# Farming system profitability and impacts of commodity price risk

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#### Abstract

Choosing a cropping system strategy is a long-term decision, with unknown future yields and prices. Most analyses use average commodity prices; however, price variance affects risk and returns. To investigate price risk for the different strategies, we used experimental data from locations within the Australian northern grains region over a 4.5 year period. Then used Monte Carlo random selection from a range of historical commodity prices to generate a range of possible gross margins (\$/ha) for experimental yields and costs. The inclusion of legumes and their associated price variance in cropping systems tended to increase risk and profitability. When using either recent or long-term grain prices, the profitability ranking of system strategies rarely changed. Choosing key production strategies to maximise farming system productivity outweighs responding to current commodity prices.

## Keywords

Gross margins, variable costs, income, system strategies, crop rotation, rainfed cropping

#### Introduction

Leading farmers in the Australian northern grains regions (NGR) often achieve the yield potential of individual crops. However, the overall performance of systems is harder to measure and less frequently considered (Bell et al., 2019; Zull et al., 2020). Opportunity cropping interspersed with fallow periods to accumulate plant available water (PAW) is a key feature of rainfed cropping within the NGR. Therefore, rather than focusing on fixed crop rotations, this analysis focused on choosing key long-term system strategies to maximise profits. Commodity prices vary greatly from year-to-year and introduces risk. Therefore, growers were concerned about how prices affects strategy selection.

#### Methods

Data collected from a series of field-experiments was used to investigate the long-term agronomic and economic performance of different system strategies, as well as the effect of commodity price risk. Experiments commenced in 2015 at seven locations: the core site at Pampas near Toowoomba and six regional centers across Qld (Emerald, Billa Billa, Mungindi) and northern NSW (Spring Ridge, Narrabri, and Trangie). Systems with current best-commercial practices (*Baseline*) at each location were compared to alternative system strategies: *Higher nutrient supply* (budgeting for 90 percentile crop yield), *Higher legume* 

Table 1. Market commodity prices (Profarmer, 2018) and range of farm gate prices including the minimum, first quartile  $(Q_1)$ , expected (median), third quartile  $(Q_3)$ , and maximum prices used to calculate the range of system gross margins for each crop grown across the farming systems experiments.

gross marging for each crop grown across the farming systems experiments.											
	Port prices						Farm gate	Gap between			
	10-yr						mean prices	3-yr mean and			
	median	Farm-gate prices from 2008-2017 (\$/t)†					2016-18	10-yr median			
Crop	(\$/t)	Min	$Q_1$	Median	Q3	Max	(\$/t)†	prices (\$/t)			
Barley	258	177	192	218	254	276	214	-4			
Canola	543	453	475	503	548	748	478	-25			
Chickpea	544	367	474	504	679	841	791	287			
Cotton <sup>#</sup>	1267	941	1058	1090	1133	1961	1066	-24			
Durum	339	242	270	299	315	319	277	-22			
Faba bean	422	254	314	382	433	621	379	-3			
Field pea	375	224	265	335	402	422	324	-11			
Maize	321	221	275	281	293	305	285	4			
Mungbean	950	499	631	667	869	919	869	202			
Sorghum	261	189	203	221	231	277	215	-6			
Sunflower	749	576	637	709	846	1104	865	156			
Wheat (APH)	309	218	242	269	283	287	247	-22			

<sup>†</sup> Farm gate prices adjusted for transport, grading or bagging costs or losses. <sup>#</sup> (Lint + seed 40% turnout)

(>50% of crops), *Higher crop diversity* (decrease risks of losses to soil-borne disease and weeds), *Higher crop intensity* (plant crops with a lower PAW threshold), and *Lower crop intensity* (plant on a full soil profile). At Pampas these systems were implemented in a factorial format across systems including a mix of summer and winter crop choices, summer-dominant, and winter-dominant cropping systems.

