Grasslands Society of Southern Australia – 2021 Annual Conference

Changing Production Systems: Improving Profit in Australian Dairy

High pasture harvest is not enough for consistently high levels of profit – a high percentage of pasture in the diet is also required!

David Beca, Red Sky Agricultural Pty Ltd

Introduction

Pasture harvest is important to pasture-based dairy farm profit due to pasture being a much lower-cost feed than concentrates and other forages. If a pasture-based farmer then feeds a high per cent of supplement, this undermines the benefit of low-cost pasture by increasing the average cost of feed. As a result, any argument relating to the benefit of pasture to dairy farm profit is likely to be based on either both pasture harvest and pasture as a percentage of the diet being important for delivering a high level of profit, or both not being important.

Nevertheless, a majority of Australian dairy farmers and their advisors can often be heard to make the following two statements:

1. A high level of pasture harvest is important for delivering a high level of profit; and
2. The choice of production system by a farmer is **not** relevant in determining the level of profit for a farm.

The second statement infers that a high percentage of pasture in the cows' diet is **not** important for delivering a high level of profit. This paper reviews the relationship between these two statements.

The arguments outlined in this paper only apply to pasture-based dairy farmers and not feedlot or total mixed ration (TMR) farmers. As defined by Beca (2020b), 'pasture' includes all pasture and other crops consumed by the cows in-situ as well as any pasture mechanically harvested on the dairy farm, and 'pasture-based' refers to farms where cows consistently walk to paddocks and harvest the pasture themselves. There is no minimum percentage level of pasture in the diet required for the definition of being pasture-based, although in practice it is rare to see pasture-based farms with less than 25-30 per cent pasture in the annual diet.

Trends in Australia dairy farming

One of the key outcomes of the widely held view that the choice of production system is unimportant is that over the last 25 years, most farmers in all dairy regions in Australia, with the single exception of Tasmanian farmers, have progressively decreased the percentage of pasture in the diet and significantly increased the percentage of supplement. This trend is outlined in Figure 1, which includes pasture as a percentage of the cows' diet for all regions of Australia, plus New Zealand (black dashed line).

Figure 1. Trend in pasture as a percentage of cows' diet (2003-2020)

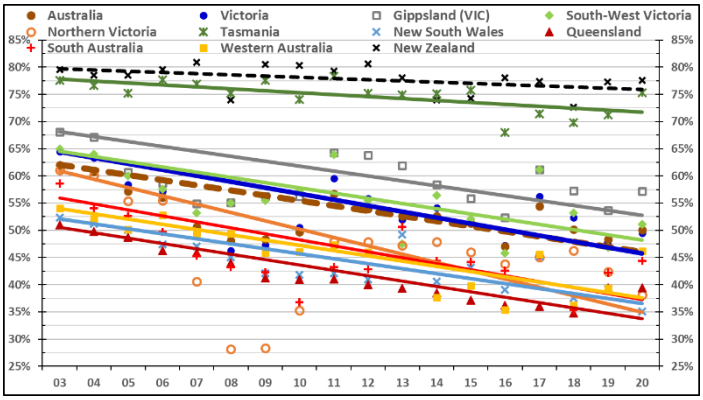
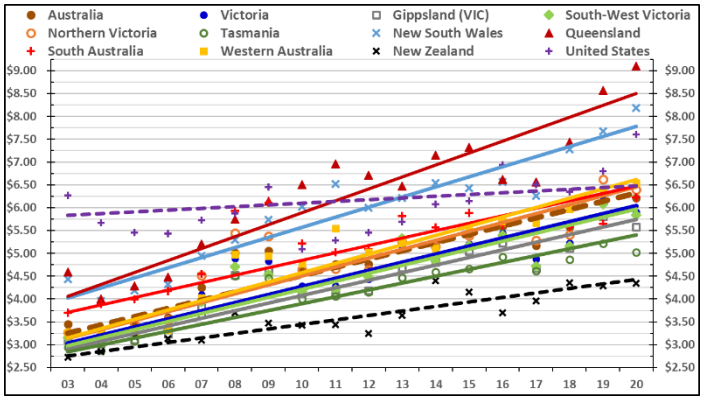


Figure 2. Trend in cost of production per kg milksolids (AUD 2003-2020)



This trend has been aligned with a strong focus on cow performance including nutrition and genetics. Over the last two decades there has also been a trend of increasing cost of production, including greater increases compared to farmers in other countries. As outlined in Figure 2, Australian farmers in all regions of the country have on average had

significantly larger increases in cost of production compared to both strongly pasture-focused countries like New Zealand and feedlot-based countries like United States (purple dashed line).

In this paper, all milk ratios are reported in 'energy corrected milk' (ECM) with this corrected to 4.0 per cent fat and 3.3 per cent protein using the formula: ECM = milk production x ((0.383 x fat% + 0.242 x protein% + 0.7832) / 3.1138). All dollar-denominated ratios are reported in AUD, except for the statistical analysis in Figures 18-20 and 23-24, which are in USD (USD:AUD foreign exchange rate = 0.747 for dataset). The basis and analysis for all data presented in this paper has been reported by Beca (2020a), Beca (2020b), and Beca (2021).

The high rate of increase in cost of production outlined in Figure 2 has been matched with a decrease in the level of profit as described by return on capital in Figure 3. As reported by Beca (2020a), neither milk price nor climatic or environmental factors would appear to be a rational explanation for these trends that have emerged over the last 20 years.

This combination of higher cost of production and lower levels of profit have resulted in all regions of Australia, with the one exception of Tasmania, losing international competitiveness. The absence of consistent levels of profit has resulted in the amount of milk produced within these regions reducing over the last two decades as outlined in Figure 4. New Zealand and United States are included as dashed lines.

Figure 3. Return on capital (2003-2020)

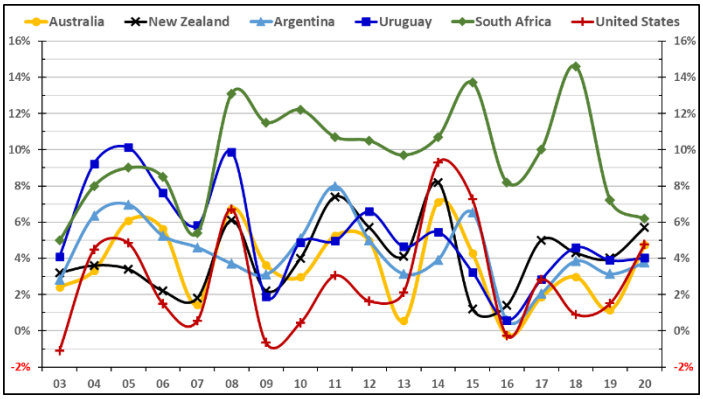
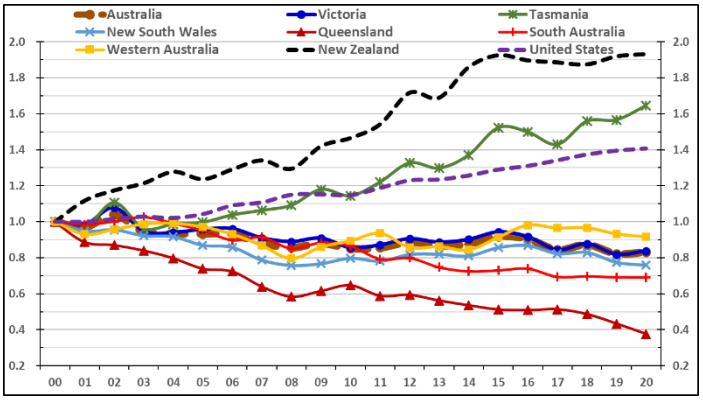


