Financial risk profiles for dryland cotton by APSIM-Ozcot and @Risk®

Sosheel Solomon Godfrey[1*], Muhuddin Rajin Anwar[1,2], Thomas Lee Nordblom[1]

[1] Graham Centre for Agricultural Innovation (an alliance between Charles Sturt University and NSW Department of Primary Industries), Albert Pugsley Place, Wagga Wagga, NSW 2650, Australia. https://www.csu.edu.au/research/grahamcentre, sgodfrey@csu.edu.au
[2] NSW Department of Primary Industries, Wagga Wagga Agricultural Institute, PMB Wagga Wagga, NSW 2650, Australia

Abstract
Dryland (rainfed) cotton is affected by weather variability, particularly extreme temperatures and rainfalls, which influence crop growth, development and yield. This variability in production was quantified in two important dryland cotton-growing regions of Australia using the Agricultural Production Systems Simulator (APSIM)-Ozcot cotton model. The present study integrates @RISK for multivariate distributions of risk posed by weather and price variations over time to define financial risk profiles that show the probabilities of losses and gains for a given management plan. These results highlight how misleading a gross margin analysis can be on its own, accounting only for variable costs and neglecting the greater share of fixed costs such as depreciation, interest on the debt, wages of permanent labour and managerial allowance controlling a farm's economic profitability over time.

Key Words
Risk, Farm financial planning, Dryland (rainfed) cotton, Crop simulation

Introduction
In 2017-18 there were 1,436 farms growing cotton in Australia, of which 66% were in NSW and 33% in QLD, that produced an estimated 4.6 million bales valued at 2.3 billion dollars. Only eight percent of the production was rainfed (without irrigation) yielding 1.34 bales/hectare on average (Cotton Australia 2018). According to Monsanto (n.d.), dryland growers with cotton in their rotation program are achieving high returns, which fluctuate with commodity prices and yields. Bange (2018) highlights the risks and prospects of dryland cotton and advocates the use of crop simulation models as one source of information to estimate potential crop yields and associated weather risks.

Methods
An earlier study by Powell and Scott (2011) described whole-farm risk profiles for a representative mixed farm of wheat, grain legumes, grazing cattle and 100 ha of irrigated cotton in the lower Namoi Valley, NSW. The present study focusses on developing economic risk profiles for 100 ha of dryland cotton on a 500 ha cotton farm with the rest being irrigated, following Frilay (2019). The hypothetical farm compared two locations: Gunnedah (Gun), NSW and Dalby (Dal), QLD (Figure 1 and Table 1). Rainfed cotton yields were simulated from 1889-2018 using the APSIM-Ozcot model (Hearn 1994; Holzworth et al. 2014) for the two sites.

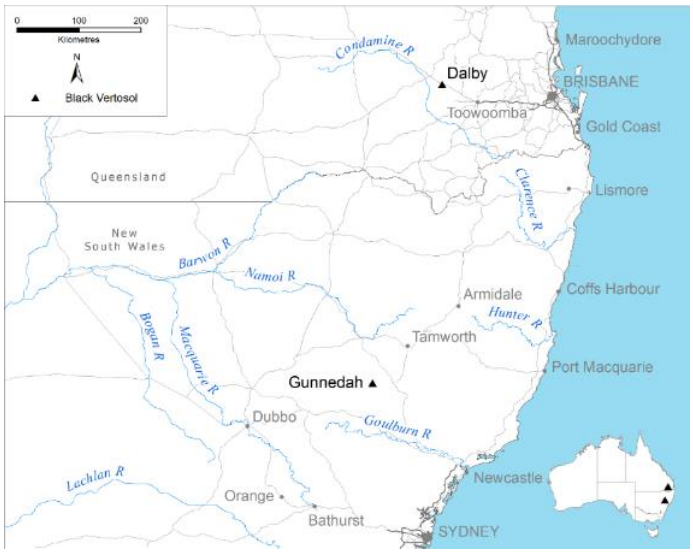

Figure 1: Cotton farms in Dalby, NSW and Gunnedah, QLD mapped by the Spatial Data Analysis Network, Charles Sturt University

Table 1: MaxT and MinT are the mean maximum and minimum October – February (O-F) temperatures (°C) each year from 1889-2018 and mean rainfalls (mm) for the same periods; soil type and mean plant available water capacity (PAWC) of the study sites. Coefficients of variation (CV%) are in parentheses.

