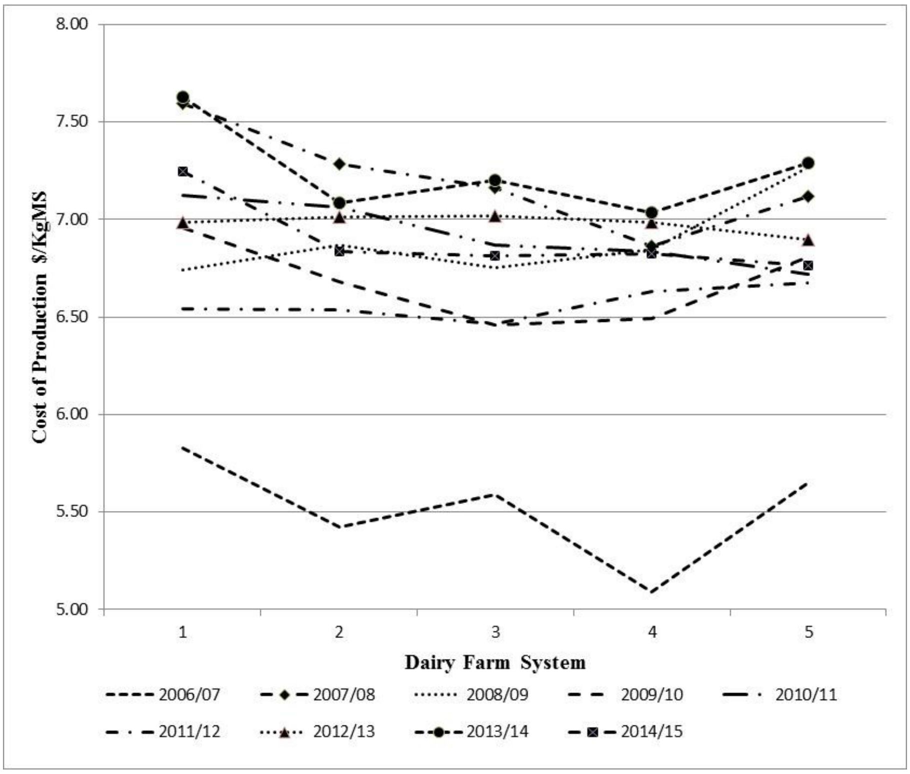

Figure 5: Cost of Production ($/KgMS) of pastoral dairy farming systems (extensive=1 to intensive=5) from 2006/07 to 2014/15

The data was further examined, therefore, to determine what cost category each farm system increased or decreased by between the two years 2006/07 and 2013/14 (the lowest and highest milk price years respectively). The data was first adjusted for inflation so while Figure 5 shows the changes in cost of production in nominal terms the differences illustrated in Figure 6 are in real terms. There was a significant difference (***) in every farm system between the operating expenses per KgMS in 2006/07 and 2013/14 (Table 1) indicating spending increased in real terms in each system over that time period. However, once the cost of capital is included the significant differences are less uniform. For systems 1, 2 and 3 there was no significant difference between the inflation adjusted cost of production per KgMS in 2006/07 and 2013/14, although cost of capital did increase significantly (by 9%) for system 3. However, both cost of capital and cost of production per KgMS did increase significantly for system 4 (9% and 10% respectively) and system 5 cost of production per KgMS increased significantly by 2% over the seven years.

