Australasian Agribusiness Perspectives – 2015
Paper 108
ISSN: 1442-6951

Are we @Risking too much?[1]

Bill Malcolm[1] and Alex Sinnett[2]

---

[1] University of Melbourne and Department of Environment and Primary Industries, Victoria
[2.] Department of Environment and Primary Industries, Victoria

1. Introduction

Managing farm risk is a task as old as farming. The aim of farm management analysis and planning, whether for research or decisions in practice, is to try and anticipate the shape of things to come. The brutal fact is that when it comes to the knowing about the future *we simply do not know* (Bernstein 1994). All we can do is have expectations and judgments about the likely size and shape of important components of things to come. This makes a role of the farm management analyst one of imagining a wide range of futures in a rigorous way, and pointing out the possibilities. Farm management analysis and planning is a way of preparing for and implementing the timeless adage of risk management: *act now as if the future we expect was already here*.

The farming game can be described as an agrarian game of chance where the odds of some of the possible happenings to the business are known and where the odds of a good many possible happenings to the business are not known or even knowable – the things that baffle probability. What to do to succeed in a game of chance where the odds of significant events and subsequent outcomes are unknown? Formal understanding of risk concepts such as probability and utility, and the distinction between risky events and uncertain events, is relatively modern. Techniques of incorporating formally the quantitative analysis of risk concepts in economic research analyses of farm decisions and choices of farmers is even more recent, culminating in probabilistic simulation methods as epitomized by the @Risk program (Palisade 2013).

The modern risk analysis tools using methods worked out over the past several centuries and culminating in the computerized probability budgeting techniques that enable risk-return analysis, ought to become the only way to analyse and plan for farm management decision-making. However, to act now as if the expected future has already arrived requires sound and sophisticated understanding of the assumptions and meaning of the probabilistic budgeting techniques and the information they do, and do not, provide.

Analysing the risks of farming for planning and decision-making information involves a different perspective and process to that of managing farming. Indeed, analysing the risks of farming formally to better inform decisions can lead to over-complicating the practical decision-situation of farmers. Farmers run their farms within a range of natural and economics conditions and combinations of those conditions; they get on with it knowing their systems deeply and knowing much about the reasonable range of natural and economic and financial situations they are likely to have to deal with. Analysts, working in the realm of imagination, are able to consider a wide range of possible eventualities, all the imaginable farming possibilities, including rare events with potentially big consequences. In practice the realm of possibilities covered by formal analysis may well exceed those considered by farmers as possibilities before they happen and become part of the farmer's experience. Though, when surprising things happen, they deal with them. As often happens when new technology becomes available, use can overtake understanding. Sometimes this does not matter: if the technology works, whether we know a lot about how and

---

[1] With grateful acknowledgment for title and inspiration for content from the much-cited 'Are we risking too much? Perspectives on risk in farm modelling' by Pannell D, Malcolm B and Kingwell R (2000), Agricultural Economics, 23: 69-78. An earlier version was presented as a contributed paper at the 59th AARES Annual Conference, Rotorua, New Zealand, February 10-13, 2015.

why it works may be neither here nor there. In other situations, such as undertaking research analysing a decision about farm choices and the implication of risk, where the output of applying the risk analysis technology is based quite directly on the input to the technology from the analyst, understanding well the explicit and implicit assumptions underlying the analysis is critically important. It is in this context that implications of the growing use of probabilistic simulation tools in farm economics research is worth contemplating. In particular, some of the traps for users using the powerful risk modelling methods of analysis in farm economics analyses are worth pondering, whether for research purposes or for practical decision-making.

By way of additional background to the discussion that follows, it is worth noting two telling observations from the past about the farm management profession in Australia. Almost 50 years ago, Keith Campbell (1957) observed that a major characteristic of farm management work in Australia up to that time was that it 'lacked analytical orientation' (p.27). Two decades later, Warren Musgrave (1976) argued that the exciting promise of the single period optimization methods for farm management analysis developed in the 1950s and 1960s had produced little, notwithstanding some 'unthinking technicians' (p.139).

As it is, practitioners of farm management analysis such as agricultural consultants are often coming at a farm problem from a body of disciplinary agricultural science knowledge, broadened to the whole farm system by practical experience, but without a production economic framework within which to think: they are not operating within the farm management economic paradigm, despite this body of knowledge being well-established since the 1940s. As Wilfred Candler (1964) said people talk of the whole farm approach to farm management, as if there is some other way to do farm economic analysis!