Figure 4. Growth in milksolids production from 2000 (base = 1.0)

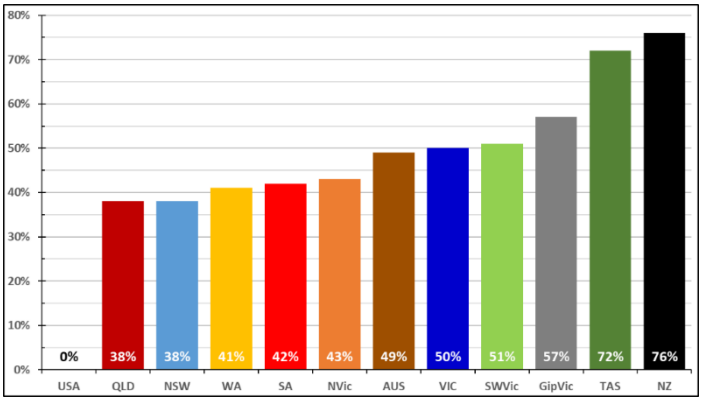


An important question is whether the substantial decreases in the percentage of pasture in the cows' diet over the last 20 years is a relevant factor in these trends. Figure 5 outlines the present estimated per cent of pasture in the cows' diet for all regions in Australia plus New Zealand and United States.

Might an increase in milk revenue be the solution to the trend of decreasing profit?

Milk revenue could be increased through either a higher milk price or a higher level of milk production per cow. To improve Australia's competitive position, any increase in milk revenue would need to be greater than in other countries.

Figure 5. Pasture as a percentage of cows' diet (2019-2020)



A significant and continuing increase in milk price would appear to be an unlikely outcome. As reported by Beca (2020a) and Beca (2021), Australian dairy farmers have been paid a competitive international milk price compared to other countries over the last 20 years. Figure 6 compares the average Australian milk price with seven other countries over the period from 2015-2020, which includes the period when Murray Goulburn and Fonterra reduced the milk price late in the year. This confirms that the average milk price paid to Australian farmers has been consistently competitive with other countries, especially those Southern Hemisphere countries that include a dairy export component.

Figure 7 compares the milk price for all the regions of Australia, as well as including New Zealand and United States, for the period from 2015-2020. This further confirms that the average milk price paid to Australian farmers in all regions has been consistently competitive with other countries, with the milk prices paid in New South Wales, Queensland and

Western Australia being similar to or higher than in United States, and significantly higher than in other Southern Hemisphere countries.

Figure 6. Milk price per kg milksolids (AUD 2015-2020)

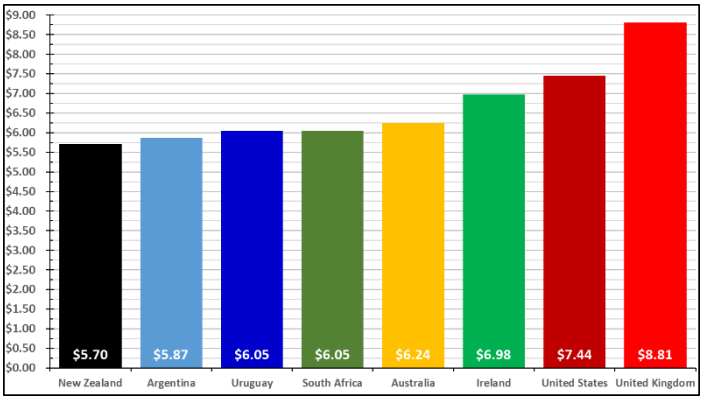
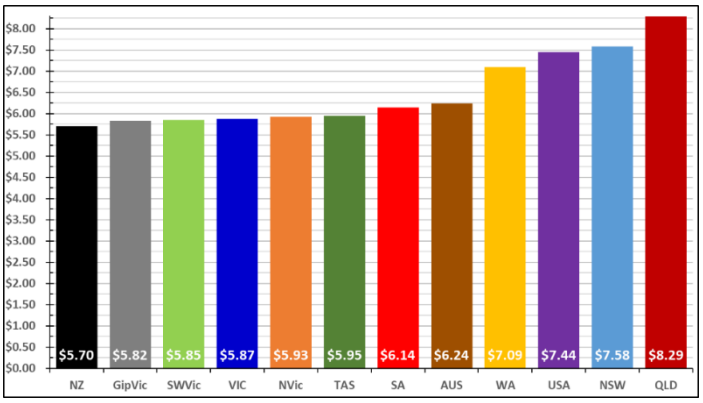
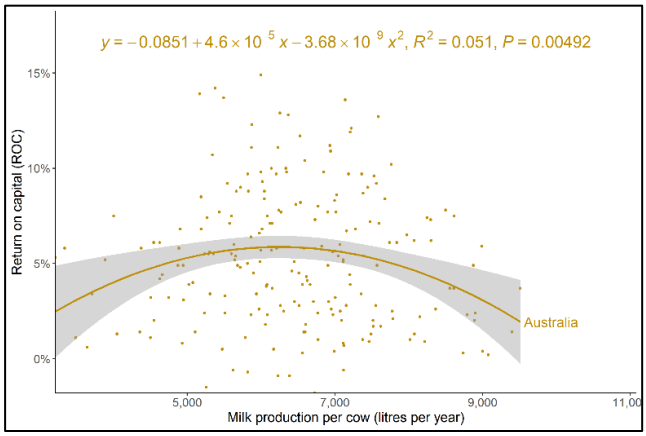


Figure 7. Milk price per kg milksolids (AUD 2015-2020)



So if a significant increase in revenue from a higher milk price does not appear to be a realistic outcome, what are the opportunities from increasing milk production per cow? Firstly, milk production per cow on pasture-based dairy farms does not positively correlate with profit, or not substantially, as reported by Beca (2020b). Figure 8 outlines the impact of milk production per cow on profit. This relationship is different to that for feedlot or TMR dairy farms where milk production per cow does positively correlate with profit, though feedlot or TMR production systems do not offer a solution for Australian dairy farmers as the cost of production on these farms is substantially higher than on pasture-based dairy farms. This is partially evidenced in Figures 2 and 14 given United States farms have a comparatively high cost of production, even though they have a very low cost of concentrate and forage per tonne dry matter, and have one of the lowest, if not the lowest, cost of production for any feedlot industry. These comparative costs of feed and production have been further reported by Beca (2020a) and Beca (2021).

