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Labour Cost and Labour Efficiency within the Australian Dairy Industry[1]

David Beca

Red Sky Agricultural Pty Ltd, Melbourne.

Abstract

Maintaining a competitive labour cost is important to the overall competitiveness of the Australian dairy industry. Total labour expense is the second largest cost centre after total feed cost on dairy farms, with all other cost centres being substantially smaller. The question explored in this paper is how labour cost-competitive and efficient Australian dairy farms are, compared to dairy farms in other countries, and how do farms in each state and region within Australia compare to each other. When the total labour cost per litre (energy corrected) on Australian dairy farms is compared to five other countries over the last six years, Australian farms have the highest cost. The Australian labour cost per litre was on average 33 per cent higher than in New Zealand and 49 per cent higher than in the United States.

Total labour cost comprises two factors: the cost of labour by unit of time and the amount of time taken to complete the required tasks on a dairy farm, which can be described as the level of labour efficiency. Labour cost per unit of time in Australia has often been reported as very high compared to other countries and this is confirmed in this paper. This need not be an impediment if labour efficiency, or productivity, is commensurately higher than in other countries. Labour efficiency requires a more nuanced reporting as it is impacted by several factors including the capability of organisational management, the level of infrastructure development and technology employed within the business, and the farm production system being implemented including whether the focus is more on pasture production or milk production.

An analysis of the level of labour efficiency in Australia, including the impact of farm size and production system, confirms that some states including Tasmania and Victoria have a comparatively high level of efficiency while other states including New South Wales, Queensland, South Australia and Western Australia have a comparatively low level of efficiency. There will also be a large variation in labour efficiency within states and regions. However, there is a significant opportunity to improve labour efficiency within the Australian dairy industry, which would be assisted through a focus on relevant labour ratios and the setting of targets for improving these ratios. The two most important labour efficiency ratios confirmed in this paper are labour cost per cow and number of cows farmed per full-time person equivalent.

[1] Mark Neal of DairyNZ worked on some of the statistical analysis presented in this paper and provided insights into methodologies and interpretation.

Key words: dairy farming, labour cost, labour efficiency, profit.

Introduction

Both the cost and the availability of labour to operate dairy farms have become important and relevant topics for Australian dairy farmers over recent years. The challenge with availability of labour has been further heightened with the onset of COVID-19 and the closing of international borders by the Australian government. Retaining access to a ready and willing pool of people interested in working on dairy farms is important to the long-term viability of the industry. Equally important is ensuring most farms are sufficiently profitable for farmers to afford the cost of employing enough labour to operate their business efficiently.

Over the last 20 years, there has been a trend of increasing cost of production on Australian dairy farms, with the rate of increase being higher than for dairy farms in most other countries. This has resulted in a reduction of profitability compared to most other countries and a reduction in national milk production as reported by Beca (2020a).

The primary reason for this reduction in profitability on Australian dairy farms has been the comparatively rapid increase in total feed costs per litre or per kilogram of milksolids. This has been a result of continuing changes in production systems where pasture has progressively contributed a lower percentage of the cows' diet, and supplements, in particular concentrates, have contributed a higher percentage. These trends were reported by Beca (2020a) and Beca (2021).

The cost of labour per litre or per kilogram of milksolids has also increased significantly over the last 20 years with the cost per person, based on hourly or annual wage rates, being often quoted as the primary factor. Australia has some of the highest minimum wage rates in the world as reported by TheGlobalEconomy.com. However, labour efficiency or productivity is the second factor that influences total labour expenses, and it is less clear how the Australian dairy industry performs regarding this factor compared to international peers or domestically between states and regions.

These trends in labour cost and efficiency are reviewed in this paper. Labour cost is defined as all employment-related expenses and includes the full cost of management. For the majority of farms where the business owner is providing the management, this requires an assessment of an imputed cost for management. Other family labour that is not being rewarded through a direct wage payment is also assigned an imputed cost.

Data Sources and Calculations

Table 1. Data sources

Country	Abbreviation	Industry Statistics	Farm Business Analysis	AUS State/Region	Abbreviation	Farm Business Analysis
Argentina	ARG	MAGYP	AACREA	New South Wales	NSW	DFMP
Australia	AUS	Dairy Australia	DFMP, QDAS, Red Sky	Queensland	QLD	QDAS
Ireland	IRE	CSO	Teagasc	South Australia	SA	DFMP, Red Sky
New Zealand	NZ	DairyNZ	DairyBase, Red Sky	Tasmania	TAS	DFMP, Red Sky
South Africa	RSA	MPO	Red Sky	Victoria	VIC	DFMP, Red Sky
United Kingdom	UK	DEFRA	AHDB	Gippsland	GipViv	DFMP, Red Sky
United States	USA	USDA	Genske Mulder	South-West Victoria	SWVic	DFMP, Red Sky
Uruguay	URU	INALE	FUCREA	Northern Victoria	Nvic	DFMP, Red Sky
				Western Australia	WA	DFMP, Red Sky

Table 1 outlines the main sources of data for national (and regional) industry statistics and for national and regional farm performance data. There is additional information on the data sources outlined in Appendix 1 including in Table 7 that outlines the basis for converting data to a standardised format. The process for standardising data is the same as that described by Beca (2020a). Data for a country or region that has a low level of reliability are denoted with an asterisk. The primary reason for the lower level of reliability is due to limitations in data sources and therefore the modelling of outcomes rather than access to individual farm-level sources of data.

Definitions of terms utilised in this paper are outlined in Appendix 2 with Table 8 outlining the methodology for calculating the ratios described in this paper. 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). Dollar-denominated ratios are identified as $AU or $US, with the statistical analysis in Figures 25-26, 29-30, 32-33 and 35-36 being in $US ($US:$AU foreign exchange rate = 0.747 for this dataset).

How Relevant is Labour Cost to the Value of Total Operating Expenses?

Table 2 includes the average value per kg milksolids (kgMS) in $AU for the period 2015-2020 of total operational expenses, total feed cost, total labour cost and the total of all other operational expenses. These are also calculated as a percentage of total expenses. As reported by Beca (2021), Table 2 confirms that total labour cost comprises 10-25 per cent of total operational expenses on pasture-based dairy farms, and on average, 18-25 per cent of total operational expenses on Australian dairy farms. Total feed cost averages 50-60 per cent of total operational expenses on Australian dairy farms, with all other operational costs contributing to the remaining 20-30 per cent of expenses.

Table 2. Australian regions and other countries, total expenses split of feed cost, labour cost, and all other costs ($AU 2015-20)

2015-2020 ($AU/kgMS ECM)	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	**$6.32**	**$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	$8.02	$4.12	$1.92	$1.98	51.4%	24.0%	24.6%
Queensland	$8.58	$4.79	$1.86	$1.94	55.8%	21.7%	22.6%
South Australia	$6.66	$3.42	$1.51	$1.73	51.4%	22.6%	26.0%
Western Australia	$7.07	$3.91	$1.46	$1.70	55.3%	20.7%	24.0%
New Zealand	$4.69	$2.04	$1.00	$1.65	43.5%	21.3%	35.3%
United States	$7.44	$4.88	$0.91	$1.66	65.5%	12.2%	22.3%
Argentina	$6.01	$3.71	$1.19	$1.12	61.7%	19.7%	18.6%
Uruguay	$6.62	$3.52	$1.18	$1.92	53.1%	17.8%	29.1%
South Africa	$5.29	$3.31	$0.63	$1.36	62.6%	11.8%	25.6%
Ireland	$5.98	$3.04	$1.21	$1.73	50.8%	20.2%	29.0%
United Kingdom*	$7.64	$4.27	$1.33	$2.04	55.9%	17.4%	26.7%
Pasture-based farms					**40%-65%**	**10%-25%**	**15%-35%**
Pasture-based farms in Australia					**50%-60%**	**18%-25%**	**20%-30%**
Feedlot / confinement farms					**60%-70%**	**10%-15%**	**15%-30%**

Figures 1 and 2 further demonstrate graphically the quantum of labour cost versus feed cost as the largest expense, and versus all other operational costs. Figure 1 compares Australia with seven other countries, including New Zealand, South Africa and Ireland, which have the lowest cost of production, and the United States and the United Kingdom, which have the highest cost of production.

Figure 2 compares all the regions of Australia, as well as including New Zealand (NZ) and the United States (USA). Regions like Tasmania (TAS), Gippsland (GipVic) and South-West Victoria (SWVic) have the lowest cost of production, with New South Wales (NSW) and Queensland (QLD) having the highest cost of production. The other abbreviations for regions in Figure 3 include VIC = Victoria, NVic = Northern Victoria, AUS = Australia, SA = South Australia, and WA = Western Australia.

Figure 1. International total expenses per kg milksolids ($AU 2015-20)

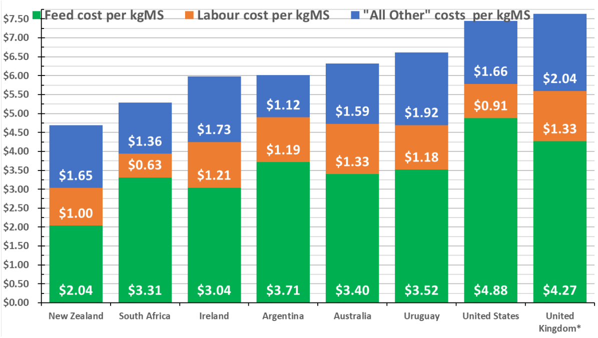
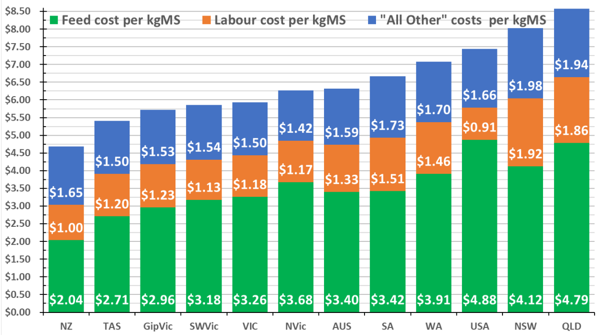


Figure 2. AUS regions plus NZ and USA total expenses per kg milksolids ($AU 2015-20)



Although feed cost has the largest impact on total operating expenses, cost of production, and profit, as reported by Beca (2021), labour cost has the next largest impact, and this cost varies significantly between country, state and region. As a result, it does have the potential to significantly impact on cost of production and profit.