The farm management economics model has farm economics as the core discipline of farm management analysis (McConnell and Dillon 1994, Malcolm 2004), with farm economists applying the whole farm approach, drawing on principles such as diminishing marginal returns and marginality, equi-marginal returns, opportunity cost, taking into account time, dynamics and risk, whilst looking forwards, and at the same time fully understanding the folly of partial analyses centred on average technical ratios and backward-looking accounting-oriented performance analysis and average cost of production analyses. For agricultural analysts who are already attempting to understand risky farm systems and answering questions about risky farm systems *without* farm economics as the core discipline, what does the advent of computer tools for sophisticated risk analysis mean? In the main it may well mean there is one further element of farm management analysis for them to get wrong, if analysts persist with approaches to their task mindless, rather than mindful, of farm economics and risk analysis.

2. Farm Risk

Running a business, or simply living, means making decisions now in the hope some things that we want to happen will happen, and some things we do not want to happen will not happen. In making these decisions and trying to shape our future, there is not much that we can be certain about. This is risk. Risk refers to the chance of things happening, or not happening. In farm management economics, to put a measure on risk it is common to define it as the volatility over time of key elements of the farm system such as crop yields, prices, interest rates, rainfall, pasture growth, annual profit, annual net cash flow and so on. Volatility is defined as the variability around the average that elements such as these can take in any year over a run of years, as an approximation of the volatility these elements may take over the run of years that is the relevant planning period.

Risk matters because it has consequences. The consequences of risk ultimately determine whether the farm owners achieve their goals or not. A farm buyer, like any investor, has to make decisions and take actions in the present, in the anticipation that particular happenings will occur in future which, taken together, deliver the goals the farm owner is striving to achieve. To make good decisions now to create good chances of achieving the aimed-for future circumstances, decision- makers use information, intuition, judgments.

We simply do not know the future rainfall, yields, stocking rates, prices, interest rates the business will encounter. What has happened in the past is one guide to the rain, yields, prices and interest rates that can happen, simply because they have happened. What has happened does not indicate everything that could happen. Thinking about the future requires imagining what could happen, using information to weigh up the likelihood of the things that can be imagined, actually happening. While the past is a guide to the types of rain, yields, stocking rates, prices, interest rates that have happened, and, because the range of many conditions in natural and economic environments in the near future planning period are not going to be greatly different to the past, it can be presumed that the natural and economic forces that created the past rain, yields, stocking rates, prices and interest rates, will prevail to a large extent in the near future. Even if information from the past gives the size of many of the things that could happen in the near future planning period, when these things will occur remains unknown. Focussing on the relevant planning period, and remembering that far enough out into the future there is no relevant planning period, the decision-maker needs to imagine and analyse what it might mean for their business 'if this happens' and 'if that happens', and, importantly, 'if these several things happen at the same time'.

Using computer-based risk analysis methods requires the analyst to estimate probability distributions for the variables of interest, such as seasonal rainfall; prices of output; performance determinants of output like crop, pasture and animal yields, reproduction performance; and key costs such as feed costs and interest rates. Choosing the form of the distribution to use is, like farm management analysis itself, a mix of science and art. On this note, Vose (2008), an authority on choosing distributions, reminds analysts to test themselves that they are not simply using a normal distribution because of a lack of imagination! Regardless and whatever distribution is considered to best fit data and expectations, the degree of correlation between related events needs to be considered and defined if it will exist. Further, for some probabilistic parameters, truncating tails of distributions whose events take us into and beyond worlds of the absurd, helps pass the tests of common sense which should be routinely applied to farm management analyses.

It is usual and useful to segment the total risks of farming into categories: business risk and financial risk are the common classifications, though there is nowadays a case for adding a third category, institutional risk. Whilst it is analytically useful to categorize risks by their nature, the effect on achieving goals or not comes from the combined and inter-related consequences of the playing out of all the risky events the business encounters. Briefly, and broadly, business risk refers to yields and price risk, the risk of pest and disease outbreaks, drought and flood. Financial risk refers to the risk a business has to deal with that is related to the amount of debt the business has to service, i.e. pay interest on and repay borrowed capital. More precisely, in farming, financial risk is about the proportions of debt and equity in the total capital (total assets) of a farm business and the rate of earning of the total assets relative to the cost of the debt. The third risk, institutional risk, refers to changes beyond the farm gate in public policies and in the value chain.

The reason for separating business risk and financial risk is that they have different consequences for the farm business and require different actions to manage them. Even more important, the farmer has different levels of control over the two broad types of risk. The farmer has some control over the equity and debt structure of a business, at least to the extent of making initial decisions about financing the business and making subsequent changes to financing arrangements. Managing business risk by managing for yield and price volatility involves decisions and actions too, albeit of a different nature. The whole farm approach to analysing farm businesses, and the whole economy approach to understanding the role and performance of farm businesses, highlights that the risks that make up these three categories of risk effecting farming, affect each other. Most obviously, low yields or low prices for output will mean low farm net cash flow available to service debt. Some of the volatility of annual net profit or annual net cash flow for instance comes from volatility of yield and prices, but some comes from having to service debt, regardless of what may be happening with the weather and in the markets. Distinguished volatility of outcomes related to financing the business from volatility that comes from yields and price fluctuations is critically useful.

