Addendum to Key Determinants of Profit for Pasture-based Dairy Farms South Africa versus Australia

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Background to South Africa data

The South Africa analysis comprises 244 sets of dairy farm data relatively equally spread across the four years of 2014/15, 2015/16, 2016/17 and 2017/18. The farms are primarily from two States; KwaZulu-Natal and Eastern Cape, although there are a small number of datasets from outside these states. South African dairy farmers experience a climate (due to latitude and altitude) that is similar to New South Wales and parts of Western Australia. The focus on domestic (not export) milk supply and the requirement for flatter milk supply curves also makes the conditions in South Africa similar to New South Wales, Queensland and Western Australia.

The great majority of the 244 sets of farm data were collected by Intelact South Africa (independent consultants), with the balance collected by Red Sky. All the sets of farm data were processed through Red Sky software, so they have all been analysed using a uniform methodology. The four years included years of high, medium and low milk prices, high and medium (not low) supplement prices, and good, average and poor weather (so average, higher than average and lower than average pasture harvest).

All graphs from the main paper, 'Key Determinants of Profit for Pasture-based Dairy Farms' (Beca 2020) are replicated in this addendum using the same figure numbers and titles, with the Australian (gold) and South African (green) graph of each ratio plotted side-by-side. All graphs are in USD, with the average foreign exchange rate for each year applied to that year. As with the main paper, all milk ratios are reported in 'energy corrected milk' (**ECM**) with this corrected to 4.0% fat and 3.3% protein using the formula: ECM = milk production x ((0.383 x fat% + 0.242 x protein% + 0.7832) / 3.1138). South Africa reports protein as total protein rather than true protein, so non-protein nitrogen was assumed to be 5.5% of total protein to correct for this.

The software program, R, was used to undertake the statistical analysis. There is a fuller explanation of the relevance of both the R^2 and P values and their interpretation on pages 2 and 3 of the main paper. In brief, the R^2 determines the strength of the association between the two factors on the graph and the percentage of variation of the ratio on y-axis that can be explained by the ratio on the x-axis. The P determines the strength of the trend depicted in the graph, and the shaded area represents a 95% confidence interval, that is, if multiple random samples were analysed, 95% of the confidence intervals constructed in a similar way would contain the true population mean. For an association between variables, typically a P value of less than 0.05 is used as a threshold to determine its statistical significance, that is, there is less than a 5% chance or one in twenty that the association has occurred due to random variation. The great majority of the figures in this paper have a P value of less than 0.001, which means there is less than one chance in a thousand that this association has occurred by chance.

Potential bias in South Africa data

Unlike the Australia data, there is some potential bias in the South Africa data as described in Figures A-I below. This bias would not be unexpected and could come from 3 main sources:

1. The great majority of South Africa data was collected by a single consultancy company from its clients, and as a result the farmers will have a commonality in focus on particular characteristics of production systems. With the Australia data, the great majority of this was collected via industry/government supported projects or in association with farmer study/ discussion groups, so the data is drawn from a full spectrum of production systems without commonality of focus.
2. The South Africa pasture-based dairy industry has a comparatively unique commonality of focus over the last 20 years on increasing pasture harvest through increasing stocking rate. This has developed from most farmers in the dairy industry recognising there was an opportunity to improve profitability through increasing pasture harvest, and although the industry has in general been successful in this endeavour, one of the outcomes has been that the production systems have changed in a comparatively uniform way. There is not a similar focus or outcome in the Australian dairy industry.
3. The great majority of South African farms have a percentage of the farm irrigated, though the proportion of irrigated versus dryland varies substantially. This significantly confounds the impact of pasture harvest and stocking rate on business performance as the level of pasture harvest on irrigated land is usually 70%-100% higher than for the associated dryland on the same farm. With the Australia data, there is a large proportion of farms that are entirely dryland, and the difference between irrigated and dryland pasture harvest is much smaller (30%-60%), both within and between farms.

The impact of this potential bias, and in particular point 3, is illustrated in **Figures A & B**. Firstly, in Figure A, the variation explained by pasture harvest on profit in South Africa (R^2 = 0.24 and P <=0.001) is much lower than in Australia (R^2 = 0.41 and P <=0.001), and lower than similar studies in New Zealand.

Figure A. Impact of pasture harvest in tonnes of dry matter of pasture per hectare per year on profit

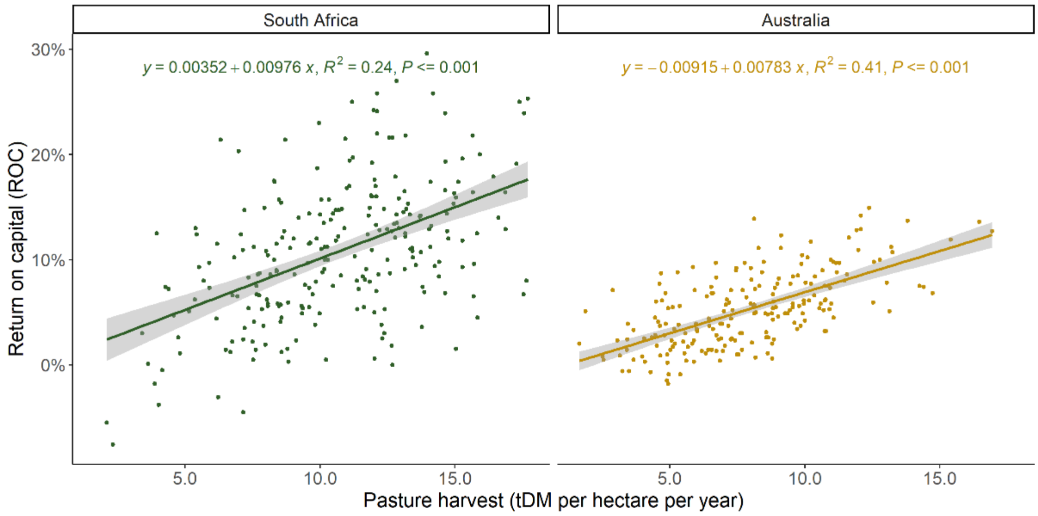


Figure B outlines how the variation explained by pasture harvest on profit in South Africa (R^2 = 0.24 and P <=0.001) significantly increases and substantially closes the gap on the Australia result when **irrigated** (R^2 = 0.30 and P <=0.001) and **dryland** (R^2 = 0.37 and P <=0.001) pasture harvest are analysed independently.

Figure B. Impact of irrigated and dryland pasture harvest in tDM of pasture per hectare per year on profit

South Africa – IRRIGATED **South Africa – DRYLAND**

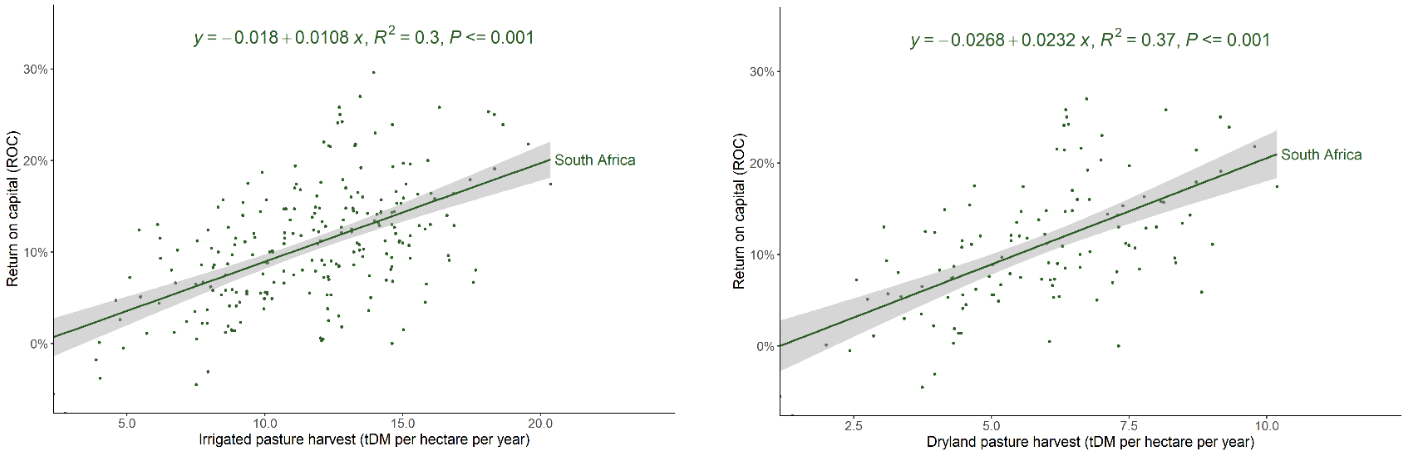


Figure C outlines how the variation explained by stocking rate on profit (through its associated impact on pasture harvest) is strongly evident in the Australia data (R^2 = 0.25 and P <= 0.001), though is significantly weaker in the South Africa data (R^2 = 0.03 and P = 0.0054). This provides further background to the proposed sources of bias, and in particular South Africa's focus on increasing stocking rate.

Figure C. Impact of stocking rate on profit

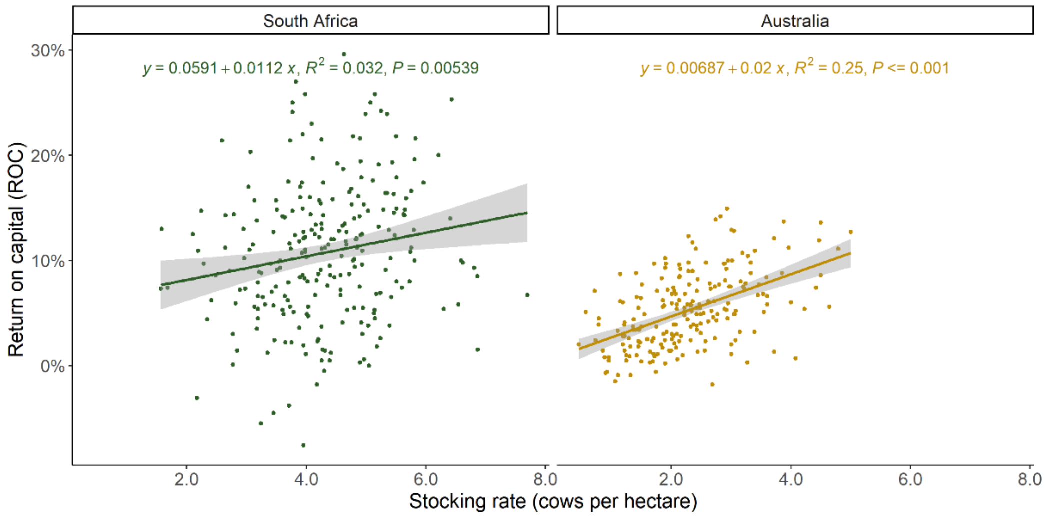


Figure D outlines how the Australia data has a weak positive relationship between pasture harvest per hectare and pasture consumed per cow (R^2 = 0.05 and P = 0.0015), whereas the South Africa data has a strong positive relationship between increasing pasture harvest and increasing pasture consumed per cow (R^2 = 0.41 and P <= 0.001). This would confirm that unlike in the Australia dataset, the South Africa farms progressively reduce the amount of pasture fed per cow as pasture harvest per hectare decreases, which is having the effect of progressively moving the production system to one that is reliant on higher consumption of supplements per cow. This would infer that farms progressively become more highly stocked per tonne of available pasture as pasture harvest decreases, which would be consistent with the observed commonality of focus in South Africa of increasing stocking rate in the pursuit of higher levels of pasture harvest.

Figure D. Impact of pasture harvest on pasture consumed per cow

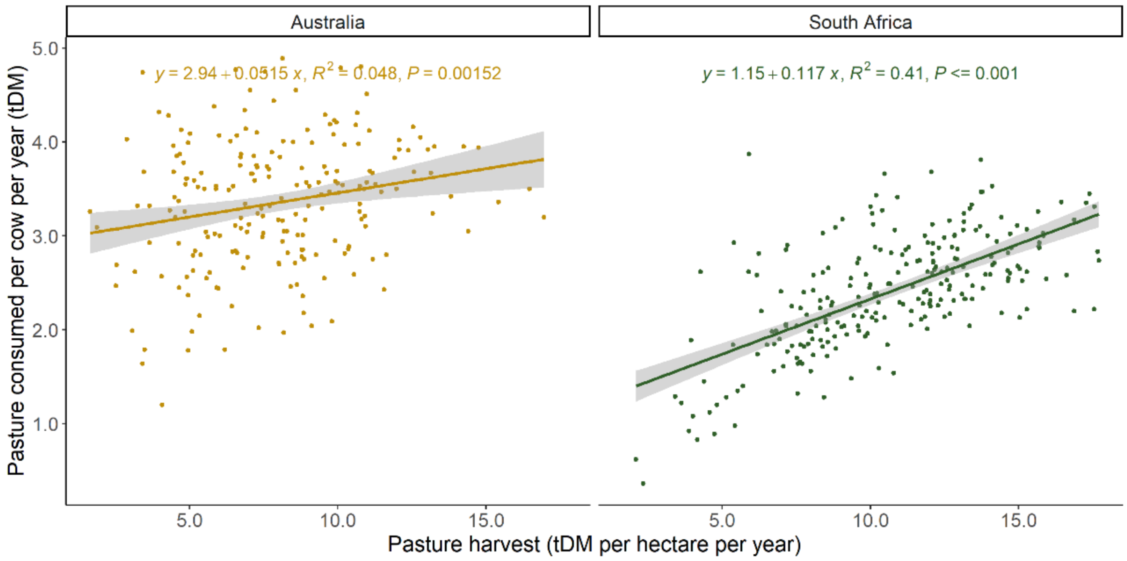


Figure E for Australia outlines the 'usual' trend in declining milk production per cow as pasture increases as a per cent of the diet, and concentrates (as well as other supplements) decrease in proportion. This 'usual' trend is due to the substitution of concentrates for pasture, with the lower energy density and higher fibre content of pasture reducing total cow intake and so reducing milk production. In the Australia data the R^2 = 0.32 and P <= 0.001. In the South Africa data this trend is **not** evident (R^2 = 0.01 and P = 0.274), suggesting that those farms with a higher level of milk production per cow are on average producing pasture of substantially higher energy density than those farms with more average levels of milk production per cow. It might be inferred that these farms with higher levels of milk production per cow have reduced or eliminated any difference between pasture energy density and the balance of the diet. Conversely, those farms with a lower level of milk production per cow are on average producing pasture of substantially lower energy density than farms with more average levels of milk production per cow, and increasing the difference between pasture energy density and the higher energy density of the balance of the diet. The more northerly latitude of South Africa compared to Australia, and the widespread reliance on kikuyu as part of the pasture mix, would be factors that allow for a much greater variation in pasture energy density on South African farms compared to southern Australian farms.

Figure E. Impact of pasture as per cent of diet on milk production per cow

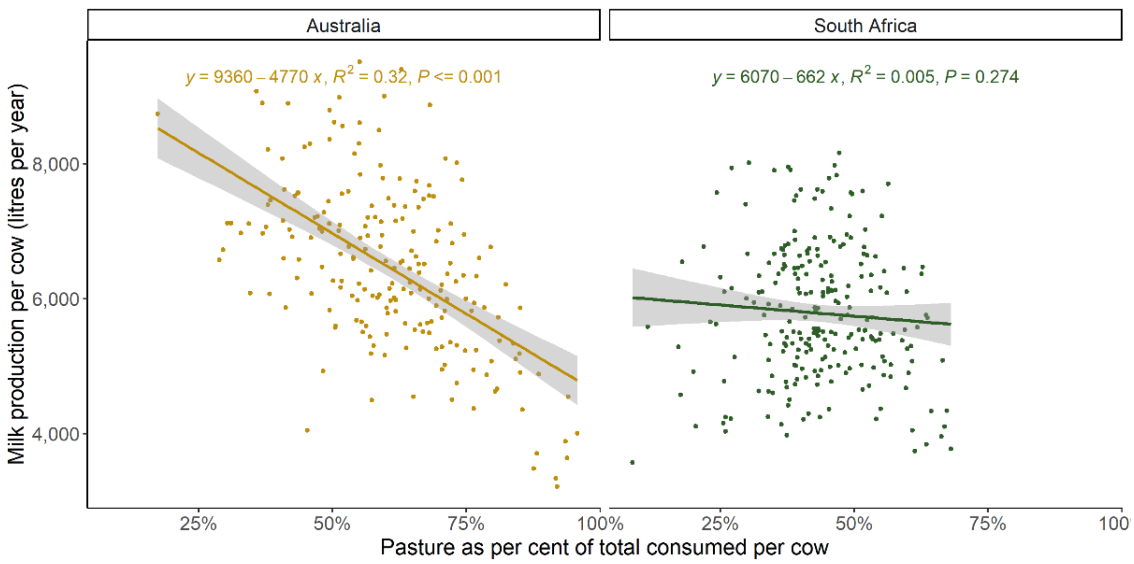


Figure F outlines how the level of milk production per cow in the Australia data is not influenced by the amount of pasture consumed per cow per year (R^2 = 0.002 and P = 0.513), whereas in the South Africa data, increasing levels of pasture consumed per cow have a positive impact on increasing milk production per cow (R^2 = 0.14 and P <= 0.001). As with Figure E, one explanation could be that those South African farms with a higher level of pasture consumption per cow are producing pasture with a significantly higher level of energy density than the average (and those farms with a lower level of pasture consumption per cow are producing pasture with a significantly lower level of energy density than the average). This explanation of Figures E and F could be further developed to infer that those farms in South Africa that are producing substantially higher quality pasture than average farms, have higher pasture consumption per cow and higher levels of milk production per cow. Conversely, those farms that are producing substantially lower quality pasture than average farms, have lower pasture consumption per cow and lower levels of milk production per cow.

Figure F. Impact of pasture consumed per cow on milk production per cow

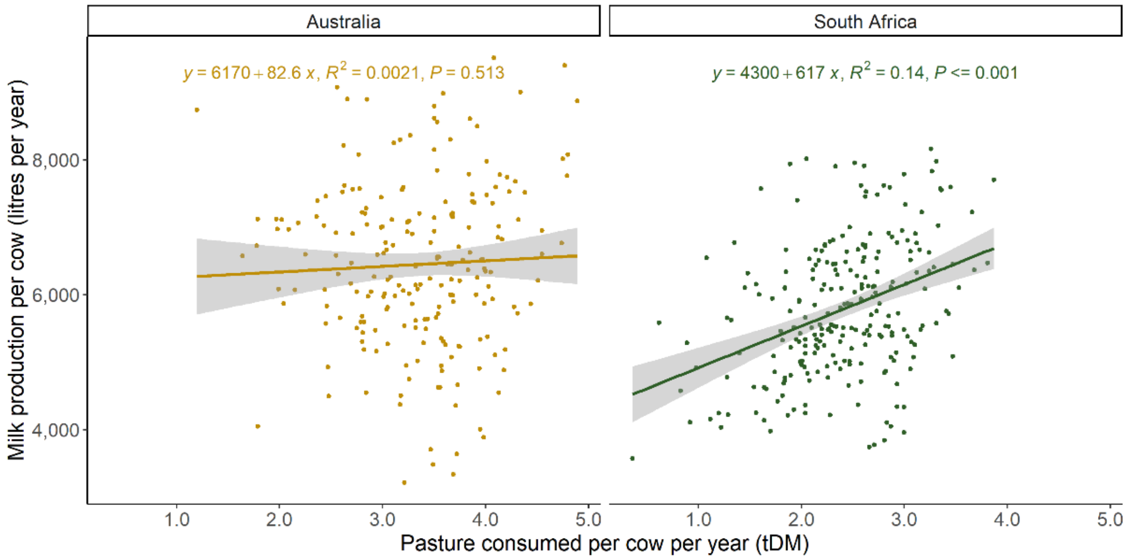


Figure G is a corollary to Figure E and F, and confirms that the relationship between concentrate consumed per cow and milk production per cow is similar within the two datasets. The correlation in the Australia data includes R^2 = 0.63 and P <= 0.001 and in the South Africa data includes R^2 = 0.53 and P <= 0.001. This does confirm that at least one of the factors resulting in improvements in milk production per cow in the South Africa dataset is the higher consumption of pasture per cow and **not** higher consumption of concentrates or other supplements.