Is There a 'Problem' with Labour Cost in Australia?

How do Australian dairy farmers compare to their peers internationally? Figure 3 outlines the labour cost per litre in $US cents over the last 18 years for six countries including Australia, New Zealand, Argentina (ARG), Uruguay (URU), South Africa (RSA), and the United States. Over this period, labour cost per litre in Australia has moved from being similar to NZ over the period 2003-2010, to being much higher than NZ post this period, as well as being higher than for all the other countries.

The performance of the six countries is further highlighted in Figure 4, which compares the average labour cost per litre over the last six years (2015-2020). AUS has the highest cost for any of the countries, with this being 33 per cent higher than NZ, and 49 per cent higher than USA.

Figure 3. International labour cost per litre ($USc ECM 2003-20)

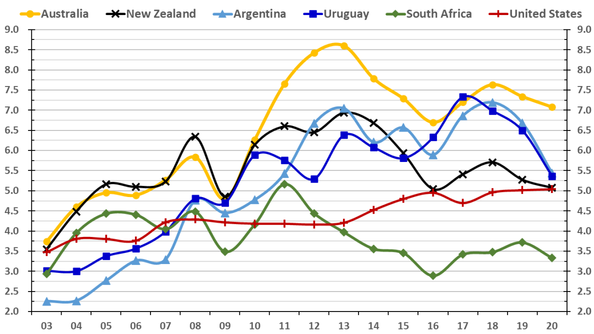


Figure 4. International labour cost per litre ($USc ECM 2015-20)

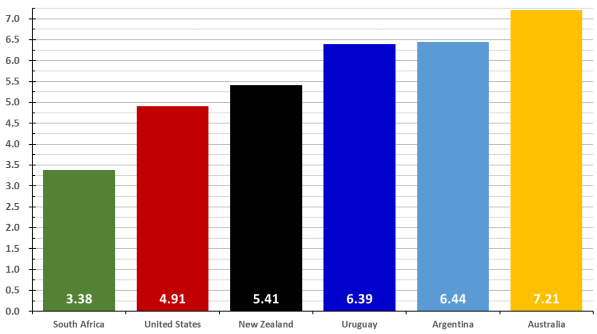


Figure 5 outlines the labour cost per kg milksolids in $AU over the last 18 years for all regions of Australia as well as NZ and USA, which are included as dashed lines. Over the period of 2003-2008, labour cost per kg milksolids in all regions of Australia were in a relatively narrow band and were similar to the cost in NZ and USA. Post this period, labour cost per kg milksolids in all regions of Australia has increased at a much higher rate than in NZ and USA.

The performance of all Australian regions, plus NZ and USA, is outlined in Figure 6, which compares the average labour cost per kg milksolids over the last six years (2015-2020). This further highlights the position of WA, SA, QLD and NSW. WA and SA now have a labour cost per kg milksolids that is around 50 per cent higher than NZ and USA, while QLD and NSW now have a labour cost that is close to 100 per cent higher than NZ and USA.

Figure 5. Australian regions plus NZ and USA labour cost per kgMS ($AU ECM 2003-20)

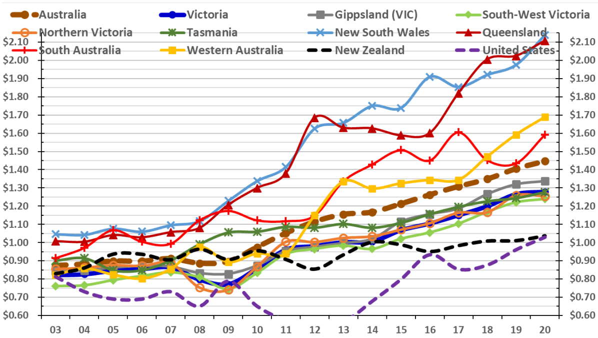
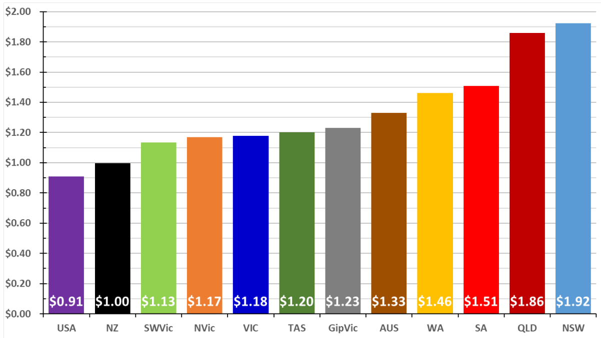


Figure 6. Australian regions plus NZ and USA labour cost per kgMS ($AU ECM 2015-20)



Labour cost per litre (or per kg milksolids) has been increasing at a much higher rate on most Australian dairy farms compared to farms in other countries, and it is now significantly higher than in most competing countries. In addition, the increase has been much higher in WA, SA, QLD and NSW than for the balance of Australia.

This high labour cost can be broken down into two components, the unit cost per person or per unit of time, and the amount of time taken to complete the required tasks on a dairy farm. This second component could be described as the level of labour efficiency. Changing labour cost will involve changes to one or both of these components. To describe these changes and the impact on total operating expenses, cost of production, and profit, would require the utilisation of relevant labour ratios.

Calculating Labour Cost and Labour Efficiency

Although for many industries it could appear self-evident to utilise the primary sale product in labour ratios, this is not the case with pasture-based livestock production. This is due to pasture harvest or consumption being the primary driver of profit for dairy farms, and not milk production, as reported by Dillon et al. (2005) and Beca (2020b).

Milk production per cow on pasture-based dairy farms does not positively correlate with profit, or not substantially, as reported by Beca (2020b). In instances where milk production per cow does correlate with profit, then this is unlikely to be due to higher levels of supplementation per cow as reported by Neal and Roche (2020). In that paper, Neal and Roche reported that the more profitable farmers did not use greater levels of supplement, but instead had greater pasture harvest, lower expenses per hectare and per kg milksolids, and had less capital in the business per hectare.

This relationship is different to that for feedlot or total mixed ration (TMR) dairy farms where milk production per cow does positively correlate with profit as reported by Lormore (2018). For clarity, references in this paper to 'pasture-based' dairy farms versus feedlot or TMR farms include the following. 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.

Table 3 outlines a hierarchy of dairy farm ratios based on their impact on profit as reported by Beca (2020b). Labour cost per cow was described as the most important ratio for monitoring labour financial performance due to it having the strongest correlation with profit. This ratio had a marginally higher correlation with profit than labour cost per litre. Beca also reported that if a second labour ratio was to be utilised, then this should be cows per full-time staff equivalent, as a second ratio will have more utility if it has a substantially different construct to the first ratio, so that it might convey additional knowledge about business performance in the labour area. Cows per full-time staff equivalent was recommended over litres per full-time staff equivalent as it had a higher correlation with profit.

Table 3. Hierarchy of dairy farm ratios based on their impact on profit (Beca 2020b)

Primary ratio	**R^2**	**P**	**Secondary ratio or proxy**	**R^2**	**P**
Return on total capital (ROC) [defines profit]	**Comparator for other ratios**		Profit per hectare	0.79	<= 0.001
			Profit per cow	0.73	<= 0.001
Operating profit margin	0.75	<= 0.001	Profit per litre	0.76	<= 0.001
Cost of production per litre	0.44	<= 0.001	Total expenses per litre	0.51	<= 0.001
Pasture harvest	0.41	<= 0.001			
Pasture cost per tonne dry matter	0.23	<= 0.001			
Milk price	0.20	<= 0.001			
Milk production per hectare	0.20	<= 0.001	Stocking rate	0.25	<= 0.001
Supplement cost per litre	0.20	<= 0.001	Total feed cost per litre	0.21	<= 0.001
Core per cow cost	0.20	<= 0.001			
Labour cost per cow	**0.18**	**<= 0.001**	**Cows per full-time staff equivalent**	**0.13**	**<= 0.001**
			Labour cost per litre	0.17	<= 0.001
			Litres per full-time staff equivalent	0.11	<= 0.001
Core per hectare cost per tonne dry matter of pasture harvest	0.17	<= 0.001			
Pasture as per cent of diet	0.08	<= 0.001	Pasture consumed per cow	0.07	0.001

Beca (2020b) also reported that both ratios referencing litres, namely labour cost per litre and litres per full-time staff equivalent, must be calculated on energy corrected milk (ECM) or the correlation with profit decreases substantially. An alternative would be to calculate these ratios based on kg milksolids.

However, there is another important issue with selecting relevant ratios and this is that there needs to be a causal relationship with profit for a ratio to be relevant. In this instance, the overwhelming causal link between labour and profit is cows, and not litres. Ask almost any dairy farmer what tasks they spend most time undertaking, and they will reply milking the cows, feeding the cows, drafting and moving cows, maintaining the health of their cows, and ensuring their cows get pregnant. The time attributed to the cows is estimated to be around 60-70 per cent of the total time. Edwards et al. (2019) reported that the milking routine alone on a New Zealand dairy farm represented 43-58 per cent of a conventional 40-hour work week. The next most time-consuming set of tasks, though much less time consuming than cow tasks, are related to the land (hectares) including applying fertiliser, maintaining and renovating pasture, and growing and conserving forage supplements. Any labour tasks directly related to litres are comparatively minor.