Location	Latitude Longitude	O-F average MaxT (°C)	MinT (°C)	Rainfall (mm)	Soil type	PAWC (mm)
Dalby, QLD	27.3° S, 151.4° E	30.5 (4%)	16.3 (5%)	408 (35%)	Black Vertosol	285
Gunnedah, NSW	31.6° S, 150.4° E	30.7 (5%)	15.5 (8%)	341 (42%)	Black Vertosol	207

Representative data for soil parameters to 150-180cm soil depth in increments of 10-15cm for each site were obtained from the APSoil database (Dalgliesh 2009). The model was reset each year on the planting date, i.e. 15th October at a plant available water capacity (PAWC) of 100% allocated to reflect subsequent changes in rainfall on productivity while excluding the carry-over effect of soil water and nutrients from the previous year. Cotton was assumed to be planted at 1-metre row spacing with single skip (Dal SS and Gun SS) and double skip (Dal DS and Gun DS) row configurations. Based on current practice, nitrogen fertiliser (100 kg N/ha) was applied as urea at planting, and an additional varying amount (0.1 to 56.8 Kg N/ha) was applied at approximately first flower for each site and year based on soil-nitrogen balance, ensuring soil nitrate remains non-limiting as in APSIM-Ozcot.

Farm profit and loss budgets were generated using the definitions of Malcolm et al. (2005). We also incorporated balance sheets, and cash flows in our financial model to generate decadal (10-year) risk profile distributions as described by Hutchings (2013).

Thirty-four years of data from 1984-85 to 2017-18 were used to build a probabilistic model using historical cotton bale prices (ABARES 2018), APSIM-Ozcot generated cotton yields and nitrogen applications per hectare. For variable costs, single skip (SS) and double skip (DS) 2018-19 gross margin budget estimates from CottonInfo (2018) were used. The cost of hired labour and $0.7m debt allocations for dryland cotton were based on estimates from Frilay (2019). A managerial allowance of $30,000 per annum was allocated to the dryland cotton portion of the farm based on PayScale (2019) estimates. Annual equipment depreciation costs were similarly allocated.

We generated multivariate distributions for the cotton price, yield, nitrogen application and cost variables and combined them using copulas based on the maximum likelihood method (Hardaker et al. 2015). Driven by these distributions over 100,000 decadal iterations of Monte Carlo simulation using @Risk 7.6 (Palisade 2018), ending gross margins (GM) and net profit after tax (NPAT) are shown for each treatment at each location.

Results

Single skip dryland cotton appears to give positive gross margins 85 and 96 percent of the time at the Gunnedah and Dalby farms, respectively (GM in Figure 2). Double skip dryland cotton does less well at both locations, appearing to give positive gross margins only 45 and 79 percent of the time at the Gunnedah and Dalby farms, respectively (GM in Figure 3). But gross margins do not account for all the important costs that affect the financial outcome of the enterprise.

Estimates of net profits after considering fixed costs, interest and taxes provide a more complete picture of the farm's likelihood of improving its level of equity (or detracting from it). Single skip dryland cotton appears able to improve farm equity only 56 percent of the time at Gunnedah but 81 percent of the time at Dalby (NPAT in Figure 2). Double skip dryland cotton appears to be profitable 12 percent and 59 of the time on the Gunnedah and Dalby farms, respectively (NPAT in Figure 3).

Our results starkly contrast the likely outcomes of the single and double skip production methods in the two farming areas by taking into account their differences in weather variations over the long-run. These results show how misleading a gross margin analysis can be on its own, accounting only for variable costs and neglecting the greater share of factors controlling a farm's profitability over time.

