Investigating Changes in Sheep Production using Criteria of Profit, Wealth, Cash and Risk to Inform Decisions by Researchers and Farmers

by

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1. Introduction

In the next decade sheep farmers will probably experience rising real costs of key inputs such as labour, fertilizer, fuel, capital equipment. Rising real labour costs will follow from growth in the economy causing living standards to rise in general, while growth in the non-agricultural sectors of the economy, such as the services sector, will contribute to increases in the capacity of the non-agricultural economy to compete labour away from agriculture. Any trend for oil prices to rise in real terms will contribute to real fertilizer and fuel costs increasing, along with freight and transport costs. A range of insurances probably will continue a trend to increase in real terms, as the risk of adverse natural events increases and is increasingly reflected in premiums. At the same time, real prices received for sheep meat and wool will fluctuate, probably around the long term declining trend. Put together, real costs for sheep farmers will likely rise, real prices will not likely rise on any continued basis, and sheep farmers net returns will continue to be squeezed – unless they do something differently. Continuing with business as usual for the next decade is an option that brings with it declining annual net incomes and running down current wealth. That is, not innovating, continuing with the current, would be likely make sheep producers poorer by the end of the decade.

All of the above would be true even if the sheep farmer had the same goals and objectives for the next decade as applied for the past, but who is in the position of unchanging goals? Farm family situations change: children grow up; young adults set out on their own journey; young farmers seek to build their businesses; older farmers slow down. Add to the inevitable cost-price squeeze imperatives to build wealth for retirement and build the business to support offspring coming into the business, and the scene is set for a decade of change. This raises questions: which change? How to judge change? How much change can the business and the people in it bear? What criteria to use to judge if a change is likely to be a good move or not? These questions are explored in the rest of this paper. Judging whether a change to the way a sheep business currently operates is worth doing or not involves forming a view about how well the change will help to meet the goals the owners of the business are striving to meet over the relevant future planning period. Thus the starting point is to define the goals: what do the farm family want to achieve over the next 5,8,10 years, where do they want to be? Having defined this, the next question is ‘How might we get there?, and, of the choices of means of achieving the goals, which way of doing it is likely to be the best bet? The farm management economic methods of Lamb Directions helps inform answers to these questions.

For sheep farmers to have choices about which innovations to consider, and to adopt and implement, research has to be done. The stage prior to change on farm is the research and development effort. Research and development done now has the potential to increase the productivity and profit of farms in the lamb industry, and to improve the effect this industry has on the environment for the ensuing thirty years. For researchers to make informed choices about which areas to research, of the many possible innovations that are available, and which questions to investigate, pre-experimental analysis of farm systems is done. Pre-experimental analysis of farm systems is a first look at potential changes to farm systems to identify which ones look to have big payoffs and which ones look less attractive. This information can help guide researchers about where to focus their efforts.

In this paper is presented both pre-experimental modelling to inform research efforts and farm case study analysis to inform farmer decisions about changes. First is a summary of some pre-experimental economic modelling which has been done to establish which changes to lamb farm systems generate the greatest improvements in farm profit and risk. This analysis is a useful precursor to scientific R&D because it identifies what sort of changes are most likely to be adopted by lamb farm operators. Without adoption, the benefits of R&D will not be realised. In the second part of this paper the focus moves on from analysis of lamb farm systems to inform research decisions to analysis of a case study farm to provide information to inform farmer decisions about adopting changes to their farm system.

2. Pre-experimental analysis of potential changes in prime lamb production to inform research decisions

Not all changes to farm systems are equally attractive. The aim of pre-experimental analysis of potential changes to sheep production systems is to 'put some numbers' on the likely size of the benefits of some obvious potential sources of improvement in productivity and profitability, thereby putting the magnitude of gains from these changes in perspective and informing decisions about research priorities.

A whole-farm economic model has been used to analyse the likely effects on farm profit and risk of some changes to a prime lamb production system. The 15 scenarios of changes to the prime lamb production system investigated are:

- Base Case
- Mating ewes at 12 months of age, with unchanged prices and with changed prices
- Reduced flock health costs
- Increased lamb growth rate and reduced age at sale
- Increased lamb feed efficiency and increased turn off
- Increased fleece weight
- Increased proportion of lambs reaching 50 kg sale weight

- Reduced ewe mortality
- Increased ewe longevity with average mortality and with reduced mortality
- Increased fleece weight and price wool
- Increased weaning rate with stocking rate maintained
- Increased stocking rate
- Increased ewe feed efficiency
- Increased ewe and lamb efficiency plus increased turn off
- Increased stocking rate and increased weaning rate

The model comprises a series of sub-models which represent the physical structure of the farm, the livestock system used, and the feed supply . The economic and financial performance of the farm is recorded over a 7 year planning period, using annual balance sheets, profit budgets and cash flow budgets. The pre-experimental analysis has the following characteristics:

- it is a 'first-look' analysis: changes to the farm system are evaluated in a partial sense (as if they are the only change being made)
- the effects of the change on the farm business are estimated for a single year once the change being investigated is fully operational (the steady state)
- the change in annual net profit (surplus) generated by each change is estimated as annual extra revenue minus annual extra costs, including extra feed and labour costs and the annual opportunity cost of extra capital invested
- the cost of changing the system to achieve the improved performance of the system (i.e. the development costs) are not counted in the first look analysis because precisely how the improved performance may be achieved has not yet been defined, i.e., the research has not been done.
- the estimated annual surplus (profit or cash) for each innovation represents an amount that would be available to cover the undefined extra annual costs that will be need to be incurred to achieve the changed state of affairs, and to add to the wealth of the farm owner.

The physical structure of the farm is represented by data which describes the amount of land, labour and capital used in production. The livestock system is defined by the number and type of animals in each of up to 17 livestock classes. The feed supply of the farm refers to the area and type of pastures used to provide energy to livestock. The analysis of the prime lamb case-study farm is conducted over a seven-year period. Each year is depicted as a fortnightly livestock calendar and feed budget. The livestock calendar tracks the number of animals in each livestock class throughout the year. It also records the revenues and costs associated with animal husbandry and livestock trading activities when they occur. The feed budget balances energy demanded by animals with energy supplied by the feed sources.

Fortnightly animal energy requirements are calculated in the model using equations originally designed and published in Freer *et al.* (2010). These calculations work on a daily basis and account for the most important sources of energy demand, namely liveweight change and gestation state. This data is aggregated to a fortnightly frequency. The summed product of the energy requirements of each class of sheep and the number of sheep in each class gives the whole-farm energy demand at a fortnightly frequency.

An estimate of the amount of energy supplied by the feed supply of the farm has been calculated using the SGS pasture model. These estimates are based on the actual climate of Hamilton over the period 1970 to 2010. Distributions of pasture growth rates were constructed for each fortnight to capture the variability in pasture growth which occurs from year to year. Pasture quality in each fortnight was found to vary little from one year to the next and so average values were used for these variables.

Energy demanded by livestock and energy supplied by pastures are balanced in annual feed budgets. If energy supply is less than energy demand in a particular fortnight the difference is provided in the form of purchased supplementary feed with an energy content of 12MJ ME/kg. No specific fodder conservation strategies are used in times of surplus however the calculations in the feed budget include the carryover of 67% of surplus pasture from one fortnight to the next.

The model uses stochastic simulation to represent risk. Specifically, all 'risky' variables in the model (variables such as yields and commodity prices which are subject to uncontrollable variation over time) are represented by probability distributions rather than single values. By sampling many times from the distributions of possible values that risky variables may take, distributions of expected farm profit (rather than single values) can be calculated using this model. The variation of the distribution of farm profit around the mean is a measure of risk.

The budgets which represent each year of operation of the farm are linked to allow dynamic effects of changes to the livestock system or the feed supply to be represented. For example, sowing a new pasture in year 2 alters the feed supply of the farm in year 2 and in all subsequent years. Similarly, the occurrence of risky events can also have dynamic effects. For example, a poor season of pasture growth in year 3 reduces the amount of feed available to livestock in both years 3 and 4 because less surplus feed is available to be carried over from spring of year 3 to summer of year 4.