So the two ratios that will be the focus of the balance of this paper, and which should be utilised by farmers, advisors, and dairy industry organisations, are labour cost per cow and cows per full-time staff (or person) equivalent. There will be further references in this paper to labour cost per litre and litres per full-time staff equivalent, though these are only being provided so that the impact of these ratios can be understood.

There is an important issue regarding calculating cows per full-time staff equivalent, as this needs to be done in a consistent and relevant way. This ratio should be calculated based on the total number of cows in the herd (milking and dry cows) divided by the number of people working on the dairy platform based on a standardised dairy farming week (say 48-50 hours). The time should include all tasks relating to the cows (milking and dry cows) and to raising the calves through to 5-6 months of age. It should also include all tasks involved in delivering feed to the cows and these calves, as well as all management involved in maintaining the milking platform. These tasks are intended to be all those that are undertaken on every dairy farm, which ensures that comparisons between farms are robust and relevant.

The following tasks should be excluded from the calculation of cows per full-time staff equivalent as they are not undertaken on all dairy farms, with some farms undertaking these tasks but others contracting them to other parties and so replacing the time with a fee to this external party. These tasks include the time involved in operating a support area, raising heifers from 5-6 months of age through to their entry into the milking herd, physically conserving supplements and applying fertiliser, and developing farm infrastructure.

Where sources of data for this paper calculated this ratio without utilising these criteria, an adjustment has been made based on an estimate of the percentage of total time applied to the tasks that should be excluded.

How Big is 'The Problem' with Labour Cost in Australia?

The quantum of the potential problem relating to the Australian dairy industry's high labour cost can be assessed by reviewing the labour cost per cow over recent times. Figure 7 outlines the labour cost per cow in $US over the last 18 years for six countries. Over this period, labour cost per cow in Australia has moved from being much lower than USA and quite close to NZ over the period 2003-2005, to being similar to USA and substantially higher than NZ and all other countries.

Figure 7. International labour cost per cow ($US 2003-20)

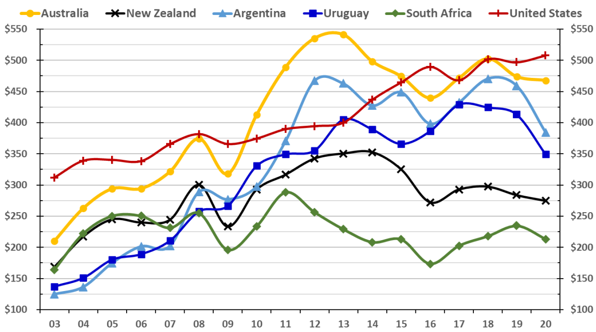
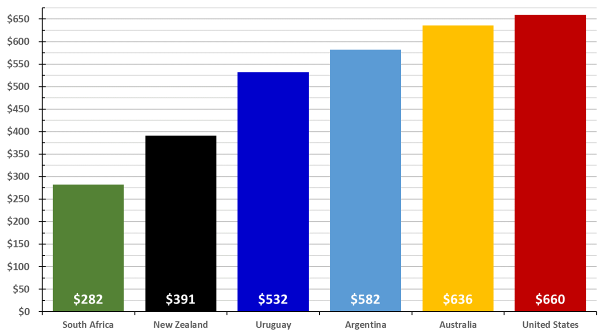


Figure 8. International labour cost per cow ($AU 2015-20)



The performance of the six countries is further highlighted in Figure 8, which compares the average labour cost per cow in $AU over the last six years (2015-2020). AUS has the second highest cost for any of the countries, with this being just 4 per cent lower than USA and 60-65 per cent higher than NZ.

Figure 9 outlines the labour cost per cow in $AU over the last 18 years for all regions of Australia as well as NZ and USA, which are included as dashed lines. Over the period of 2003-2008, labour cost per cow in all regions of Australia were in a relatively narrow band and were between NZ on the low side and USA on the high side, with the exceptions of SA and NSW. Post this period, labour cost per cow in all regions of Australia has increased at a much higher rate than in NZ, with NSW, QLD, SA and WA all increasing at a much higher rate than in USA.

Figure 9. Australian regions plus NZ and USA labour cost per cow ($AU 2003-20)

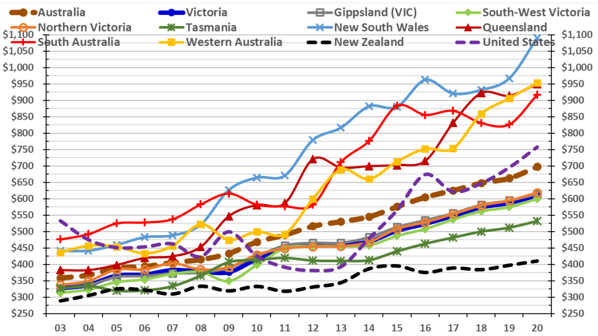
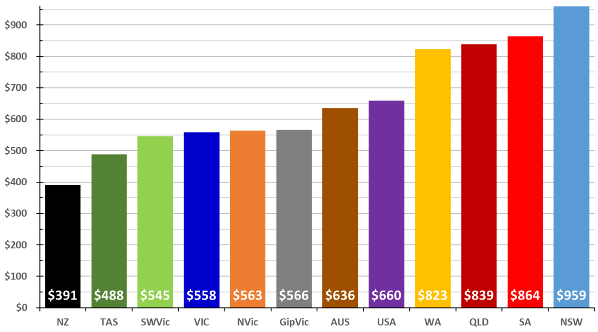


Figure 10. Australian regions plus NZ and USA labour cost per cow ($AU 2015-20)



The performance of all Australian regions, plus NZ and USA, is outlined in Figure 10, which compares the average labour cost per cow over the last six years (2015-2020). This further highlights the position of WA, QLD, SA and NSW in particular. All four states now have a labour cost per cow that is over 110 per cent higher than NZ, and between 24 and 45 per cent higher than USA.

These comparisons confirm that labour cost per cow has increased rapidly on most Australian dairy farms, and it is now significantly higher than in competing pasture-based countries and similar to the cost in the US feedlot industry. The difference in cost is substantial and it is reducing the competitiveness of the Australian dairy industry compared to dairy industries in other countries.

Cost Per Unit of Time: How do Australian Pay Rates Compare to Other Countries?

There do not appear to be any published comparisons of international farm salaries for the countries being referenced in this paper. However, a comparison of minimum wage rates per hour for these countries is likely to be relevant, with all countries employing farm staff at a range of pay rates above the minimum wage, with the most junior staff often being initially employed at, or close to, the minimum wage.

Eight countries have been compared including the six countries from most of the previous figures plus Ireland (IRE) and the United Kingdom (UK). Sources of minimum wage data include government websites for AUS, NZ, USA, IRE and UK, TheGlobalEconomy.com website for ARG and URU, and dairy farm benchmark data for RSA. USA data includes a mix of the minimum federal wage rate and the minimum state wage rates, where these are higher than the federal rate, with these minimum rates weighted to states with higher levels of milk production. All levies are added and included in these country wage rates, with these including superannuation, social security, workers/health insurance, payroll tax, and other levies.

Figure 11 outlines the minimum wage rates per hour in $US over the last 18 years for the eight countries. Over this period, Australia has retained the highest minimum hourly rate for all the countries. The UK pay rate was significantly influenced in 2017 and 2018 by the pound appreciating against the US dollar, and it would be reasonable to presume that the UK wage rate would revert over time to a smaller premium to the US and Irish values.

Figure 11. International minimum wage rates including taxes/levies ($US/hr 2003-20)

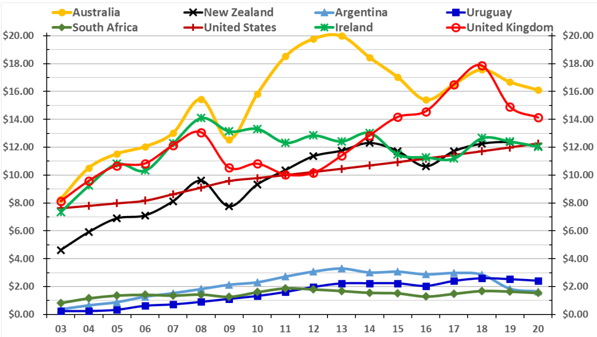
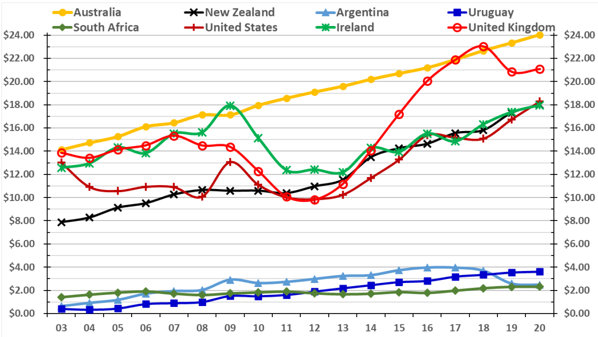


Figure 12. International minimum wage rates including taxes/levies ($AU/hr 2003-20)

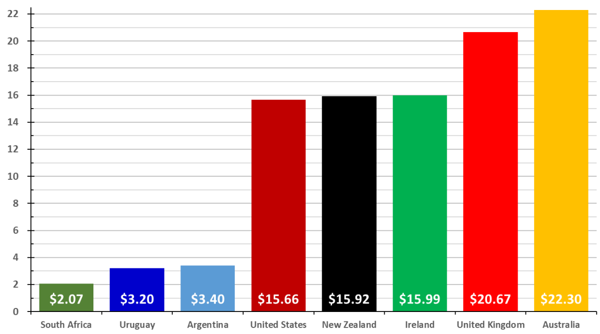


The most relevant comparisons are with those countries that have a similar (or higher) standard of living to Australia, as these are the countries that are likely to have similar access to a more productive source of labour, as well as similar access to capital that may be employed to improve labour efficiency or productivity. Conversely countries like RSA, ARG and URU, where wage rates are much lower, are countries where the labour resource is less productive and access to capital more limited.