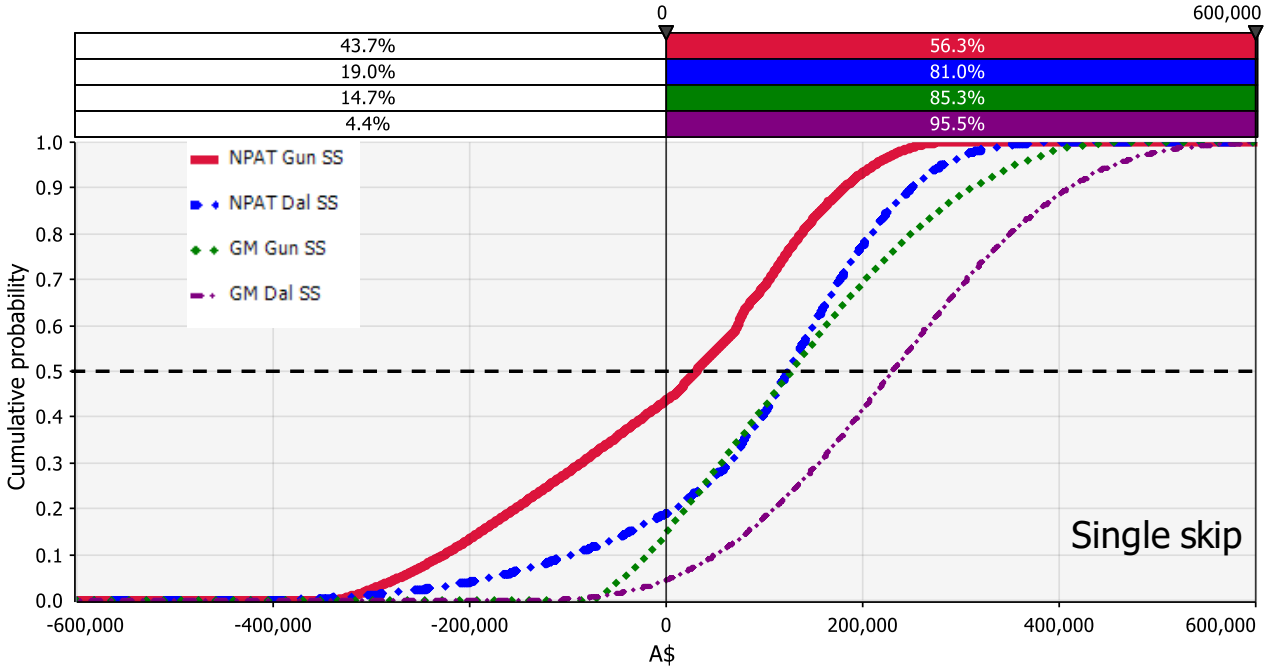

Figure 2: Single skip cotton cumulative frequency distributions that show Dalby to have better Gross Margin (GM) and Net Profit After Tax (NPAT) than Gunnedah

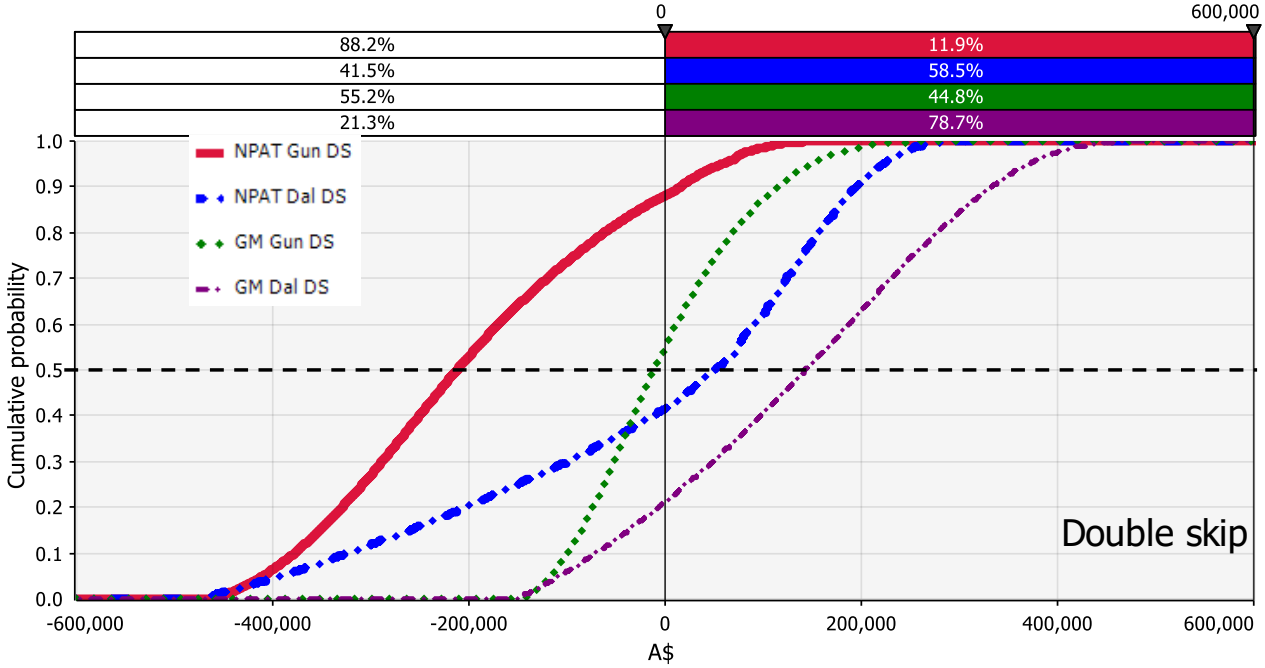

Figure 3: Double skip cotton cumulative frequency distributions that show Dalby to have better Gross Margin (GM) and Net Profit After Tax (NPAT) than Gunnedah

Conclusion

Risk in dryland cotton production based on variability in production and prices was captured in this analysis by using APSIM-Ozcot with @RISK. The method used is powerful as it summarises the long-term portfolios of GM and NPAT for single skip and double skip row configurations at both locations (Figure 2 and Figure 3). The combination of price variations due to international trade and production variations due to local weather provide a wide range of conditions that can affect farmers' financial outcomes. Our results starkly contrast the likely outcomes of the single and double skip production methods in the two farming areas by taking into account their differences in weather variations over the long-run.