Generally farms are set up to perform 'well enough' under a reasonable range of values of the key risk variables. Levels of these variables beyond this range cause more than usual difficulties or create more than usual opportunities. The rare events with large consequences warrant particular attention. The cumulative effects of rare sequential runs and combinations of events cause most challenges for owners and managers and their businesses. Running farm models numerous times, with the full range of risky events included in the distributions used, captures the effects of rare combinations of events occur and their consequences.

In analysing and understanding risks to farm systems, events also contribute to the outcomes of farm production processes but we cannot estimate probabilities of these events occurring. The rare events with big consequences, or combinations of rare events with big consequences, are one relevant focus. There are also uncertain factors, or uncertainties, to which we cannot attach subjective probabilities - events or combinations of events about which we have no idea about the probabilities of them occurring.

3. Defying the odds: the things that baffle probability?

Whilst incorporating risk into farm budgets using probability distributions for key risky variables captures risk, what about uncertainty? How are uncertain events considered in assessing the implications of risk and uncertainty for farm businesses? In a sense, the effects of events which have occurred in the past and which were uncertainties at the time they occurred, and which affected rain, yields, stocking rates, prices, costs experienced in the past, are at later dates known about and information about them occurring are able to be incorporated in estimates of possible future probability distributions of rain, yields, stocking rates, prices, costs, provided the subjective estimates of future distributions are being based to some extent on knowledge of past occurrences. We may not know why prices or yields reached an all-time low or high in the recent past, but having happened, it becomes a known possibility from the past and this information can influence subjective judgments about future price and yield distributions to include in analyses. Regardless, by definition estimated probability distributions of future yields and prices have nothing to say about what other unknown and uncertain events might do to the yields and prices and the fortunes of the business. Estimated distributions of future outcomes of running a farm business need to be interpreted in full recognition of the fact that the system needs capacity to deal with unknowns and uncertainties beyond that indicated by how the future operation of the system looks with risk incorporated in the analysis. Being able to produce distributions of outcomes and put odds on the risky bet involved still leaves Mishan's Horse and Rabbit Stew analogy about benefit cost analysis (Mishan 1976). In practice, what we know about risk may be swamped by what we know nothing about, the uncertainty. It may be that, excited by the elegance and apparent profundity of incorporating probability distributions, generating distributions of outcomes and estimating contributions to total variance, analysts end up having more confidence in their results than is justified, because there remains so much about the situation that, as Bernstein (1998) says, 'we simply do not know'.

4. What measure of risk?

Risk is measured as volatility of an important outcome such as annual operating profit, annual net cash flow or annual growth in wealth. The measures of variance used could be the variance (v), the standard deviation (SD), the average deviation, or the coefficient of variance (CV). Commonly, standard deviation and coefficient of variance are used. The standard deviation gives an absolute number as the size of the volatility around the mean and the coefficient of variance give the volatility around the mean as a percentage. When the same amount of capital is involved in the options being compared then any of the measures of variance can be compared to assess the volatility of the performance of the options. When different options being compared have different amounts of capital involved, neither of the absolute and relative measures of volatility, the SD and CV, tell the full story. For example, an investment of $10m with a mean annual profit of $1m and a SD of $0.5m has a CV of annual profit of 50%. Similarly, an investment of $5m and a mean annual profit of $0.5m and a SD of $0.25m has a CV of 50%. But $1m +/- $500,000 in 2/3 of cases is not likely to be considered the same in risk terms as $0.5m+/- $250,000 in 2/3 of cases. The amount of capital at risk matters and needs to be to the fore amongst the information coming out of an analysis of risky farm investment. The box and whisker diagram, overlay of full distributions diagram, and risk:return frontier diagrams, can provide more complete pictures of the risk story than a single measure such as the SD or CV.

Interpreting the risk information from a farm analysis requires looking at the question from a number of angles. Standard SD and CV measures do not put the focus on the events in the tails of distributions. The question needs to be explicitly asked: what might it mean for managing the farm business if a rare event or, more important, a combination of rare events occurs and the impacts are potentially very significance? This is where discrete scenario analysis comes in. Define the circumstances and explore the implications.

Further, as with any farm analysis, 'the answer' is not in the numbers: the numbers partly inform the answer and the actions. Alongside the numbers that have been estimated for a particular situation or query sits a range of non-quantitative information about the question at hand; information about the question that, though hard to quantify, will likely be as important or more important than the numbers about extra profit, cash, growth and risk. Measure what you can and think hard about what you cannot measure is the rule.