Figure G. Impact of concentrate consumed per cow on milk production per cow

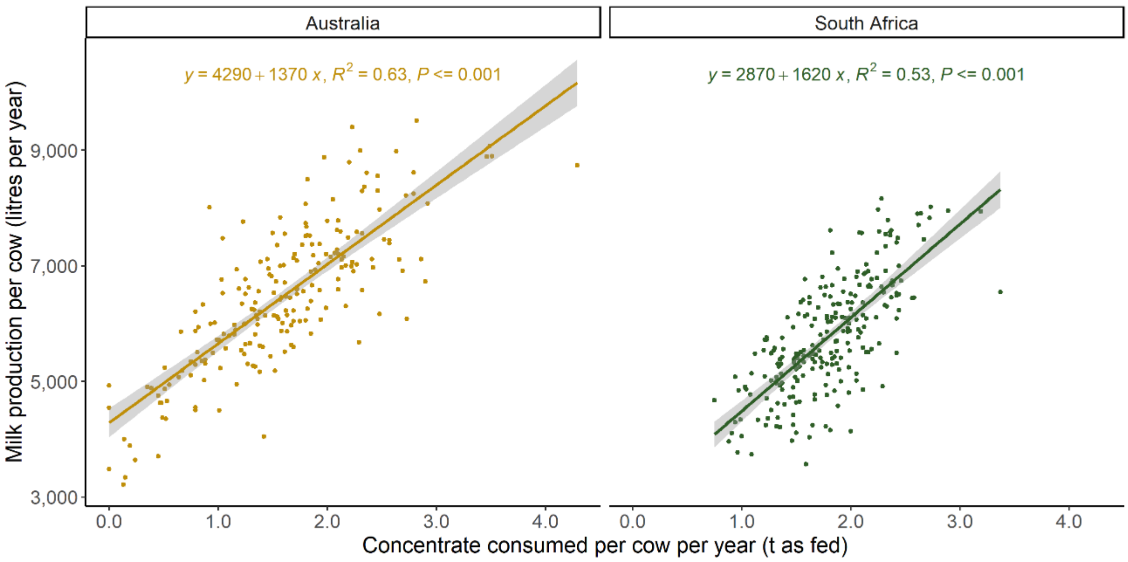


Figure H outlines that there is **no** difference between the two datasets in the relationship of total consumed per cow and milk production per cow. The correlations are close to being identical in equation, R^2 and P values. For Australia these are y = -2480 + 1620x, R^2 = 0.93 and P <= 0.001 and for South Africa these are y = -3100 + 1660x, R^2 = 0.94 and P <= 0.001. **This does further confirm that the basis for improvements in milk production per cow in the South African dataset is the higher consumption of**

pasture per cow (and not concentrates or other supplements), **and by inference, it is this higher pasture consumption per cow that is resulting in higher milk production per cow and contributing to a higher level of profit**. The higher consumption of pasture per cow could be provided by a combination of higher pasture dry matter intake and higher energy density per kilogram of pasture dry matter.

Figure H. Impact of total consumed per cow on milk production per cow

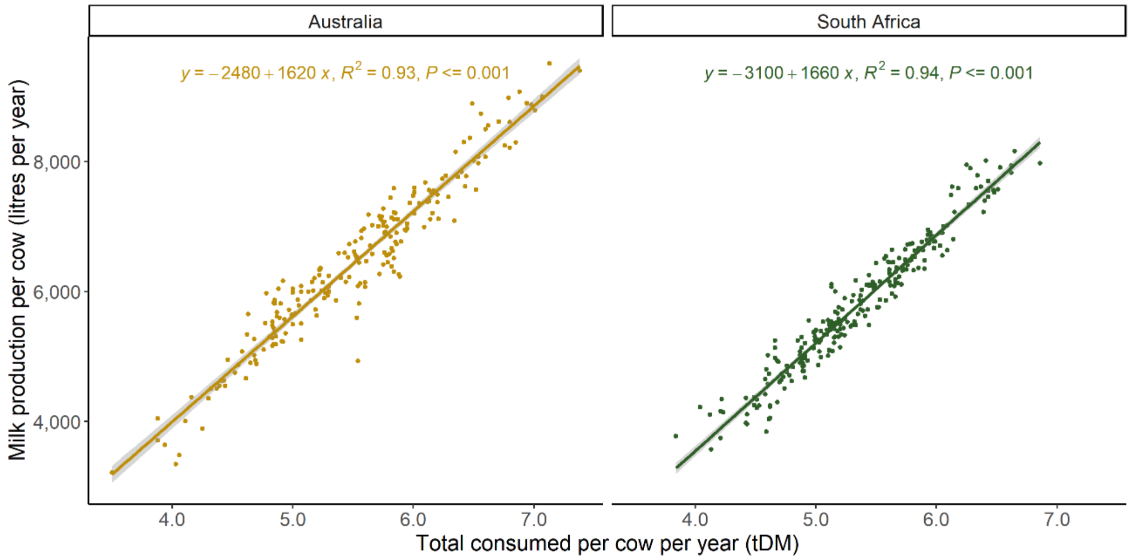
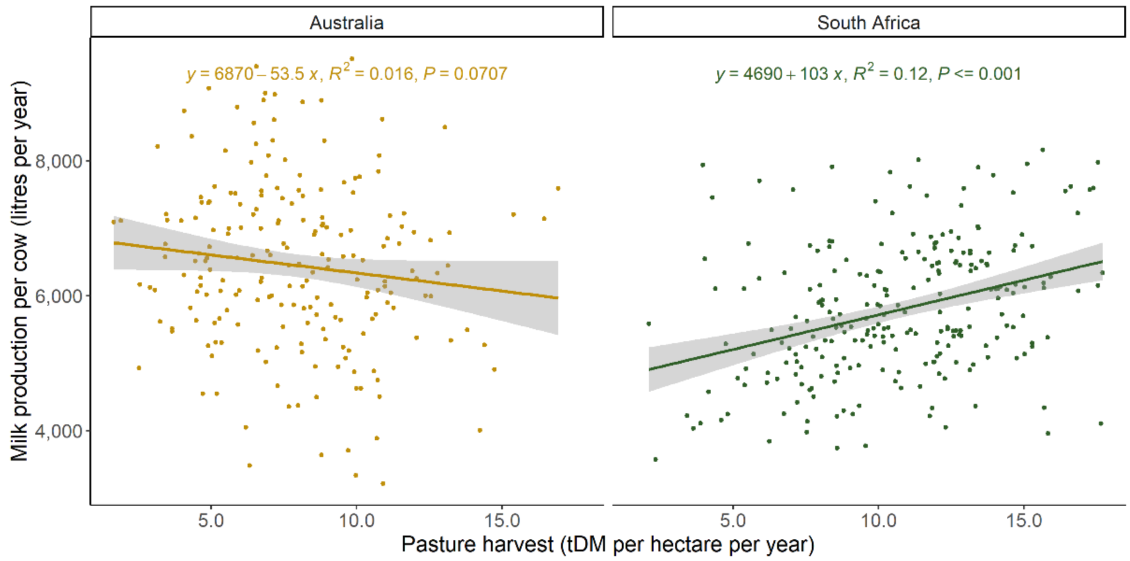


Figure I outlines how the Australia data has **no** significant relationship between pasture harvest and milk production per cow (R^2 = 0.01 and P = 0.071), whereas the South Africa data has a positive relationship between increasing pasture harvest and increasing milk production per cow (R^2 = 0.12 and P <= 0.001). One explanation for the positive correlation in the South Africa data could be from a potential difference between higher average energy density in irrigated pasture (and higher pasture harvest) and lower average energy density in dryland pasture (and lower pasture harvest). Another explanation would be similar to the more probable explanation of Figures E and F, namely, that farms producing higher levels of pasture harvest are producing pasture of higher quality given the biological link between these two factors. For the South Africa farms, this increase in quality is of such a magnitude that the increase in average energy density of the total diet is providing the opportunity to increase both pasture consumed per cow and total consumption per cow, which is resulting in the association between higher levels of pasture harvest and higher levels of milk production per cow. Conversely, the 'poorer' farmers are doing the reverse, including harvesting less pasture per hectare.

Figure I. Impact of pasture harvest on milk production per cow



The identifed potential bias in the South African data would impact on a number of the relationships outlined in the balance of this paper and may explain a significant proportion of the difference to the relationships identified in the Australian data. The relationships that may have been confounded by this potential bias are identified by the figure title being coloured **red**.

Replication of all Australia figures from main paper with these compared to South Africa data

Figure 1. Impact of profit per hectare on profit (expressed as return on total capital)

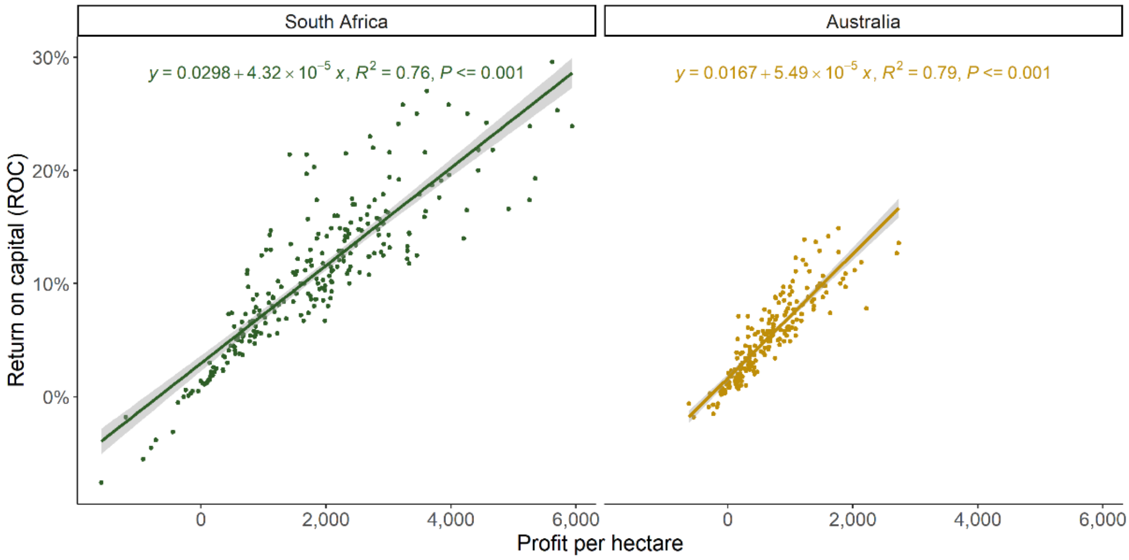


Figure 2. Impact of profit per cow on profit (expressed as return on total capital)

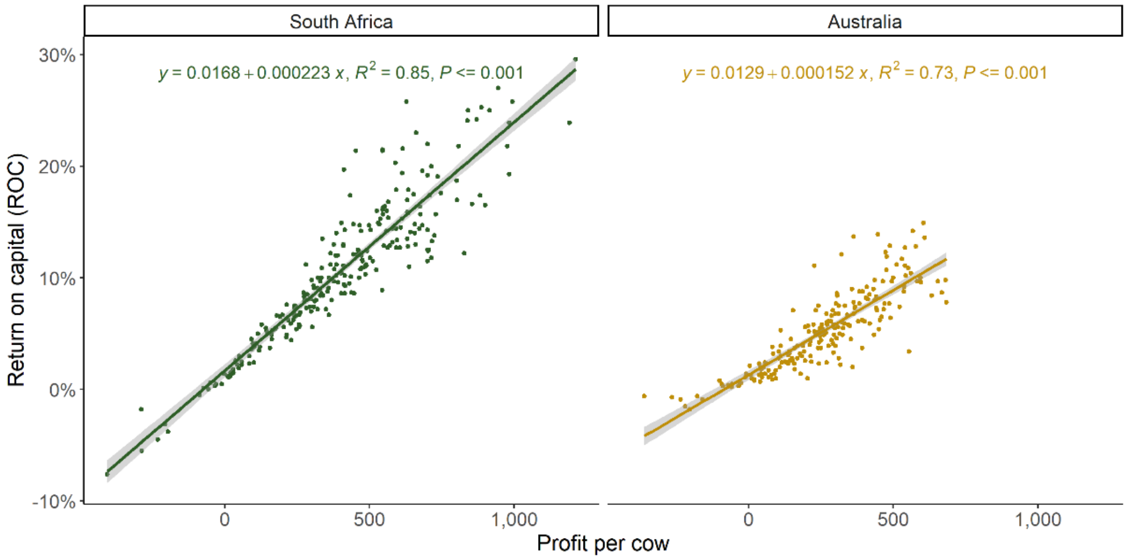


Figure 3. Impact of operating profit margin on profit

Figure 4. Impact of total expenses per litre on profit

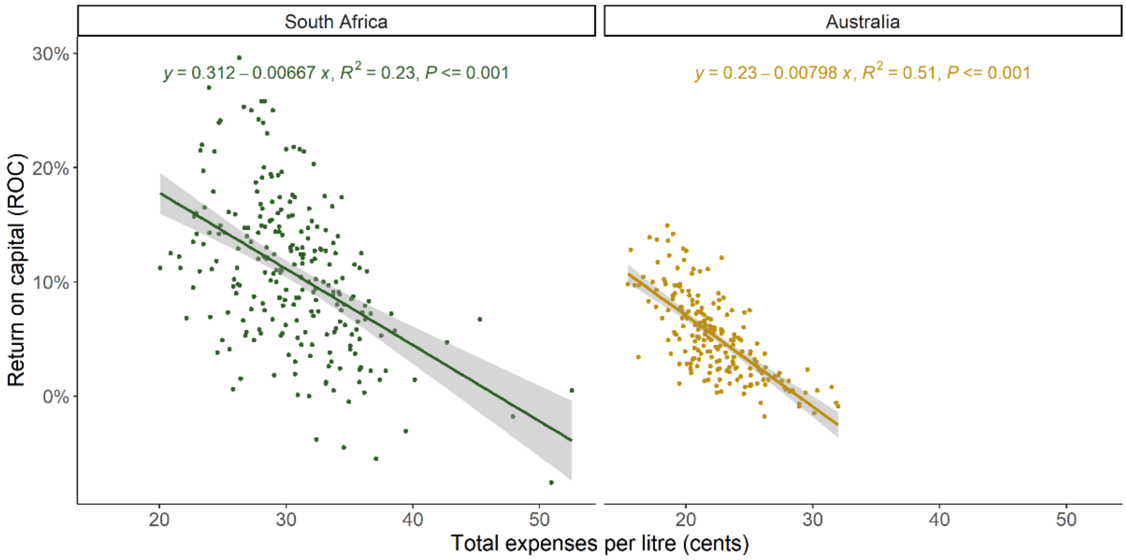


Figure 5. Impact of cost of production per litre on profit

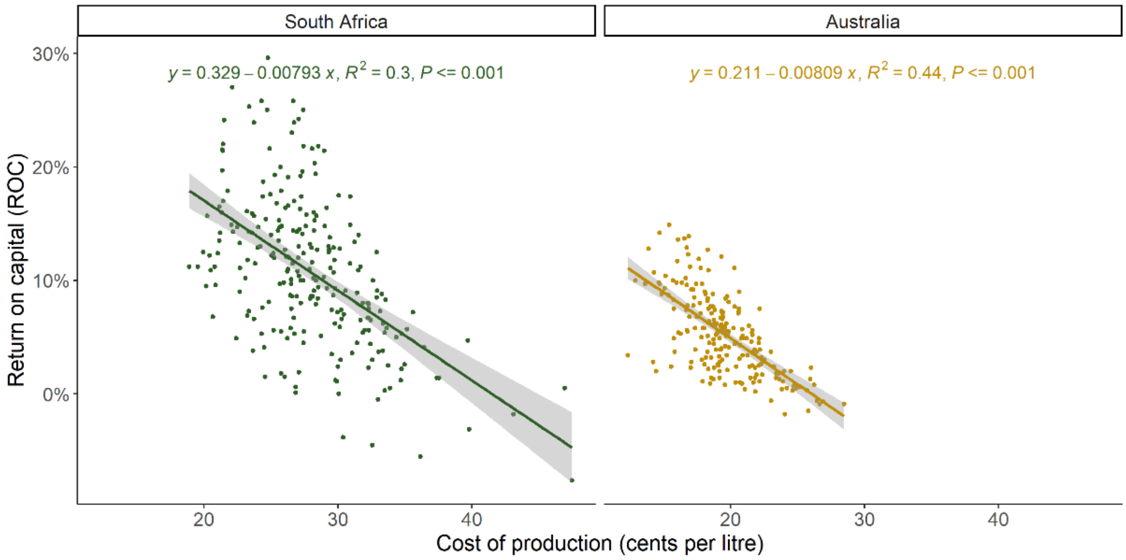


Figure 6. Impact of pasture harvest in tonnes of dry matter per hectare per year on profit