Figure 8. Milk production per cow impact on return on capital (profit)



The second factor is that Australian dairy farmers have been increasing milk production per cow at a similar rate to other countries over both the last 40-year and 20-year timeframes as reported by Beca (2021). So not only is it unlikely that a focus on increasing milk production per cow will increase profit, but any increase in milk production per cow is likely to be matched by farmers in other countries and not improve Australian dairy farmers' competitive position. As a result, it would be reasonable to conclude that for all regions of Australia, decreasing cost of production rather than increasing milk revenue is the only reliable and sustainable option for increasing profitability on most dairy farms.

Have changes in pasture harvest been negatively impacting on profit?

Before exploring the question as to the impact of changes in the per cent of pasture in the diet, it is worth reviewing whether changes in pasture harvest have been negatively impacting on profit. When farmers and their advisors discuss perceived problems with high cost of production, pasture harvest is often nominated as the main problem. This is seen as especially relevant when comparisons are made with New Zealand and Ireland.

However, it does not appear that the level of pasture harvest in Australia has been a factor in these trends. Although there is limited data available on regional changes in pasture harvest, it does appear that Australian dairy farmers on average have maintained, if not increased, pasture harvest over the last 20 years.

As outlined in Figure 9, Australian farmers have made at least as much progress in improving pasture harvest as say New Zealand dairy farmers, who have made little, if any, progress over the last 20 years. It is also noteworthy that Australian dairy farmers on average were similarly, or more, profitable (based on return on capital) than New Zealand farmers over the period from 2003-2007 when, if anything, there was a greater gap between the levels of pasture harvest in each country.

Figure 9. Pasture harvest in tonnes dry matter per hectare (2003-2020)

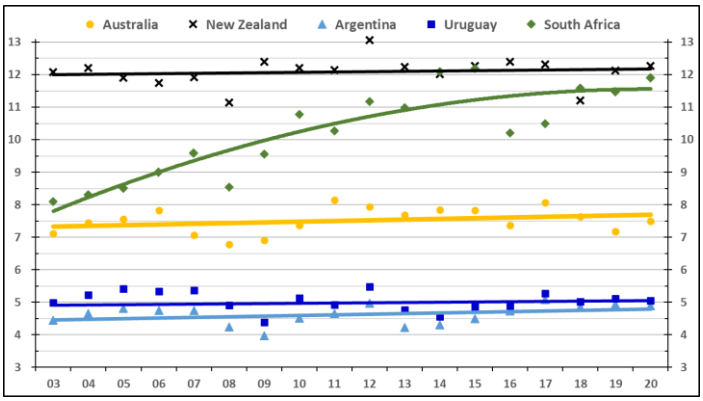
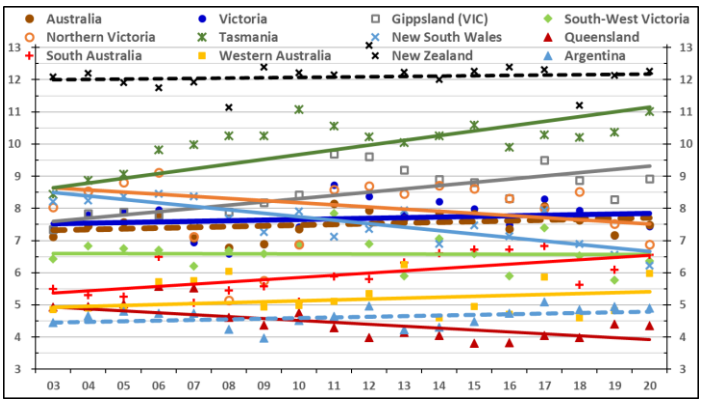


Figure 10. Pasture harvest in tonnes dry matter per hectare (2003-2020)



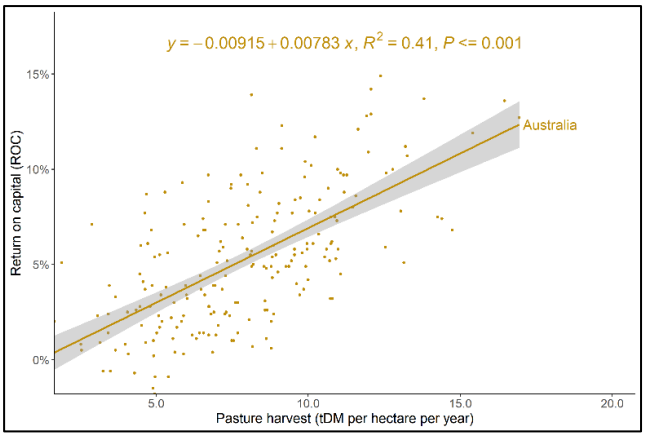
South Africa's significant increase in pasture harvest in Figure 9 was based on increasing areas under irrigation and a strong focus on pasture management.

Figure 10 outlines the changes in pasture harvest within each of the regions of Australia, with New Zealand and Argentina included as dashed lines. Tasmania and Gippsland have made significant progress in increasing pasture harvest over the last 20 years, with these two regions having the highest pasture harvest, the highest per cent of pasture in the cows' diet, and the lowest cost of production.

New South Wales, Queensland and Northern Victoria have seen the largest decreases in pasture harvest, while also having the largest decrease in per cent of pasture in the cows' diet, and the greatest increase in cost of production. The deceases in pasture harvest are at least partially a result of decreasing pasture as a per cent of the diet as reported by Beca (2020b).

Why does pasture harvest correlate with profit?

Figure 11. Pasture harvest (tDM) impact on return on capital (profit)



It is worth considering why the level of pasture harvest on a dairy farm does correlate strongly with profit, as outlined in Figure 11 as reported by Beca (2020b). This relationship was also reported by Dillon et al. (2005) and Neal and Roche (2020). The reason is that the cost of pasture is comparatively low compared to any other feed source, and that higher levels of pasture harvest most often result in a further lowering of the cost of pasture. In addition, a higher pasture harvest will in all probability result in a higher number of cows being farmed per hectare and a higher volume of milk being produced per hectare.

The comparative cost of pasture is outlined in Figure 12, which includes a cost of pasture for all regions in Australia, as well as for New Zealand, Argentina, Uruguay, South Africa, Ireland and United Kingdom. Also included in Figure 12 is a cost of concentrate and forage, as well as a calculation of how much greater the cost of concentrate and forage is compared to pasture. These feed costs can be referred to as a 'consumed' feed cost and include the production or purchase cost as well as wastage and any storage cost.