2.1 The case-study farm

The case study farm represented is a 1,000 hectare lamb farm in south-west Victoria. The soils are 80% red loam clay, and 20% self-mulching black flats. The feed supply of the farm comprises 800 hectares of a high-performance ryegrass and clover pasture, and 200 hectares of a lucerne and plantain mix. The entire farm is fenced into 10-hectare paddocks and a rotational grazing system is used.

The livestock system of the farm consists of 10,000 first-cross ewes joined to Dorset rams to produce prime lambs at an average weaning rate of 130%. Ewes weigh 70-75kg each and are purchased at 10 months of age, joined at 12 months and retained for 5 years. The farm operator estimates the average stocking rate throughout the year is around 25 DSE.

All ewes are joined in a six-week period from mid-February until the end of March. Lambing occurs in early August and weaning occurs in mid-December. At weaning the composition of lambs by weight is typically 30% at 50kg, 50% at 40kg and 20% at 30kg. In a “bad” year (usually one in which there has been a prolonged period of very cold, wet weather) these proportions become 20% at 50kg, 50% at 40kg and 30% at 30kg.

Lambs are sold at 50kg liveweight so lambs that have reached this weight at the time of weaning are classed as “heavy” and sold. Those that have not reached 50kg by weaning are classed as “light” and are retained on the lucerne and plantain pasture over summer. Light lambs are sold in mid-March, by which time 70% have typically reached 50kg liveweight and the remaining 30% have reached 40kg. In a bad year, these proportions are 50% each.

The total energy demand of lambs does not change in the model from normal to bad years, despite the fact that the weighted average liveweight gain is less. This is because bad years refer to the occurrence of periods of very cold, wet weather which slows the growth of lambs. Such events are not captured in the ME required calculations because doing so requires data which does not currently exist, such as wind speed in sheltered areas, whether lambs are wet or dry, fleece weight and so on. Accordingly, lambs are assumed to require the same amount of energy in good and bad years, but the average liveweight of lambs sold is higher in good years than bad.

The energy balance of the farm has been calibrated from discussions with the operator of the case-study farm. Specifically, pasture growth figures have been adjusted so that very little supplementary feed is required in a normal year, and the most likely time of a feed shortage is in autumn. Given the variation in pasture growth from year to year, the average annual cost of supplementary feed is around $12,500 ($1.25 per ewe). This relatively low level of supplementary feeding is achieved despite the relatively high stocking rate by maintaining a high-quality feed supply and using a rotational grazing system.

2.2 The Changes to the Farm System that were Investigated

The changes considered in this analysis relate to altering the parameters of the farm system described above. However, the model is also sufficiently flexible to allow entirely different farm systems to be represented. This includes the possibility of adding a cropping enterprise, altering the timing of lambing, implementing a split joining system, or shifting from a first-cross to a merino-based ewe system.

Regardless of the type of change to the farm system considered, technical information describing the costs and benefits of the change are critical inputs. In each of the scenarios considered here, the benefits of the change are clear – for example, increasing the weaning rate results in more lambs being sold, and hence more livestock trading revenue. Some of the costs associated with the changes to the farm system are automatically captured in the model, but not necessarily all the costs of establishing the changed system are included. This is because, for some changes, the costs of achieving the change is not yet known.

For example, consider increasing weaning rate. If the weaning rate is increased, in the analysis the number of lambs on the farm increases, whole-farm annual energy demand increases, and hence the average supplementary feed cost increases. Also, with more lambs weaned and sold, total animal husbandry and sale costs increase. However, the costs of the changes that actually make the increased weaning rate possible are not implicitly included because the changes to achieve this goal are not explicitly defined, or the subject of research yet to be done. Suppose, to increase the weaning rate, costs may be incurred for known changes such as using extra labour to monitor sheep more closely, to purchase a supplement, to create a sheltered lambing area, or to obtain better lambing genetics, or some other change yet to be researched. These costs are unlikely to be zero so to establish whether the benefits of a given change to the farm system will exceed the total costs, as many extra costs as possible need to be identified and quantified.

In pre-experimental modelling such as this, *all* the extra costs of achieving the improved performance of the system, the extra costs of running the animal activity and the extra costs of changes to the farm to make the changed performance of the activity possible may not be known. Thus an estimate of net benefit from a change is made up of extra returns minus identified extra costs, but this net benefit may still have to also cover some undefined and uncounted costs associated with the change. Further, estimates of total surplus have been calculated here in the steady state – after the change has been fully implemented on the farm. Accordingly, the estimates do not include any development costs which may be incurred prior to reaching the steady state. Changes to farm systems which are not profitable in the long run are very unlikely to be adopted; hence the focus of a 'first look' analysis such as this one should be on the steady state.

More detail on exactly which costs have been included in this analysis is provided in the description of the scenarios presented in the Appendix. Once *all* costs associated with making these changes are taken into account, some of them may not increase profit at all. The reason some costs have not been counted in this analysis is because they are currently not known. Rather than simply inventing the value of the currently unknown and hence uncounted extra annual costs and then calculating the resulting net benefits, the method used here to evaluate changes to the farm system is to calculate the overall increase in net profit generated by each change, taking into account all the costs and benefits which can currently be counted. This increase in profit, or the 'total surplus' generated by each change represents the maximum that could be spent on any currently uncounted extra annual costs to make the change and to provide a satisfactory return on any extra capital used.

The aim of pre-experimental modelling to inform decisions about research investments is to rank the changes in production systems which are likely to be good bets for further research. For a given change to increase whole-farm profit, the surplus generated must be sufficient to meet any uncounted extra annual costs, and to provide a satisfactory return to any extra capital invested. The following schematic this clear:

Total surplus EQUALS Extra annual benefits that can be defined and are counted LESS Extra annual costs associated with the change, but not all such costs	⇔	**Total surplus** EQUALS The amount available to pay the uncounted extra annual costs of the change PLUS The required rate of return on extra capital

All else being equal, the greater total surplus is for a given change, the more likely it is that the change will increase farm profit. However, the magnitude of uncounted extra annual costs and the timing and magnitude of development costs will ultimately determine whether this is the case or not.

2.3 Results of pre-experimental sheep system modelling

A total of 15 changes to the farm system have been investigated in this research. The graph below contains a summary of the effects on farm profit and risk generated by each of these changes. In Appendix 1, a detailed description of each scenario is presented, including a discussion of the main determinants of the change in farm profit and risk. The measure of profit used in this analysis is net profit after interest and tax. This is also the annual contribution to equity. Using this variable means all the changes to the farm system can be compared on the same basis, because the opportunity cost of using extra capital is reflected in annual interest costs.