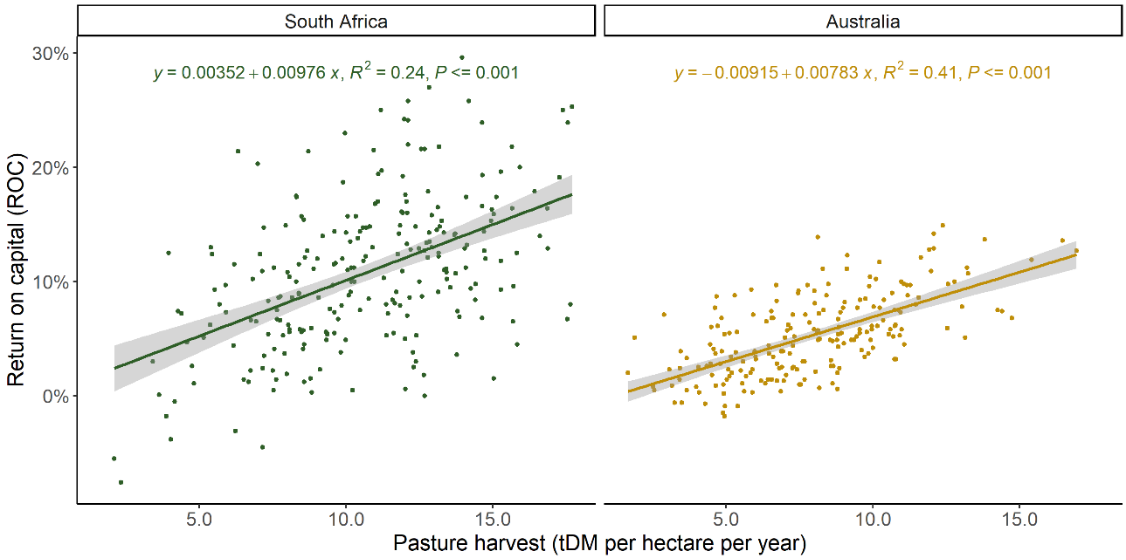


Figure 7. Impact of milk production per hectare on profit

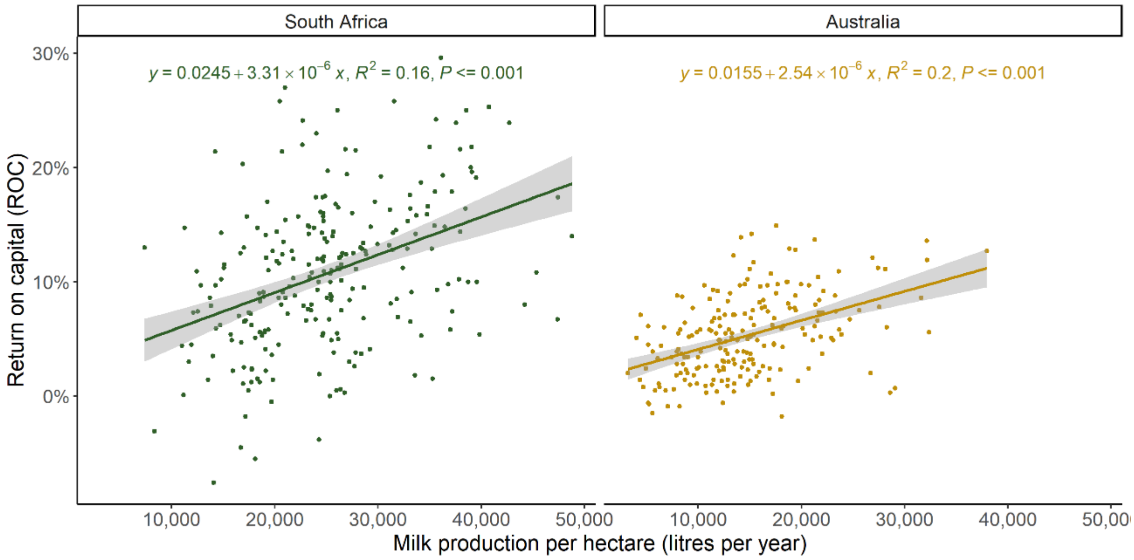


Figure 8. Impact of milk production per cow on profit

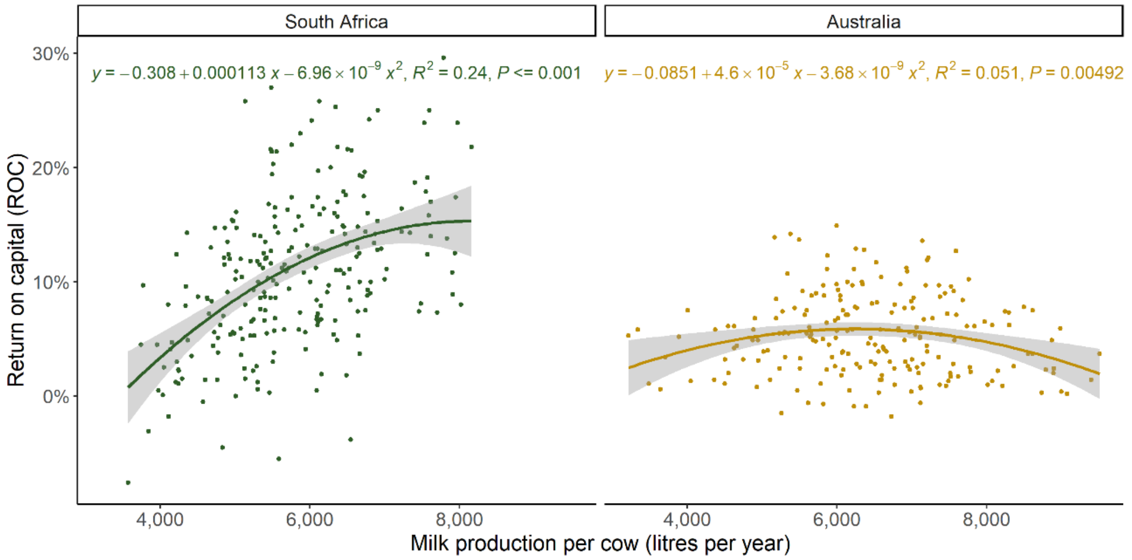


Figure 9. Impact of stocking rate on profit

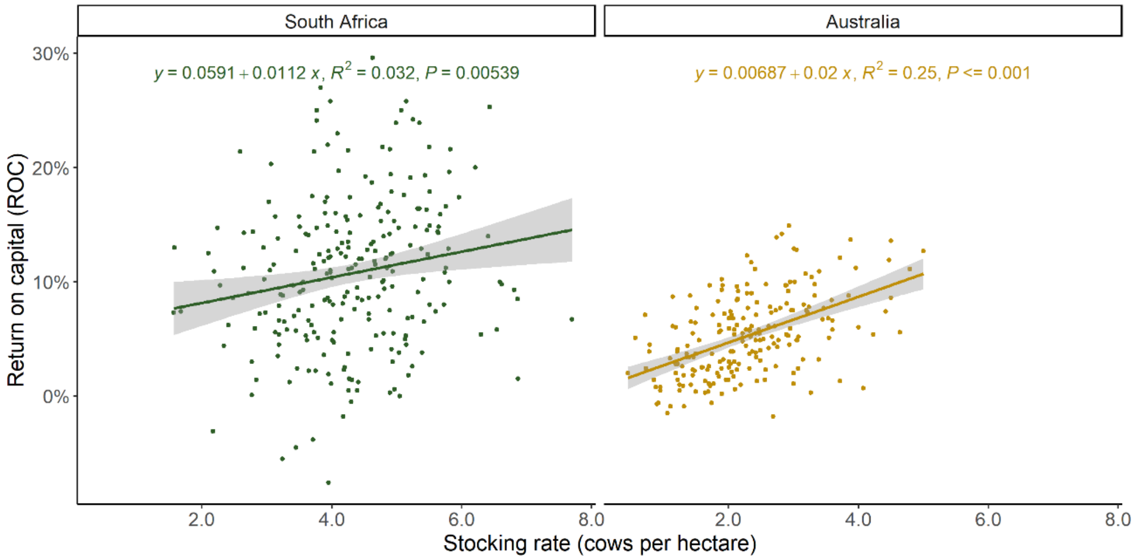


Figure 10. Impact of milk production per cow on milk production per hectare

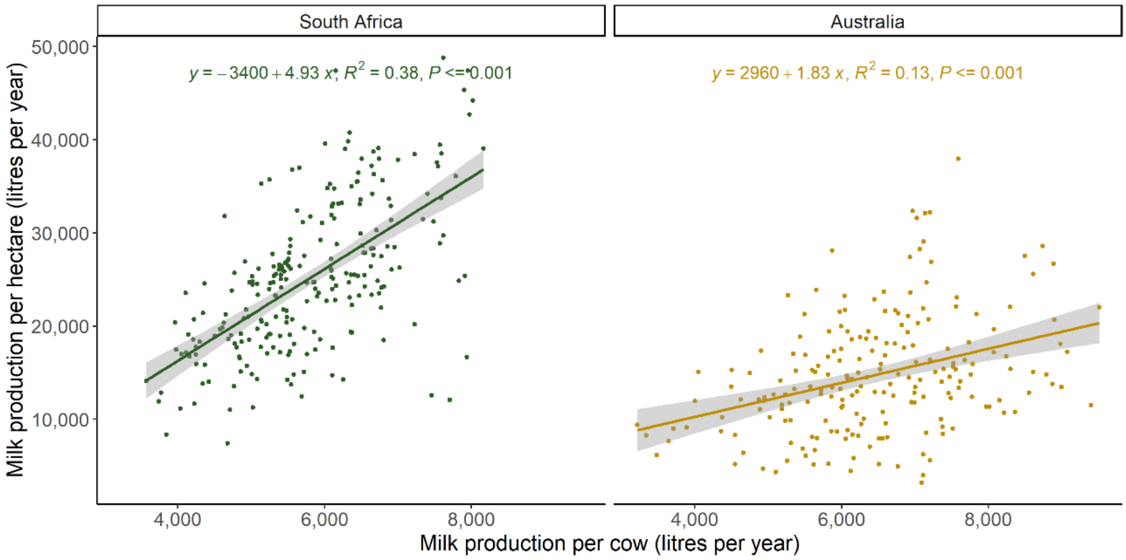


Figure 11. Impact of stocking rate on milk production per hectare

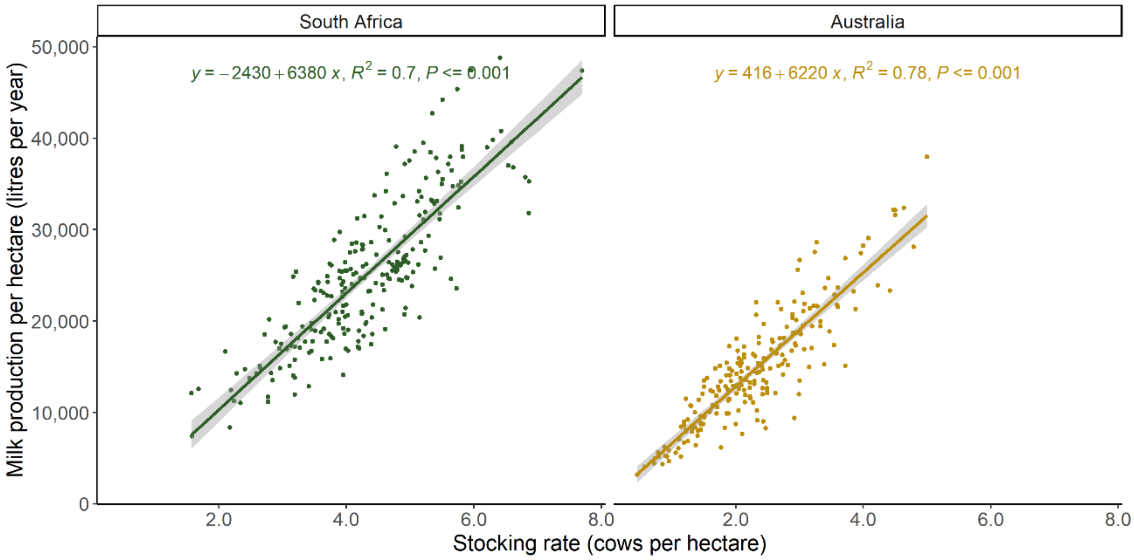


Figure 12. Impact of total pasture cost per tonne dry matter on profit

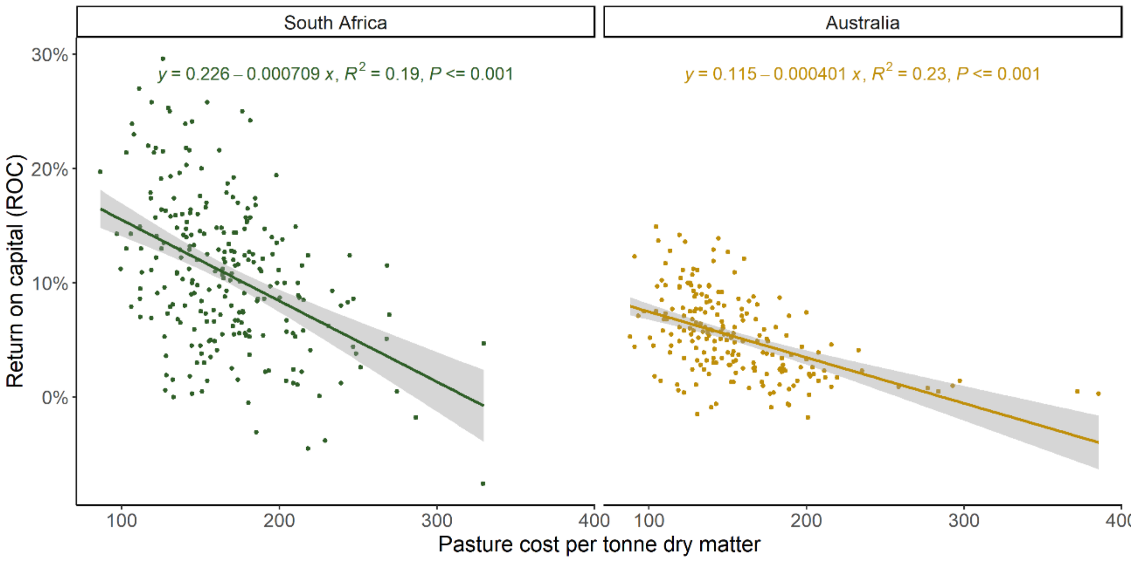


Figure 13. Impact of total feed cost per litre on profit

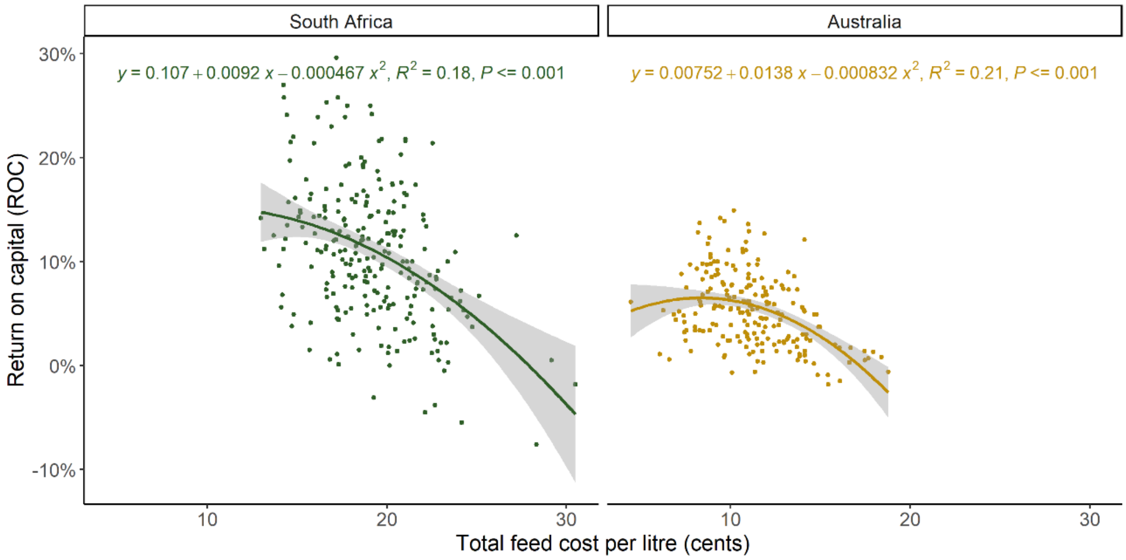


Figure 14. Impact of supplement cost per litre on profit

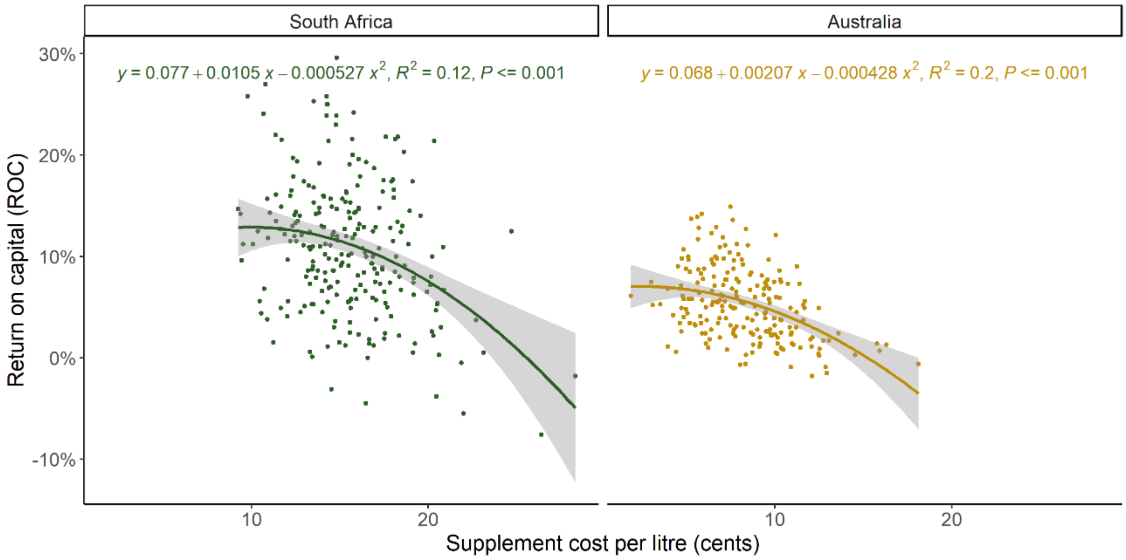


Figure 15. Impact of 'core per cow cost' on profit

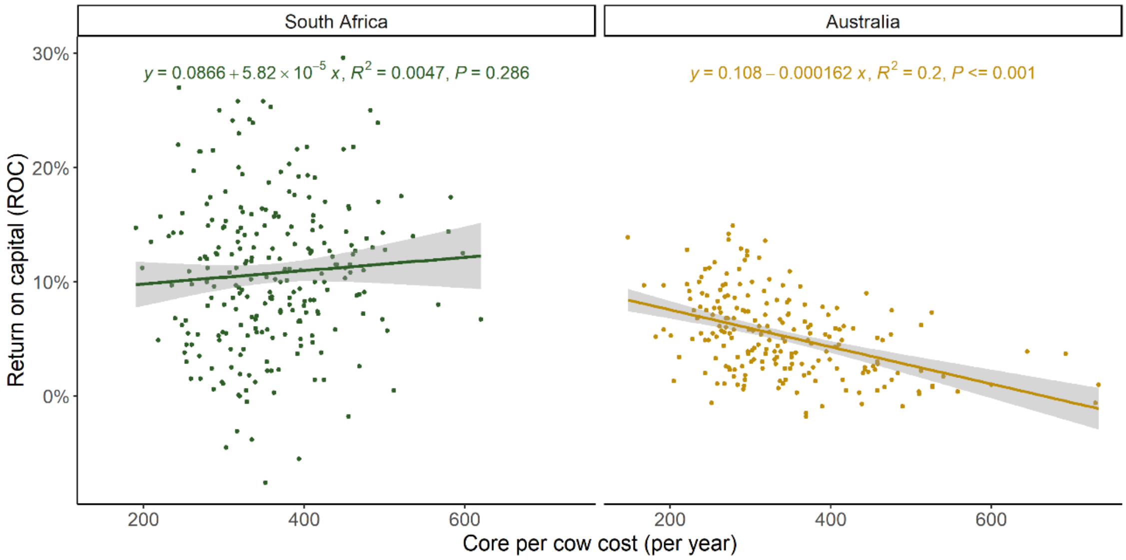


Figure 16. Impact of milk price on profit

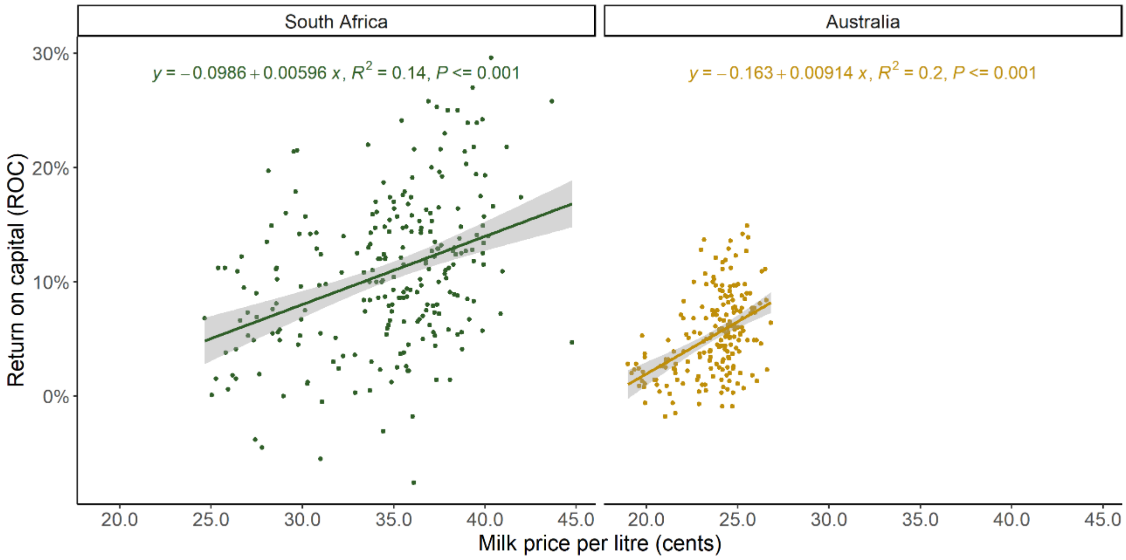


Figure 17. Impact of labour cost per cow on profit

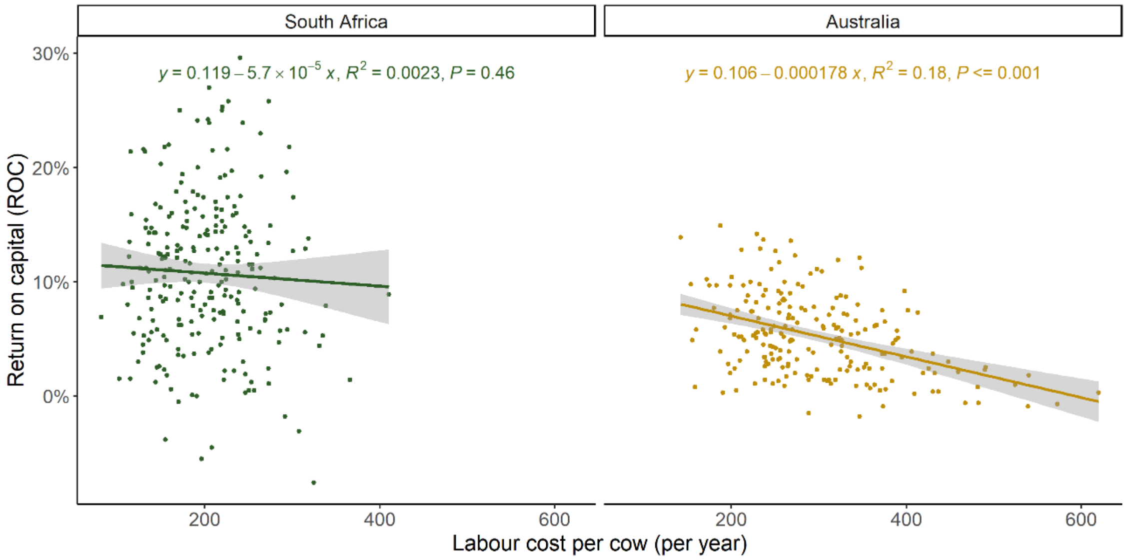


Figure 18. Impact of 'core per hectare cost per tonne dry matter of pasture harvest' on profit