5. Financial risk analyses is needed as well as economic risk analysis

We worked through Spring and Winter
The Summer and the Fall
But the Mortgage worked the hardest
And the steadiest of us all
It worked on nights and Sundays
It worked each holiday
Settled down among us
And it never went away

(Ry Cooder: 'Taxes on the farmer feeds us all')

Often, analyses are done only considering business risk, leaving out financial risk, which is a major part of any farm risk story. The output of a risk analysis of a farm investment could be in terms of a distribution of net present values from a large number of runs of the life of the investment. In this case, what does a distribution of net present values for outcomes of an investment mean in terms of business and financial risk? Usually the discounted cash flow analysis of a farm benefit cost analysis is done using the implicit assumption that the funds can be borrowed and lent at the market rate of interest, and the investor can manipulate the stream of cash flow to satisfy their needs as set by their preferences for consumption and saving through time. In this situation, a distribution derived by risk analysis of the net present values of a farm investment is a distribution of the additions to wealth from the investment above the wealth that could be achieved if the capital involved was instead invested at the discount rate or opportunity cost of the capital. When debt and debt servicing of the investment are not incorporated explicitly in the net cash flow analysis, the distribution of NPVs represents the business risk inherent in the proposal. The variance of the distribution is a measure of the volatility of outcomes that is caused by the volatility of prices and yields, i.e. business risk. The only sense in which such an analysis could be interpreted as incorporating financial considerations as well as business risk would be if it was the case that the investment was financed by the investor borrowing all the capital at the discount rate and repaying it through the life of the investment as cash surpluses occurred.

Alternatively, the output of a risk analysis of a farm investment could be in terms of a distribution of possible annual operating profits over the life of the investment. At the level of operating profit, effects of financing arrangements are not considered. Such a distribution captures the business risk of the proposal. More typically, analysis of financial risk is also required, where the series of annual net cash flows after the debt servicing associated with specific borrowings and debt servicing and volatility of interest rates. When this is done, the distribution of annual net cash flows after debt servicing represents the whole risk of the investment, incorporating both business and financial risk. Usefully, when risk analysis is done this way to include the effects of financing arrangements, the way financial risk exacerbates the business risk of an investment proposal is highlighted. While the business risk facing alternative farm investments may often be similar, e.g. the same or similar exposure to rainfall, yield, price risk for different farm activities, financial risk will vary depending on the quantity of capital required for each investment and the relative proportions of this that come from equity or borrowings, and the terms of the financing.

An example of total risk of the business, defined as business risk plus financial risk, and the size of the relative contributions of the two components identified, is shown in Figures 1 and 2 below. The distribution of annual operating profit in Figure 1 represents business risk. The coefficient of variation is 43%. The distribution of annual net cash flow after interest and principal for an example farm business before tax is shown in Figure 2. The coefficient of variation with financial risk added has increased from 43% to 105%. The effect of increasing gearing on total risk of the business is evident. As debt increases, the volatility of net cash flow after principal and interest increases markedly. Financial risk exacerbates the business risk faced by operators of farm businesses.

Figure 1 Distribution of Operating Profit (Business Risk)