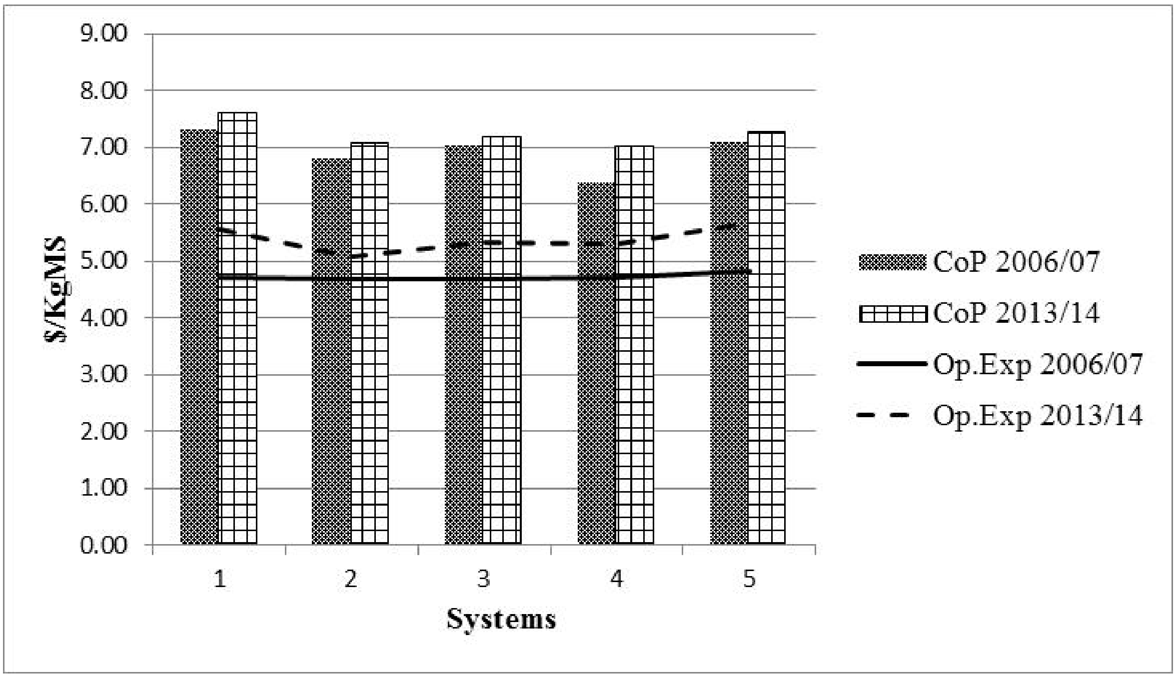

Figure 6: Inflation adjusted Operating Expenses and Cost of Production ($/KgMS) by pastoral dairy farming systems (extensive=1 to intensive=5) in 2006/07 and 2013/14.

The breakdown into cost categories (Table 1) provides an insight of how the different systems responded to milk price increases.

System	Operating Exp $/KgMS	Change in Variable Costs $/KgMS							
		Feed	Grazing & Run-off	Breeding	Animal Health	Farm Dairy	Calf Rearing (not labour)	Stock	Other Working
1	**18%**			27%					
2	**8%**	40%							
3	**13%**	60%		21%		12%	39%	10%	9%
4	**13%**	83%	19%	20%	20%		157%		
5	**17%**	87%							

System	Change in Fixed Costs $/KgMS											
	Pasture Renovation	Fertiliser	R&M	Vehicle	Fuel & Oil	Freight & General	Electricity	Labour	ACC	Rates	Farm Insurance	Depreciation
1		31%	48%								33%	
2	35%					-18%		-15%	-21%	16%	43%	-31%
3	28%		28%	16%				-6%		25%	46%	-22%
4	67%		28%				14%		-20%		50%	-15%
5	93%				110%			-18%	-44%		47%	-24%

Table 1: The percentage change of $/KgMS in operating expenses and specific cost categories that have significantly (*, **, ***) changed between 2006/07 and 2013/14, by pastoral dairy farming systems (extensive=1 to intensive=5).

System 1, low input farms, increased operating expenses by 18% by increasing breeding (herd improvement), fertiliser, repairs and maintenance (R&M) and farm insurance expenses per kilogramme of milksolids. As expected the majority of the increases were not in variable costs. In contrast systems 2, 3, 4 and 5 all significantly increased supplementary feed expenses within the bounds of their system definition. They all also significantly increased pasture renovation so the emphasis was on improving pasture feed yields too. Both labour and plant and machinery efficiency improved per kilogramme of milksolids with significant decreases in labour and/or associated accident insurance (ACC) expenses and depreciation in systems 2 to 5. While increases in rates and insurance are out of farmer control the significant increase in pasture renovation for 4 systems and R&M for 3 of the 5 systems reinforces spending patterns observed by Gray et al, (2016). The farmers they studied treated development (pasture renovation) and R&M as discretionary items reliant on cash flow; at the 2013/14 high milk prices there would, therefore, have been sufficient funds to spend.

Conclusion

Analysing nine years of farmer data provides evidence that metrics can mislead; while profit per hectare increases and operating expenses per KgMS can increase as systems intensify the metrics that reflect resources employed, operating return on dairy assets and cost of production show no significant difference between systems. After allowing for inflation the cost of production differences between the lowest and the highest milk price years also disappear apart for the more intensive systems 4 and 5. When specific cost categories were examined in the inflation adjusted numbers low input farms were seen to have increased mostly fixed cost expenditure in higher milk price years whilst systems 2 to 5 increased variable costs (mostly feed but also other expenses) as well. The significant increase in spending of pasture renovation and repairs and maintenance in the higher milk price year confirms the discretionary nature of such expenditure. With no significant difference between the profitability or cost of production of systems as they intensify, industry research and extension would be better employed using the correct metrics to identify and champion best practice within each system than between systems.

References

Barry, P. J., Ellinger, P. N., Hopkin, J. A., and Baker, C. B. (2000) *Financial Management In Agriculture.* Danville: Interstate Publishers Inc.

DairyNZ (2016) *DairyNZ Economic Survey 2013 – 14.* Hamilton: DairyNZ Limited

Hammond, N. (2016) A comparison of New Zealand dairy production systems using physical and financial key performance indicators. A thesis presented in partial fulfilment of the requirements for the degree of Bachelor of AgriScience (Honours), Massey University, New Zealand

Hedley, P., and Kolver, E. (2006) *Achieving High Performance From A Range Of Farm Systems In Southland.* Proceedings of the 2006 South Island Dairy Event.