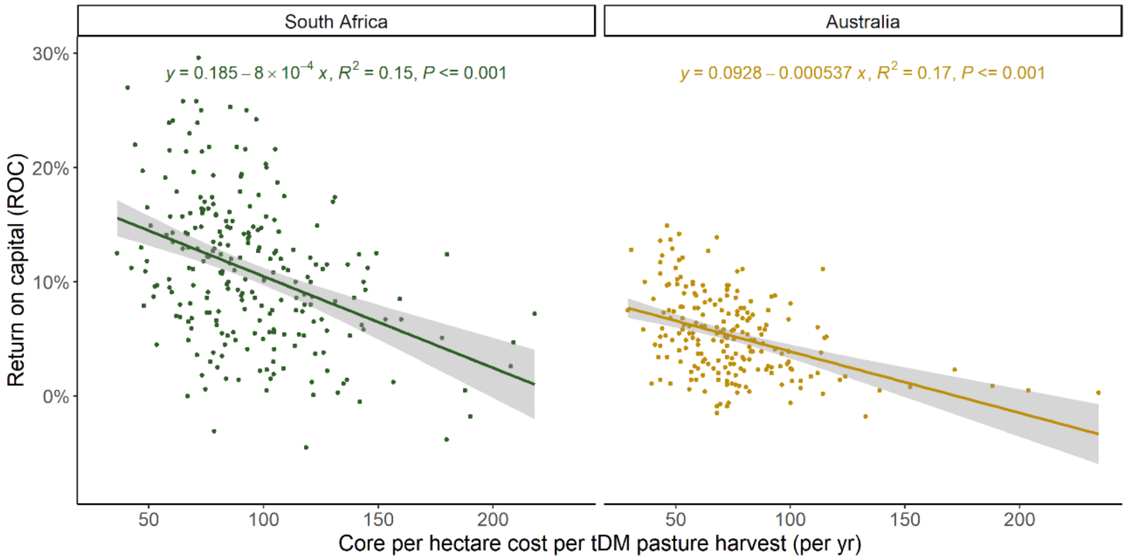


Figure 19. Impact of labour cost per litre on profit

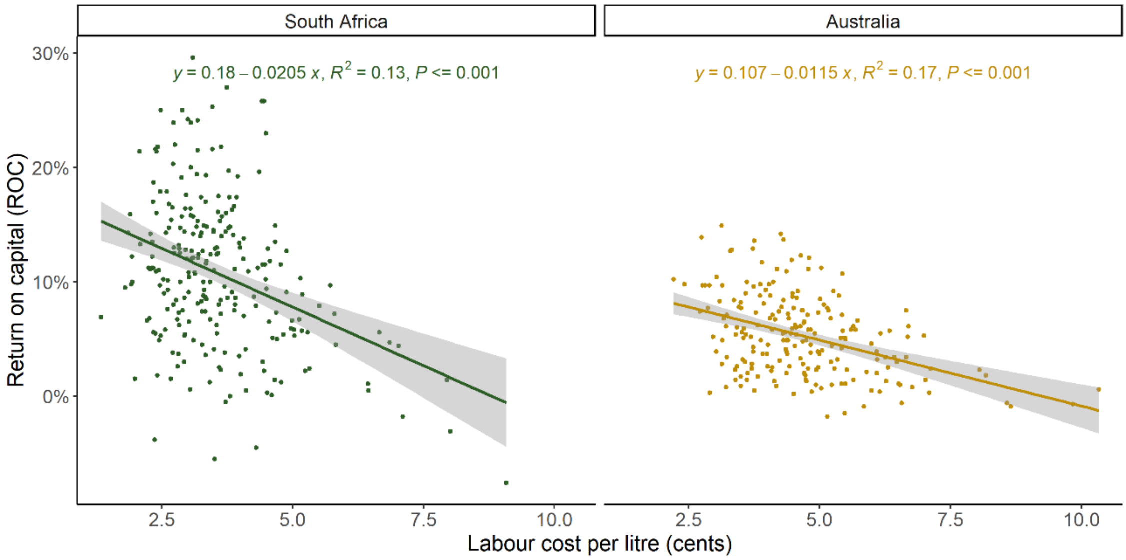


Figure 20. Impact of labour efficiency (cows per full-time staff equivalent) on profit

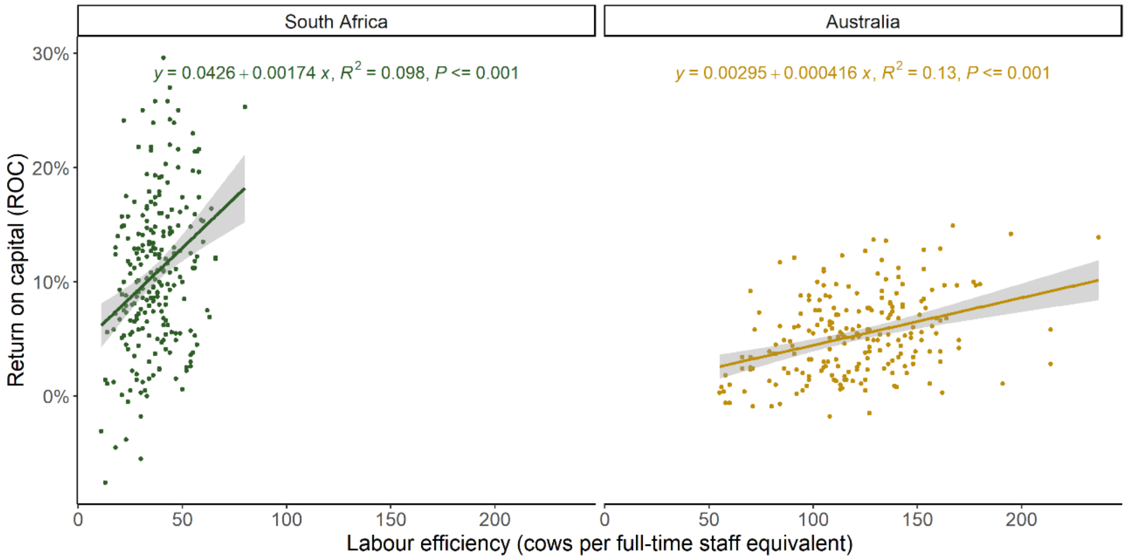


Figure 21. Impact of labour efficiency (litres per full-time staff equivalent) on profit