In every Australian region and every country in the table, the cost of concentrate is substantially greater than the cost of pasture. The cost of forage is also significantly higher than for pasture.

Regardless of whether pasture cost is low in Tasmania and Gippsland (and New Zealand), or high in Northern Victoria, New South Wales and Western Australia, the cost of concentrate is substantially higher than for pasture. Concentrate cost in Australia ranges from around 130 per cent higher than pasture in Northern Victoria to around 460 per cent higher than pasture in Tasmania.

So the causal reason why pasture harvest correlates strongly with profit is that pasture is the lowest cost source of feed by a wide margin and increasing pasture harvest allows more milk to be produced per hectare from this low-cost feed. The feed cost variances outlined in Figure 12 can also be utilised to quantify the impact of differing proportions of pasture to concentrate and forage in the diet.

How could farmers make a large change to cost of production and profit?

As outlined in Figure 13, total feed cost comprises 50-60 per cent of total operational expenses for an Australian dairy business, which means the impact of a low feed cost is that the cost of production is lower, which has a strong positive impact on profit.

Given the dominant impact of feed cost on total expenses and profit, if a pasture-based farmer or region wished to substantially reduce their cost of production and increase their profit margin, then reducing feed cost would logically need to contribute to this. This could only be accomplished by either significantly reducing the unit cost of feed or by changing the mix of feeds to reduce the average cost.

Although some individual farmers may be able to significantly reduce the unit cost of feed, this would not appear possible for large groups of farmers, and not for one group of farmers in a region compared to other farmers in competing regions or countries. So the only realistic option for most Australian dairy farmers to significantly reduce their cost of production and increase their profit margin would be for these farmers to change the mix of feeds, by including significantly more low-cost pasture and significantly less high-cost supplement.

Figure 12. Cost of pasture, concentrates, and forages (AUD/tDM 2015-2020)

2015-2020 (AUD/tDM)	Pasture Cost *	Concentrate Cost **	Concentrate : Pasture Ratio	Forage Cost **	Forage : Pasture Ratio
Australia	**$135**	**$427**	**+ 216%**	**$237**	**+ 76%**
Victoria	$126	$412	+ 227%	$223	+ 77%
Gippsland	$94	$428	+ 356%	$226	+ 140%
South-West Victoria	$114	$410	+ 260%	$214	+ 88%
Northern Victoria	$175	$398	+ 128%	$231	+ 32%
Tasmania	$85	$475	+ 461%	$236	+ 178%
New South Wales	$196	$450	+ 130%	$292	+ 49%
Queensland	$148	$473	+ 220%	$302	+ 104%
South Australia	$157	$396	+ 152%	$256	+ 63%
Western Australia	$192	$460	+ 140%	$215	+ 12%
New Zealand	$56	$338	+ 506%	$297	+ 434%
Argentina	$133	$248	+ 86%	$193	+ 45%
Uruguay	$114	$355	+ 210%	$207	+ 81%
South Africa	$108	$409	+ 278%	$155	+ 44%
Ireland ***	$70	$439	+ 525%	$250	+ 256%
United Kingdom ***	$97	$418	+ 331%	$263	+ 171%

* Pasture cost includes fertiliser, pasture renovation, greenfeed crops and irrigation
** Concentrate cost and forage cost include wastage and storage costs
*** Ireland and United Kingdom pasture and suplement costs are estimated

Figure 13. Split of feed cost, labour cost and "all other" costs (AUD 2015-2020)

2015-2020 (AUD / kgMS)	Total Expenses	Total Feed Cost	Total Labour Cost	"All Other" Costs	Feed Cost as % Total Exp.	Labour Cost as % Total Exp.	"Other" Costs as % Total Exp.
Australia	**$6.31**	**$3.40**	**$1.33**	**$1.59**	**53.8%**	**21.1%**	**25.1%**
Victoria	$5.94	$3.26	$1.18	$1.50	54.9%	19.8%	25.3%
Gippsland	$5.72	$2.96	$1.23	$1.53	51.8%	21.5%	26.7%
South-West Victoria	$5.86	$3.18	$1.13	$1.54	54.3%	19.4%	26.3%
Northern Victoria	$6.26	$3.68	$1.17	$1.42	58.7%	18.7%	22.6%
Tasmania	$5.41	$2.71	$1.20	$1.50	50.1%	22.2%	27.7%
New South Wales	$7.99	$4.10	$1.91	$1.97	51.4%	24.0%	24.7%
Queensland	$8.58	$4.79	$1.86	$1.94	55.8%	21.7%	22.6%
South Australia	$6.67	$3.43	$1.51	$1.74	51.4%	22.6%	26.0%
Western Australia	$7.08	$3.92	$1.46	$1.70	55.3%	20.7%	24.0%
New Zealand	$4.68	$2.03	$1.00	$1.65	43.5%	21.3%	35.3%
United States	$7.46	$4.87	$0.89	$1.70	65.3%	12.0%	22.8%
Argentina	$6.07	$3.32	$1.12	$1.63	54.7%	18.4%	26.9%
Uruguay	$6.49	$3.49	$1.28	$1.73	53.8%	19.6%	26.6%
South Africa	$5.31	$3.32	$0.63	$1.36	62.6%	11.9%	25.5%
Ireland*	$5.06	$2.38	$1.10	$1.58	47.0%	21.8%	31.2%
United Kingdom*	$6.24	$3.38	$1.26	$1.60	54.1%	20.2%	25.6%
Pasture-based farms					**45%-60%**	**15%-25%**	**20%-35%**
Pasture-based farms in Australia					**50%-60%**	**20%-25%**	**20%-30%**
Feedlot / confinement farms					**60%-70%**	**10%-15%**	**15%-30%**

All per kg milksolids (MS) costs based on energy corrected milk (corrected to 4.0% fat and 3.3% protein)
* Ireland and United Kingdom costs are estimated

Figures 14 and 15 further demonstrate graphically the quantum of feed cost versus labour cost as the second largest expense, and versus all other operational costs. Figure 14 compares Australia with seven other countries, including

New Zealand and Ireland, which have the lowest cost of production, and United States, which has the highest cost of production. Figure 15 compares all the regions of Australia, as well as including New Zealand and United States.