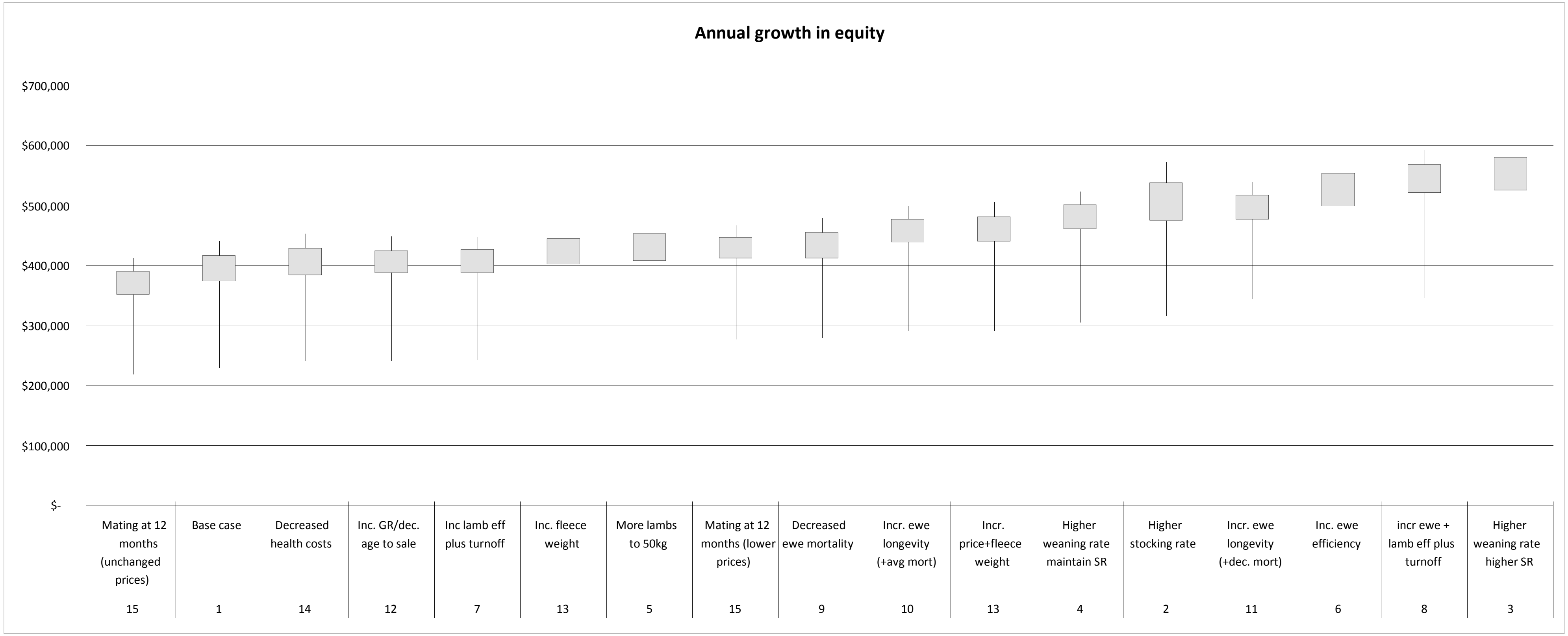

Figure 1. Boxplot and whisker plot indicating the 5th, 25th, 75th and 90th percentiles for annual growth in equity for each of the scenarios tested. The numbers below the scenario title on the x axis refer to the number of the scenario investigated.

In figure 1, the top and bottom of the boxes for each scenario represent the 25th and 75th percentiles, respectively. This means that on average, annual net profit will fall between these two values 50 per cent of the time, or one year out of every two. The top and bottom of the whiskers represent the 5th and 95th percentiles, respectively. Annual net profit will fall between these values nine years out of every ten.

The main determinants of profit and risk for this farm are the value of lamb sold, and the cost of replacement ewes. These two phenomenon are closely related. Accordingly, changes to the farm system which have the greatest effect on these two variables are expected to have the greatest effect on farm profit and risk.

This expectation is borne out in the results presented here – *increasing the stocking rate and the weaning rate causes the greatest increase in farm profit because these changes cause the greatest increase in the value of lambs sold. Scenarios where ewe mortality is decreased and ewe longevity is increased also cause relatively large increases in farm profit because this reduces the cost of replacement ewes, the largest single variable cost of this farm system.*

3. Lamb Directions: Using farm economic methods of analysis to figure out the effects of a change in a case study sheep business on profit, cash flow, wealth and the risk of it all.

Evaluating potential changes to farm systems involves considering the effects of these changes on farm profit and risk. This has been partially done for four changes to the livestock system of a prime lamb operation in south-west Victoria.

3.1 Lamb Directions

The analytical method used was similar to the Dairy Directions Project approach used by Malcolm *et al*. (2012) and as shown in Figure 2. It comprised several key elements: a real case study farm; close involvement of an industry steering committee; and whole farm modelling focussed on the technical, biophysical, economic, financial and risk aspects of the farm business. The essence of the approach is to ask the question: what changes are available to a sheep and lamb producing business to maintain and improve profit over the next decade in the face of rising real costs and fluctuating but not increasing real prices for output. The approach is to compare the likely performance of the farm system over a medium term planning period without any adaptation to rising real costs and real prices received fluctuating around a stable trend, to the performance of the business with some plausible changes to the system. A range of alternative futures for the business are examined.

Central to the Lamb Directions research is significant input from an industry steering group, comprising six local sheep farmers, two agricultural consultants, a sheep extension officer, a sheep scientist and agricultural economists. The steering group provides direction about which scenarios to test, what assumptions to use in making farm system changes, and interpreting the results. This ensures the analyses are subject to rigorous questioning and that a broad range of well-grounded perspectives are considered.

The biophysical component of the analysis is undertaken using GrassGro®; a computer program developed by CSIRO Plant Industry Australia that enables the interacting processes of pasture growth and animal production in sheep and beef enterprises to be examined, including rainfall variability. In the Lamb Directions case study research, annual whole farm budgets are built that utilise the biophysical inputs and outputs from GrassGro®. Risk is assessed for each option using @Risk, an add-in software package to Microsoft Excel, which allows probability distributions to be defined for uncertain variables and use Monte Carlo sampling. The approach is to 'purchase' the farm at the start of year one, run it for the planning period (7 years in this case) and then 'sell' the business at the end of the period, accounting for all annual incomes and expenditures in the interim and estimating the addition to owners wealth from the whole process. A large number of iterations of runs of 7 years of farming were analysed to form distributions of the full range of possible outcomes for the key measures of farm business performance, profit, cash and wealth.

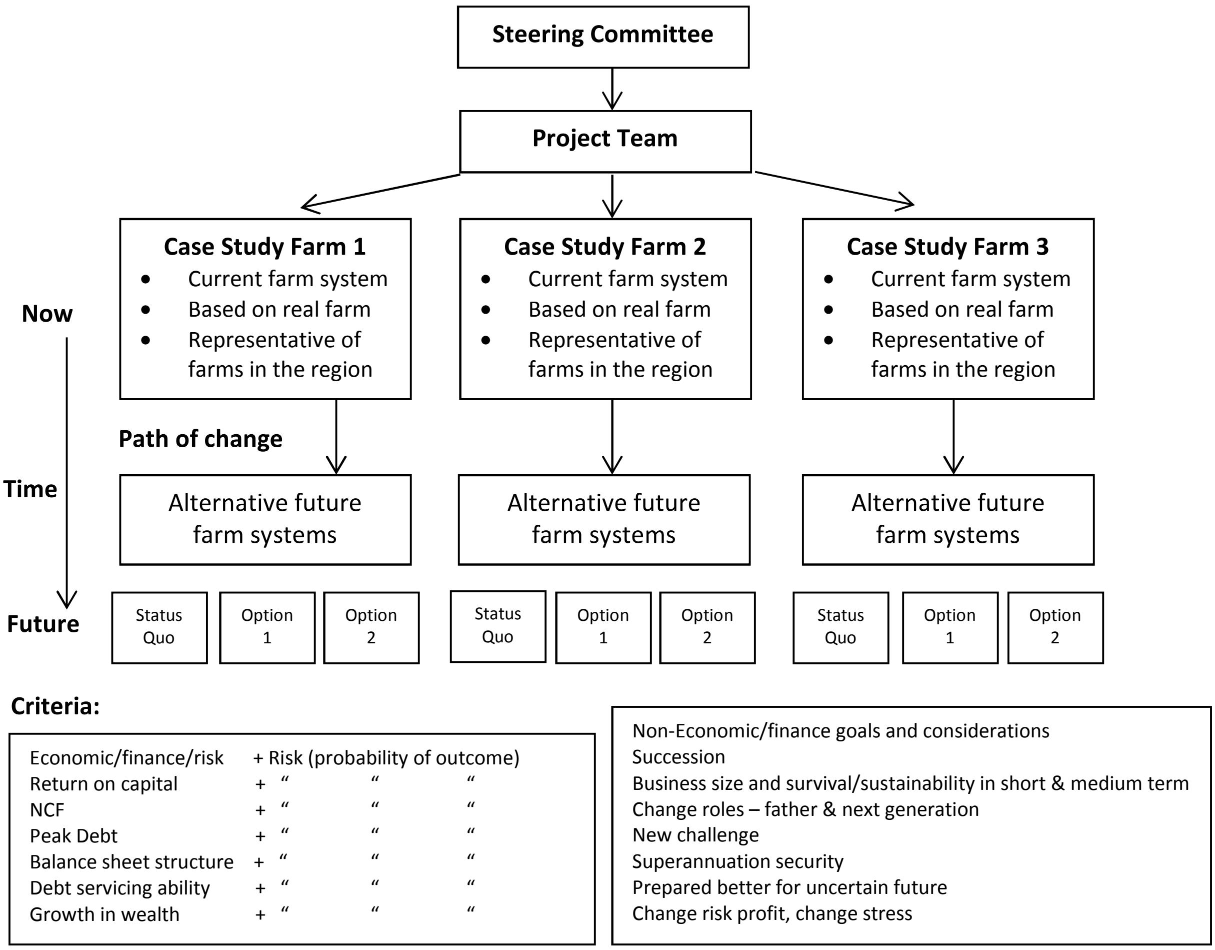

Figure 2: The Lamb Directions Approach

3.2 Criteria for judging the merit of a change to a business

In farm management economics the criteria for evaluating the merit of a change to how a farm business operates are:

- Will the change make the business more economically efficient? Economic efficiency is measured by percentage return on capital managed, with the return being annual operating profit (also called Earnings before interest and tax). Judging whether a change will improve economic efficiency involves investigating whether the return on the *extra capital* invested to make the change is attractive, all things considered including risk, compared with investing a similar quantity of capital in another way. If the return on extra capital invested exceeds the return currently being earned on the capital in the farm business, then the investment will raise the overall return on total capital invested in the business.