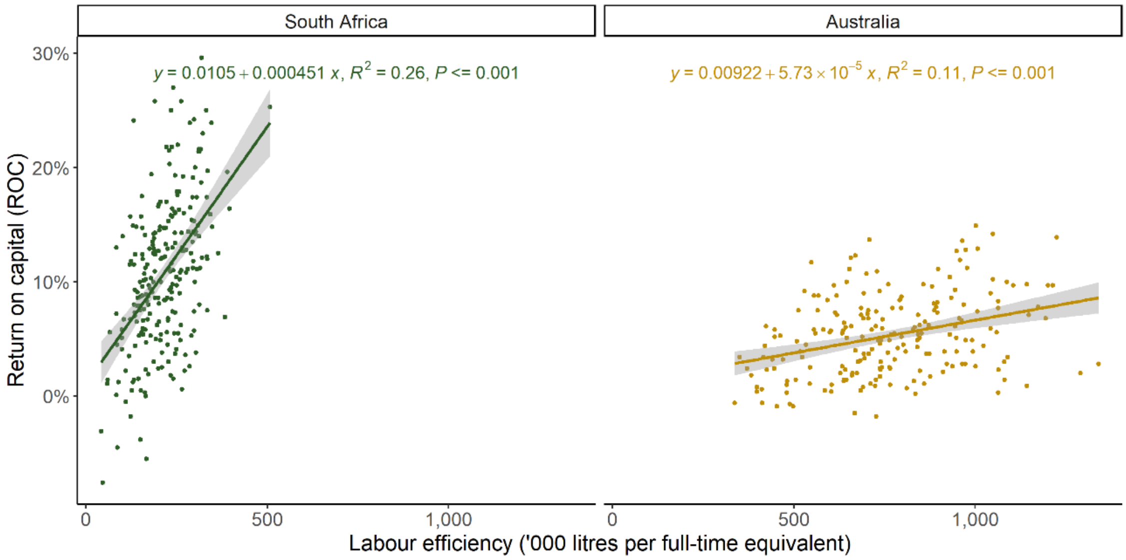


Figure 22. Impact of pasture as per cent of diet on profit

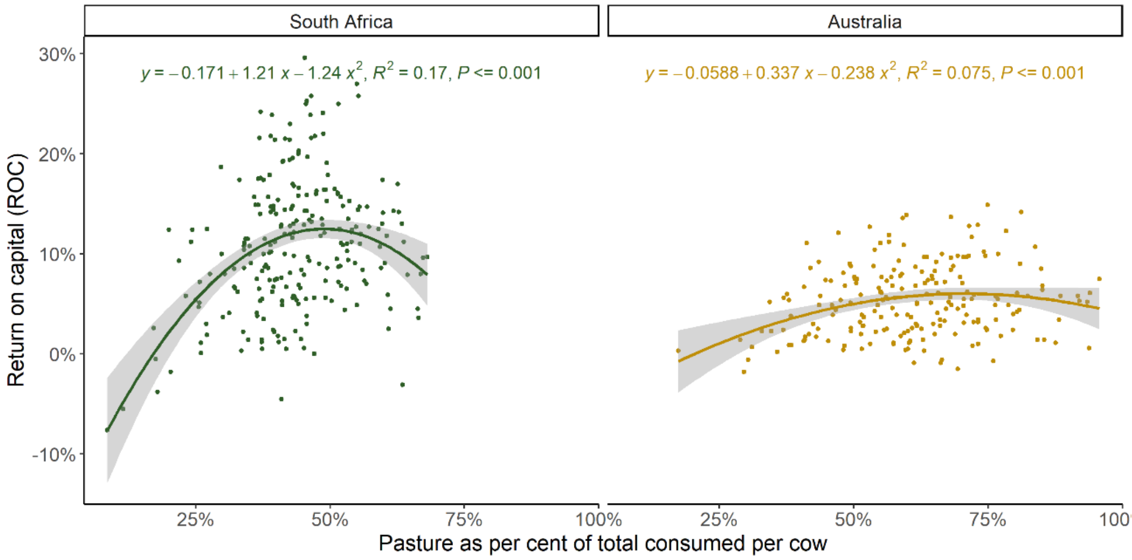


Figure 23. Impact of pasture consumed per cow on profit

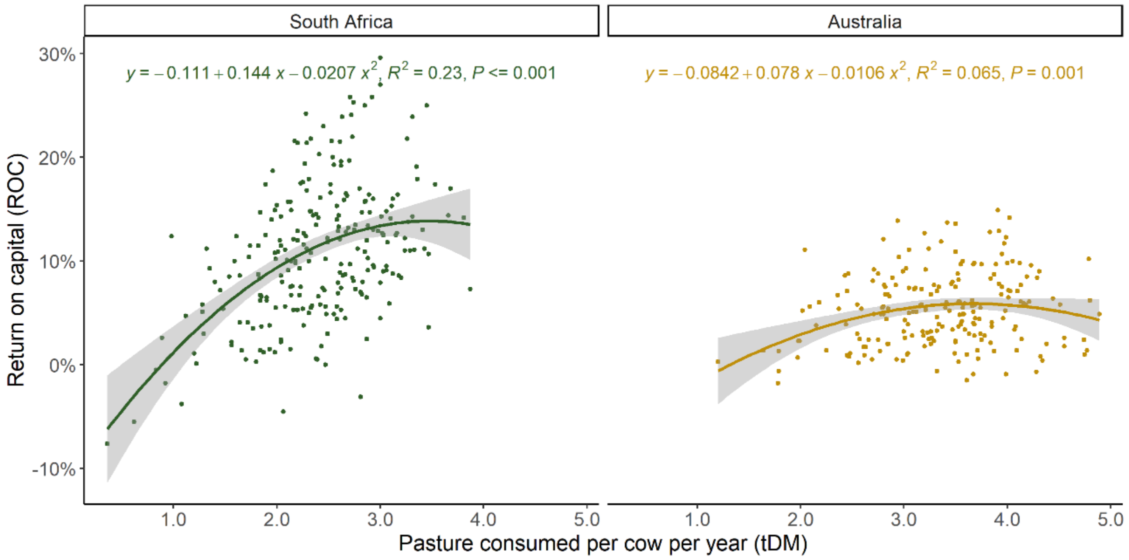


Figure 24. Impact of farm size (hectares) on profit

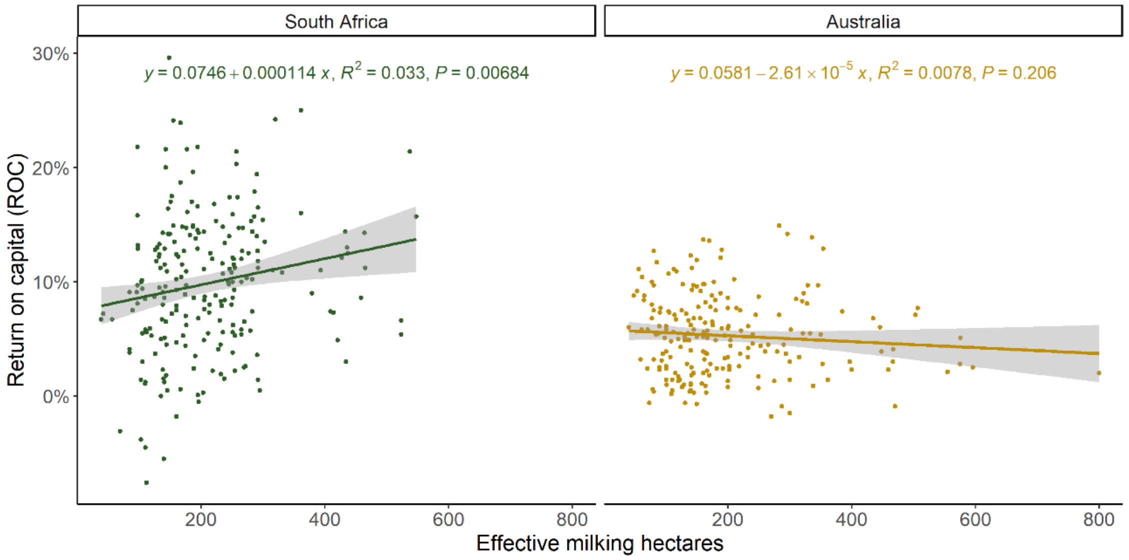


Figure 25. Impact of farm size (cow numbers) on profit

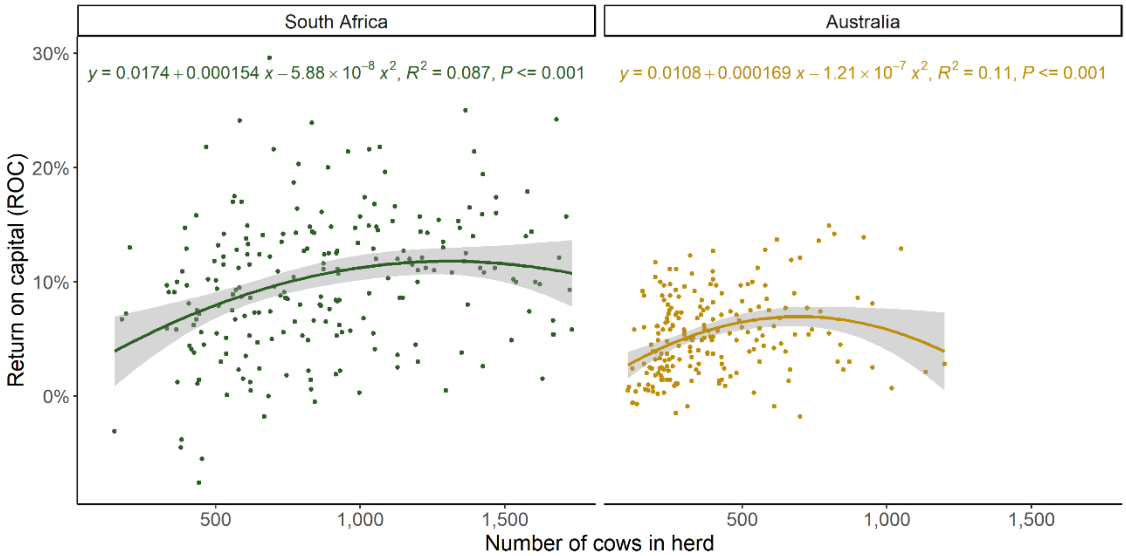


Figure 26. Impact of grams concentrate per litre on profit

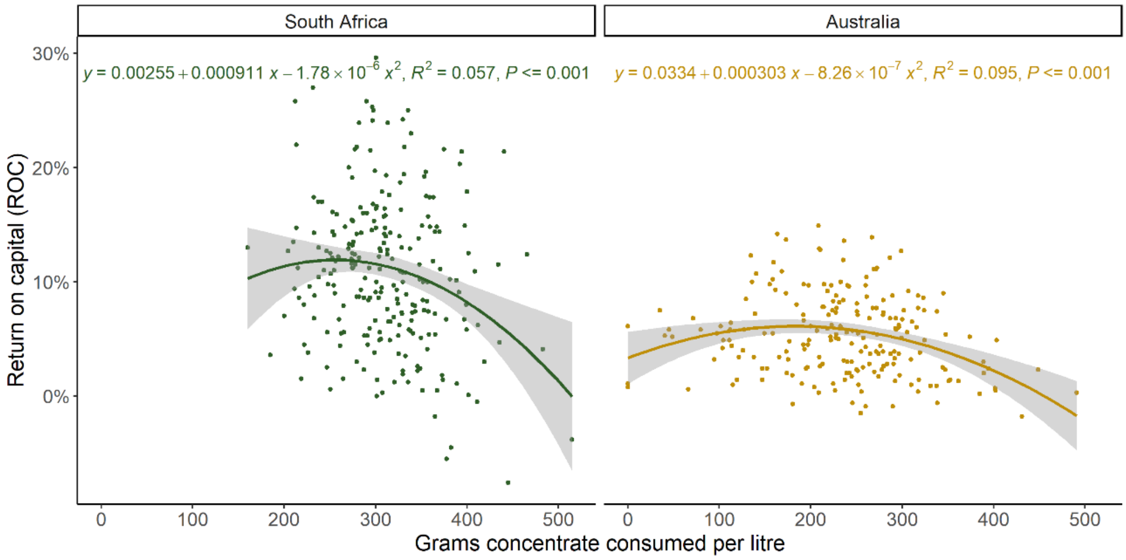


Figure 27. Impact of grams supplement per litre on profit

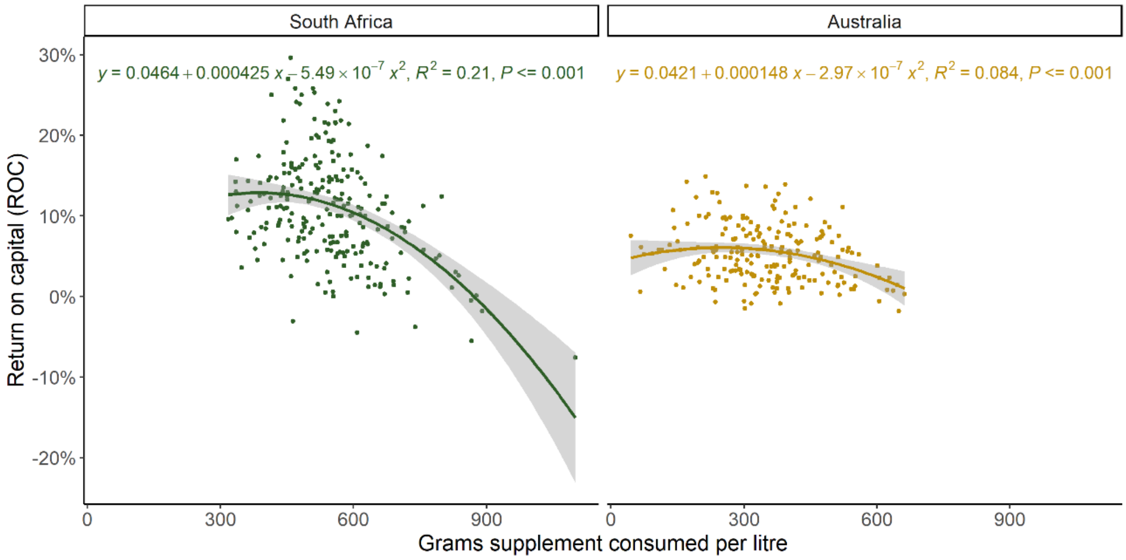


Figure 28. Impact of income over feed costs per cow on profit

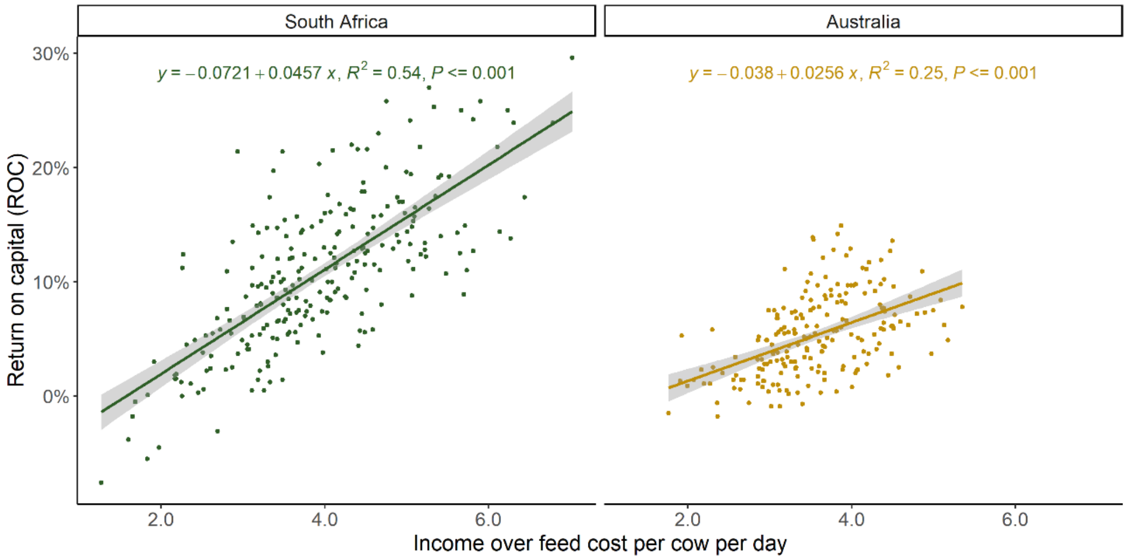
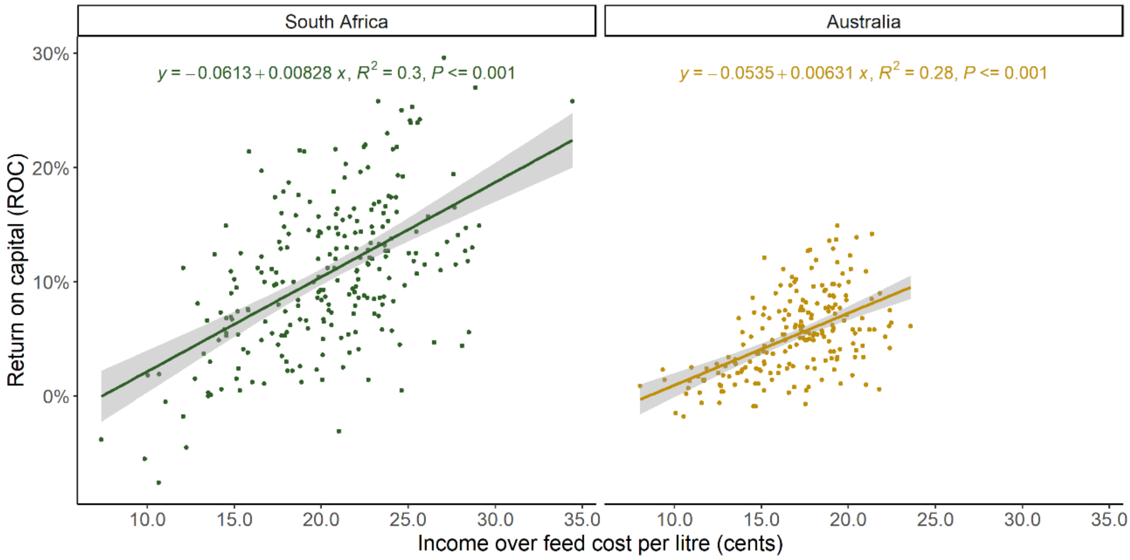


Figure 29. Impact of income over feed costs per litre on profit



Why does profit improve with increase in pasture harvest?

Figure 6 (recopied). Impact of pasture harvest in tonnes of dry matter per hectare per year on profit (ROC)

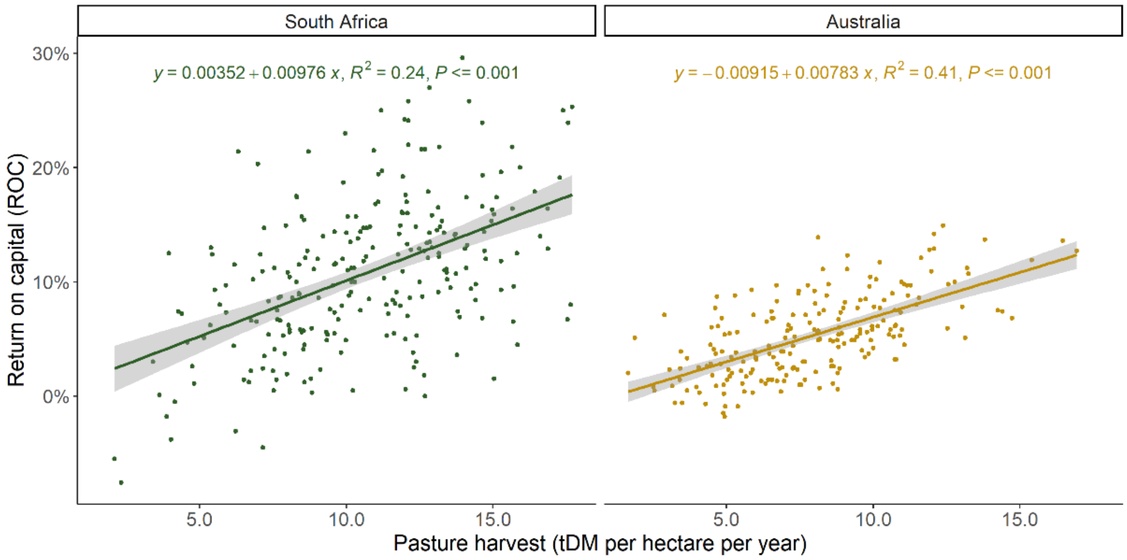


Figure 30. Impact of pasture harvest on profit per hectare

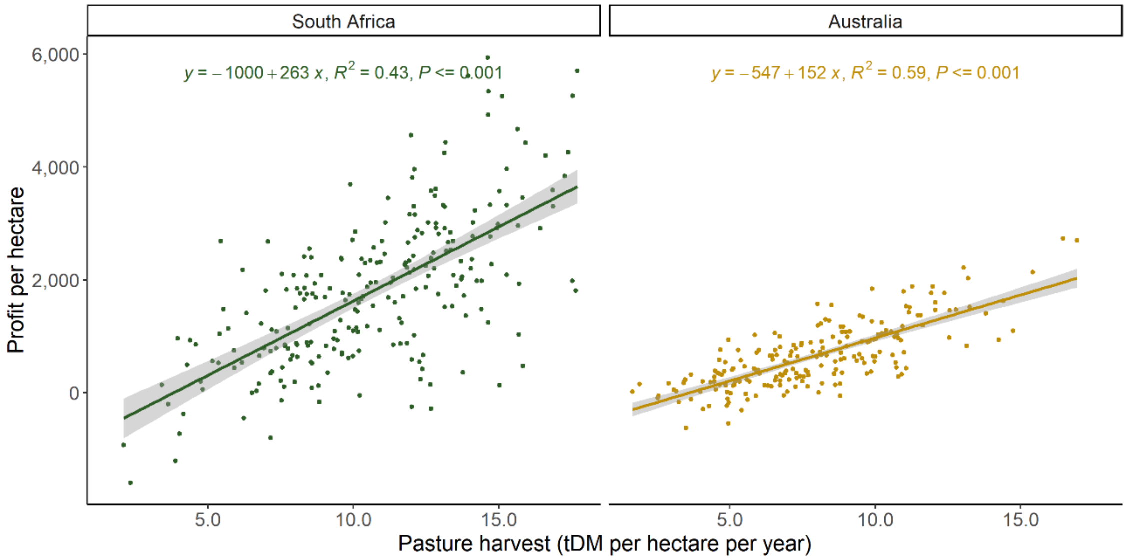


Figure 31. Impact of pasture harvest on profit per cow

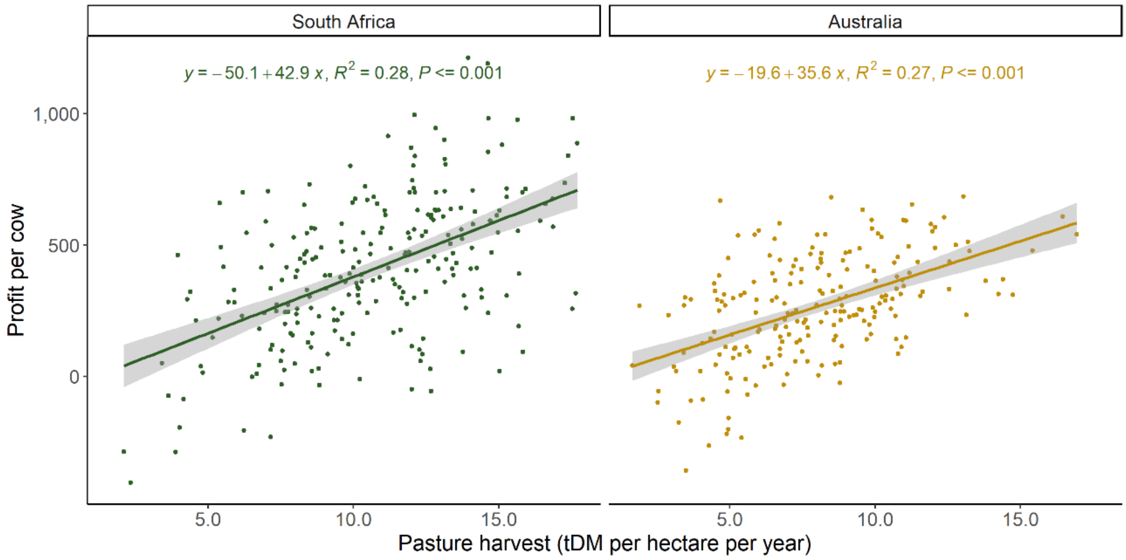


Figure 32. Impact of pasture harvest on cost of production per litre

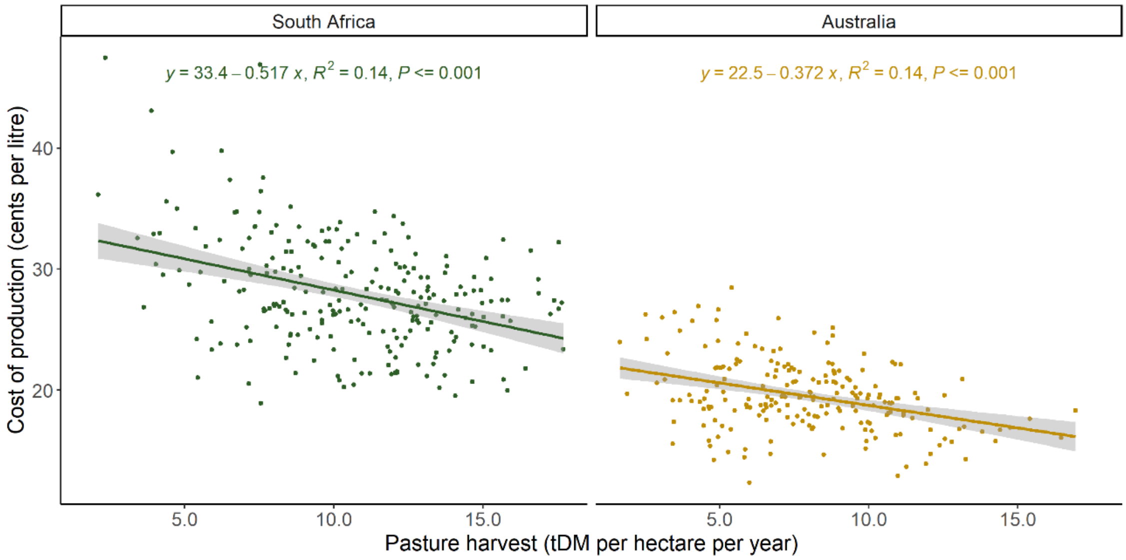


Figure 33. Impact of stocking rate on pasture harvest

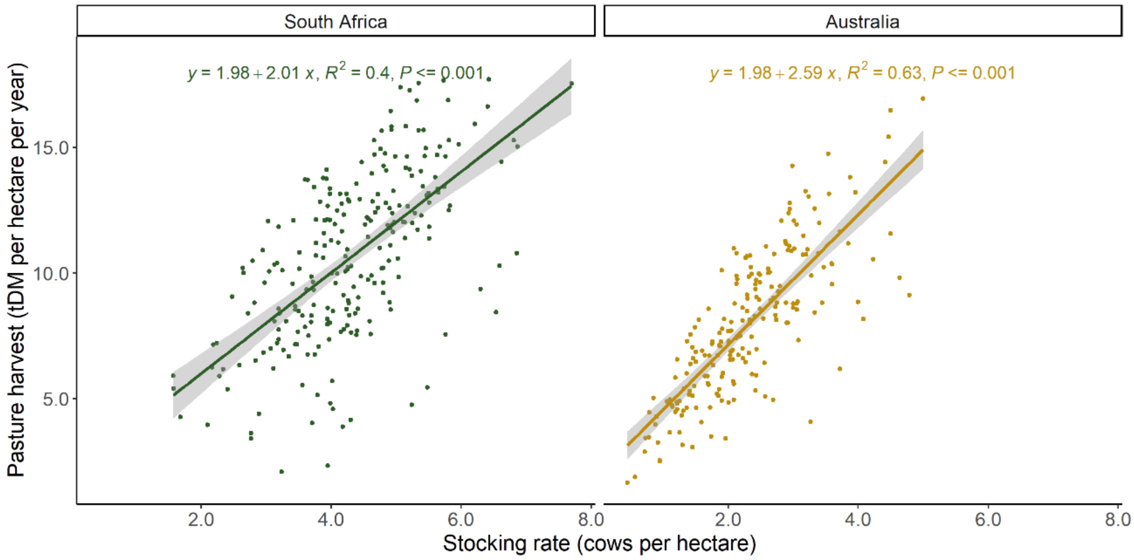


Figure 34. Impact of increasing pasture harvest on 'core per hectare cost per tonne dry matter of pasture harvest'