Figure 14. Feed cost plus labour cost plus 'All Other' costs / kgMS (2015-20)

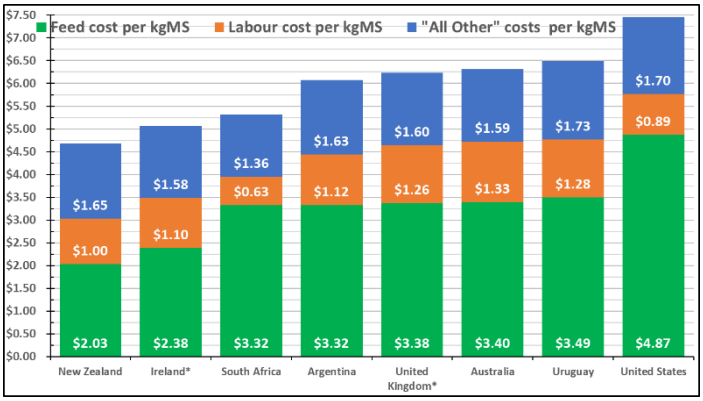
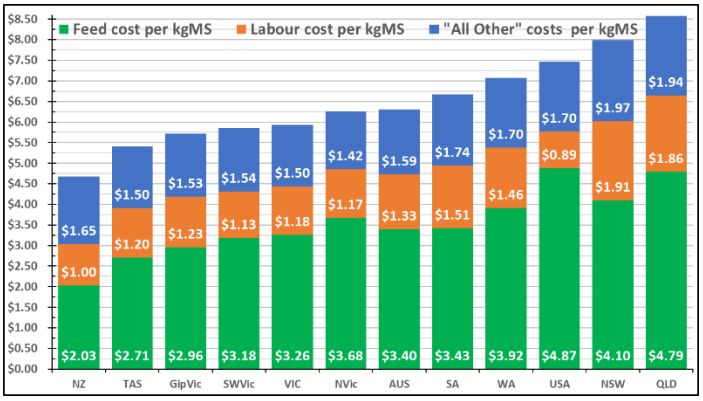


Figure 15. Feed cost plus labour cost plus 'All Other' costs / kgMS (2015-20)



What then is the impact of pasture percentage in the cows' diet?

The impact of variations in the per cent of pasture in the cows' diet can be demonstrated through a simple mathematical equation as outlined in Figure 16 for average Australian feed costs. However, two calculations have been completed in the table; one where the pasture cost is held constant for all options of pasture per cent in the diet, and the second where pasture cost is more correctly lower when pasture is a higher percentage of the diet. The variations in pasture cost for differing percentages of pasture in the diet are based on an analysis of a large unbiased Australian dataset as reported by Beca (2020b).

Figure 16. Change in consumed feed cost in AUD/tDM as percentage of pasture in the diet changes (2015-2020)

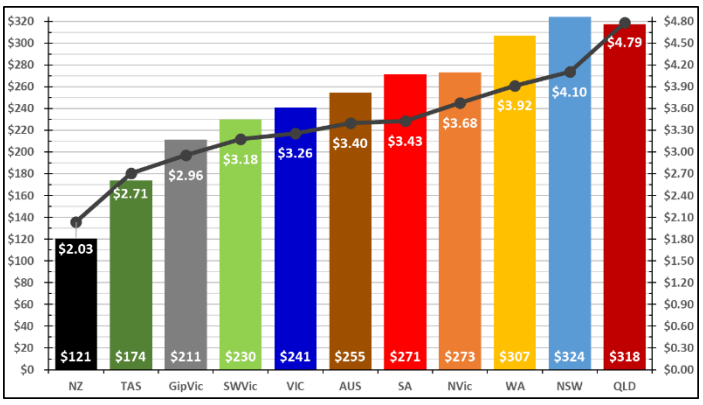
AUSTRALIA average feed cost 2015-2020 (AUD per tonne dry matter)								
Pasture percent of diet	**0%**	**20%**	**30%**	**40%**	**50%**	**60%**	**70%**	**80%**
Pasture cost *		$135	$135	$135	$135	$135	$135	$135
Pasture cost **		$165	$155	$144	$134	$124	$114	$103
Concentrate cost ***	$427	$427	$427	$427	$427	$427	$427	$427
Forage cost ***	$237	$237	$237	$237	$237	$237	$237	$237
Supplement cost ******	$370	$370	$370	$370	$370	$370	$370	$370
Average feed cost *	**$370**	**$323**	**$299**	**$276**	**$252**	**$229**	**$205**	**$182**
Average feed cost **	**$370**	**$329**	**$305**	**$280**	**$252**	**$222**	**$190**	**$157**

* Pasture cost (and Average feed cost) include pasture cost held constant for all variations in pasture percent
** Pasture cost (and Average feed cost) include pasture cost adjusted for impact of variations in pasture percent
*** Concentrate cost and forage cost include wastage and storage costs
**** Supplement cost based on 70% concentrate plus 30% forage

Both calculations of average feed cost highlight the large negative impact on the total dietary feed cost as more supplement is added, and as pasture percentage is reduced. The quantum of the impact of moving from say 70 per cent pasture in the diet to 30 per cent pasture in the diet for the average Australian farmer is to increase the average cost of feed by around 50-60 per cent, or from $190 to $305 per tonne dry matter based on a variable pasture cost. This has a substantial negative impact on feed expenses per kg milksolids, which will consequently negatively impact on total expenses per kg milksolids, cost of production, operating profit margin and profit (return on capital).

These impacts can be further demonstrated in Figure 17, which matches the dietary average feed cost for Australian regions (plus New Zealand) over the period of

Figure 17. Average consumed feed cost per tDM (LHS) vs Total feed cost per kg milksolids (RHS) (AUD 2015-2020)



2015-2020 with the total feed cost per kg milksolids for each region.

Confirming the relationships between the average 'consumed' feed cost and key business performance ratios

It could appear self-evident that the average cost of feed (per tonne dry matter) would have a major impact on profitability given feed costs comprise around 50-60 per cent of total expenses. This can be confirmed from Figures 18-20 as reported by Beca (2020b).

Figure 18. Consumed feed cost per tDM impact on feed cost per litre (ECM)

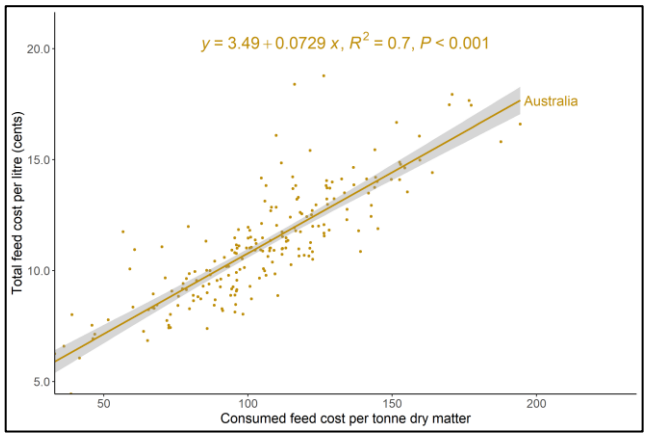


Figure 19. Feed cost per litre (ECM) impact on total expenses per litre (ECM)