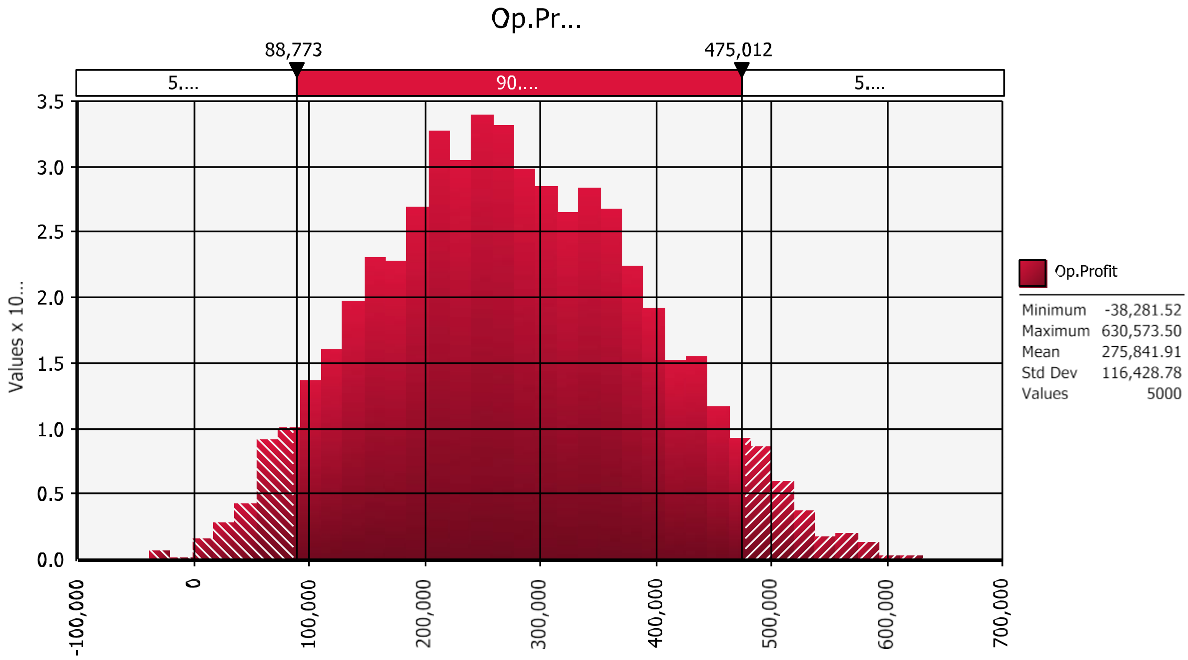
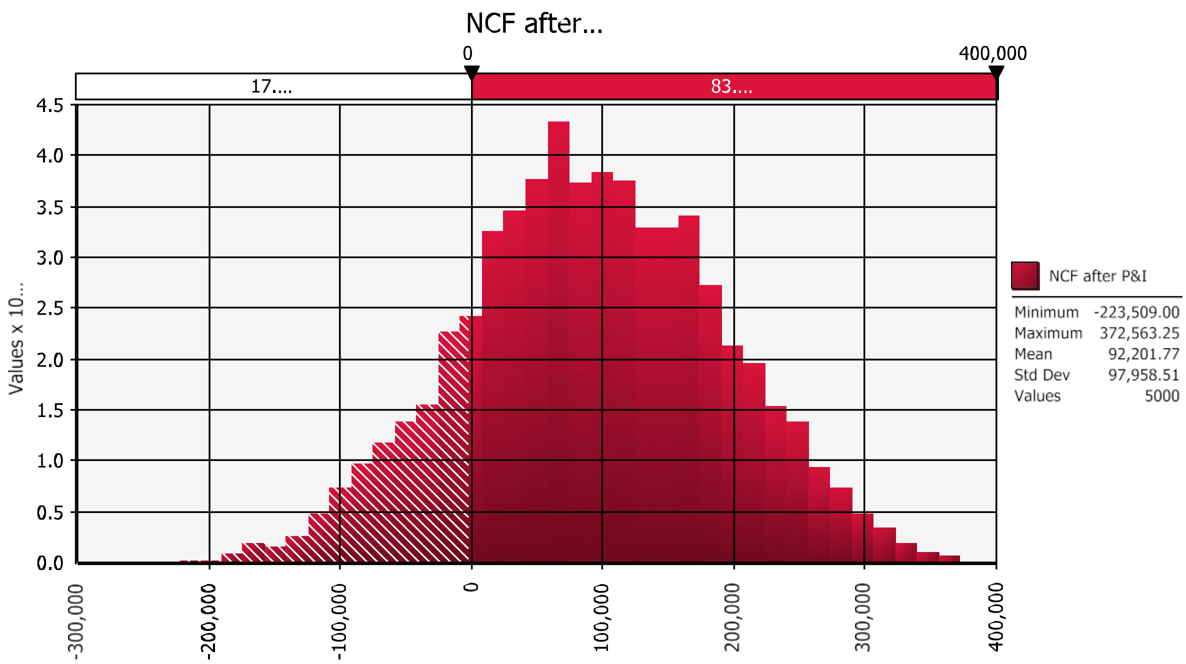
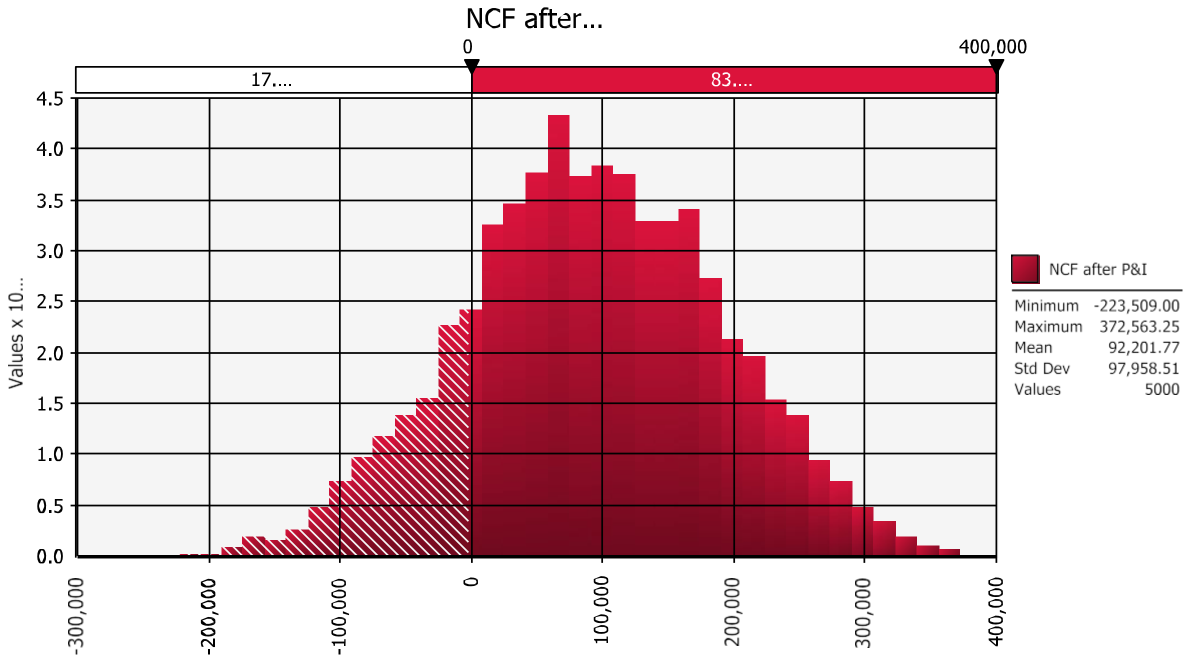