Figure 12 outlines the minimum wage rates per hour in $AU over the last 18 years for the eight countries. Again this highlights that the Australian minimum wage rate has at least maintained, if not increased, its premium to other countries minimum wage rate over the last two decades. Presently there would appear to be no reason to presume that this premium will reduce over the next 5-10 years.

The performance of the eight countries is further highlighted in Figure 13, which compares the average minimum wage rate per hour in $AU over the last six years (2015-2020). AUS has the highest minimum wage rate of all the countries, with this being 8 per cent higher than UK as the next highest, and around 40 per cent higher than USA, NZ and IRE. If just the differences in the 2020 wage rates were calculated, then this 40 per cent difference to the USA, NZ and IRE wage rates is somewhat lower at 30-35 per cent.

Figure 13. International minimum wage rates including taxes/levies ($AU/hr 2015-20)



All farm businesses are likely to pay a range of wage rates within their employee pool, with the average farm wage rate likely to be 10-25 per cent above the minimum wage rate for each country. However, this minimum wage rate comparison can be used to reasonably infer the variation in the cost of employed staff, excluding management, for dairy businesses in each country.

The cost of management across the more developed countries of Australia, NZ, USA, IRE, UK and the balance of Western Europe are estimated to be similar based on the limited amount of benchmark data available. Management cost, including imputed owner-operator management cost, is estimated to comprise around 40-60 per cent of the total labour cost on average sized farms. However, this proportion will be lower for substantially larger farms where employed labour contributes a higher percentage of total labour cost and will be higher for substantially smaller than average-sized farms where employed labour contribute a lower percentage of labour cost. In addition, the proportion of management cost will be lower for less labour efficient farms where employed labour cost per cow is higher than average and will be higher for more labour efficient farms where employed labour cost per cow is lower than average.

Assuming management cost does comprise 40-60 per cent of the total labour cost, then Australia's 30-40 per cent higher wage rate for employed staff would on average convert into a 15-20 per cent premium on the total labour cost. Given total labour cost comprises 18-25 per cent of total operating expenses, a 15-20 per cent higher labour cost would on average convert into a 3-5 per cent increase in total expenses.

Figure 14 outlines the potential impact on the comparative performance of Australian dairy farm labour cost if a 20 per cent premium on the wage rate was removed. This figure compares the average labour cost per kg milksolids in $AU over the last six years (2015-2020) with the dotted yellow column marked with an asterisk and a value of $1.11 representing the adjusted value. This adjusted value is competitive with Argentina and Uruguay but still has an 11 per cent premium to NZ.

Figure 15 also outlines the potential impact on the comparative performance of Australian dairy farm labour cost if a 20 per cent premium on the wage rate was removed. This figure compares the average labour cost per cow in $AU over the last six years (2015-2020) with the dotted yellow column marked with an asterisk and a value of $530 representing the adjusted value. This adjusted value is again competitive with Argentina and Uruguay but has a 36 per cent premium to NZ.

Figure 14. International actual and modelled labour cost per kgMS ($AU ECM 2015-20)

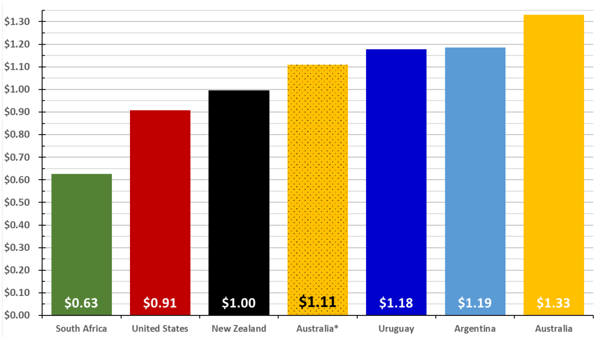
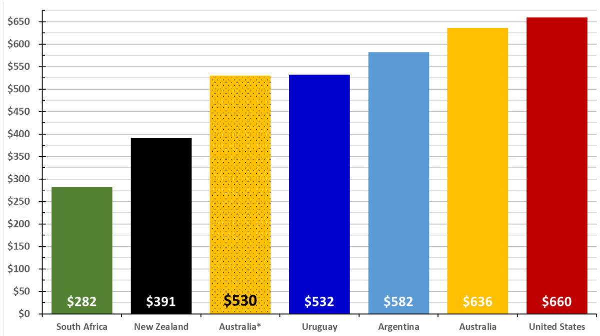


Figure 15. International actual and modelled labour cost per cow ($AU 2015-20)



It can be concluded that the unit cost of time for labour in Australia includes a substantial premium to other countries on what is the second-largest cost centre in a dairy business after total feed cost. Total labour cost generally comprises around 18-25 per cent of total operating expenses on Australian dairy farms.

Although some individual farms may be able to reduce the unit cost of time for labour, including by averaging down the unit cost through the mix of people employed, this would not appear possible for large groups of farms, and not for a region compared to farms in competing regions or countries. So the only realistic option for most Australian dairy farms to significantly reduce the cost of labour would be for these farms to reduce the amount of time required to operate the business by increasing labour efficiency.

Number of Labour 'Units': How Labour Efficient are Australian Dairy Farms?

As already described in this paper, the primary ratio for measuring labour efficiency on a dairy farm is cows farmed per full time person equivalent. This ratio has been confirmed to correlate with profit and it includes the important causal link with cows. How do Australian farms compare to farms in other countries on this measure?

Figure 16 outlines the cows farmed per full time person equivalent over the last 18 years for six countries. ARG and USA are represented by dashed lines as this ratio has been estimated from other ratios and limited benchmark data. However, over this period, Australia has maintained a position of being the second most labour efficient country behind NZ.

The performance of the six countries is further highlighted in Figure 17, which compares average labour efficiency over the last six years (2015-2020). Data for USA and ARG (denoted by asterisk) was estimated from more limited data. Although NZ is around 25 per cent more labour efficient than AUS, AUS is significantly more labour efficient than the balance of the countries.

Figure 16. International labour efficiency = cows per full time person equivalent (2003-20)

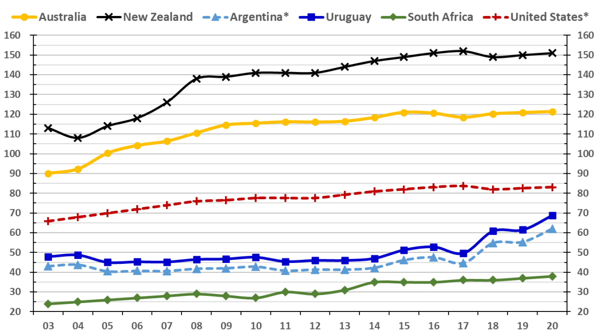
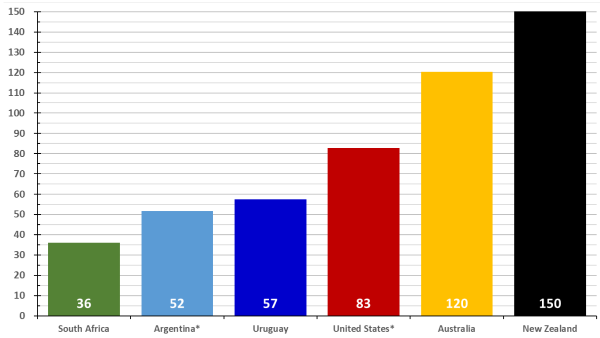


Figure 17. International labour efficiency = cows per full time person equivalent (2015-20)



Another point to note is that NZ is almost 100 per cent more labour efficient than USA, with both countries having good farm infrastructure, both utilising modern technology, and both considered to have access to good quality management and a pool of relatively capable farm staff. The main difference is the production system in each country, where NZ is predominantly pasture-based and USA is almost entirely feedlot-based, with feedlot or TMR systems requiring a much higher input of time per cow as is outlined in the section on farm production systems.

There are a number of other factors that are likely to influence labour efficiency including the level of infrastructure improvements and the size of the dairy shed, the level of technology utilised such as cup removers, and the skill level of management in activity planning and task implementation.

Figure 18 outlines labour efficiency in cows farmed per full time person equivalent over the last 18 years for all regions of Australia as well as NZ. This highlights a number of trends. Firstly, over the period 2003-2007, TAS, VIC and WA all had relatively competitive levels of labour efficiency compared to NZ, whereas TAS is the only region that has maintained a competitive position with NZ since that period. Secondly, TAS and VIC have still significantly improved labour efficiency over the 18-year period. And thirdly, NSW, QLD, SA and WA have all made little or no progress in improving labour efficiency over this period.

Figure 19 includes the same data as Figure 20, though trendlines have been added. This further highlights the trends already described, as well as outlining one further trend. NSW, QLD, SA, WA and

Northern Victoria have been reducing labour efficiency. These are the five regions where farmers have been implementing the largest changes to their production systems through the reduction of pasture in the cows' diet and an increase in supplements, moving their production systems the furthest along the spectrum towards a feedlot-type or TMR system.