- Will the change result in building greater wealth by the end of the planning period than would be achieved by investing in something else or by doing nothing different over the planning period, considering the relative uncertainties about the prospective addition to wealth.
- Will the change be able to be financed? How much extra debt will be incurred to make the change, over what terms and at what interest rate, and will the changed business be able to meet these debt servicing obligations? To form a view about this question involves doing cash flow analysis, considering the reality that future cash flows are not knowable for sure and they will fluctuate considerably from year to year.
- How will the change to the way the sheep business operates over the coming decade affect the current exposure to risks of the business, and by how much? And, how do the owners of the business feel about the new risk situation they will be in if they proceed with the change*? In the analysis that follows total risk is estimated and shown as probability distributions of outcomes. Both business risk (volatility of weather, prices, yields) and financial risk (net cash flow (NCF) after servicing debt) are accounted for, showing up as total volatility of profit, returns on capital, NCF and changes wealth.*

Forming a judgement about whether to adopt a change to a sheep business requires information about the implications of the change for profit, wealth, cash and risk. So, how are profit, wealth, cash and risk effects estimated? This question is answered in the following example about a real farm case study. In this case study, the farm owner is currently running a business that is performing at a high standard of technical and economic efficiency, but this level of performance may not be adequate to meet the goals of the owners over the next decade in the face of a cost price squeeze. Options for change have been identified that are technically feasible and which would be acceptable to the owners, and the economic, finance and risk implications of these options have been analysed. The method used aims to provide information about how good a bet is each of the options; informing the decision maker about the profit, wealth and cash implications of each change, and the risk associated with the required level of each of these criteria being met. For instance, the probability of being able to service the debt involved with the change is a critical consideration for any change, even if they are a good idea in economic terms. To inform about risk, probability distributions are used for key parameters such as future rainfall, prices, costs, debt servicing ability, instead of the traditional approach of using single value 'most likely' or 'average' levels of these parameters.

Always a common criticism of particular pieces of farm economic analysis is the validity of assumptions made about the levels of the key parameters that determine outcomes, such as extra carrying capacity, timing of increases in carrying capacity, prices of wool and sheep meat and so on. There is no avoiding making assumptions, because the future cannot be known. Decision makers either do so explicitly or implicitly. Some of these parameters are risky because their levels are volatile phenomena over time. Some of these assumed levels of performance of key parameters have risk associated with them because they are not known for sure, such as the relationship that will operate when extra fertilizer and pasture seed is introduced and the extra pasture dry matter that will result from these extra inputs. This relationship is a matter of judgement, and different experts will hold that different 'response functions' will apply in the situation. To deal with this form of uncertainty, probability distributions are used around key unknown technical relationships, similar to the way probability distributions are used for uncertain future prices and costs and rainfall. To sum up, uncertainty about future parameters that are volatile, and about the levels of technical performance that will apply, are both dealt with by using probability distributions about the levels of these phenomena. The ultimate aim of this approach is to provide information to the decision maker about the size and the variability of the net benefits that will flow from the change.

3.3 The Lamb Directions Case Study Analysis

The farm is a prime lamb enterprise located in south-west Victoria, with an average rainfall of approximately 730 millimetres. Farm area is 560 hectares. The farm is a second generation owner / operator business, with family and additional labour used when required. The operation is a low input medium output business, generating returns that are typical of the top 20 per cent of farms for the region. The farm has grown over the years. In five to ten years' time the owner plans to hand over to the next generation. A total of $3.7 million is currently invested in the business. Debt is minimal. Equity is 98 per cent.

Across the farm there are three different soil classes and pasture types; 312 hectares (56%) of rocky barrier country, consisting of wallaby grass and sub clover; 168 hectares (30%) of black flats, consisting of phalaris and strawberry clover; and 80 hectares (14%) of open country, consisting of perennial ryegrass and leura/trikkala clover. The carrying capacity of the barrier country is approximately 14.5 dry sheep equivalents (DSE) per hectare, on the black flats it is 15 and on the open country it is 21.5 DSE per hectare. On average approximately 40 tonnes of supplementary feed is fed out each year and mainly during the winter period prior to lambing.

Flock structure is 3,000 Coopworth Composite ewes, with 1,000 joined to a maternal sire and the remainder to a terminal sire. This gives approximately 700 replacement ewe lambs. Ewe reproduction performance is 129 per cent lambs sold. Stocking rate is 6.6 ewes to the hectare, which equates to 16 (DSE) per hectare. Lambing is in mid-July and weaning is early December. Light lambs (25%) are drafted early December and sold as stores (34 kilograms liveweight approximately) and heavy lambs (75%) are drafted progressively and sold to Coles (44 kilograms liveweight approximately). Usually all lambs are sold by the end of December. Approximately 3,000 lambs are sold annually, which equates to a total of 62,000 kilograms carcass weight of lamb produced, thus 110 kilograms per hectare. About 22 kilograms of clean wool is produced per hectare.

Mean expected gross income for the *status quo* system is estimated to be $418,000, which is made up of lamb sales worth $319,000, wool sales of $48,000, and livestock trading profit of $51,000. Total variable costs are $157,000, giving a total whole farm gross margin of $261,000, which is $466 per hectare and $29 per DSE. Overhead costs are $95,000 including owner/operator allowance for labour and management of $60,000. Mean expected annual operating profit (before interest and tax) is $166,000. The modified internal rate of return on capital from running this business over the seven year planning period is 5.4 per cent. The standard deviation of mean steady state operating profit is $74,000. The challenge was to define 'alternative futures' (herein referred to as 'scenarios') for this business, which is operating well under current conditions, that will maintain or increases efficiency (profit), liquidity (cash) and wealth (growth), with risk considered in the face of rising real costs and fluctuating returns.

3.3.1 Development Options

The steering committee identified a range of development options that had the potential to maintain and/or increase profit of the farm. In addition to the '*status quo*' case, four alternative futures were defined and investigated, as described below. In Table 1 in Appendix 2 the details and assumptions relating to the farm systems analysed are set out. All dollars are nominal dollars for the year in which they occur, with annual inflation of 3.1 per cent for costs from year one and 3.0 per cent for income. The four scenarios have been modelled for the prime lamb system to grow its wealth when it is already operating in the top 20 per cent of its peers. These options are: (i) Intensification – increasing stocking rate from 16 to 22 dry sheep equivalents per hectare; (ii) Expansion – increasing land area from 560 to 800 hectares; (iii) Intensification and expansion – increasing stocking rate from 16 to 22 dry sheep equivalents per hectare across a total farm area of 800 hectares; and (iv) Increasing lambing percentage from 130 to 145 per cent.