	Emerald Spring Ridge												
Baseline	Wheat; 1681	Chickpea; 3076	Wheat; 1769	Sorghum; 3109	Wheat; 3608	Chickpea; 3063	Wheat; 3176						
Higher nutrient	Wheat; 1967	Chickpea; 3141	Wheat; 2003	Sorghum; 3527	Wheat; 3505	Chickpea; 3329	Wheat; 3005						
Higher legume	Chickpea; 1852	Wheat; 3782	Chickpea; 1941	Sorghum; 3002	Wheat; 3724	Fababean; 4256	Wheat; 3225						
Higher diversity					Wheat; 3619	Fieldpea; 3631	Wheat; 3409						
Higher Intensity	Wheat; 1893	Mung;81: Wheat;2685	Wheat; 1582	Sorghum; 2381	Wheat; 3717	Sorgh	um; 2978 Chickpea; 1981						
Lower intensity					Wheat; 3620		Cott	on; 1523					
	BillaBilla Trangie - red soil												
Baseline	Wheat; 4629	Barley; 6465	Wheat; 1698	Chickpea; 1843		Wheat; 4866	Wheat; 1199	Barley; 1361					
Higher nutrient	Wheat; 4706	Barley; 6280	Wheat; 1735	Chickpea; 1803		Wheat; 6220	Wheat; 1525	Barley; 1549					
Higher legume	Wheat; 4738	Faba; 3454 Mung	; 117 Sorg	; 2854 Chickpea; 1016		Wheat; 5663	Chickpea; 471	Barley; 947					
Higher diversity	Wheat; 4878	Fieldpea; 3425 Sorg	hum; 1445	Canola; 775									
Higher Intensity	Wheat; 4718	Mung; 348 Sorghum	; 0 Wheat; 1396			Wheat; 4703	Chickpea; 462	Fieldpea; 233					
Lower intensity	Wheat; 4674	Sorghum	; 0	Wheat; 3003		Wheat; 5034		Barley; 1408					
Mungindi Trangie - grey soil													
Baseline	Wheat; 2810	Chickpea; 1487		Wheat; 736		Wheat; 2760	Wheat; 1720						
Higher nutrient	Wheat; 2474	Chickpea; 1447		Wheat; 831		Wheat; 2444	Wheat; 1337						
Higher legume	Wheat; 2993	Chickpea; 1455		Chickpea; 200		Wheat; 3263	Chickpea; 690						
Higher diversity	Sunflower	;712 Sorghum; 0		Durum; 767									
Higher Intensity						Wheat; 2766	Chickpea; 586						
Lower intensity	Wheat; 2937	Cotton; 2	97	Wheat; 1185		Wheat; 2780							
		Narrabri		1/01,	/2015 1/0	1/2016 31/12	2/2016 31/12	2/2017 31/12/2018					
Baseline	Wheat; 2148	Chickpea; 2723	Wheat; 2430		-	🗖 Barley	🗖 Fi	eldpea					
Higher nutrient	Wheat; 2170	Chickpea; 2752	Barley; 1608		-	🗖 Canola		laize					
Higher legume	Wheat; 1919	Fababean; 2780	Wheat; 2190		-	🗖 Chickpea		lungbean					
Higher diversity	Wheat; 2124	Fieldpea; 2188	Canola; 505		-	Cotton	Se Se	orghum					
Higher Intensity	Wheat; 2098	Canola; 3159	Wheat; 2022	Sorghum	; 530	Durum		unflower					
Lower intensity	Wheat; 2125	Cotton;	1141		-								
1/01,		/2016 31/12/20		/12/2017 31/12/2	2018	🗖 Fababea		/heat					
Baseline	wheat; 5563	Core site - mixed opp		sorghum; 444	4 wheat; 5863	Core site - high Mung; 403 sorgh	um; 5606 chickpea; 1437	sorg; 898 sorghum; 2350					
Higher nutrient	wheat: 5358	sorghum; 641		sorghum; 500			um; 5573 chickpea; 1549						
Higher legume	fababean; 4602	sorghum; 628		sorghum; 440				sorg; 743 Mungbean; 729					
Higher diversity	canola; 2761	sorghum; 6334		Cotton; 128			um; 4580 durum; 1652 :						
Higher Intensity	· · ·												
Lower intensity	wheat; 5300	Cotton; 16	59 wheat; 1060										
,		Core site - summ	ner	1 - C		Core site -	- winter						
Baseline	wheat; 5280	maize; 3247	n; 4442	wheat; 532	wheat; 5329 chickpea; 3600 wheat; 2390								
- Higher nutrient	wheat; 5535	maize; 3413	sorghun	n; 4525	wheat; 529	8 chickpea; 34	195 wheat; 1853						
Higher legume	fababean; 4572	maize; 3828	mungt	oean; 590	fababean; 47.	21 wheat; 6304	chickpea; 1877						
Higher diversity	wheat; 5662	cotton; 174	5 sorghun	n; 4038	canola; 285	2 durum;7774	chickpea; 1906						
Higher Intensity	wheat; 5863 Mur	<mark>ig; 403 sorghum; 560(</mark>	5 chickpea; 1437 sc	rg; 898 sorghum; 235	0 wheat; 5863	Mung; 403 sorgt	num; 5606 chickpea; 1437	sorg; 898 sorghum; 2350					
Lower intensity	maize; 71	134 mungbe	an; 878	cotton; 178	8 wheat; 563	7	chickpea; 2015						
1/01/	2015 1/01/2	2016 31/12/2016	31/12/	/2017	1/01/2015	1/01/2016 31/	/12/2016 31/:	12/2017 31/12/2018					