Figure 18. Australian regions plus NZ labour efficiency = cows/full time person equivalent (2003-20)

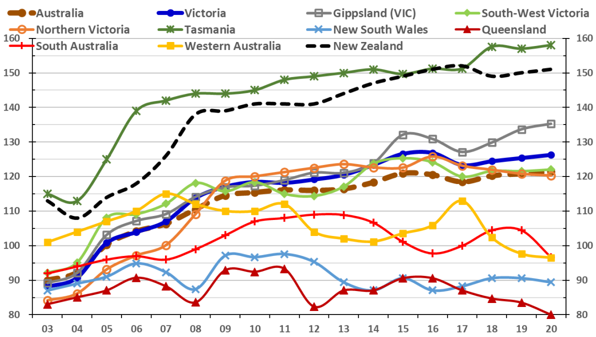
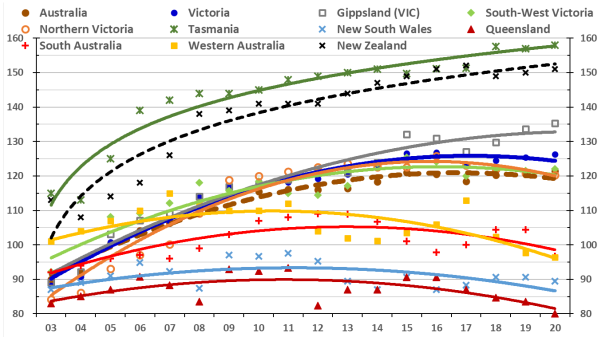
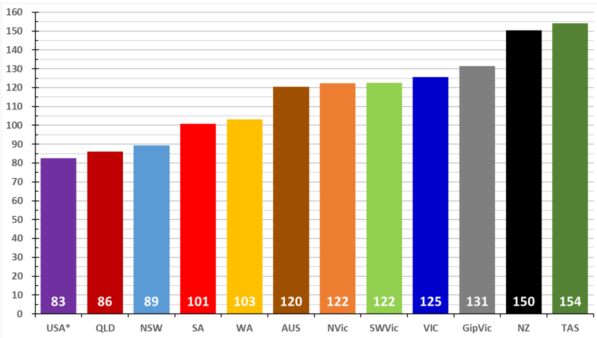


Figure 19. Australian regions plus NZ trend in labour efficiency = cows/full time person equivalent (2003-20)



The performance of all Australian regions, plus NZ and USA, is outlined in Figure 20, which compares average labour efficiency over the last six years (2015-2020). This further highlights the significant difference in performance of TAS and VIC, including all three regions in Victoria, compared to NSW, QLD, SA and WA.

Figure 20. Australian regions plus NZ and USA labour efficiency = cows per full time person equivalent (2015-20)



In reviewing the variations in labour efficiency for each of the states and regions in Australia, the differences in labour efficiency between Tasmania and the three Victorian regions might reasonably be explained by the smaller average size of Victorian farms compared to Tasmania and the variations in farm production system along with the increased labour requirements for irrigation management in Northern Victoria. As will be further outlined in the balance of this paper, all four of these Australian regions effectively have competitive labour efficiency compared to NZ given farm size and production system variations, with NZ understood to have the most labour efficient dairy industry in the world.

However, the significantly lower labour efficiency in NSW, QLD, SA and WA could only partially be explained by the smaller average farm size in QLD and NSW and the further reductions in pasture as a percentage of the diet compared to Victoria. This would indicate that there are some other unrealised opportunities to improve labour efficiency compared with the balance of Australia. These four states were the ones that were largely protected from both domestic and international competition until the Australian dairy industry was deregulated in 2000. It would be reasonable to presume that this historical protection will have reduced the pressure for farmers within these states to adopt more efficient and competitive farm management practices, with this potentially remaining a legacy issue that could be addressed to the benefit of these farmers.

The next four figures (21-24) have been included to highlight the problem when farmers and their advisors select a ratio to monitor that does not have a causal impact on profit. An example is the use of litres or milksolids produced per full time person equivalent. Presently this is widely used within the Australian dairy industry, including being promoted for use by dairy industry organisations.

As outlined earlier, cows per full time person equivalent is the labour efficiency ratio that correlates most strongly with profit and importantly has a causal impact on profit. Energy corrected litres (or milksolids) had a weaker correlation with profit, and critically, there is not a causal impact on profit with this ratio. Non-energy corrected litres had a significantly weaker correlation with profit than using energy corrected litres (or milksolids) as reported by Beca (2020b), and also does not have a causal impact on profit.

Figure 21 outlines energy corrected litres produced per full time person equivalent over the last 18 years for six countries. Unlike with cows per full time person equivalent where NZ was the most efficient by a wide margin, with AUS being next most efficient and USA being substantially less efficient than AUS, with litres per full time person equivalent, all three countries have similar performance.

Figure 22 compares the six countries average performance under the same ratio over the last six years (2015-2020). Again this highlights that the use of this ratio masks the actual comparative performance of NZ, AUS and USA if an understanding of the impact of labour efficiency on profit is the intention.

Figure 21. International litres per full time person equivalent (2003-20)

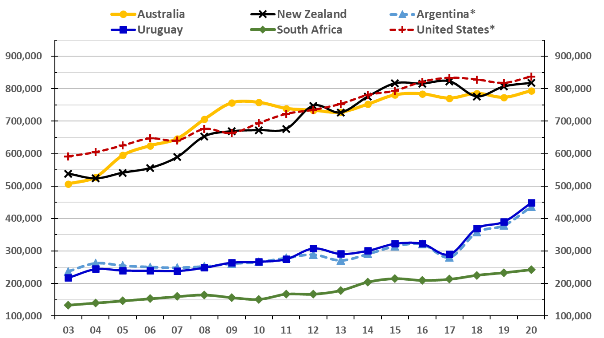
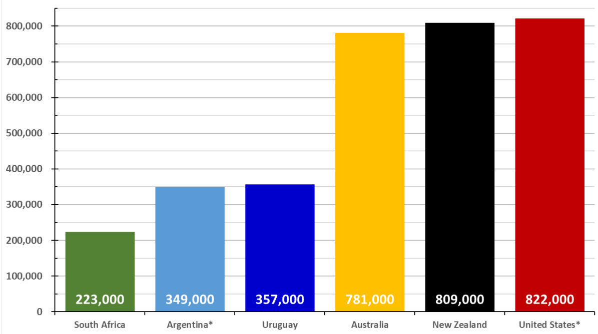


Figure 22. International litres per full time person equivalent (2015-20)



This outcome would be further clouded and would become even more misleading if the comparison was made with non-energy corrected milk. This would significantly increase the USA performance as this country has the lowest milk components of the three countries, and significantly decrease the NZ performance as this country has the highest milk components by a wide margin. These changes would result in the actual performance in labour efficiency of the three countries being entirely reversed, with NZ moving from being the most efficient of the three countries to being described as the least efficient, and USA moving from the least efficient to being described as the most efficient.

This problem with using a ratio that does not have a causal relationship with profit is further highlighted in Figure 23, which outlines energy corrected litres produced per full time person equivalent over the last 18 years for all regions of Australia as well as NZ. Although the performance of NSW and QLD appears poor as it did when utilising cows per full time person equivalent, all the other states and regions appear similar in performance, with many appearing to perform better than NZ.

The performance of all Australian regions, plus NZ and USA, is outlined in Figure 24, which compares average energy corrected litres produced per full time person equivalent over the last six years (2015-2020). Again this highlights that the use of this ratio masks the actual comparative performance of almost all states and regions, including their comparative performance with NZ and USA.

Figure 23. Australian regions plus NZ and USA litres per full time person equivalent (2003-20)

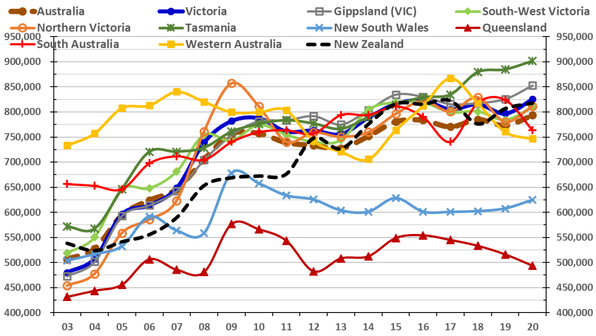
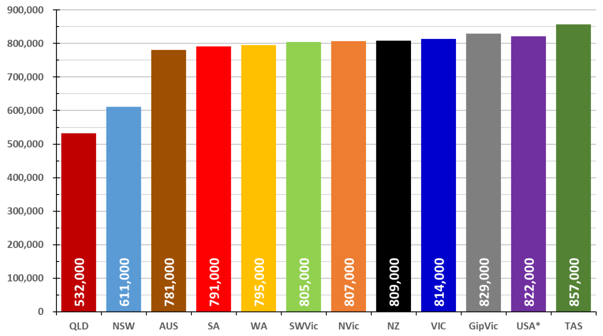


Figure 24. Australian regions plus NZ and USA litres per full time person equivalent (2015-20)



As with the international comparisons, this outcome would be further clouded and would become even more misleading if the comparison was made with non-energy corrected milk. This would significantly inflate the performance of SA and WA (as well as QLD and NSW) as these states have comparatively low milk components, and significantly decrease the performance of TAS as this state has the highest milk components by a wide margin. In addition, it would produce the wholly erroneous result of suggesting SA and WA have higher labour efficiency than NZ when in reality these states perform at around 68 per cent of the efficiency of NZ.

What Might be the Impact of Farm Size on Labour Efficiency?