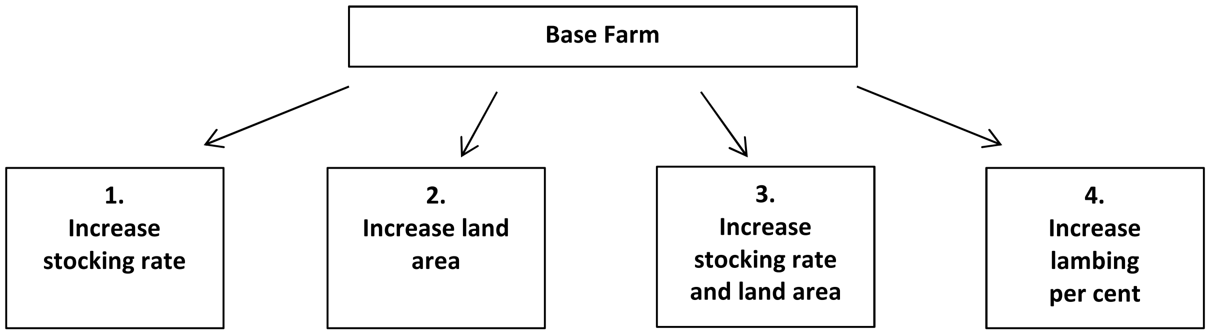

Figure 3: The Options for the case study farm

- *Future scenario 1: Increasing stocking rate*

The steering committee considered that the base farm could be improved through increasing pasture production and consumption. It was agreed that a stocking rate in the low to mid 20's would be possible, albeit with extra risk involved. Lifting stocking rate required raising soil fertility levels on the black flats and open country land classes from an Olsen P of approximately 7 to 12. This would require applying 169 tonnes of superphosphate fertiliser in year 1 at a cost of $56,000. Intensification of stocking rate would also require additional fencing of paddocks according to land class to enable greater pasture production and utilization, at a total cost of $113,000 and adding to the existing water system at a cost of $18,000. Stocking rate could be increased from 16 to 22 DSE per hectare (or 6.6 to 9.6 ewes to the hectare), thus an extra 1,680 sheep being carried, valued at $244,000. The total extra investment in the business to make these changes is $434,000. With the increase in livestock numbers, variable costs such as animal health, shearing, freight, selling, supplementary feed and base fertiliser application all increased accordingly. There was a slight rise in fuel and vehicle running costs and general repairs and maintenance. It was assumed that additional labour would have to be hired during the busy livestock periods at an estimated cost of $15,000 per annum. Steady state with this change would be achieved by year 3.

- *Future scenario 2: Increasing land area*

The second scenario involved expanding the farm by purchasing an additional 240 hectares of land that is of the same type and carrying capacity as the existing farm, with the same proportions of soil types and pastures, and is within a 20 kilometre radius of the home block. Stocking rate has remained the same as the '*status quo*' base case at 16 DSE per hectare. An extra 1,580 sheep are able to be carried on the expanded farm area. The additional land could be purchased in year one at a cost of $4,660 per hectare (including transfer charges), which is 10% less than the value of the base farm, giving a total purchase of $1.12 million. The additional sheep were valued at $230,000. With the increase in livestock numbers, variable costs such as animal health, shearing, freight, selling, supplementary feed and maintenance fertiliser application all increase accordingly. There is also a slight increase in some variable costs such as fuel, repairs and maintenance. There is also increases in all fixed costs, such as rates and administration and particularly labour at $15,000 extra labour cost, compared to the '*status quo*'. Steady state with this change would be achieved by year 2.

- *Future scenario 3: Increasing stocking rate and increasing land area*

Scenario three is a combination of the changes in scenarios one and two: increasing stocking rate from 16 to 22 DSE per hectare *and* increasing land area by 240 hectares, thus farming a total of 800 hectares at a stocking rate of 22 DSE per hectare. As with scenario two the additional 240 hectares of land purchased is of the same type and carrying capacity as the existing farm, with the same proportions of soil types and pastures, and is within a 20 kilometre radius of the home block. Increasing stocking rate involves lifting Olsen P soil fertility levels from approximately 7 to 12 on the black flats and open country land classes, requiring in year one 242 tonnes of superphosphate fertiliser at a cost of $81,000. Intensification also required additional fencing of paddocks according to land class at a total cost of $162,000 and adding to the existing water system at a cost of $26,000. The increase in stocking rate combined with a 240 hectare increase in area enables an extra 3,980 sheep to be carried, valued at $578,000. The additional land would be purchased at a cost of $4,660 per hectare (including transfer charges), which is 10 per cent less than what the base farm value, giving a total cost of $1.12 million. All up an extra $2 million would be been invested into the business. As with scenarios 1 and 2 the increase in livestock numbers means variable costs such as animal health, shearing, freight, selling, supplementary feed and maintenance fertiliser application all increase accordingly. There would be a rise in fuel and vehicle, repairs and maintenance and general expenses. There would also be a slight increase in fixed costs. It was assumed that an additional labour unit would have to be employed and this cost is estimated at $40,000 per annum. Owner/operator allowance is also increased by $10,000 p.a. to reflect the increase in the management demands arising from the increase in size and risks of the intensified business. Steady state with this change would be achieved by year 3.

- *Future scenario 4: Increasing lambing percentage*

The final scenario involved increasing lambing percentage of the base case. Considering biological factors it was considered realistic to achieve an increase in lambing percentage from 129 to 145 per cent. This increase could be achieved through ewe nutritional management by growing more pasture and additional subdivision of paddocks for better livestock control. Increasing pasture growth could be done by raising the Olsen P soil fertility levels from approximately 7 to 9 on the black flats and open country land classes. This would require 56 tonnes of superphosphate fertiliser at a cost of $19,000. Additional fencing would cost $44,000 and adding to the existing water system would cost $8,800. An extra $72,000 in total would be invested into the business. There would be a rise in fuel and vehicle costs of $1,000 and it is assumed that additional labour would have to be hired during the busy livestock periods at an estimated cost of $5,000 per annum. Steady state with this change would be achieved by year 2.

3.4 Results

- *Future scenario 1: Increasing stocking rate*

Increasing the amount of pasture grown and consumed would increase profit for this business (Table 1). Is it a good investment? Based on the additional $434,000 invested into the business for scenario 1 the marginal modified internal rate of return (MIRR) on extra capital was 18.4% (Table 2). This is an attractive return on marginal capital compared with other investments that are similarly risky, e.g. the stock market.

Over a large number of runs of 7 years of farming, the average annual operating profit (before interest and tax) in the 'steady-state' for this option was about $82,000 higher than in the *status quo* case (Table 2). The modified internal rate of return of the whole-farm business over the seven years increases from 5.4 to 6.8 per cent (Table 1). The average nominal owner's capital at the end of year 7 was estimated to be $2.524m after an interest rate of 9 per cent was paid on the extra $434,000 borrowed to intensify the business, compared with an average net worth of $2.135m from the *status quo* case, a real increase of $388,000 from increasing stocking rate (Table 3). Risk over the whole distribution of potential outcomes increased relative to the *status quo* base case (Figure 4). The *status quo* had an average annual operating profit (before interest and tax) of $166,000 with a standard deviation around the average of $74,000 (CV of 45%). The system with an increased stocking rate had an average annual operating profit (before interest and tax) of $248,000 and a standard deviation of $120,000.

In Figure 4 is shown a box and whisker plot of annual operating profit (before interest and tax) in the steady state for the *status quo* case and each development scenario. Each plot shows the mean value, with the outer limits of the box showing the 25 and 75 percentile ranges and the tips of the whiskers showing the 5 and 95 percentile limits. For scenario 1 (increased stocking rate) compared to the *status quo,* the mean annual operating profit is higher, but variability has increased. The standard deviation of annual operating profit in the steady state is $120,000 with a CV of 48 per cent.

In Figure 5 risk is shown differently by plotting the 7 year modified internal rate of return against the standard deviation of the return; showing risk versus return. As return increases so too does risk. The mean whole farm MIRR of this option is 6.8% with a SD of 2.2% and a CV of 32%.

- *Future scenario 2: Increasing land area*

Increasing land area resulted in a system that was more profitable than the *status quo* case. Annual mean operating profit level in the steady state increases by $92,000 (Table 2). Is this a good investment? The return on marginal capital (MIRR) is 7.7 per cent: this return is from farming and from a nominal increase in the value of the land purchased at the annual rate of inflation of 3 per cent. The return on additional capital of 7.7 per cent raises the modified internal rate of return of the whole farm including the additional land to 6.1 per cent, which is higher than *status quo* MIRR of 5.4 per cent on a smaller capital base.