Figure 2 Net Cash Flow after Principal and Interest (Business and Financial Risk)



In Figure 2 the annual net cash flows are after principal and interest but before tax. These are expected to range from a loss of some $200,000 through to a gain of around $400,000, with most likely net cash flow of $56,000. In any year, there is an 83% chance that the NCF after servicing debt will be positive, and a 17% chance the business will not be able to service debt - roughly a 4/1 on bet that the business will be able to service the debt in any year.



6. Incorporating some dynamic effects of the farm system when modelling the performance of the farm over time and under risk

Sometimes a steady state whole farm budget is constructed and some price and yield risk is incorporated; the budget is run many times for different combinations of risky variables, and a probability distribution of outcomes is generated. If that is all that is done, such an approach assumes away the reality that as things change the operator of the farm will change the way the farm is run. A farmer will manage their farm system each year through the years of a planning period in response to the particular prices, costs, weather circumstances that prevail at the time and those that are anticipated during the current and near term production period. This will involve them taking a range of strategic and tactical steps, with each action effecting how parts of the system perform subsequently.

When analysing a farm option over a medium term planning horizon, where dynamics are important, the implications of what is done in one time period on subsequent time periods has to be taken into account, somehow. This is why dynamic programming was developed. The 'curse of dimensionality' involved in trying to represent the many future possible combinations and permutations of events and decisions and actions and consequences that result from an initial state of affairs means some pragmatic ways are needed to simulate the operation of a farm over time under changing and risky conditions. A practical approach to modelling the operation of a farm system through time is to capture in a proxy way, some of the costs and benefits that will result from the dynamic changes that will occur through the planning period in response to changes in prices and costs and rainfall. For example, suppose we have constructed a model of a grazing business with probabilistic supplies of pasture dry matter represented in each year/season/month the model is run. The performance of the business will be affected by shortages of feed relative to the demand for it by livestock and the cost of feed shortages will not be avoided whatever is done, though some ways of managing feed shortages will be less costly than others. In the steady state or most common year farm model run over a run of years with probabilistic variables, in a year of the run of years when feed supply is short, the cost of purchasing additional ME to meet livestock demand can be used as proxy for all the various opportunities that the operator of the farm will exploit in such a year to manage and minimize the added cost of that years feed deficit. What the farmer will do in practice – sell stock and buy back, or agist stock, or feed through - does not matter for the purposes of the analysis, provided it is reasonable to consider that the consequences of the options to meet the feed shortage will be similar in whole farm economic and financial terms and other ways too. Allowing for the cost of feed shortages in some way is a better way to handle the dynamics of a grazing system than to ignore the fact that under some circumstances changes to the steady state farm activities will be implemented and incur costs, and instead running the model over time as if costs and benefits and effects on farm performance of responding to changed circumstances had never incurred.

Capturing dynamics simply and practically when modelling crop systems through time under risky prices and yields can be a more complex challenge than the grazing situation where feed supply is main source of variability, and the gross margin per DSE of feed demand will not be greatly different regardless of animal activity. With cropping, crop yields in one year are a function of the growing conditions and crop or pasture type, yields and nutrition, weed and disease status of the previous year. This is where the curse of dimensionality can start to run riot. First, agronomic and economic sound crop sequences can be mapped out over the life of the sequence according to land class on the farm in question, incorporating significant complementary year on year effects on yield through the sequence, with yield in any year a function of that year's rainfall. The costs of nutritional, weed and disease control inputs are met in the model each year for crop and pasture based on the expected yields. These input costs may sometimes be proxies for alternative steps the farmer may take to achieve similarly satisfactory nutrition, weed and disease conditions.