In most circumstances farm size is not a relevant factor in determining profit for pasture-based dairy farms as reported by Neal and Roche (2020) and Beca (2020b). Figure 25 from Beca (2020b) confirms that the number of cows in herd could explain 11 per cent of the variation in profit as described by return on capital, with both very small and very large farms having lower profit than farms within a wide moderate farm-sized band. Pasture-based dairy farms have no significant economies of scale as reported by Beca (2006).

Figure 25. Farm size (number of cows in herd) impact on profit (return on capital)

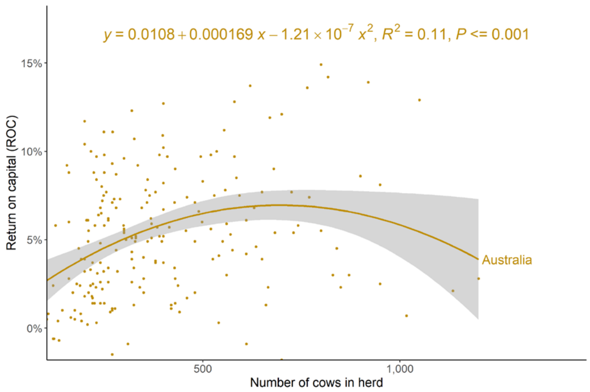
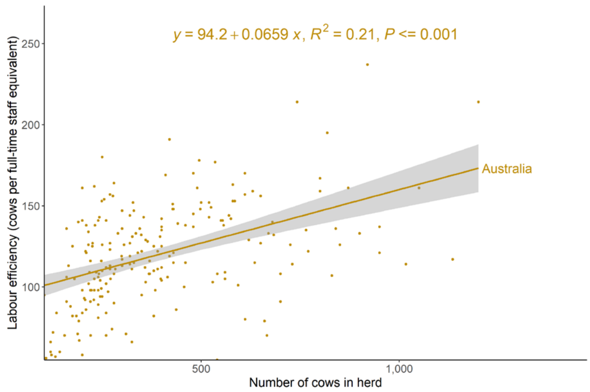


Figure 26. Number of cows in herd impact on labour efficiency (cows per FTE)



However, there is a gain in labour efficiency associated with farm size. Figure 26 confirms that farm size, as described by number of cows in herd, could explain 21 per cent of the variation in labour efficiency as described by cows per full time person equivalent. The trendline equation is y = 94.2 + 0.0659x, so for every 100 additional cows in the herd there is an increase in labour efficiency of 6.59 cows per full time person equivalent (cows per FTE).

Although this impact of farm size on labour efficiency is significant, it is not of a sufficient quantum to explain the majority of variation in labour efficiency between countries. Figure 27 compares the average size of dairy farm in 2020 for eight countries. For instance, NZ, as the most labour efficient country, does have an advantage in average farm size (440 cows) which could explain a 10-11 cow higher number of cows farmed per full time person equivalent compared to Australia with its smaller average farm size (279 cows).

Figure 28 compares the average size of dairy farm in 2020 for all Australian states, plus NZ and USA. TAS is the most labour efficient state and does have an advantage in average farm size compared to VIC which could explain a 13-14 cow higher number of cows farmed per full time person equivalent. This difference, and the impact of differences in the production systems, can largely explain the variations in labour efficiency.

Figure 27. International number of cows per farm (2020)

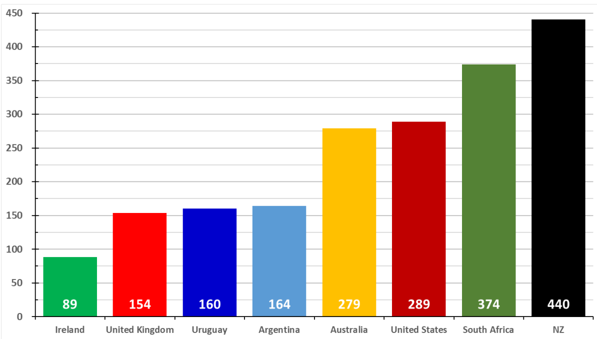
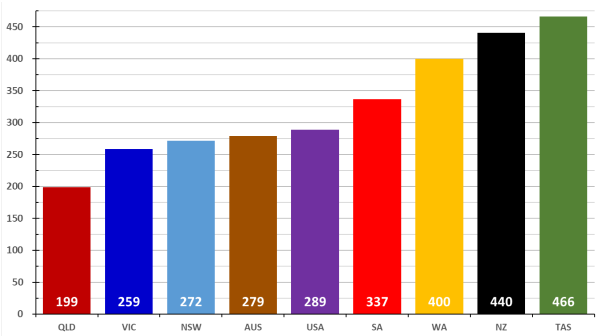


Figure 28. Australian states plus NZ and USA number of cows per farm (2020)



This explanation does not cover the additional reduction in labour efficiency for WA, SA, NSW and QLD. Farms in WA and SA on average have production systems that require more labour time, but the average size of farm is significantly greater than in VIC and these two factors might be expected to limit any impact on labour efficiency. So this does not provide an explanation for the 18-19 per cent lower labour efficiency in WA and SA.

Farms in NSW are on average slightly larger than in VIC, which would partially compensate for the additional labour time required for the production systems being implemented in this state, leaving most of the 29 per cent lower labour efficiency unexplained.

Farms in QLD are on average smaller than in VIC with this difference potentially explaining a 4-cow lower number of cows farmed per full time person equivalent. As with NSW, the production systems being implemented in QLD also require more time than for farms in VIC, though overall QLD would be in a similar position as NSW.

What Might be the Impact of Milk Production Per Cow on Labour Cost and Efficiency?

As milk production per cow increases, and cows are run at a higher level of performance, there is a need for more time to be allocated to care for the cows' needs, including the increased levels of supplementation, and to ensure the higher level of production is maintained. Table 4 outlines the most relevant factors that are impacted by changes in milk production per cow, with labour cost being one of these as reported by Beca (2020b).

Labour cost per cow increases significantly as milk production per cow increases. Figure 29 confirms that milk production per cow could explain 19 per cent of the variation in labour cost per cow.

Table 4. Impact of milk production per cow on profit (Beca 2020b)

As milk production per cow INCREASES	Change	R^2	P
Return on Capital (PROFIT)	**No change**	**0.05**	**0.0049**
Cost of production per litre	**No change**	*0.02*	*0.213*
Core per cow cost	Increases	0.28	<= 0.001
Supplement cost per litre	Increases	0.26	<= 0.001
Total feed cost per litre	Increases	0.22	<= 0.001
Labour cost per cow	**Increases**	**0.19**	**<= 0.001**
Pasture cost per tonne dry matter	Increases	0.12	<= 0.001
Core per hectare cost per tDM of pasture harvest	Increases	0.09	<= 0.001

Figure 30 confirms that labour efficiency decreases significantly as milk production per cow increases, and that milk production per cow could also explain 10 per cent of the variation in labour efficiency as described by cows per full time person equivalent.

Figure 29. Milk production per cow impact on labour cost per cow ($US)

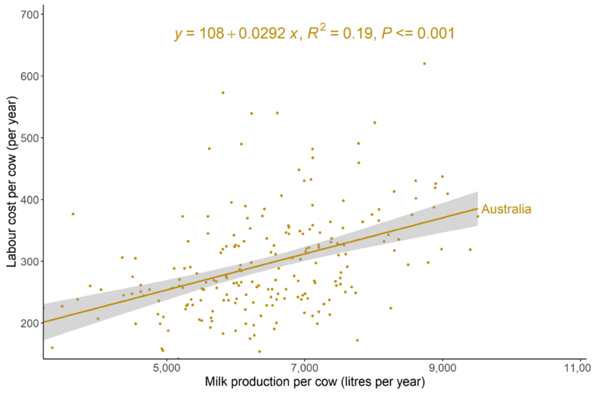
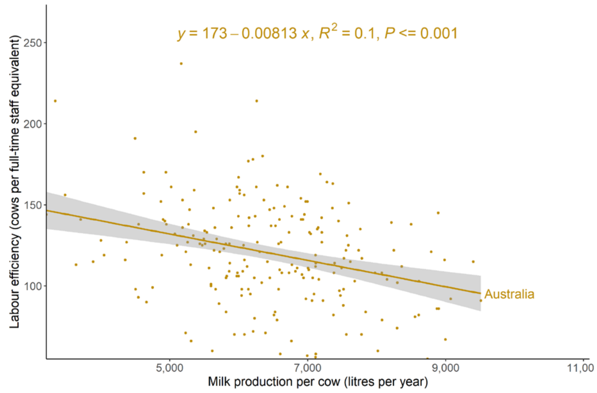


Figure 30. Milk production per cow impact on labour efficiency (cows per FTE)



Both relationships are strong and significant, and confirm that as milk production per cow increases, labour cost increases and labour efficiency decreases.

Figure 31. International and Australian regions milk production per cow (ECM litres 2015-20)

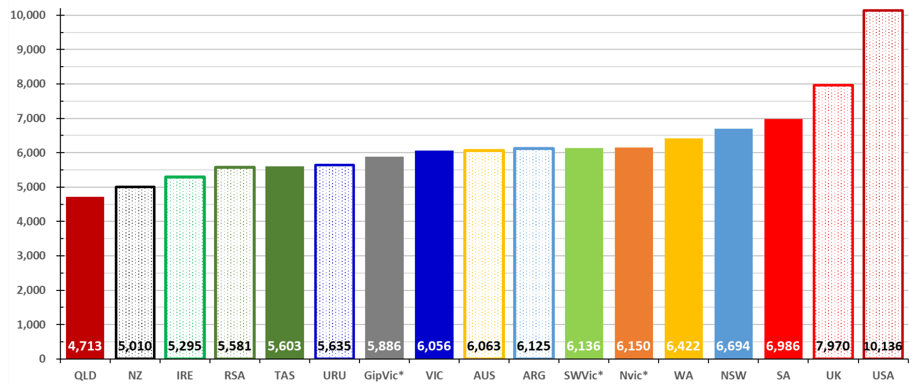


Figure 31 provides some perspective of the levels of milk production per cow within Australia and internationally. Country-level milk production in Figure 31 is represented by a dotted pattern and has the level of milk production per cow in black font. The variations in regional milk production in Victoria (denoted by asterisk) are estimates based on benchmark variations.