After an annual interest rate of 9 per cent nominal was paid on the extra $1.348m borrowed to intensify the business, estimated average additional real wealth of the owners at end of 7 years is predicted to be $2.153m (SD $763,747, CV 35%) compared with $2.135m with the *status quo* case, a real increase of $18,000 in wealth over the *status quo* case (Table 3). This highlights that if interest costs to purchase the extra land was 9 per cent p.a., and gains in land value was only inflation, then there is nothing in this investment for the farmer.

Table 1. Whole farm profit and loss results: Average Performance

		Status Quo	Scenario 1	Scenario 2	Scenario 3	Scenario 4
		Base Farm (fully costed)	*1. Increase stocking rate*	*2. Increase land area*	*3. Increase stocking rate and land area*	*4. Increase lambing %*
Whole Farm Profit & Loss (steady state year)						
Gross Income		$418,000	$593,000	$599,000	$845,000	$476,000
Variable Costs		$157,000	$234,000	$222,000	$333,000	$165,000
- Supplementary feed		$11,000	$33,000	$16,000	$49,000	$9,000
- Fertiliser (super)		$28,000	$40,000	$40,000	$57,000	$30,000
- Pasture maintenance / development		$7,000	$7,000	$10,000	$12,000	$7,000
Total Gross Margin	- total	$261,000	$359,000	$376,000	$511,000	$312,000
	- per DSE	$29	$29	$30	$28	$33
	- per Ha	$466	$642	$470	$639	$557
Overhead Costs:		$35,000	$52,000	$58,000	$85,000	$40,000
Operating Profit (EBIT)		$166,000	$248,000	$258,000	$356,000	$212,000
Interest & Lease Costs		$5,000	$44,000	$126,000	$182,000	$11,000
Net Farm Income		$161,000	$204,000	$132,000	$175,000	$201,000
Tax Payable		$10,000	$10,000	$10,000	$10,000	$10,000
Net Profit / Change in Equity		$151,000	$194,000	$122,000	$165,000	$191,000
Economic Analysis						
Modified Internal Rate of Return		5.4%	6.8%	6.1%	7.1%	6.6%

Table 2. Whole farm <u>marginal</u> profit and loss results: Average Performance

	Status Quo	Scenario 1	Scenario 2	Scenario 3	Scenario 4
	Base Farm (fully costed)	*1. Increase stocking rate*	*2. Increase land area*	*3. Increase stocking rate and land area*	*4. Increase lambing %*
		Extra			
Marginal Analysis (additional compared to Status Quo) (steady state year)					
Gross Income		$175,000	$181,000	$427,000	$58,000
Variable Costs		$77,000	$65,000	$176,000	$8,000
- Supplementary feed		$22,000	$5,000	$38,000	-$2,000
- Supplementary feed (tonnes)		88	19	147	-8
- Fertiliser (super)		$12,000	$12,000	$29,000	$2,000
- Pasture maintenance / development		$0	$3,000	$5,000	$0
Overhead Costs		$17,000	$23,000	$50,000	$5,000
Owner/Operator Allowance		$0	$0	$10,000	$0
Operating Profit (EBIT)		**$82,000**	**$92,000**	**$190,000**	**$46,000**
Interest & Lease Costs		$39,000	$121,000	$177,000	$6,000
Net Farm Income		**$43,000**	**-$29,000**	**$14,000**	**$40,000**
Tax Payable		$0	$0	$0	$0
Net Profit / Change in Equity		$43,000	-$29,000	$14,000	$40,000
Economic Analysis					
Marginal Modified Internal Rate of Return		18.4%	7.7%	10.1%	13.4%

Table 3. Increase in Wealth

Increase in Wealth	Opening Equity	Opening Assets / Development (nominal)	Opening Debt (nominal)	Cash Flow from Farming (nominal)	Adjustment of Assets by 3% CPI (nominal)	Closing Assets / Development (nominal)	Closing Equity (nominal)	Increase in Wealth (nominal)	Marginal Increase in Wealth (nominal)
Base Farm (status quo)	$3,633,000	$3,713,000	$80,000	$1,415,000	$721,000	$4,434,000	$5,768,000	$2,135,000	
1. Increase stocking rate	$3,633,000	$4,151,000	$518,000	$1,723,000	$801,000	$4,951,000	$6,157,000	$2,524,000	$388,000
2. Increase land area	$3,633,000	$5,061,000	$1,428,000	$1,171,000	$982,000	$6,043,000	$5,786,000	$2,153,000	$18,000
3. Increase stocking rate and land are	$3,633,000	$5,687,000	$2,054,000	$1,461,000	$1,097,000	$6,784,000	$6,191,000	$2,558,000	$423,000
4. Increase lambing percent	$3,633,000	$3,785,000	$152,000	$1,777,000	$735,000	$4,520,000	$6,145,000	$2,512,000	$377,000

- *Scenario 3: Increasing stocking rate and increasing land area*

Increasing the amount of pasture grown and thus consumed and increasing land area would increase profit of this business (Table 1). Over a large number of runs of 7 years of farming, the average annual operating profit in the 'steady-state' for this option was estimated to be $190,000 higher than in the *status quo* case (Table 2). The return on extra capital (MIRR) invested in this development option is 10.1 per cent. The modified internal rate of return of the whole-farm business increased from 5.4 to 7.1 per cent. After assuming an interest rate of 9% on the $2 million borrowed to expand the farmland and increase its productivity, the wealth generated after 7 years is $423,000 better than the *status quo* case (Table 3).

Risk over the whole distribution of outcomes increased significantly relative to the *status quo* case for both operating profit and modified internal rate of return (Figures 4 and 5). This option had an average annual operating profit of $356,000 and a standard deviation of $172,000 and a CV of 48%. With an additional $2 million invested in the business, a marginal modified internal rate of return on capital of 10.1% was earned, with an SD of 6.6% and a CV of 65%.

- *Scenario 4: Increasing lambing percentage*

Increasing lambing percentage added least to mean annual steady state operating profit compared with the other development options (Table 2). It also cost the least to implement. Over a large number of runs of 7 years of farming, the average annual operating profit in the 'steady-state' for this option was about $46,000 higher than in the *status quo* case, with a SD of $78,000 and a CV of 37%. The return on whole farm capital after the change averages 6.6 per cent; an improvement on the 5.4 per cent without the change. The return on marginal capital is predicted to average 13.4 per cent. The mean real addition to wealth from this option is predicted to average $377,000 more than the base case achieves (Table 3).