If a substantial risky event such as a serious drought or disease or weed event occurs at a threshold level that would mean in practice the planned sequence of crop activities would be discontinued, a new sequence that is designed to follow on from the defined serious risk event is commenced in the following year and proceeds for the area of land the remainder of the planning period. The performance of the activities in the changed sequence is adjusted to the extent required by the nature and extent of the cause of the change in the initial sequence. This approach requires that a small number of discrete circumstances (thresholds) are defined that would necessitate changing the activity sequence initially envisaged, and the alternative sequence and performance of the activities in it that would be implemented is defined and available in the model. For example suppose we are modelling a crop farm with a crop and pasture sequence running for 8 years, with the yields a function of the growing season rainfall based on a distribution akin to the growing season rainfall over the past 60 years. The 1982 drought occurring again means planned crops are not grown or yield little. The subsequent year is high rainfall so the initial intended crop sequence is diverted onto a revised crop sequence where, in effect, a new sequence commences which reflects what the farmer response would be following a year when little crop was grown because of a serious drought.

A practical way of tackling dynamics in farm analysis is to define discrete situations and investigate 'what if?' Information from discrete scenarios, such as various combinations of most likely, poor, good levels, and how the farm would be run in those circumstances, with likelihoods attached, is of great value to decision-makers. Discrete well-thought out scenarios are a relatively simple and highly effective approach.

7. Putting probabilities on variables and coefficients that are not stochastic, but our knowledge about the value to use to represent them in the system is incomplete

Building computer models of farm systems for farm analysis involves one way or another estimating the main input-output relationships that make up major parts of the whole farm production function. In such budgets, enough is known about some relationships to be able to form a good judgment about their dimensions. In other cases, little may be known. For example, in converting feed to milk, much is unknown about the associative effects that divert marginal additions of metabolizable energy to various uses in the cows body that are not identifiably to do with maintenance, body weight or milk production. This effect can be (i) ignored, or (ii) given a single arbitrary value or (iii) given a probability distribution around possible values. The shape of the distribution allocated will depend on what is known about the phenomenon. If there is no reason to have a distribution where some values are more likely than others, a uniform distribution can be used, i.e. within this range any of these possible values are equally likely.

8. Over-modelling?

This question has wider focus than just risk modelling. Here the focus is on how much detail is required when representing different parts of a farm system in a farm model. The answer to the question about 'how much detail?' is, like all answers in farm economics, 'it depends'. It depends on the question and the purpose of the exercise. A useful rule of operation could be to go into as much detail as it necessary to answer the question with confident conviction. There is a difference between the appropriate degree of detail in modelling agricultural systems for the purposes of scientific research and that required in modelling a farm system for the purpose of informing management decision-making. And, there is a difference between the detail appropriate for modelling a farm system for economic research and that for scientific research or for management decision making. Oft-times analysts doing farm economic analysis start with, or have at hand, a generic technical model of part of a farm system designed for the purposes of scientific research, e.g. Grassgro, Dairy Mod. The output of the detailed scientific model is used as input to an often much less detailed farm economic model. However this is sometimes a trap for the unwary. Usually, calibrating the scientific system model to the farm and question at hand involves a great deal of time and effort, and always with some relatively crude 'adjustments' thrown in to make it fit reasonably. Depending on the question, sometimes the lower-level detail in the technical model is unnecessary: higher order technical values derived more simply and efficiently could be just as valuable to the overall economic analysis and results as such values derived from lower-level technical detail. For example, animal feed demand can be estimated starting inside the animals gut and working upwards and outwards to the whole farm. Or, animal feed demand can be estimated at the level of established energy requirements for a livestock unit, such as Metabolizable Energy required per Dry Sheep Equivalent or per Livestock Month, and scaled up for the animal and its physiological state to flock and herd requirements. The implied feed supply can be derived too. The degree of disciplinary depth and the balance of disciplinary breadth to answer the question in rigorous and convincing manner, correspondingly proportionate to the resources available, is the rule.

9. Interpreting probability distributions of outcomes

The risk budgeting programs also make it easy to represent probability distributions of outcomes in various forms – probability distribution functions, cumulative distribution functions, and box and whisker diagrams – and contribution to variance using tornedo graphs, spider diagrams. Often, when distributions of annual profit or net cash flow or wealth have been created by running the farm simulation many times with risky key variables, the outputs in the form of distributions of outcomes are interpreted as being 'best' or whatever, without much appreciation of what is being implicitly assumed for this conclusion to be the correct conclusion for the case at hand. Making sense of these various outputs requires care and insight and awareness of what may be being implicitly assumed under various interpretations. The results of running a farm budget many times with probabilistic inputs of key risk variable can be presented in a number of ways. Alternative farm plans can be evaluated in terms of risk and return, using the concepts of mean-variance frontiers and stochastic dominance, as set out in Anderson *et al* (1977), Makeham and Malcolm (1981), Boehlje and Eidman (1984), King and Robson (1984), McConnell and Dillon (1994), Hardaker, Huirne *et al* (2004), and stochastic efficiency analysis, as explained in Hardaker, Huirne *et al* (2004) and Hardaker, Richardson *et al* (2004).