What Might be the Impact of Pasture Harvest on Labour Cost and Efficiency?

As pasture harvest increases, the greater focus of all labour is on pasture production and there is a lesser focus, and reduced time, allocated to milk production per cow. Farmers that focus on pasture harvest are also likely to breed a genotype of cow that performs better on pasture and allocates more energy to maintenance as opposed to milk production. As a result, this type of cow is likely to become pregnant more quickly and survive longer in the herd, reducing operating costs, as reported by Harris and Kolver (2001). Table 5 outlines the most relevant factors that are impacted by changes in pasture harvest, with labour cost being one of these as reported by Beca (2020b).

Table 5. Impact of pasture harvest on profit (Beca 2020b)

As pasture harvest DECREASES	Change	R^2	P
Return on Capital (PROFIT)	**Decreases**	**0.41**	**<= 0.001**
Cost of production per litre	**Increases**	**0.14**	**<= 0.001**
Core per hectare cost per tDM of pasture harvest	Increases	0.31	<= 0.001
Pasture cost per tonne dry matter	Increases	0.23	<= 0.001
Supplement cost per litre	Increases	0.12	<= 0.001
Labour cost per cow	**Increases**	**0.09**	**<= 0.001**
Core per cow cost	Increases	0.08	<= 0.001

Labour cost per cow increases significantly as pasture harvest decreases. Figure 32 confirms that pasture harvest could explain 9 per cent of the variation in labour cost per cow.

Figure 33 confirms that labour efficiency decreases significantly as pasture harvest decreases, and that pasture harvest could also explain 8 per cent of the variation in labour efficiency as described by cows per full time person equivalent.

Figure 32. Pasture harvest impact on labour cost per cow ($US)

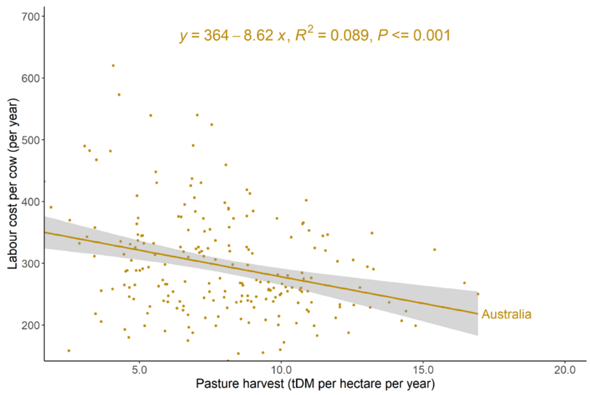
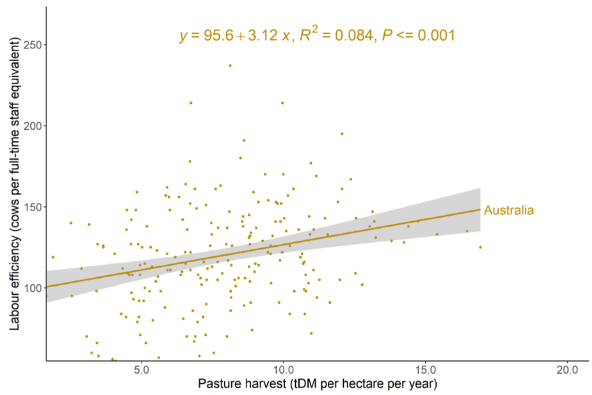


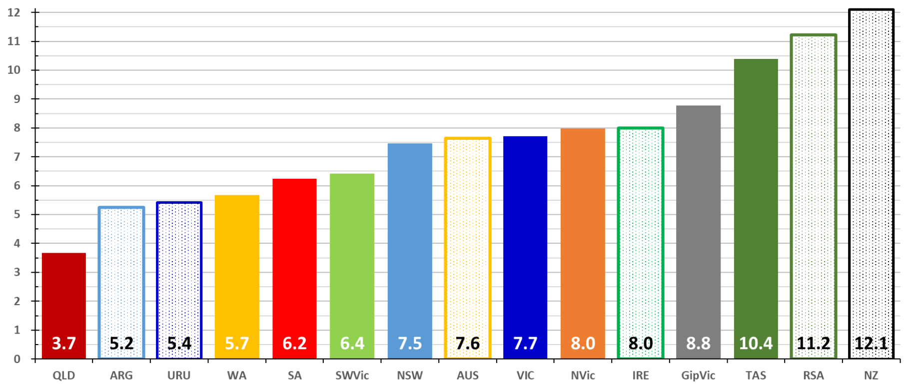
Figure 33. Pasture harvest impact on labour efficiency (cows per FTE)



Both relationships are strong and significant, and confirm that as pasture harvest decreases, labour cost increases and labour efficiency decreases.

Figure 34 provides some perspective of the levels of pasture harvest within Australia and internationally. Country-level pasture harvest in Figure 34 is represented by a dotted pattern and has the level of pasture harvest in black font.

Figure 34. International and Australian regions pasture harvest (tDM/ha per year 2015-20)



What Might be the Impact of the Farm Production System on Labour Cost and Efficiency?

As a production system changes and the pasture percentage in the cows' diet decreases, milk production per cow is likely to increase and pasture harvest is likely to decrease as reported by Beca (2020b). Most of the operating costs increase on a per litre or per milksolids basis, with cow-related costs increasing per cow and land-related costs increasing per hectare per tonne dry matter of pasture harvested.

Farmers that focus on feeding higher levels of supplement and targeting higher levels of milk production per cow are also likely to breed a genotype of cow that performs better when more concentrate is fed to the cow, and which allocates more energy to milk production as opposed to maintenance. As a result, this type of cow is likely to become pregnant less quickly and survive for a shorter period in the herd, increasing operating costs, as reported by Harris and Kolver (2001). Table 6 outlines the most relevant factors that are impacted by changes in the per cent of pasture in the cows' diet, with labour cost being one of these as reported by Beca (2020b).

Table 6. Impact of pasture as percentage of cows' diet on profit (Beca 2020b)

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**
Pasture consumed per cow	Decreases	0.68	<= 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

Labour cost per cow increases significantly as pasture per cent in the diet decreases. Figure 35 confirms that pasture per cent in the diet could explain 8 per cent of the variation in labour cost per cow.

Figure 36 confirms that labour efficiency decreases as pasture per cent in the diet decreases, although pasture per cent in the diet could explain just 3 per cent of the variation in labour efficiency as described by cows per full time person equivalent.

Figure 35. Pasture per cent in diet impact on labour cost per cow ($US)

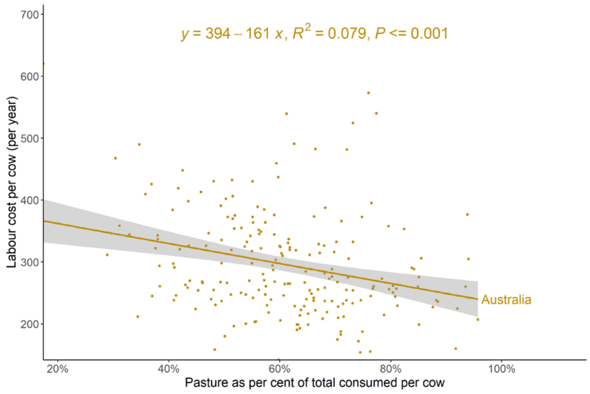
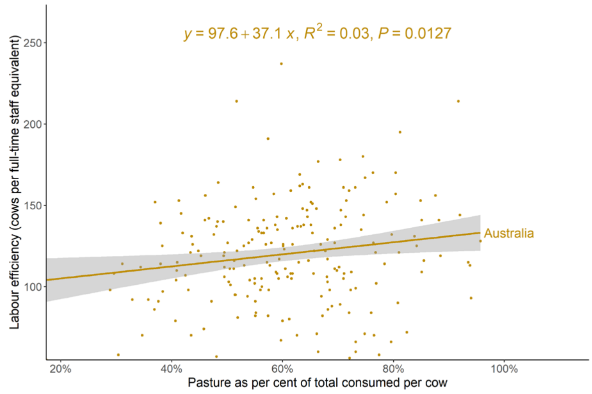


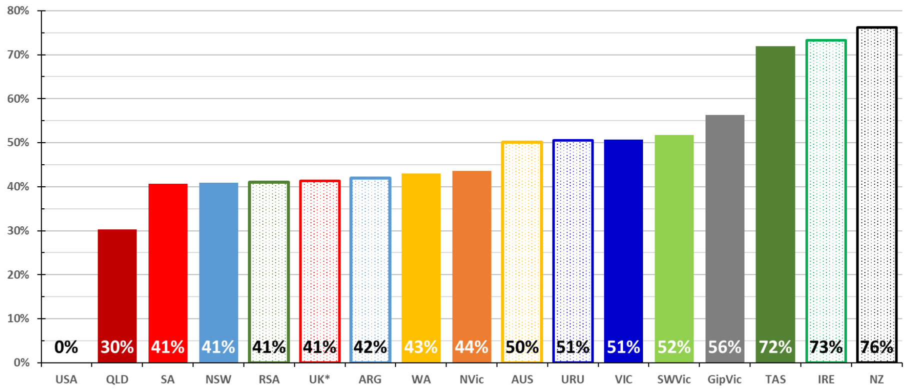
Figure 36. Pasture per cent in diet impact on labour efficiency (cows per FTE)



Both relationships are significant and confirm that as pasture percentage in the cows' diet decreases, labour cost increases and labour efficiency decreases.