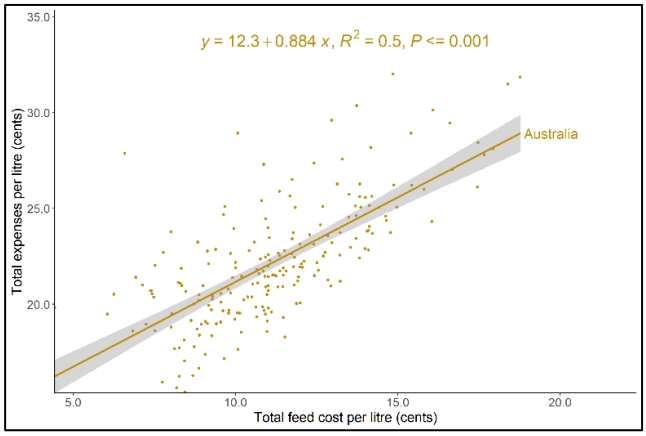


Figure 18 confirms that the average consumed cost of feed per tonne dry matter could explain 70 per cent of the variation in the total feed cost per litre (or per kg milksolids).

Figure 19 confirms that the total feed cost per litre (or per kg milksolids) could explain 50 per cent of the variation in total expenses per litre (or per kg milksolids). Neal and Roche (2020) reported a similar relationship between imported feed (supplements) in tonne dry matter per cow and total expenses per kg milksolids.

Figure 20 confirms that total expenses per litre (or per kg milksolids) could explain 51 per cent of the variation in profit as described by return on capital. This relationship was also reported by Neal and Roche (2020).

Each relationship is both strong and significant, confirming the importance of maintaining a low cost of feed for delivering a sound, or high, level of profit.

Figure 20. Total expenses per litre (ECM) impact on return on capital (profit)

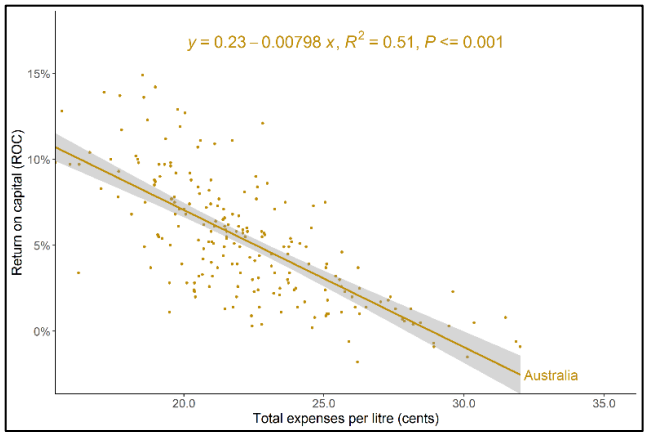
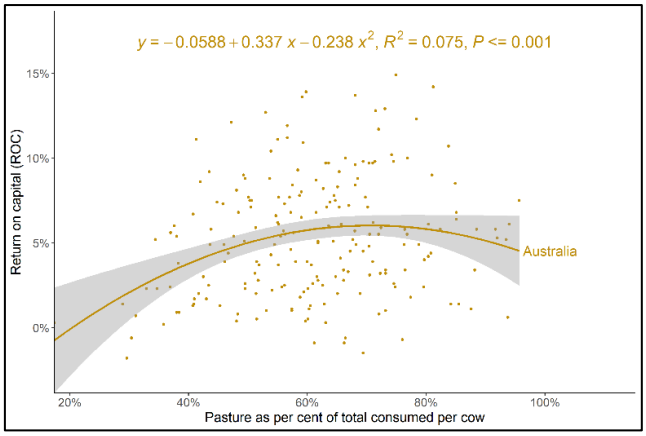


Figure 21. Pasture per cent in cows' diet impact on return on capital (profit)



There is strong supporting evidence that pasture as a percentage of the cows' diet correlates with profit. Figure 21 confirms that pasture as a per cent of the cow's diet could explain 8 per cent of the variation in profit as described by return on capital. As reported by Beca (2020b), the relationship can be described as one where as pasture as a per cent of the cow's diet decreases, there is initially little variation or impact on profit, although a negative impact becomes increasingly evident as the percentage of pasture decreases.

In addition, pasture as a per cent of the cow's diet has a significant impact on a wider group of ratios that are correlated with profit. Figure 22 outlines this wider group of ratios as reported by Beca (2020b).

There is also relevant practical evidence of the impact of the per cent of pasture in the cows' diet within the Australian dairy industry and internationally. New Zealand and Ireland (Hurley and Murphy 2015) are countries that demonstrate the advantage of including a high percentage of pasture in the diet on cost of production and profit, whereas Tasmania demonstrates this nationally along with Gippsland as the next best exponent.

Figure 22. Impact of decreasing pasture per cent in the cows' diet

As pasture as per cent of cows' diet DECREASES	Change	R^2	P
Return on Capital (PROFIT)	**Decreases**	**0.08**	**<= 0.001**
Cost of production per litre	**Increases**	**0.16**	**<= 0.001**
Supplement cost per litre	Increases	0.58	<= 0.001
Total feed cost per litre	Increases	0.50	<= 0.001
Core per hectare cost per tDM of pasture harvest	Increases	0.49	<= 0.001
Pasture cost per tonne dry matter	Increases	0.26	<= 0.001
Core per cow cost	Increases	0.09	<= 0.001
Labour cost per cow	Increases	0.08	<= 0.001
Pasture harvest	**Decreases**	**0.10**	**<= 0.001**

Does pasture harvest and pasture as a percentage of the cows' diet impact on the second largest cost centre in dairy farming: the cost of labour?

Another interesting aspect of the combined impact of pasture harvest and pasture as a per cent of the cows' diet is that both have a significant positive correlation with lower labour cost. As reported by Beca (2020b), the most relevant ratio for monitoring labour in a dairy business is labour cost per cow.

The impact of pasture harvest on labour cost is outlined in Figure 23. Figure 23 confirms that pasture harvest could explain 9 per cent of the variation in labour cost per cow.

The impact of pasture as a per cent of the cows' diet on labour cost is outlined in Figure 24. Figure 24 confirms that pasture as a per cent of the cows' diet could explain 8 per cent of the variation in labour cost per cow.

Labour cost per kg milksolids comprises 20-25 per cent of total operational expenses for an Australian dairy business, and when combined with feed cost per kg milksolids, they jointly comprise 70-80 per cent of total operational expenses. This further supports the argument that both pasture harvest and pasture as a per cent of the cows' diet are factors that have a substantial impact on dairy farm profit.