If results of risk analysis in farm management analysis for research or for farm decision-making are presented as a mean or expected value and a decision is based on the mean or expected value, the implicit assumption is that the decision maker is indifferent to the risk about the size and frequency and timing of the individual outcomes that combine to form the mean or expected value. Or, if the results are presented as CDFs and first degree stochastic dominance is evident (one CDF continuously clear to the right of the others), the interpretation that this stochastically dominant option is preferable has the quite reasonable implicit assumption that the decision maker prefers more to less. If however the CDF's cross over, or have different range of outcomes, called second degree stochastic dominance, then the attitude to risk of the decision maker matters in determining which option is best. Stochastic Efficiency with Respect to a Function (SERF) analysis (Hardaker, Huirne et al 2004, Hardaker, Richardson et al 2004), for some defined attitudes to risk of a decision-maker, can provide added information for interpreting the results of a risk analysis, subject to the insights of Pannell *et al* (2000) that the particular decision-makers' view about the risk of a potential change to a farm system may or may not matter as much as other aspects of the situation, such as change in technology; or subject to McInerney's (1979) observation that in practice more and more elaborate pre- decision analysis cannot improve decisions or outcomes as much as identifying a good plan and getting on with it and making it work.

10. Conclusion: Are we @Risking too much?

Are we @Risking too much? No! Risk budgeting using the computerized probabilistic budgeting tools available is a great advance in farm analysis. We may not know all the odds of all the happenings – we simply do not know and we have to deal with uncertainty - but farmers running their businesses successfully and achieving many of their goals over runs of years, decades and generations demonstrate that they do know how to weigh up the risks and the risks versus returns. They farm and manage risk mindfully. The same applies to using risk modelling methods to analyse farm systems and the decision choices of farmers, whether done for research or for advisory purposes. Modelling the behaviour of managers of farm systems, and the operation of the farm systems, over time, incorporating dynamics, and accounting for distributions of risky variables using a probability budgeting tool, opens up the possibility to better represent some of the future volatility around farm performance, and provide more useful information on which to draw conclusions, than using the single value, static budgeting methods of history. Mindful @Risking in farm management analysis for research or advice is the way to go.

11. References

Anderson JR, Dillon JL and Hardaker JB, (1977), *Agricultural Decision Analysis*, Iowa State University Press, Ames, Iowa, USA.

Bernstein, PL, (1998), *Against the Gods: The Remarkable Story of Risk*, John Wiley and Sons, New York, USA.

Boehlje MD and Eidman, VR, (1984), *Farm Management*, John Wiley and Sons, New York, USA.

Campbell KO, (1957), Contemporary agricultural economics in Australia, Review of Marketing and Agricultural Economics, 25(1-2), 24-33.

Candler W, (1964), University training in farm management, Discussion Paper No. 27, Department of Agricultural Economics and Farm Management, Massey University, NZ.

Hardaker JB, Huirne RBM, Anderson JR and Lien G, (2004), *Coping with Risk in Agriculture*, 2nd ed., CAB International Publishing, Cambridge, Massachusetts, USA.

Hardaker JB, Richardson JW, Lien G and Schumann KD, (2004), 'Stochastic efficiency analysis with risk aversion bounds: a simplified approach', Australian Journal of Agricultural and Resource Economics', 40(2), 253-270.

King PK and Robison LJ, (1984), 'Risk efficiency models', in PJ Barry (ed), *Risk Management in Agriculture*, Iowa State University Press, Ames, Iowa. USA.

Makeham JP and Malcolm B, (1981), *The Farming Game*, Gill Publications, Armidale, NSW.

Malcolm B, (2004), 'Where's the Economics?' The core discipline of farm management analysis has gone missing', Australian Journal of Agricultural and Resource Economics: 48(3), 395-417.

McConnell D and Dillon JL, (1994), *Farm Management for Asia: A Systems Approach*, Food and Agriculture Organization, Rome.

McInerney J.P, (1979), 'Review of Agricultural Decision Analysis', by J.R.Anderson, J.L.Dillon, and J.B.Hardaker, Iowa University Press, Iowa, 1977, Journal of Agricultural Economics 30, 80-82.

Mishan EJ, (1976), *Cost-benefit Analysis*, Allen and Unwin.

Musgrave W, (1976), 'Problems of change in Australian agricultural economics', Australian Journal of Agricultural Economics, 20(3) 133-143

Palisade, (2013), @RISK – Risk Analysis Add-in for Microsoft Excel version 6.1.2. Palisade Corporation: Newfield, New York, USA.

Pannell D, Malcolm B and Kingwell R, (2000), 'Are we risking too much? Perspectives on risk in farm modelling', Agricultural Economics, 23, 69-78.

Vose D, (2008), *Risk Analysis: A Quantitative Guide*, John Wiley and Sons, New York, USA.,