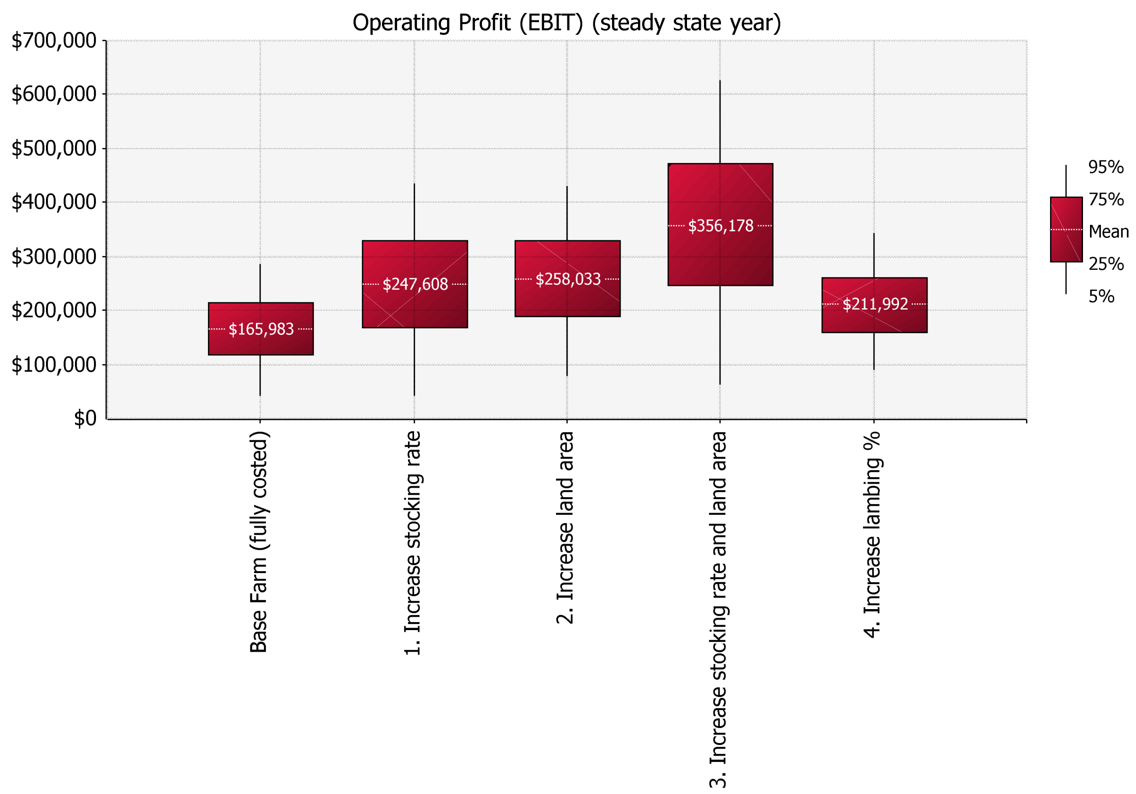

Figure 4. Operating Profit (EBIT) (steady state year).

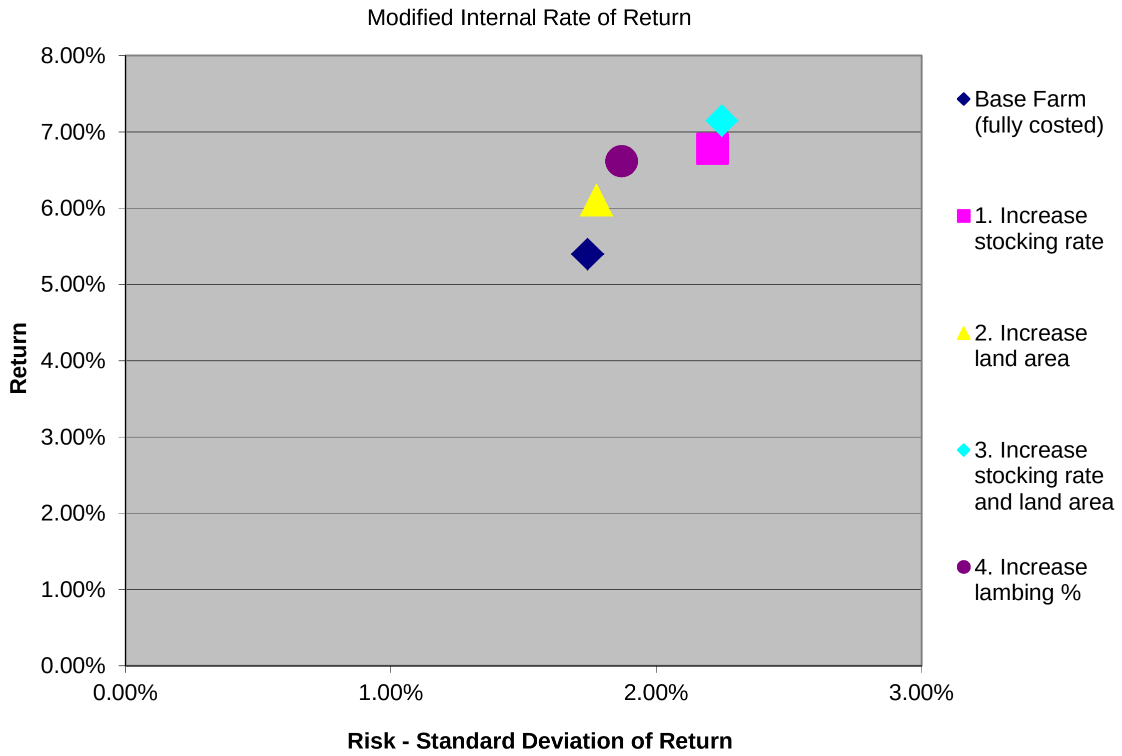

Figure 5. Modified Internal Rate of Return for Whole Farm, 7 years, with 4 Development Options.

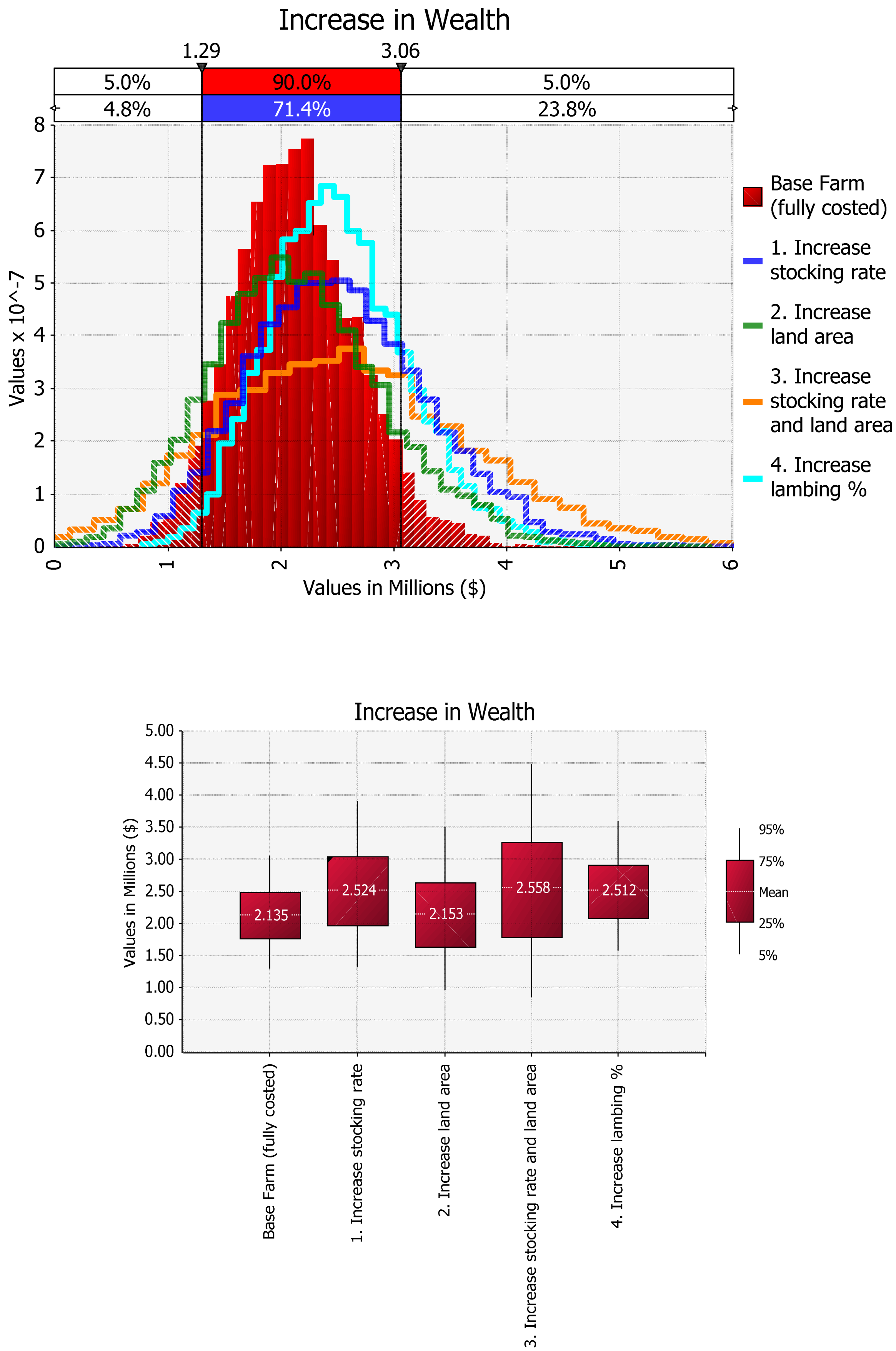

Figure 6. Increase in Wealth: Probability Distributions

3.5 Financing the Potential Changes to the Farm System and the Implications for the Financial Risk Component of Total Risk.