Figure 23. Pasture harvest impact on labour cost per cow

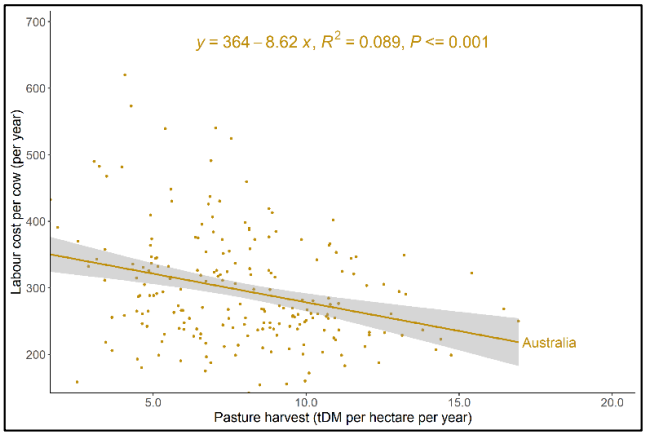
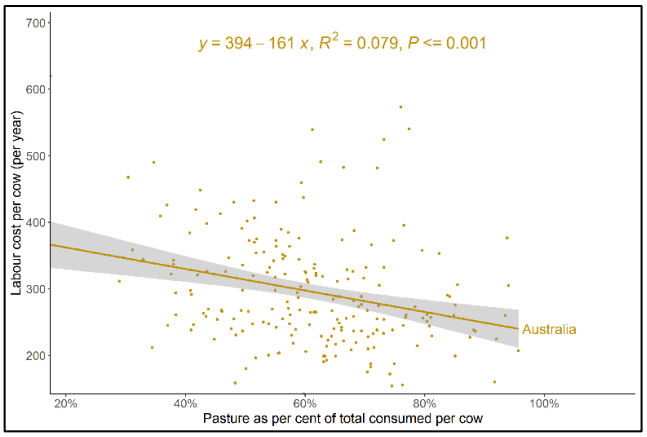


Figure 24. Pasture per cent in cows' diet impact on labour cost per cow



Discussion

There are two major challenges that individual farmers would need to overcome should they wish to make a significant change in production system by increasing pasture as a percentage of the diet. These were previously reported by Beca (2020a). Firstly, for most farmers, this production system change will require a reduction in stocking rate (fewer cows per hectare), and for all farmers, a reduction in concentrate or supplement feeding rate per cow. These changes will result in a reduction in milk production per hectare and, as a result, a reduction in revenue per hectare. Although this reduction in revenue would be undertaken to improve cost of production and improve business profitability, this remains a significant challenge to manage.

The second major challenge would be that a significant increase in pasture as a percentage of the diet may not be sustainable for many farms given the cow genotype on these farms. For instance, a 15 per cent decrease in supplement

as a percentage of the cow's diet (say from 50 per cent to 35 per cent) could convert into a reduction in concentrate feeding rate of 2.0-2.5 kg per cow per day. For many farms, a reduction in concentrate feeding rate of this scale would result in the cows losing too much bodyweight and being unable to efficiently produce milk or get pregnant. The impacts of these differences in cow genotype have been documented by Harris and Kolver (2001). As a result, a majority of Australian dairy farmers may need to start breeding the type of cow that can efficiently produce milk with a high percentage of pasture in the diet, which would take some time to achieve. Both of these challenges would be worthy of further investigation by the Australian dairy industry.

Conclusions

Significantly decreasing the percentage of pasture in the cows' diet, as the majority of dairy farmers in Australia have done over the last 20 years, effectively undermines the advantage that pasture can deliver within a low cost of production dairy business. For pasture harvest to significantly contribute to a low cost of production, this requires that a large proportion of the diet comprises low-cost pasture and a comparatively smaller proportion of the diet comprises higher-cost supplement.

The arguments outlined in this paper confirm that the following two statements are correct:

1. A high level of pasture harvest **is important** for delivering a high level of profit; and
2. The choice of production system by a farmer **is relevant** in determining the level of profit for a farm, that is, a high percentage of pasture in the cows' diet **is important** for delivering a consistently high level of profit.

It is inconsistent to argue that the first statement is correct without arguing that the second statement is correct, given it is the low cost of pasture compared to other feed sources that causes the first statement to be correct, though pasture harvest can only significantly impact on profit if the expression of this lower feed cost is not significantly increased by higher-cost supplements.

Over the last 20-25 years, the Australian dairy industry has progressively increased its cost of production through the inclusion of supplements as a higher proportion of the cows' diet. This is the primary cause of the industry's widespread reduction in profitability and loss of international competitiveness. It would appear certain that a deeper understanding of the impact of pasture as a percentage of the cows' diet on profit, along with a change in the industry's focus to increasing pasture as a percentage of the diet, will be required to reverse these negative trends in dairy farm profit and national milk production. This will also be essential if the Australian dairy industry is to regain its international competitiveness, along with regaining a comparative advantage to other land uses within Australia.

REFERENCES

Beca, D. (2020a), 'Evaluating the Loss of Profitability and Declining Milk Production in the Australian Dairy Industry', *Australasian Agribusiness Perspectives* 23, Paper 9, pp. 136-164.

Beca, D. (2020b), 'Key Determinants of Profit for Pasture-based Dairy Farms', *Australasian Agribusiness Perspectives* 23, Paper 16, pp. 247-274.

Beca, D. (2021), 'Australian Dairy Industry Farm Performance Data: International and State-by-State Competitiveness', *Report published on Red Sky website*, http://redskyagri.com/page/redsky_58.html.

Dillon, P., Roche, J.R., Shalloo, L. and Horan, B. (2005), 'Optimising financial returns from grazing in temperate pastures', *Utilisation of Grazed Grass in Temperate Animal Systems*, Proceedings Satellite Workshop, 20th International Grasslands Congress, Cork, Ireland, pp. 131-147.

Harris B.L. and Kolver E.S. (2001), 'A review of Holsteinization on intensive pastoral dairy farming in New Zealand', *Journal of Dairy Science* 84, E56-E61.

Hurley C. and Murphy M. (2015), 'Building a Resilient, Flourishing, Internationally Competitive Dairy Industry in Ireland', *Proceedings of 2025 Agri Food Strategy Committee*, The Department of Agriculture, Ireland. Available from: http://redskyagri.com/page/redsky_46.html.

Neal, M.B. and Roche, J.R. (2020), 'Profitable and resilient pasture-based dairy farm businesses in New Zealand', *Animal Production Science* 60(1) pp. 169-174.

SOURCES OF DATA

AACREA (Asociación Argentina de Consorcios Regionales de Experimentación Agrícola) www.crea.org.ar; producer-owned organisation in Argentina that has as its main purpose to help producers improve the economic and financial results of their farm business. AACREA has the largest dataset of dairy farm performance in Argentina.

AHDB (Agriculture and Horticulture Development Board, United Kingdom) www.ahdb.org.uk.

