Risk aversion and fertiliser decisions

16 April, 2024 by David Pannell

This Pannell Discussions is about risk aversion and its influence on strategic decisions about the optimal rate of a fertiliser to apply, particularly nitrogen fertiliser.

Over the years this has been a topic of some confusion and misinformation. The key question is whether nitrogen fertiliser is a risk-decreasing input (higher rates have lower risk) or a risk-increasing input (higher rates have higher risk). If it's a risk-decreasing input, then farmers who are more risk-averse would tend to put on more fertiliser. But if it's a risk-increasing input, risk aversion would encourage lower fertiliser rates.

In Australia, a common assumption amongst scientists who work on fertilisers is that grain farmers consider fertilisers to be risk-increasing, and hence they don't apply enough fertiliser to maximise expected profits.

Interestingly, in North America, the usual assumption is exactly the opposite. People assume that farmers perceive fertilisers to be risk-reducing – and that is seen as one of the reasons many farmers apply too much fertiliser. It's true that many farmers in those regions do apply excessive fertiliser, causing lost profits, water pollution and unnecessary greenhouse gas emissions. But how much of that is due to risk aversion?

I'd observe that most of the commentary about the effect of risk aversion on fertiliser use is conducted in an evidence-free zone. It is largely based on assertions and assumptions. Two types of evidence are relevant to the discussion: (a) what do farmers themselves perceive regarding whether fertilisers are risk increasing or risk decreasing, and (b) what does the biological and economic evidence say?

There is a small amount of evidence about farmers' perceptions. For example, a few surveys in the US have found that various farmers do see fertiliser as risk-reducing, while one recent survey in Western Australia indicates that risk aversion has almost no impact on fertiliser decisions of grain growers (Petersen et al. 2023).

On the other hand, there is a lot of empirical evidence about the actual effect of nitrogen fertiliser rates on the riskiness of agricultural production. Examples of studies that have looked at this include Just and Pope (1979) (using experimental data for corn and oats in Mississippi), Nelson and Preckel (1989) (using farm data for corn in Iowa), Love and Buccola (1991) (using farm data for corn in Iowa), Roosen and Hennessy (2003) (using experimental data for corn in Iowa), Rajsic et al. (2009) (using experimental data for corn in Ontario, Canada), Monjardino et al. (2015) (using a crop simulation model for wheat in southern Australia), Gandorfer et al. (2011) (using experimental data for various crops in Germany), Meyer-Aurich and Karatley (2019) (using experimental data for wheat in Germany), Schaub and El Benni (2023) (using experimental data for pasture and wheat in Switzerland), and Chai et al. (2023) (using experimental data for corn in various US states).

In every case, the empirical results indicate that fertiliser is a **risk-increasing** input.

In addition to these studies, which focus primarily on production risk, we know that price risk acts to further increase overall risk at higher input rates, assuming that additional fertiliser increases expected yield (Sandmo, 1971). In other words, price risk also contributes to nitrogen fertilizer being a risk-increasing input.

As far as I am aware, there is absolutely no empirical evidence that fertiliser is a risk-reducing input, in any country, for any type of crop. That raises interesting questions about why some American farmers think it is one.

On the other hand, the degree to which risk increases as the fertiliser rate increases is generally very low. It's so low that my view is that risk aversion should usually be an irrelevant consideration when choosing fertiliser rates. In Chai et al. (2023), we found that realistic levels of risk aversion changed the optimal fertiliser rate by less than 1 kg/ha — much too little to matter. You can see why in Figure 1.