Acknowledgements

We are indebted to several people for making this paper possible in its present form with their contributions and comments:

- To Janine Powell, Economist and Partner AgEcon for answering several questions related to costing dryland production of cotton
- To James Frilay and Dale Ashton, Research Economists, Australian Bureau of Agricultural and Resource Economics and Sciences (ABARES), for providing the breakdown of the cost of production and financial performance data for dryland and irrigated cotton in Australia based on the Australian Agricultural and Grazing Industries (AAGIS) survey and the Murray-Darling Basin Irrigation survey
- To Md Asaduzzaman, Research Officer (Cropping Weeds), Southern Cropping Unit, NSW Department of Primary Industries for sharing publications on dryland cotton
- To Deanna Duffy and the Spatial Data Analysis Network (SPAN) of Charles Sturt University (CSU) for the map

References

ABARES (2018). Agricultural commodity statistics 2017. ABARES, Canberra. Available at: http://www.agriculture.gov.au/abares/publications/display?url=http://143.188.17.20/anrdl/DAFFService/display.php?fid=pb_agcstd9abcc0022017_IugZg.xml Accessed 20 Dec 2018.

Bange M (2018). Raingrown (dryland) cotton. In Australian Cotton Production Manual 2018. pp. 16-18. Cotton Research and Development Corporation, Canberra. Available at: https://www.cottoninfo.com.au/publications/australian-cotton-production-manual Accessed 20 Dec 2018.

Cotton Australia (2018). Australian cotton industry statistics Mascot NSW 2020. Available at: https://cottonaustralia.com.au/uploads/publications/03-051801_COTTON_ANNUAL_2018_DR4.pdf Accessed 14 Feb 2019.

CottonInfo (2018). Australian cotton industry gross margin budgets. Available at: https://www.cottoninfo.com.au/sites/default/files/img/Dryland%202018-19.pdf Accessed 15 Jan 2019.

Dalgliesh NP, Foale, M.A., & McCown, R.L. (2009). Re-inventing model-based decision support with Australian dryland farmers 2. Pragmatic provision of soil information for field-specific simulation and for farmer decision making. Crop & Pasture Science (60), 1031–1043.

Frilay J (2019). Murray-Darling Basin Irrigation survey [Personal Communication]. Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra.

Hardaker JB, Lien G, Anderson JR, et al. (2015). Coping with Risk in Agriculture. 3rd Ed. CABI, Malta. Available at: http://www.cabi.org/cabebooks/ebook/20153137229.

Hearn AB (1994). OZCOT: A simulation model for cotton crop management. Agricultural Systems 44(3), 257-299.

Holzworth DP, Huth NI, Devoil PG, et al. (2014). APSIM – Evolution towards a new generation of agricultural systems simulation. Environmental Modelling and Software 62, 327-350.

Hutchings TR (2013). Financial risk on dryland farms in south-eastern Australia. Available at: http://purl.umn.edu/204434.

Malcolm B, Makeham J and Wright V (2005). The farming game: Agricultural management and marketing. Cambridge University Press, Melbourne.

Monsanto (n.d.). A guide to dryland cotton. Wee Waa, NSW & Dalby, QLD. Available at: http://www.csd.net.au/system/resources/files/000/000/051/original/A_Guide_to_Dryland_Cotton.pdf?1475037444 Accessed 10 Jan 2019.

Palisade (2018). @RISK, Decision Tools Suite 7.6. Palisade Corporation, Palisade Decision Tools, Ithaca, NY. Available at: https://www.palisade.com.

PayScale (2019). PayScale Salary Survey. Seattle, WA 98134. Available at: https://www.payscale.com/my/survey/job.

Powell J and Scott F (2011). A Representative Irrigated Farming System in the Lower Namoi Valley of NSW: An Economic Analysis. Industry & Investment NSW, Narrabri. Available at: http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0003/377346/ERR-46.pdf Accessed 5 Dec 2018.