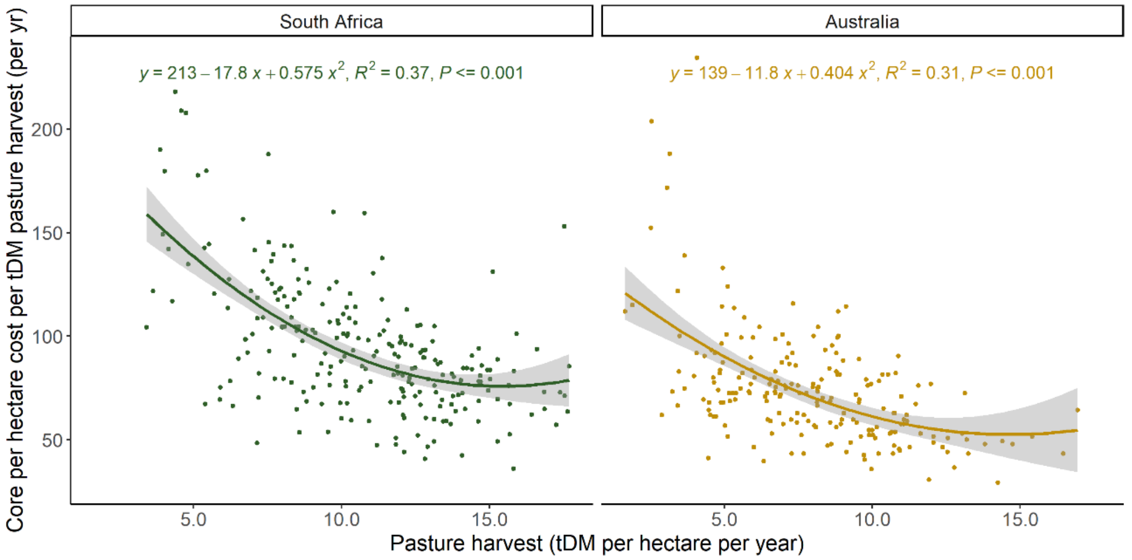


Figure 35. Impact of pasture harvest on total pasture cost per tonne dry matter

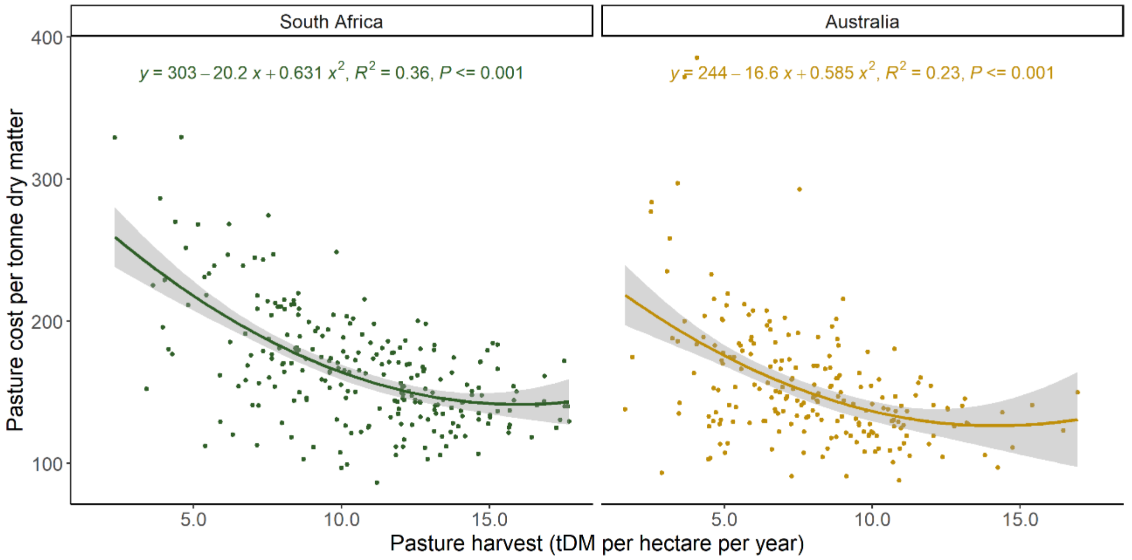


Figure 36. Impact of pasture harvest on supplement cost per litre

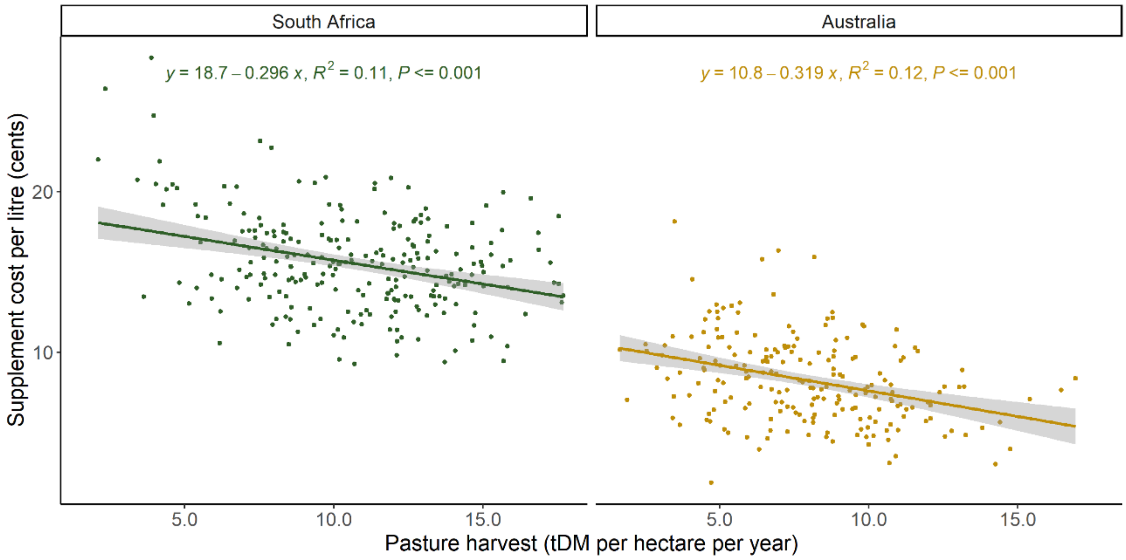


Figure 37. Impact of pasture harvest on labour cost per cow

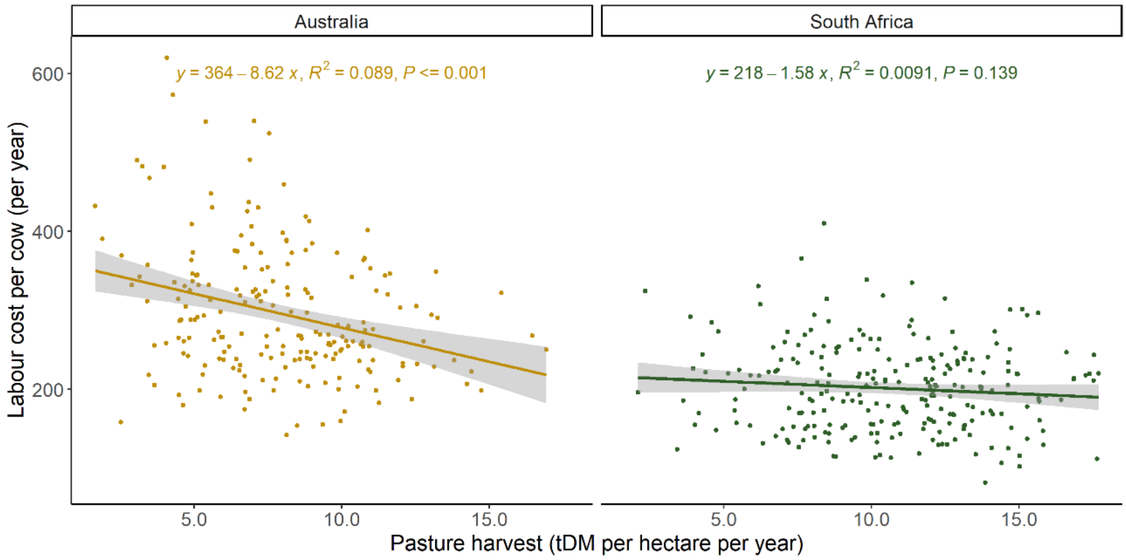


Figure 38. Impact of pasture harvest on 'core per cow cost'

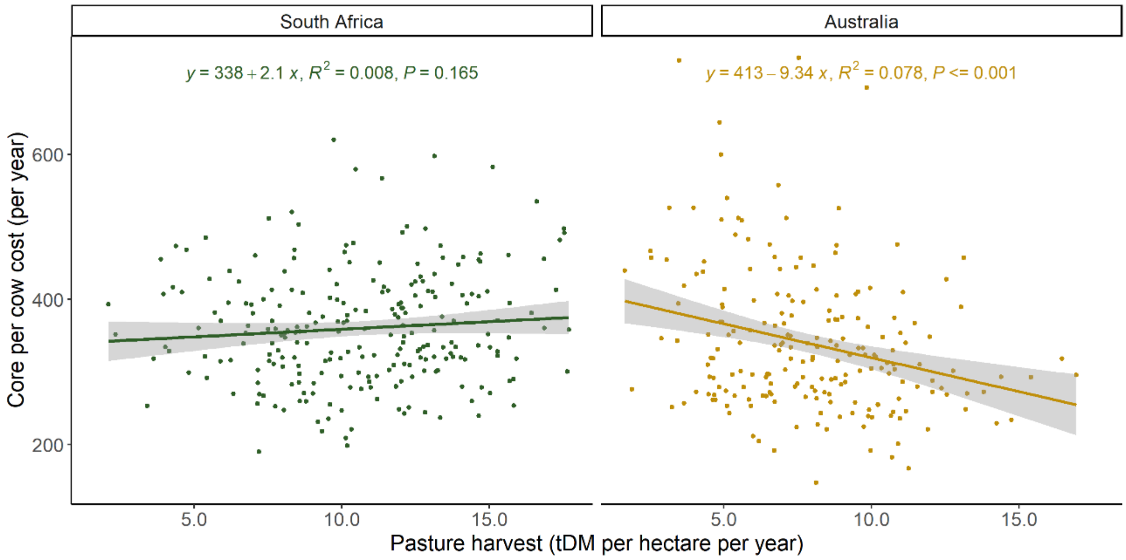
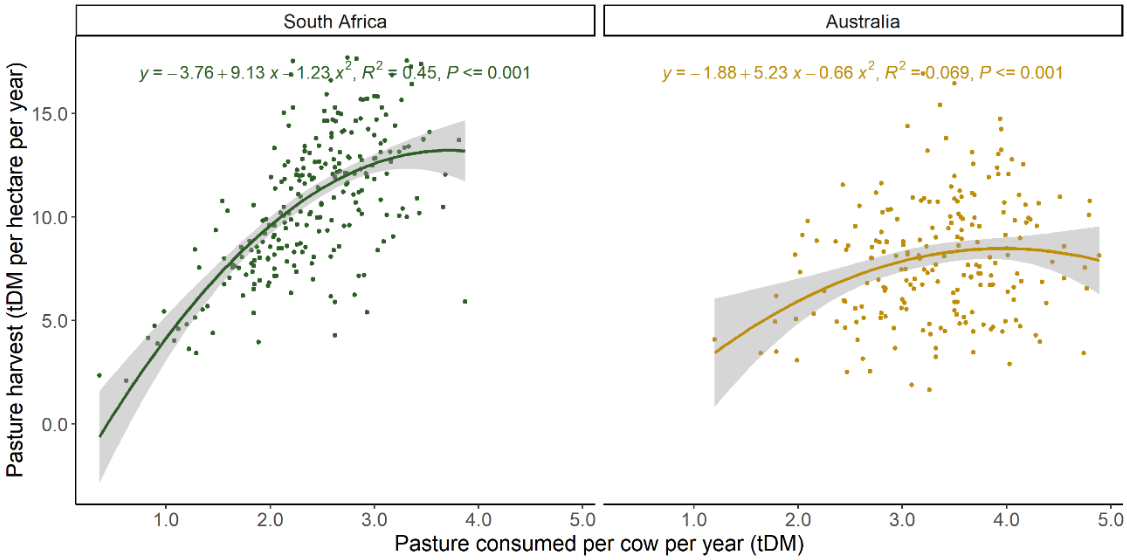


Figure 39. Impact of pasture consumed per cow on pasture harvest



Why does profit not improve (or not substantially) with increases in milk production per cow?

Figure 8 (recopied). Impact of milk production per cow on profit (ROC)

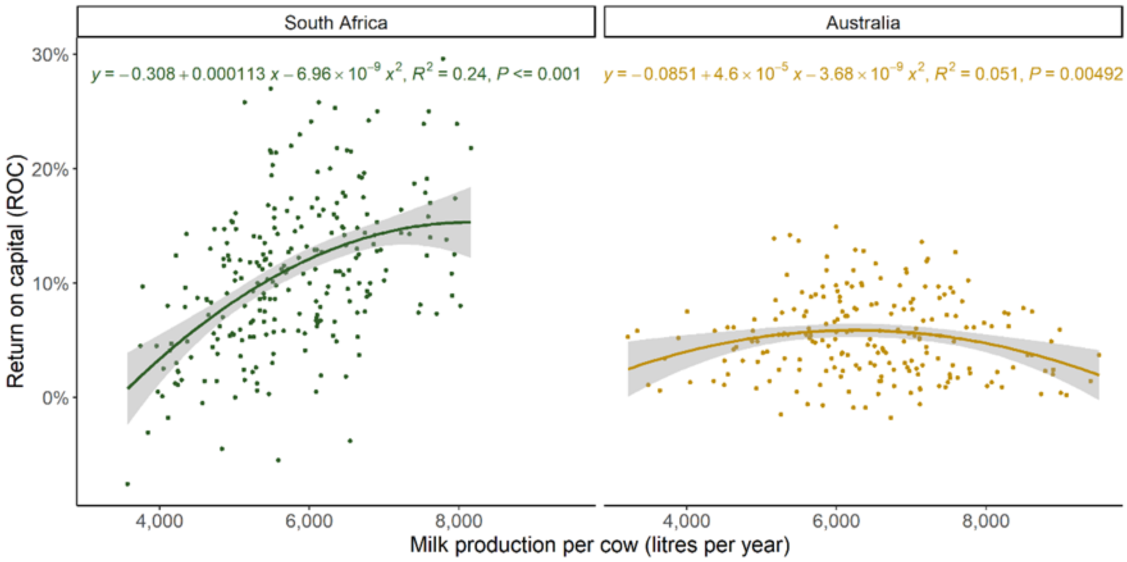


Figure 40. Impact of milk production per cow on profit per hectare

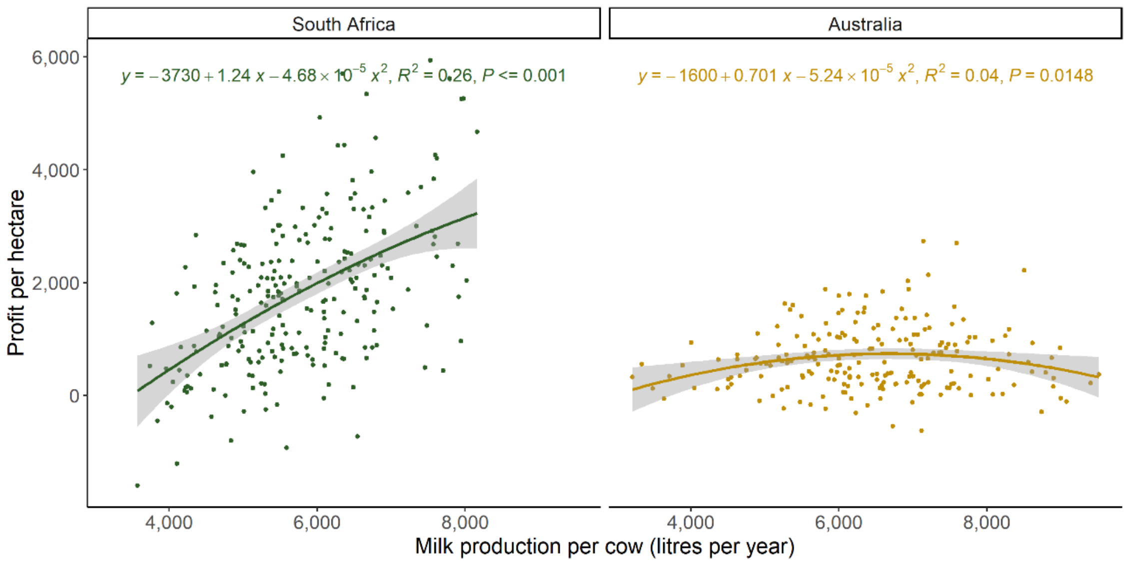


Figure 41. Impact of milk production per cow on profit per cow

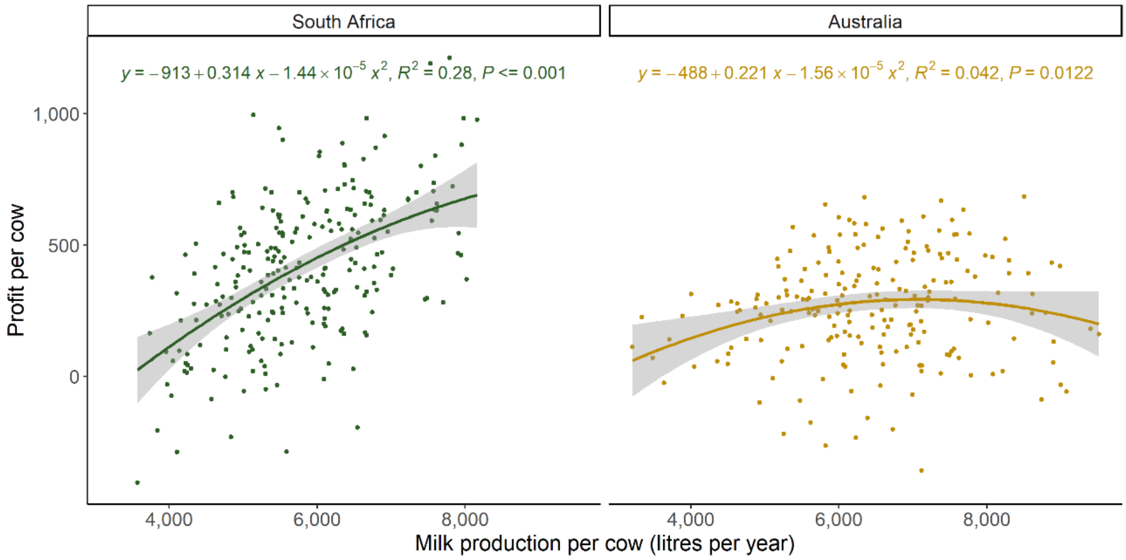


Figure 42. Impact of milk production per cow on cost of production per litre

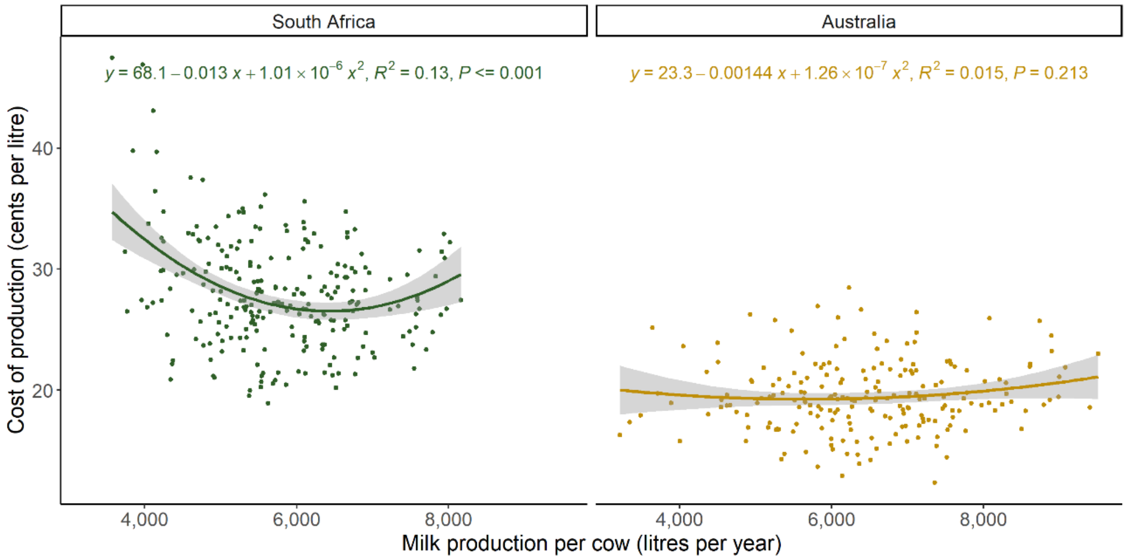


Figure 43. Impact of milk production per cow on 'core per cow cost'