Figure 37 provides some perspective of the levels of pasture percentage in the cows' diet within Australia and internationally.

Figure 37. International and Australian regions pasture as a percentage of cows' diet (2015-20)



Discussion

The Australian dairy industry could be split into two groups along state borders where Tasmania and Victoria have a comparatively high level of labour efficiency, and New South Wales, Queensland, South Australia and Western Australia have a comparatively low level of efficiency. An understanding of these differences could provide the dairy industry with an opportunity to target projects and programs that relate to improving labour efficiency for the four states with the greatest need.

It may be possible to segment factors that impact on labour efficiency into three general areas:

1. Level of infrastructure development including type and size of dairy shed as well as the quality of farm improvements; and
2. Level of 'labour-saving' technology including items such as cup removers; and
3. Level of management organisational capability that relates to task or activity planning and implementation.

Points 1 and 2 require capital and so can be negatively impacted when levels of profitability are impaired, as they have been in Australian dairying in recent years. Point 3 requires knowledge and training and so is less constrained by capital.

However, all of the Australian dairy industry, except for Tasmania, has a comparatively high labour cost per cow. This is partially due to Australia's high cost of labour per unit of time (per hour). It is also significantly influenced by the farm production systems that have been implemented across mainland Australia over the last 20 years and in particular the focus on cow production and higher supplementation, which involves less focus on pasture production and a lower percentage of pasture in the diet.

Although any decision by a farmer on what production system to adopt, and the likely impact on cost of production and profit, should be assessed using the "whole farm approach" as described by Malcolm et al. (2005), it could be beneficial for the Australian dairy industry to develop some relevant labour targets to focus discussion amongst farmers and within the industry generally. For these targets to be relevant they would need to be adjusted for farm size and for the production system, as well as potentially for the state or region.

However, one of the results of Australian farmers changing their productions systems over the last 20 years by focusing on increasing milk production per cow through increasing the amount of supplement being fed and decreasing the percentage of pasture in the cows' diet, is a decrease in labour efficiency and an increase in labour costs per cow. These changes largely explain the difference between Victorian dairy farms labour efficiency and New Zealand farms, but they do not explain the difference between New South Wales, Queensland, South Australian and Western Australian farms and their Victorian or New Zealand counterparts. Some of the variation in performance on New South Wales, Queensland, South Australian and Western Australian farms is a result of other factors that are worthy of further study, including by industry research, development and extension organisations, as improvements in labour efficiency should result in improvements in productivity and profitability. This would consequently improve domestic comparative advantage for these dairy farms, as well as improving international competitiveness.

Conclusions

Total labour cost comprises 18-25 per cent of total operational expenses on Australian dairy farms and is the second largest cost centre after total feed cost on dairy farms, with all other cost centres substantially smaller. Maintaining a competitive labour cost is relevant to the overall competitiveness of the Australian dairy industry.

Labour costs in the Australian dairy industry have increased rapidly over the last 20 years and are now very high per litre of energy corrected milk or per kg milksolids when compared to other countries. When reviewed on a state-by-state or regional basis, New South Wales, Queensland, South Australia and Western Australia have a much higher labour cost than Victoria and Tasmania.

When assessing labour cost and efficiency, the two labour ratios that should be utilised are labour cost per cow and cows farmed per full time person equivalent, as both have a causal relationship with profit. Labour cost per litre or per kg milksolids should only be used as a general guide to the contribution of labour cost to total operating expenses, and if calculated per litre then this must be undertaken on energy corrected milk for it to be relevant. Litres or kg milksolids per full time person equivalent should not be used as this ratio does not have a causal relationship with profit and if used, it will mislead farmers and their advisors as to the level of labour efficiency in a farm business.

Labour cost per cow in Australia has also increased rapidly over the last 20 years in a similar way to labour cost per energy corrected litre. Again, this cost is much higher in New South Wales, Queensland, South Australia and Western Australia than in Victoria and Tasmania.

Total labour cost comprises two factors: the cost of labour by unit of time and the amount of time taken to complete the required tasks on a dairy farm or the level of labour efficiency. Labour cost per hour in Australia, excluding the cost of management, is the highest of any country in the world and is 30-40 per cent higher than a peer group of New Zealand, United States and Ireland. Management cost in Australia is estimated to be similar to these countries.

Management cost is estimated to comprise 40-60 per cent of the total labour cost on average-sized dairy farms, which implies that Australia's 30-40 per cent higher wage rate for employed staff would on average convert into a 15-20 per cent premium on the total labour cost. Given total labour cost comprises 18-25 per cent of total operating expenses, a 15-20 per cent higher labour cost would on average convert into a 3-5 per cent increase in total expenses. This higher labour cost per unit of time need not negatively impact on profitability if labour efficiency, or productivity, is commensurately higher than in other countries. However, for the Australian dairy industry, there is not sufficiently higher labour productivity to compensate for the higher unit cost of labour.

Labour efficiency in Australia is 25 per cent lower than in New Zealand, but it is substantially higher than the other countries compared in this paper. Labour efficiency is very high in Tasmania and compares favourably with New Zealand. Labour efficiency in Victoria is 17 per cent lower than in New Zealand, with this difference being largely explained by the smaller average farm size and the differences in production systems implemented in Victoria. Labour efficiency is substantially lower in New South Wales, Queensland, South Australia and Western Australia than in Victoria, and it has been decreasing in these states in recent years. Differences in farm size and production systems do not explain the lower labour efficiency in these four states compared to New Zealand or the balance of Australia.

There are a number of factors that are likely to influence labour efficiency including the level of infrastructure improvements and the size of the dairy shed, the level of technology utilised such as cup removers, and the skill level of management in activity planning and task implementation. Other factors that influence labour efficiency include farm size (positively correlated), milk production per cow (negatively correlated), pasture harvest (positively correlated), and pasture as a percentage of the cows' diet (positively correlated).

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Appendix 1: Sources of Data

Table 7. Data sources and basis for converting data to a standardised format

Country	Benchmark data source and conversion to standardised format
Argentina	Developed from benchmark data provided by AACREA, with this converted into a similar format as utilised by Red Sky, DairyBase and Dairy Farm Monitor Project. Average annual number of farms in dataset approx 230.
Australia	Developed from a mix of Red Sky data plus Dairy Farm Monitor Project benchmark data for Victoria, Tasmania, South Australia and Western Australia. Data for New South Wales was entirely sourced from Dairy Farm Monitor Project benchmark data for the period 2012-2018, with data for 2003-2011 calculated from trends in other Australian states. Data for Queensland was entirely sourced from QDAS benchmark data. Red Sky, Dairy Farm Monitor Project and QDAS utilise a similar format for calculating benchmarks. Average annual number of farms solely in Red Sky dataset approx 80, in Dairy Farm Monitor Project dataset for Victoria approx 75, Tasmania approx 35, New South Wales approx 32, South Australia approx 21, Western Australia approx 27, and in Queensland QDAS dataset approx 88.
Ireland	Developed from Teagasc National Farm Survey data, with this converted into a similar format as utilised by Red Sky, DairyBase and Dairy Farm Monitor Project. Average annual number of farms in dataset approx 295.
New Zealand	Developed from a mix of Red Sky data plus DairyBase benchmark data. Red Sky and DairyBase utilise a similar format for calculating benchmarks. Average annual number of farms in Red Sky dataset approx 90 and in DairyBase approx 650.
South Africa	Developed from Red Sky data. Average annual number of farm businesses in dataset approx 50, representing over 60 individual farms.
United Kingdom	Developed from limited benchmark data provided by AHDB and from converting data in refereed and non-refereed publications into a farm performance model to represent average benchmark data. Benchmark data for United Kingdom should be interpreted as estimates only.
United States	Developed from benchmark data provided by Genske Mulder, with this converted into a similar format as utilised by Red Sky, DairyBase and Dairy Farm Monitor Project. Average annual number of farms in dataset estimated at 350.
Uruguay	Developed from benchmark data provided by FUCREA, with this converted into a similar format as utilised by Red Sky, DairyBase and Dairy Farm Monitor Project. Average annual number of farms in dataset approx 65.

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.

DFMP (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 primarily operates 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.

TheGlobalEconomy.com www.theglobaleconomy.com/rankings/minimum_wage.

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

Appendix 2: 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). 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 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.

Table 8. Calculations and definitions of ratios

Ratios	Calculation / Definition
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.
Farm size (cow numbers)	Total number of cows in herd (milking plus dry cows).
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.
Labour efficiency - cows per full-time staff equivalent	Total cows in herd divided by number of 50-hour full-time staff equivalents.
Labour efficiency - litres per full-time staff equivalent	Total litres (ECM) produced divided by number of 50-hour full-time staff equivalents.
Milk production per cow	Total litres (ECM) produced divided by total cows in herd.
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.
Profit margin per litre or per kg milksolids	Operating profit divided by total litres or total milksolids (ECM) produced.
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.
Stocking rate	Total cows in herd divided by effective dairy hectares.
Supplement cost per litre or per kg milksolids	(Concentrates + Forages + Grazing/Support area expenses) divided by total litres or total milksolids (ECM) produced.
Total consumed per cow (tDM/cow/year)	Total tonnes of dry matter consumed per cow in herd per year, where the energy supplied from pasture is standardised at 11.0 MJ ME/kg DM, the energy supplied from forages is standardised at 9.5 MJ ME/kg DM, and the energy supplied from concentrates is standardised at 12.5 MJ ME/kg DM.
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.