CSO (Central Statistics Office, Ireland) www.cso.ie.

Dairy Australia www.dairyaustralia.com.au.

Dairy Farm Monitor Project (Australia) www.dairyaustralia.com.au/farm/farm-business-management/dairy-farm-monitor-project.

DairyBase (New Zealand) www.dairynz.co.nz/business/dairybase.

DairyNZ www.dairynz.co.nz.

DEFRA (Department for Environment, Food and Rural Affairs, United Kingdom) www.gov.uk/government/organisations/department-for-environment-food-rural-affairs.

FUCREA (Federación Uruguaya de Grupos CREA) www.fucrea.org; producer-owned organisation in Uruguay that has as its main purpose to help producers improve the economic and financial results of their farm business. FUCREA has the largest dataset of dairy farm performance in Uruguay.

Genske Mulder (United States) www.genskemulder.com; the largest dairy farm accountancy practice in United States. Genske Mulder produce benchmark data for dairies in Arizona, California, Colorado, Idaho, New Mexico, Texas, and Washington and in the regions of the Upper Midwest and Lower Midwest.

INALE (Instituto Nacional de la Leche) www.inale.org; the Uruguayan National Milk Institute is a non-state public entity with its main task being to advise the government on dairy policy. The aim is to contribute to a joint public-private partnership aimed at the development of the Uruguayan dairy industry.

MAGYP (Ministerio de Agricultura, Ganadería y Pesca) www.argentina.gob.ar/agricultura-ganaderia-y-pesca; the Argentinian government's Ministry of Agriculture, Livestock and Fishing.

QDAS (Queensland Dairy Accounting Scheme); benchmarking analysis undertaken by Queensland Department of Agriculture and Fisheries www.daf.qld.gov.au with funding from Dairy Australia.

Red Sky Agricultural ('Red Sky') www.redskyagri.com; commercial provider of farm business analysis and benchmarking software that is primarily operating in Australia, New Zealand, and South Africa. Red Sky's major shareholder is the author of this paper.

SENASA (Servicio Nacional de Sanidad y Calidad Agroalimentaria) www.argentina.gob.ar/senasa; the Argentinian government's National Service of Agri-Food Health and Quality.

Teagasc (Agricultural and Food Development Authority, Ireland) www.teagasc.ie.

USDA (United States Department of Agriculture) www.usda.gov.

ABBREVIATIONS

AUS – Australia
GipVic – Gippsland (Victoria)
NSW – New South Wales
NVic – Northern Victoria
NZ – New Zealand
QLD – Queensland
SA – South Australia
SWVic – South-West Victoria

TAS – Tasmania

USA – United States

VIC – Victoria

WA – Western Australia

DEFINITIONS

Energy Corrected Milk (ECM): determines the amount of energy in the milk based upon milk, fat and protein and adjusted to 4.0 per cent fat and 3.3 per cent protein. ECM formula = milk production x ((0.383 x fat% + 0.242 x protein% + 0.7832) / 3.1138). AUS and US report true protein, whereas NZ, ARG, URU and RSA report total protein, so non-protein nitrogen was assumed to be 5.5 per cent of total protein to correct for this. Converting all milk ratios to energy corrected milk is required due to the otherwise confounding impact of the wide range in fat and protein per cent internationally as a result of differing cow types, diets, and production systems. This formula is used by the Dairy International Farm Comparison Network, as outlined in the following: https://dairymarkets.org/PubPod/Reference/Library/Energy%20Corrected%20Milk.

Milksolids: refers to the combined weight of fat plus protein in the milk. These are the two saleable components that primarily impact on the price paid for milk. Utilising solids rather than litres (if not energy corrected) to determine the growth rate in milk production for each region eliminates the confounding impact of changes in fat and protein percentages in each country over time.

Definition of terms:

Ratios	Calculation / Definition
Concentrate cost per tonne dry matter ('Consumed')	Consumed concentrate cost divided by tonne of dry matter consumed. Consumed concentrate cost includes the full purchase or production cost plus any storage cost prior to feeding to livestock, with wastage apportioned within this cost of feed.
Core per cow cost	[100% x (Animal health + Breeding & herd testing + Dairy shed expenses + Electricity + Freight + Grazing/Support area expenses + Industry levies) + 70% x Vehicle expenses + 50% x (Depreciation + Repairs & maintenance)] divided by total cows in herd.
Core per hectare cost per tonne dry matter of pasture harvest	[100% x (Administration fees & overheads excl. industry levies + Fertiliser excl. nitrogen + Green feed crops grazed in-situ + Pasture maintenance & renovation) + 30% x Vehicle expenses + 50% x (Depreciation + Repairs & maintenance)] divided by effective dairy hectares divided by tonne of dry matter harvested per hectare.
Cost of production per litre or per kg milksolids	(Operating expenses minus livestock revenue minus other non-milk revenue) divided by total litres or total milksolids (ECM) produced.
Forage cost per tonne dry matter ('Consumed')	Consumed forage cost divided by tonne of dry matter consumed. Consumed forage cost includes the full purchase or production cost plus any storage cost prior to feeding to livestock, with wastage apportioned within this cost of feed.
Labour cost per cow	Management & staff costs incl. imputed labour costs divided by total cows in herd.
Labour cost per litre or per kg milksolids	Management & staff costs incl. imputed labour costs divided by total litres or total milksolids (ECM) produced.
Operating profit margin	Operating profit divided by operating revenue.
Pasture as per cent of diet	Percent of energy provided from pasture harvested on the effective dairy area as a percentage of total annual energy requirements of the cows.
Pasture cost per tonne dry matter ('Consumed')	Direct pasture cost divided by tonne of dry matter harvested. Direct pasture cost includes pasture maintenance and renovation (including green feed crops grazed in situ), fertiliser (including nitrogen), all pasture irrigation costs, and the direct silage and hay costs for pasture conserved on the dairy farm.
Pasture harvest	This is the equivalent tonnage of standardised (11.0 MJ ME/kgDM) energy density pasture consumed per hectare. Any hay and silage conserved on the dairy farm is included in the total pasture yield. This is a back-calculation based on inputs and outputs.
Return on (total) capital	Operating profit divided by the total value of all assets employed in the business (regardless of ownership/financing structure). Changes in asset values, including appreciation of land values, are not included in this calculation.
Supplement cost per litre or per kg milksolids	(Concentrates + Forages + Grazing/Support area expenses) divided by total litres or total milksolids (ECM) produced.
Total expenses per litre or per kg milksolids	Operating expenses divided by total litres or total milksolids (ECM) produced.
Total feed cost per litre or per kg milksolids	(Concentrates + Forages + Grazing/Support area expenses + Green feed crops grazed in-situ + Fertiliser incl. nitrogen + Irrigation + Pasture maintenance & renovation) divided by total litres or total milksolids (ECM) produced.