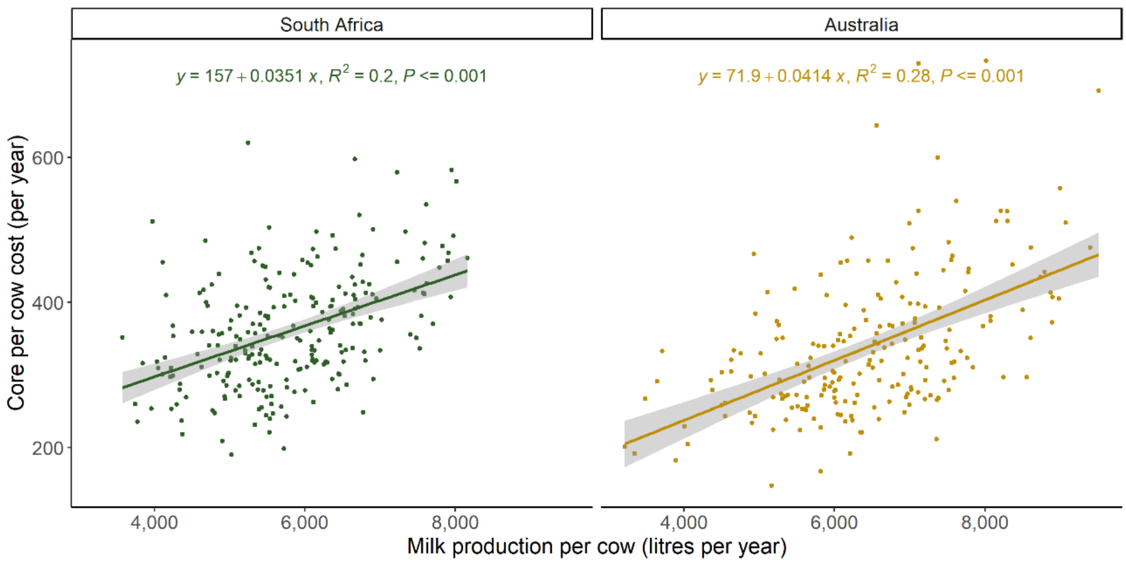


Figure 44. Impact of milk production per cow on supplement cost per litre

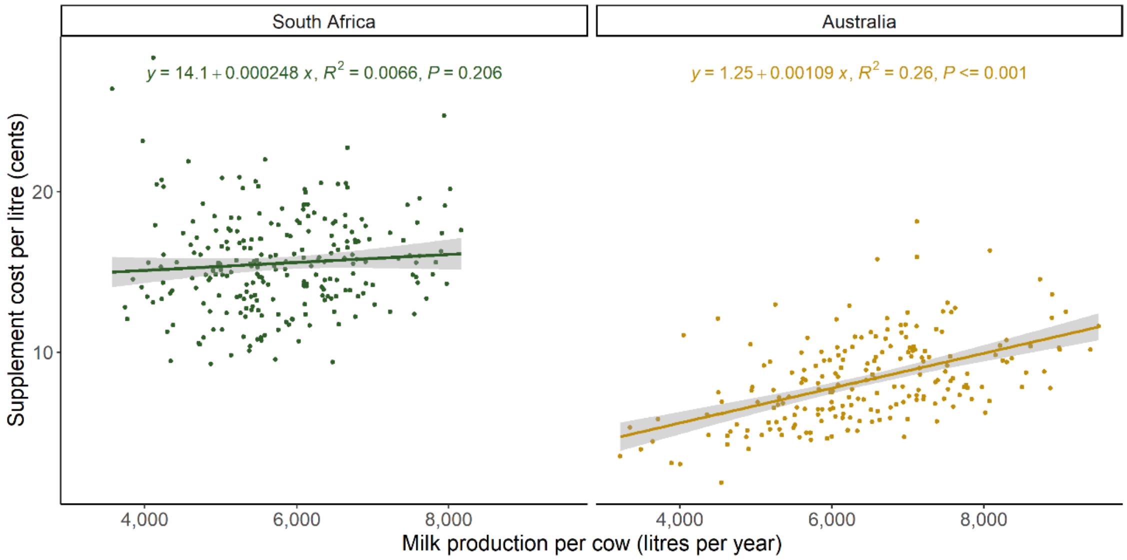


Figure 45. Impact of milk production per cow on total feed cost per litre

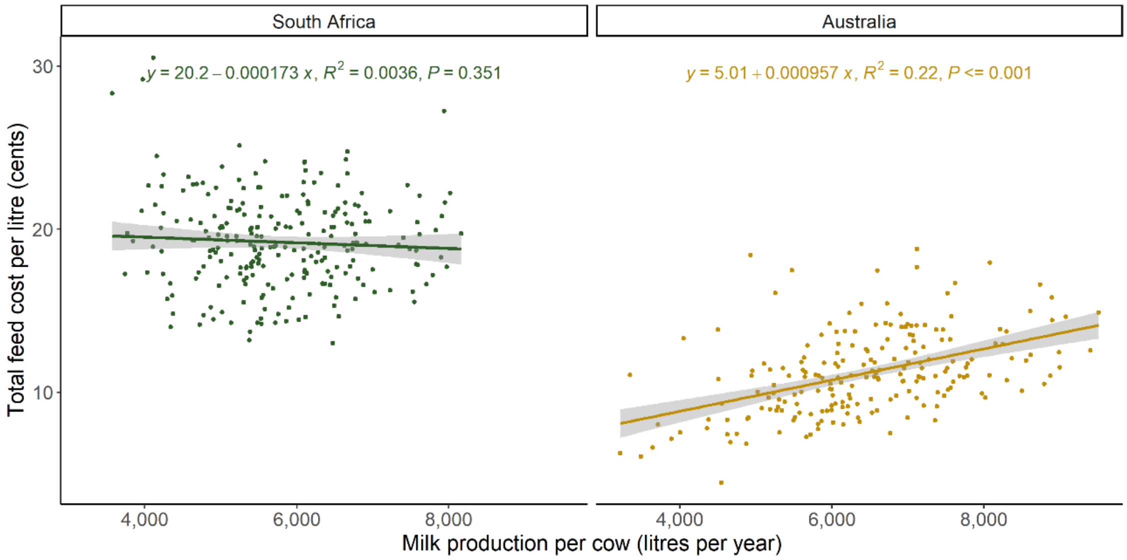


Figure 46. Impact of milk production per cow on labour cost per cow

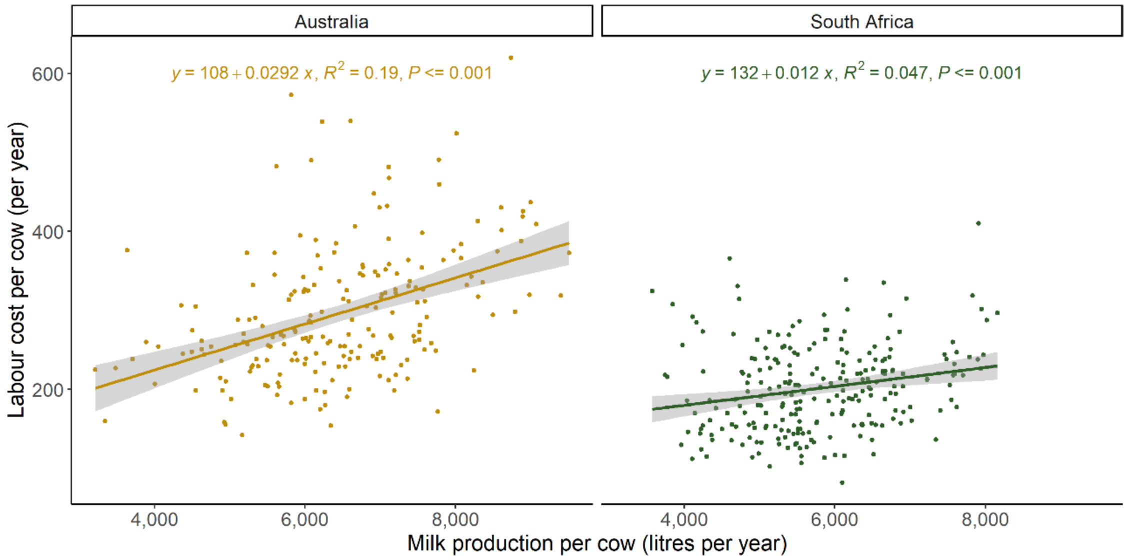


Figure 47. Impact of milk production per cow on total pasture cost per tonne dry matter

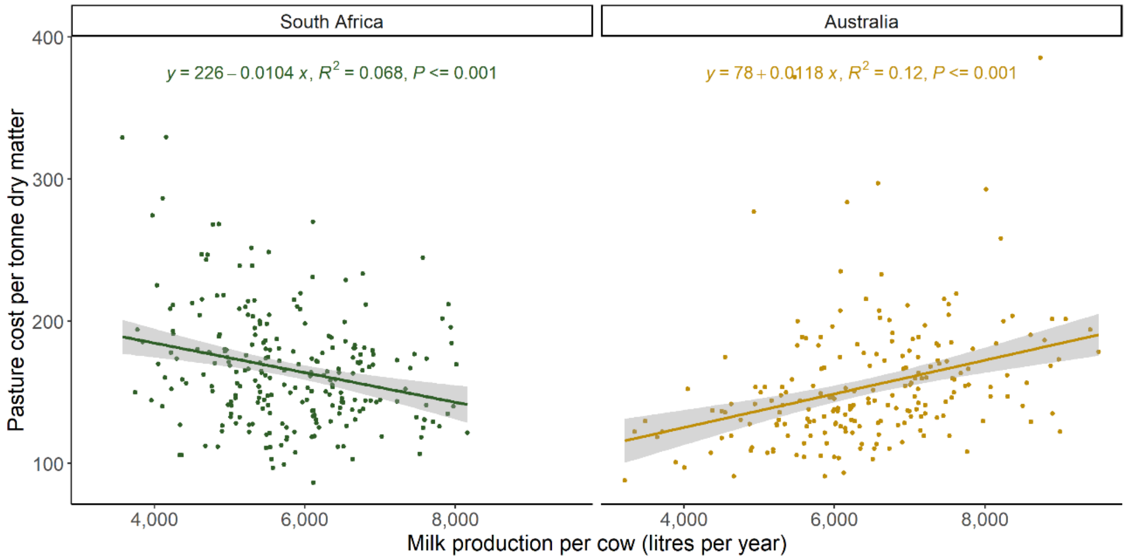
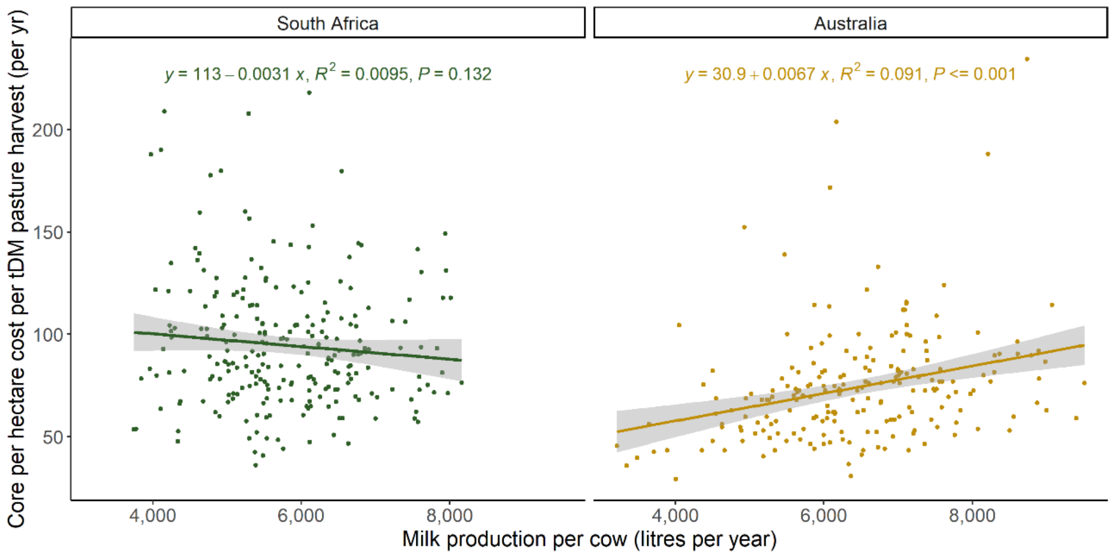


Figure 48. Impact of milk production per cow on 'core per hectare cost per tonne dry matter of pasture harvest'



What does change with the production system as per cent of pasture in the diet decreases?

Figure 22 (recopied). Impact of pasture as per cent of diet on profit (ROC)