Ho, C. K. M., Newman, M., Dalley, D. E., Little, S., and Wales, W. J. (2013) *Performance, Return, and Risk of Different Dairy Systems in Australia and New Zealand.* In: Animal Production Science. 2013, 53, (9), 894 – 906; CSIRO Publishing.

Holmes, C. W., and Mathews, P. N. P. (2001) *Feeding Conserved Forage – Implications To Grassland Management And Production.* Proceeding of the XIX International Grassland Congress, 671-677

IFCN, (2016) International Farm Comparison Network Dairy Report 2014: For A Better Understanding Of The Dairy World. Germany: IFCN Dairy Research Centre

James, S. C., and Eberle, P. R. (2000) *Economic & Business Principles In Farm Planning & Production.* United States of America: Iowa State University Press

Jensen, R. N., Clark, D. A., Macdonald, K. A. (2005) *Resource Efficient Dairying Trial: Measurement Criteria For Farm Systems Over A Range Of Resource Use.* Proceedings of the New Zealand Grassland Association 67, 47-52.

Johnson, D. M., Lessley, B. V., and Hanson, J. M. (1998) *Assessing and Improving Farm Profitability.* Baltimore: University of Maryland.

Kay, R. D., Edwards, W. M., and Duffy, P. A. (2012) *Farm Management, Seventh Edition.* United States of America: McGraw-Hill

LIC and DairyNZ (2016) *New Zealand Dairy Statistics 2015-16.* Hamilton: DairyNZ Ltd

Moss, C. (2013) *Agricultural Finance.* London : Routledge, Taylor & Francis Group

Parliamentary Commissioner for the Environment. (2015). *Update Report. Water quality in New Zealand: Land use and nutrient pollution*. New Zealand: Parliamentary Commissioner for the Environment.

Roche, J. and Newman, M. (2008) *Profitable Low Input Systems – Separating The Myth From The Magic*. Proceedings of the 2008 South Island Dairy Event.

Shadbolt, N. M. (2012) Competitive Strategy Analysis Of NZ Pastoral Dairy Farming Systems. In: International Journal of Agricultural Management, 1 (3), 19 -27.

Sinclair, E.F.R. (2011) *System 5 Profitability and Key drivers, Case studies of Canterbury system 5 dairy farms.* Unpublished Honours dissertation. Lincoln University.

Statistics, N. Z. (2017). Producers Price Index - PPI Retrieved from http://www.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=8ad1bd72-0254-4a30-a299-ac6d2de37eb7. Retrieved 20 February 2017 http://www.stats.govt.nz/infoshare/SelectVariables.aspx?pxID=8ad1bd72-0254-4a30-a299-ac6d2de37eb7

Taylor, G. (2014) *System Intensification: Is It Worthwhile?* Proceedings of the 2014 South Island Dairy Event.

Appendix follows

Appendix

DairyBase Variables	Description
Cows/ha	Peak Cows Milked divided by Milking area
KgMS/ha	Kilogrammes of milksolids divided by Milking area
KgMS/cow	Kilogrammes of Milksolids divided by Peak Cows Milked
Cows/FTE	Peak Cows Milked divided by Total Full Time Equivalent labour units (FTEs)
KgMS/FTE	Total Milksolids Kg produced divided by Total FTEs
Net Cash Income $/ha	Net Cash income from milk sales; net (sales-purchases) dairy livestock sales and other dairy farm related revenue. This value is divided by Milking area
Dairy GFR	Dairy Gross Farm Revenue (net cash income plus value of the change in dairy livestock numbers)
Op.Exp. $/ha	Total Dairy Operating Expenses: (FWE plus depreciation, feed inventory adjustment, value of unpaid family labour, owned run-off adjustment) divided by Milking area.
Op.Profit $/ha	Operating Profit (Dairy GFR less Total Dairy Operating Expenses) divided by Milking area
FWE $/Kg MS	Farm Working Expenses divided by Milksolids Kg
Op.Exp. $/KgMS	Total Dairy Operating Expenses divided by Milksolids Kg.
Op.Profit $/KgMS	Operating Profit divided by Milksolids Kg.
Op.Profit Margin %	Operating Profit Margin (Dairy Operating Profit as a percentage of Dairy GFR) as a %.
Asset T/O %	Asset Turnover (Dairy GFR as a percentage of Opening Dairy Assets).
Operating Return on Dairy Assets %	(Operating Profit plus owned run-off adjustment less rent) as a percentage of Opening Dairy Assets.
Debt Servicing Capacity %	Interest and Rent paid as a percentage of Dairy GFR and net off-farm income
Interest & Rent $/kgMS	Interest and Rent paid divided by Milksolids Kg
Debt to Assets %	Closing Total Liabilities as a percentage of Closing Total Assets.