Figure 1. Crop type, growing duration and yields (kg/ha) of experimental results for each crop within each farming system strategy at seven regional sites and the core site (Pampas, Qld) from 2015 to 2018.

Data collected included crop grain yields (corrected to 12% moisture), machinery operations, and inputs of fertilisers, seed and pesticides for each cropping sequence for 4.5 years (Apr 2015 to Dec 2019; Figure 1). Farm-gate commodity prices used the median port prices over 10-years (2008 to 2017) (Profarmer, 2018) and adjusted for inflation, transportation, grading and bagging (Table 1). The same median commodity and input prices were used to calculate the accumulated income (grain yields × commodity prices) and total gross-margins (GM) for each of the cropping strategy at each location.

Monte Carlo random selection analyses was used from the range of commodity prices received over the last 10 years to generate the possible distribution of gross margins for each farming strategy over time for given experimental yields. This generated a range of possible GMs now and in the future to be estimated for the observed experimental practices and yields. We compared gross margins using the 10-year median prices and the prices received in the last 3 years (2016-2018) to see if recent commodity prices would result in changes in the relative profitability of the systems.

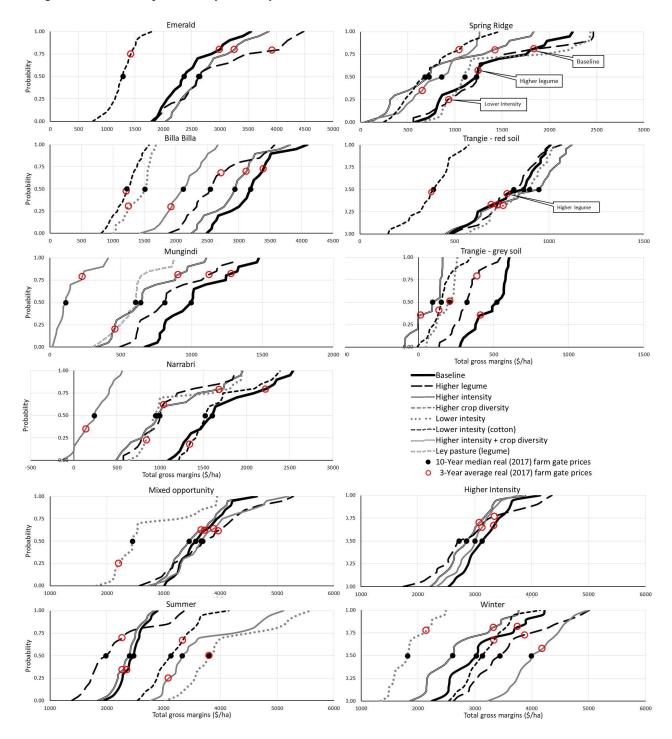


Figure 2. The possible distribution of total gross margins of systems at experimental sites, using a range of commodity prices from the last 10 years. The lowest GMs occur with the lowest grain prices (P=0) and the highest GMs with the highest grain prices (P=1). The median (P=0.5) total GM are shown as black dots using the 10-year median commodity prices, red circles use the 3-year average prices (2015-2017).

## Results

Differences in climate and sites meant that grain production and input costs varied substantially amongst sites; hence comparisons should be amongst strategies at each site (Figure 2). For example, at Billa Billa, the *Baseline* strategy had the same number of crops as the *Higher intensity* strategy, but the latter resulted in lower yields and a failed crop (Figure 1). The *Lower intensity* strategy also had lower yields than the *Baseline* but also lower variable costs than the *Higher intensity* strategy, therefore had higher GM than the latter. A Pampas, *Higher intensity* increased median GMs by 27% in the summer-dominant system.