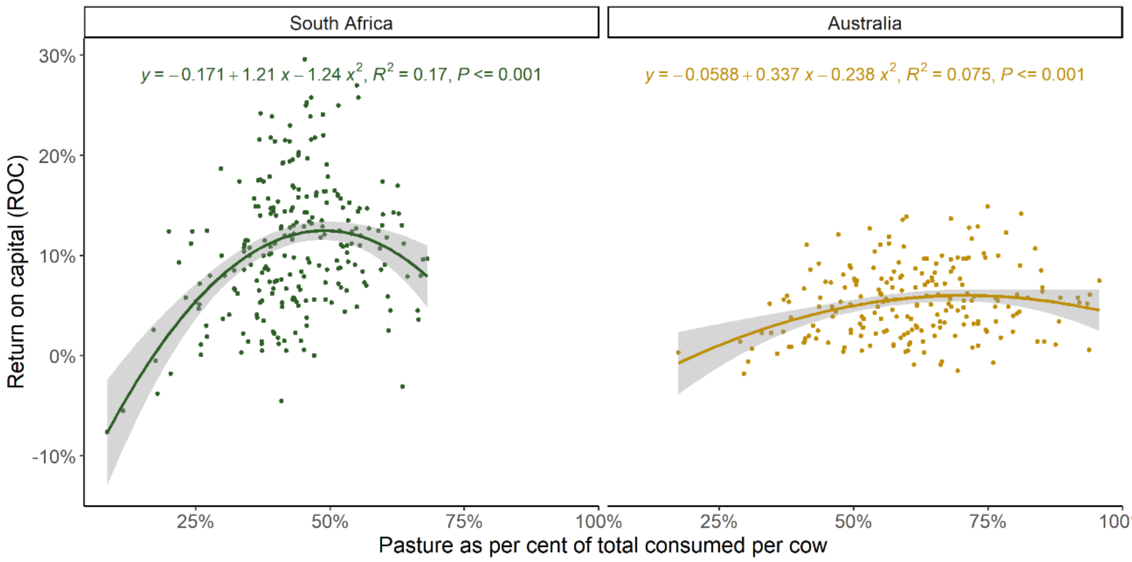


Figure 49. Impact of pasture as per cent of diet on profit per hectare

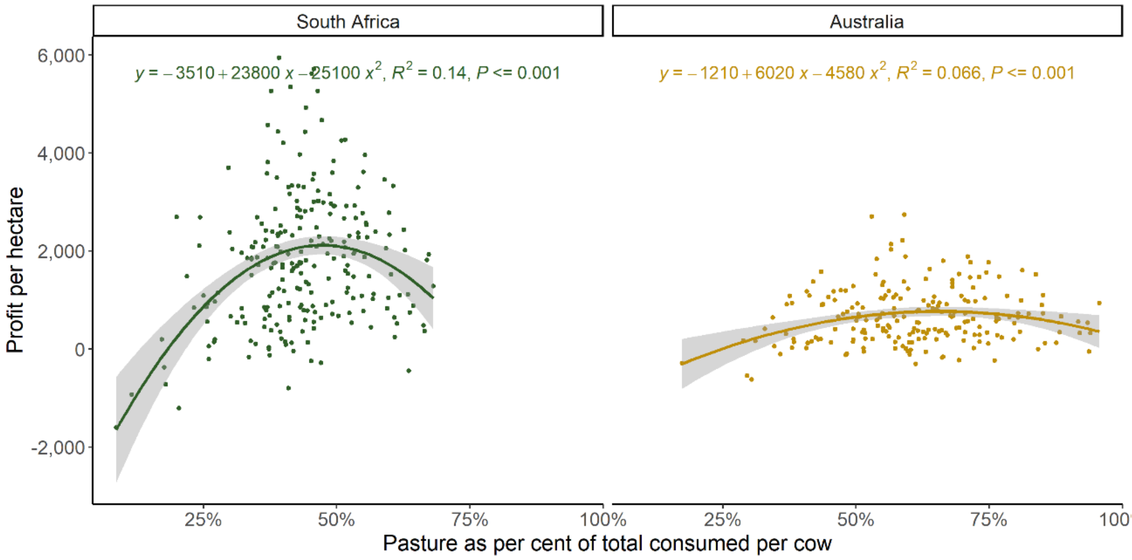


Figure 50. Impact of pasture as per cent of diet on profit per cow

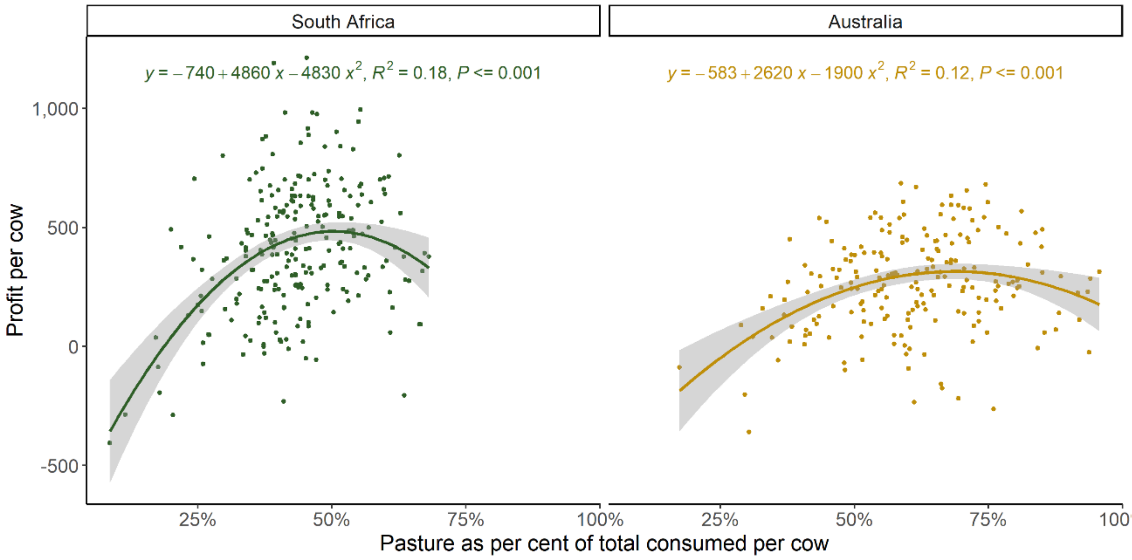


Figure 51. Impact of pasture as per cent of diet on cost of production per litre

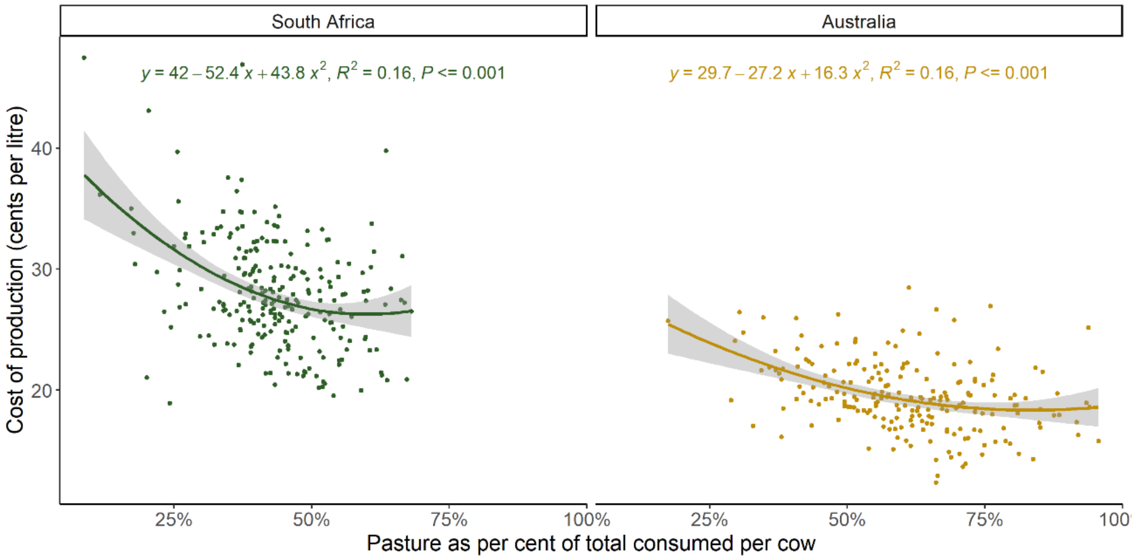


Figure 52. Impact of pasture as per cent of diet on pasture consumed per cow

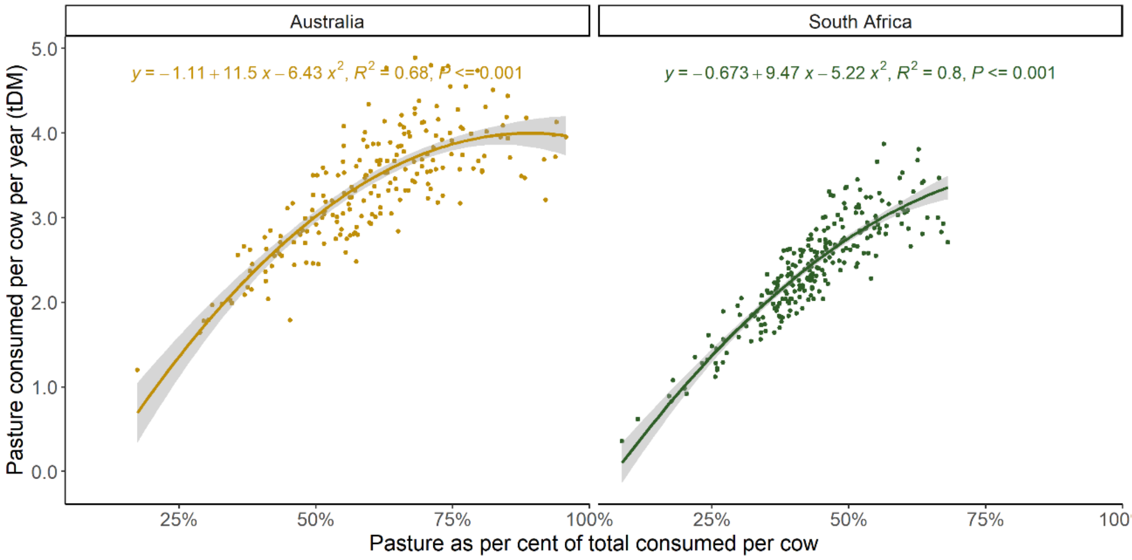


Figure 53. Impact of pasture as per cent of diet on supplement cost per litre

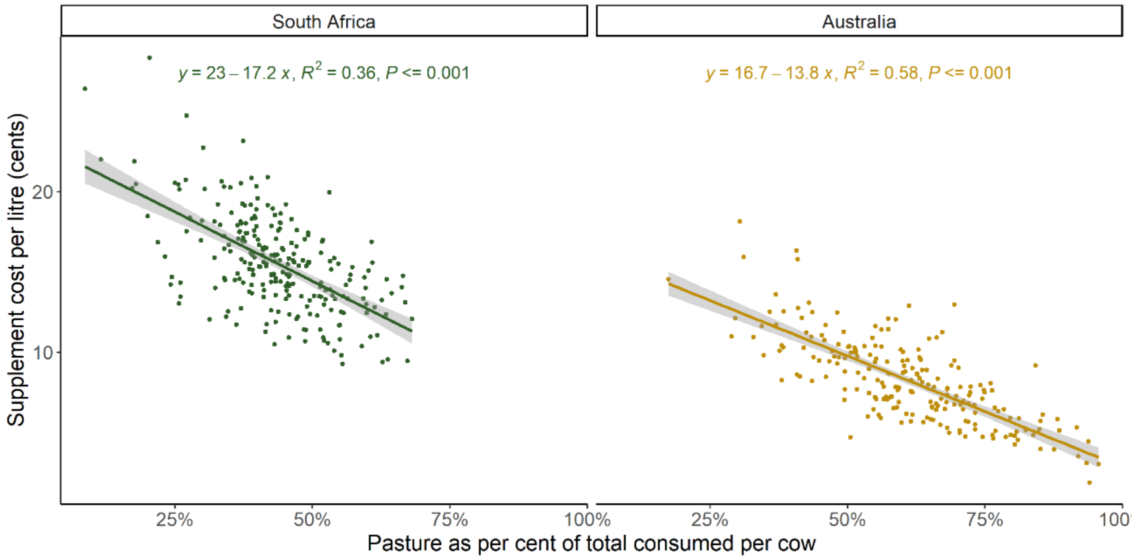


Figure 54. Impact of pasture as per cent of diet on total feed cost per litre

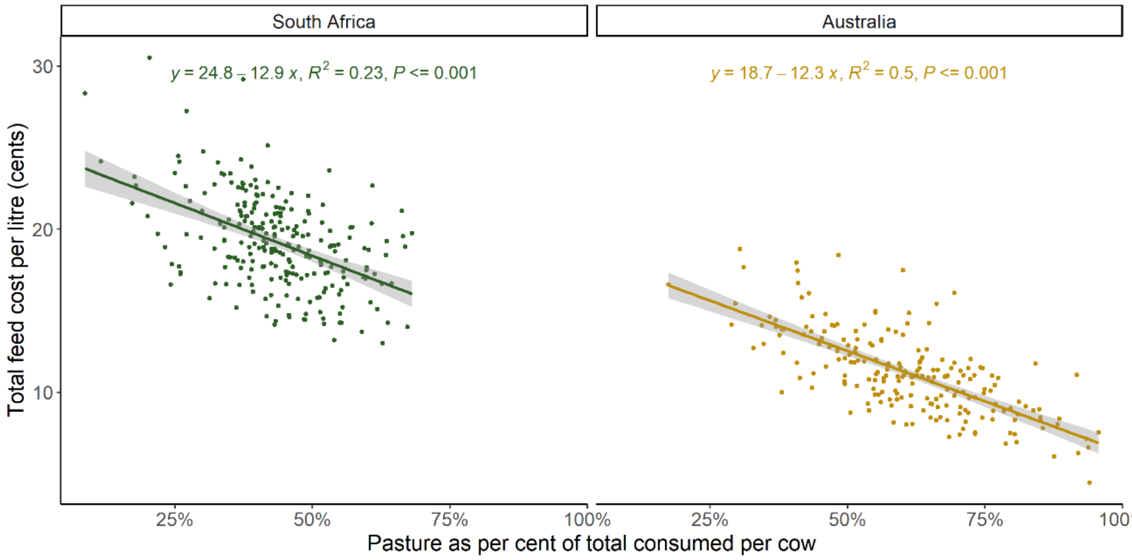


Figure 55. Impact of pasture as per cent of diet on 'core per hectare cost per tonne dry matter of pasture harvest'

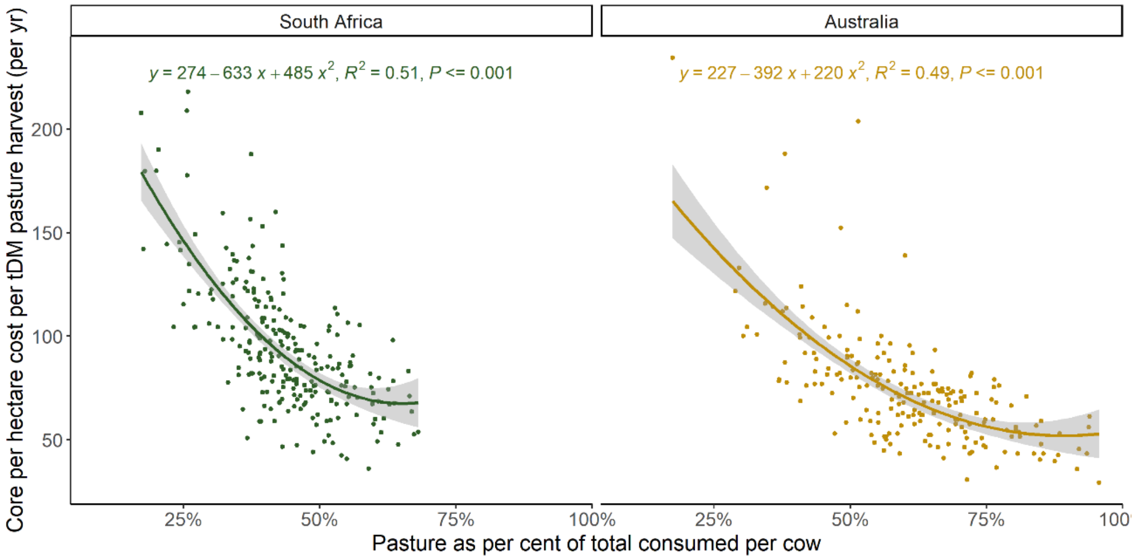


Figure 56. Impact of pasture as per cent of diet on total pasture cost per tonne dry matter

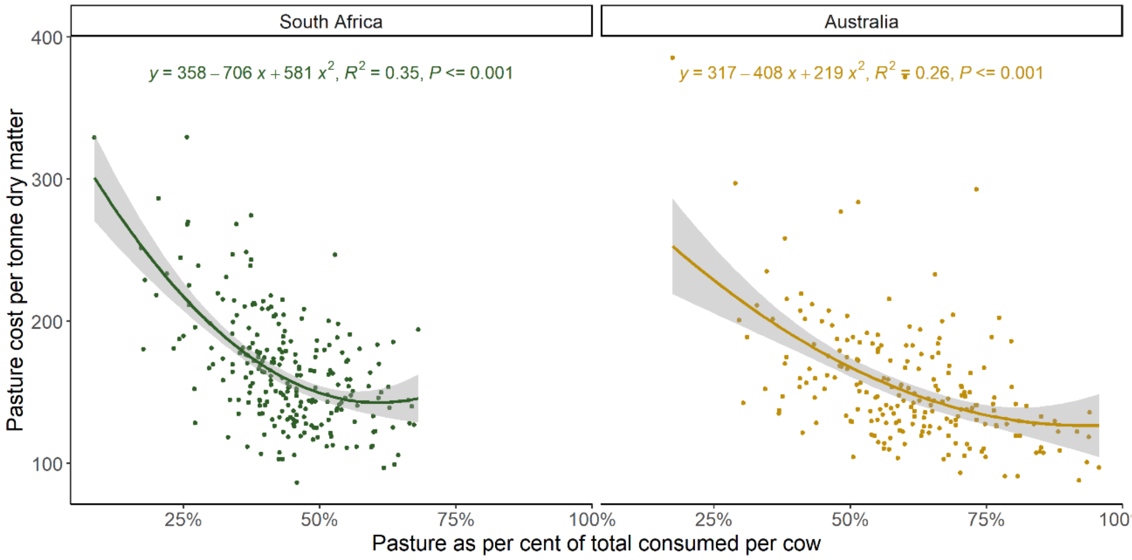


Figure 57. Impact of pasture as per cent of diet on pasture harvest

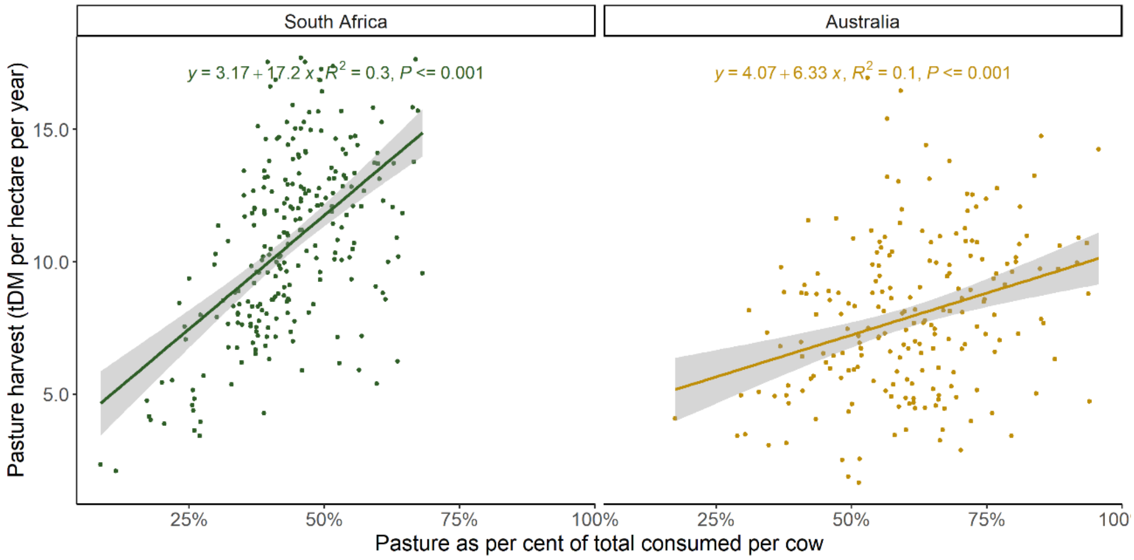


Figure 58. Impact of pasture as per cent of diet on 'core per cow cost'

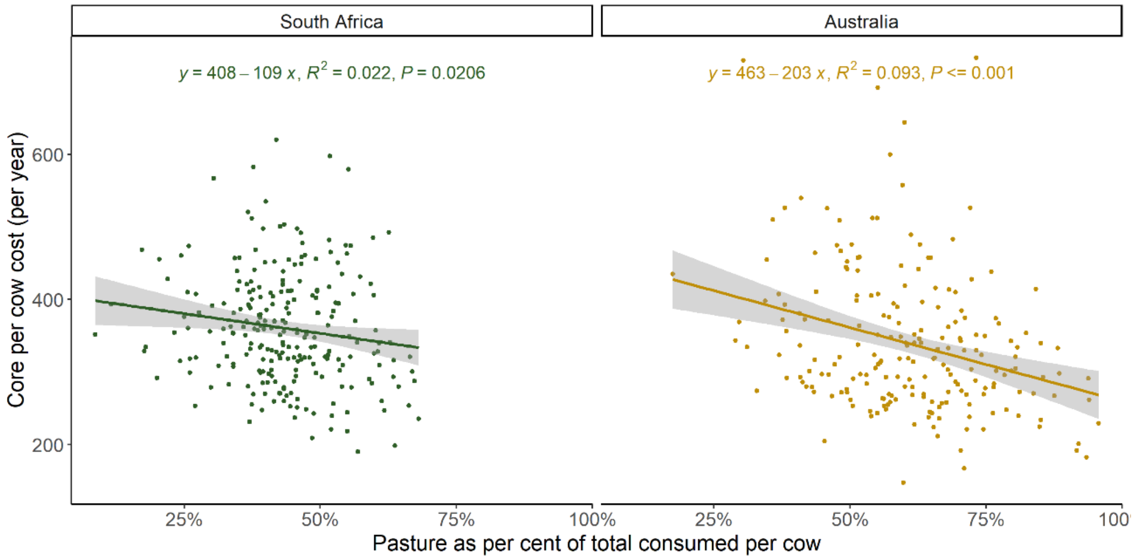


Figure 59. Impact of pasture as per cent of diet on labour cost per cow

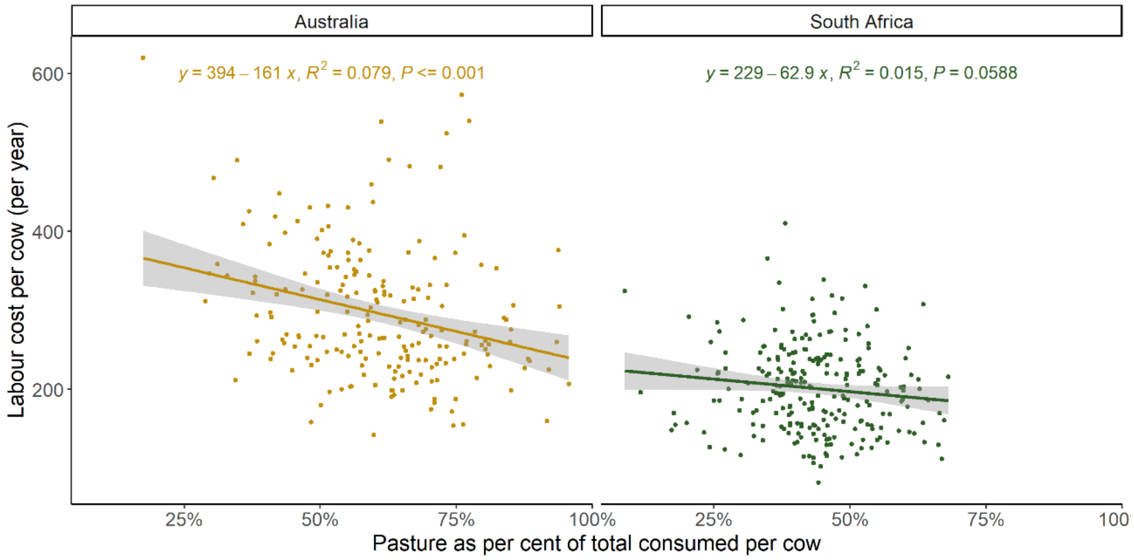


Figure 60. Impact of pasture as per cent of diet on milk production per cow

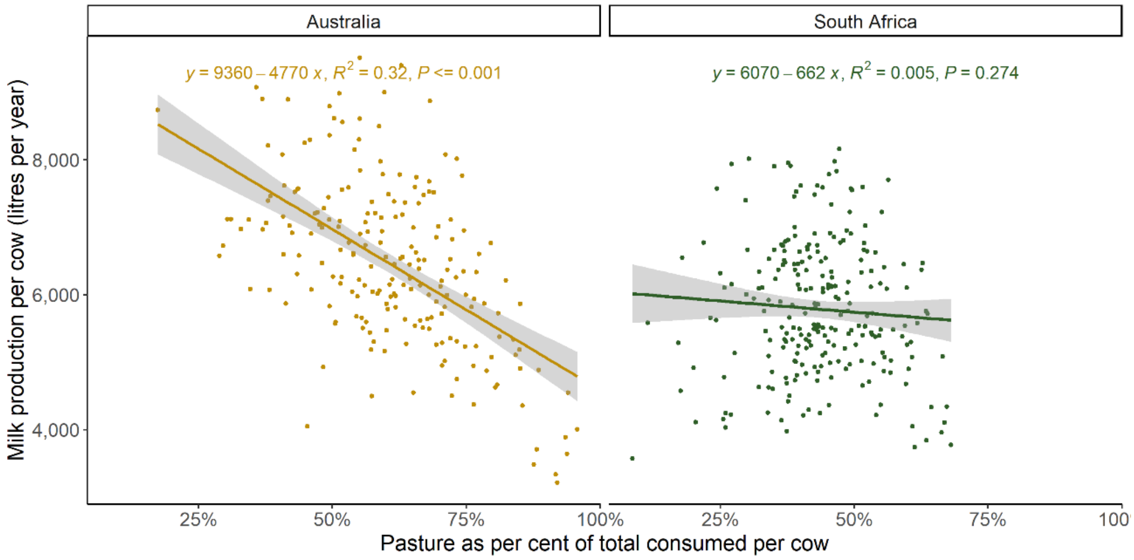
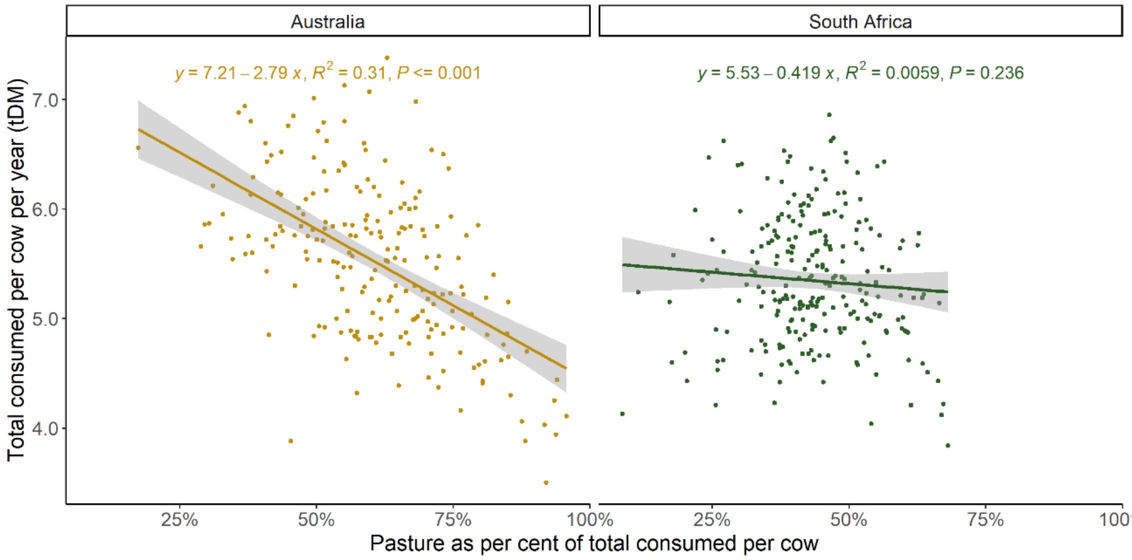


Figure 61. Impact of pasture as per cent of diet on total consumed per cow (tDM/cow/year)



References

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

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