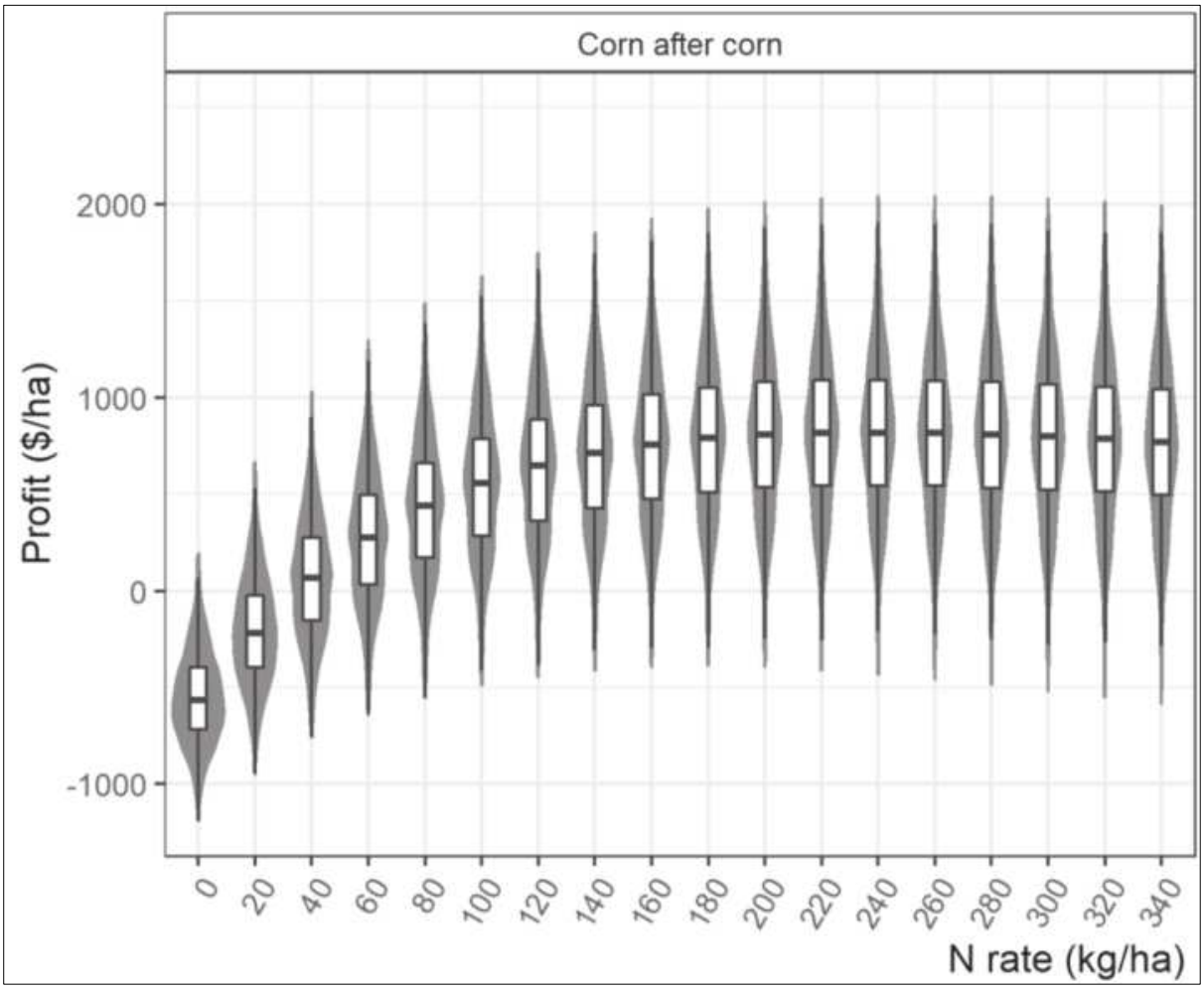

Figure 1

The black horizontal lines near the middle of the white rectangles at each nitrogen rate show the median value of profit. The vertical lines and the bulges around them show the range and distribution of profit levels for each nitrogen rate. Around the profit-maximising nitrogen rate (about 220 kg/ha), varying the nitrogen rate makes almost no difference to the risk. Higher rates are riskier (there is a wider distribution) but only very slightly, so risk aversion would not be a strong driver of the decision about nitrogen rates.

Note that the issue is not whether there is risk at a particular fertiliser rate. There is significant risk at every fertiliser rate, as indicated by the bars and bulges above and below the median line. Instead, the issue is whether a farmer can avoid some of that risk by changing to a different rate. Given that risk is very similar at all rates within the vicinity of the optimum, there is no escaping from that risk. That means that even highly risk-averse farmers have little to gain by adjusting their fertiliser rates in an attempt to avoid risk.

The results in Figure 1 are for corn in the US, but I'm confident that the situation for the main grain crops in Australia is broadly similar.

Further reading

Chai, Y., Pannell, D.J. and Pardey, P. (2023). Nudging farmers to reduce water pollution from nitrogen fertilizer, *Food Policy* 120, 102525. Full paper

Petersen, E.H., Hoyle, F.C., Scanlan, C.A., Burton, M.P., Oliver, Y.M. and Murphy, D.V. (2023). Agronomic factors are the dominant inluence on nitrogen fertilizer strategies in dryland cropping systems, *Agronomy for Sustainable Development* 43, 14. Full paper

This is #6 in my RiskWi$e series. Read about RiskWi$e here or here.

The RiskWi$e series:

405. Risk in Australian grain farming
406. Risk means probability distributions
408. Farmers' risk perceptions
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412. Risk aversion and fertiliser decisions (this post)
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