Compared to the *Baseline*, the *Higher nutrient supply* strategy, increased yields (Figure 1) and median total GMs at the Emerald and Trangie (red soil) sites by \$274 and 82/ha, respectively (Figure 2). The *Higher legume* strategy increased the median total GMs at Emerald \$255/ha; however, this increased the variable costs in most other cases – primarily from increased pesticide use. With the *Higher crop diversity*, median total GMs were lower by 30-89% (\$367-1967/ha over 4.5 years or \$82-437/ha/yr) than the *Baseline* system (Figure 2) at all locations, except Pampas where GM increased by ~33% (\$189-215/ha/yr) for the summer and winter systems. *Higher crop intensity* did not increase total crop income at any site and GMs decreased due to increased planting and harvesting costs. *Lower crop intensity* systems incurred lower costs at 6 of the 8 trials, but also had 10-63% lower total GM than the *Baseline* system at most locations (Figure 2).

## Impact of commodity price variability on system profitability

Sorghum, wheat, and maize had lower prices and price variance over the 10-years (26-40%); whereas, chickpea, mungbean, sunflower and cotton had higher price volatility (61-94%) (Table 1). This affected the possible range of total GM for each cropping system and location (Figure 2).

At Billa Billa, the *Baseline* system's median total GM was \$3189/ha(Figure 2, black dots) using the 10-year median commodity price. However, total GM could be as low as \$2490/ha when all commodity prices of that system are low, and as high as \$4092/ha with high commodity prices. Based on the last 3-year average price, the *Baseline* median GMs at Billa Billa would have increased by 6% to \$3393/ha (Figure 2, red circles). The system was more affected by the higher legume prices than the lower cereal prices.

Importantly, changing commodity prices did not change the ranking of many strategies across any sites. For example, at Billa Billa, the ranking of cropping system was consistent using both the 10-year median and the 3-year average commodity prices: *Baseline > Higher nutrient supply >Higher legume > Higher crop diversity > Lower crop intensity > Higher crop intensity* (Figure 2).

## Conclusion

We show that by increasing crop diversity within a cropping system, commodity price risk is reduced, and GMs may increase due to higher valued crops, like chickpea, mungbean and cotton. Increasing or decreasing intensity relative to the *Baseline* system resulted in lower GMs at most sites, due to increased variable costs in *Higher crop intensity* or lower income from fewer crops and missed opportunities in *Lower crop intensity* systems. With better seasonal conditions the *Higher intensity* or *nutrient* strategy may have a higher ranking. The increased inclusion of legumes and their associated price variance in cropping systems tends to increase risk but also farm profitability. The most significant outcome was that the ranking of strategies based on total GM rarely changed when using either the 10-year median commodity price or the average price over the last 3-years (2015 to 2017). Therefore, maximising long-term farming system productivity and resilience is more important than responding to current commodity prices.

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