While economic analysis and the associated risk tells whether a potential change to a farm system is a good move or not compared to other potential uses of the capital involved, financial analysis is equally important. Financial analysis is needed to inform whether the investment to make the potential change is financially feasible. That is, whether the investor and the financier can be confident that the farm business will be able to service the debt that will have to be incurred to make the change.

In section 3.4 is shown the probability distributions of potential profit, return on capital, growth in wealth over seven years for each of the changes to the farm system that have been investigated. These probability distributions show the volatility of performance from changes in prices and yields, called business risk, that the business faces with each change. The other form of risk the business will face with these potential changes is financial risk. This too can be analysed.

Assessing financial feasibility and financial risk of an investment involves first estimating the future net cash flow arising from the investment in the nominal dollar terms of the future. The business is purchased at the start, developed, and sold at the end of the period of analysis. Annual and cumulative net cash flows are estimated. The size and timing of peak debt is identified, as also is the year when cumulative net cash flow is expected to become positive. This information forms a basis for determining the terms and conditions of borrowings that are appropriate for the investment. As the economic analysis has incorporated risk analysis, so too can distributions of net cash flows be used to further inform about financial feasibility. For the expected annual and cumulative net cash flows of the investment, and a range of possible debts and associated terms, the probabilities of servicing a range of debt to implement the investment can be identified. Further, in the economic analysis the total exposure to risk was estimated, and shown in the form of the probability distribution of the key measures of performance, return on investment over the life of the investment (MIRR), wealth at end of period, and annual operating profit in steady state. In the financial analysis the proportion of total risk that is contributed by the proportion of debt in the business, called financial risk, can be estimated. The results of the financial analysis follow.

In Figure 7 is shown cumulative mean annual net cash flows for each of the different scenarios, based on the assumption that all mean annual net cash flows are devoted to servicing and repaying debt. In Table 4 is shown the proportion of financial risk to total risk. If the farmer borrowed all the capital required for the changes considered, it is expected that the combined investment of increased stocking rate and land area (Scenario 3) will involve taking on the highest debt (Table 4 and Figure 7). Under this option financial risk becomes 60% of the total risk of the business. This compares to the base case where equity is a high 98 per cent, and financial risk represents only 9 per cent of total risk of the business. Scenario two, buying more land and running it at the same intensity as the base case, is also expected to have a high financial risk compared with the base case and compared with scenarios one (increased stocking rate) and four (increased lambing percentage) (Table 4).

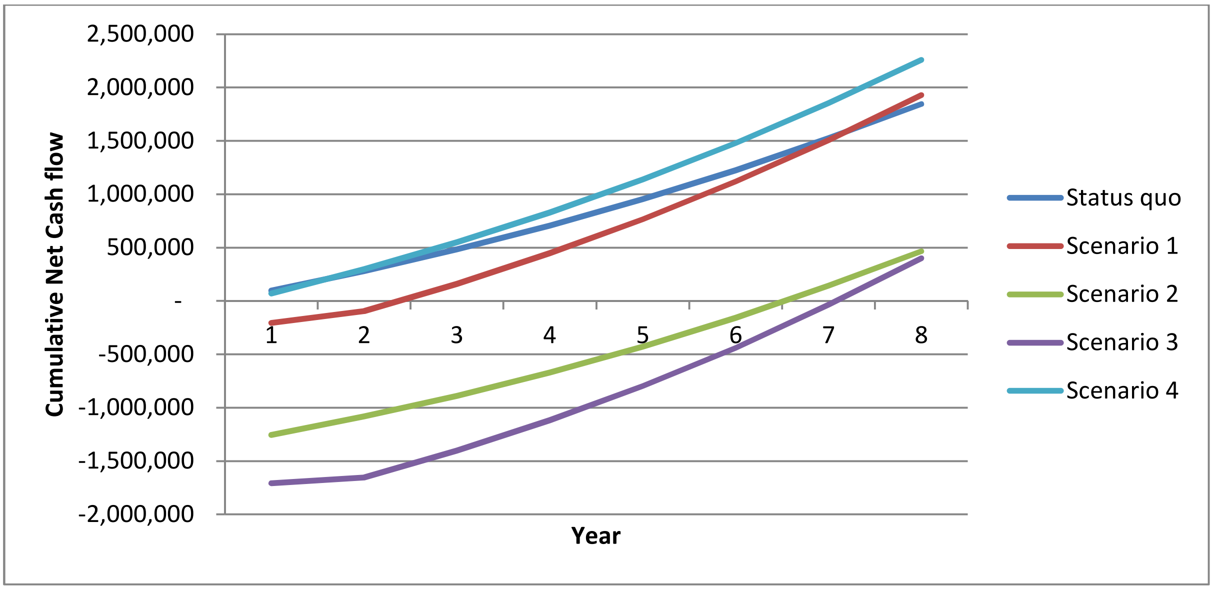

Figure 7. Cumulative mean annual net cash flows for each of the different scenarios, based on the assumption that all mean annual net cash flows are devoted to servicing and repaying debt

Table 4. The proportion of financial risk to total risk

	Capital investment required	Extra debt required [a]	Proportion of financial risk to total risk
Status Quo Base Case	$3,713,000	$80,000 (98% equity)	9%
Scenario 1: Increased stocking rate	$4,146,750	$433,750 (89% equity)	36%
Scenario 2: Increased land area, same stocking rate	$5,060,680	$1,347,680 (73% equity)	58%
Scenario 3: Increased stocking rate and increased land area	$5,681,380	$1,968,380 (65% equity)	60%
Scenario 4: Increased lambing percentage	$3,785,400	$72,400 (98% equity)	12%

[a] the total loan for each of the scenarios will include this extra debt required plus the base case debt of $80,000 (the total expected debt for each scenario is: Scenario 1 $513,750, Scenario 2 $1,427,680, Scenario 3 $2,048,380, Scenario 4 $152,400).

Refer to Figure 7 and Table 5. If all the mean annual net cash flows were devoted to servicing and reducing debt, and the farmer invested $3,633,000 equity into the business in year one, then it is expected that for the base case, and for scenario 4, the farmer will have 100% equity by the start of year two, and for scenario 2 it will be in year 3. For the more significant investment options of Scenarios 2 and 3, average levels of annual net cash flows would not service and repay debt fully until years 7 and 8 respectively (Figure 7 and Table 5).

Table 5. Starting equity and the expected time taken to reach 100% equity with mean annual net cash flows

Option	Starting equity	Time taken to reach 100% equity [c]
Status Quo	98%	1 year
Scenario 1	88%	3 years
Scenario 2	72%	7 years
Scenario 3	64%	8 years
Scenario 4	96%	1 year

[c] Based on the assumption the farmer has mean annual net cash flows available to service and repay debt

As shown in Table 6, if, the farmer took out seven year loans for the lesser capital intensive options, and 15 year loans for the more capital intensive options, then the farms annual steady state net cash flows will be greater than the fixed debt servicing obligations of principle and interest, for an amortised loan at 8% interest, in more than 80% of years (Table 6).

Table 6. The probability of annual net cash flow being greater than annual principle and interest repayments, for an amortization loan at 8% interest rate, in the steady state years

Option	Fixed annual debt servicing obligations at 8% interest	Probability of annual NCF being greater than debt servicing obligations at 8% interest
Status Quo	$15,366	98% (7 year loan)
Scenario 1	$60,021	94% (7 year loan)
Scenario 2	$166,795	86% (15 year loan)
Scenario 3	$239,311	81% (15 year loan)
Scenario 4	$29,272	99% (7 year loan)

As shown in Table 7 below, if the interest rate was 15 per cent p.a., it is expected that the net cash flows generated from either the base case, scenario 1 or scenario 4 would be greater than principle and interest repayments in more than 90% of years. Under the options involving markedly more debt, scenario 2 and scenario 3, and at 15 per cent interest p.a., the annual net cash flows cover debt servicing obligations in only 60 per cent of years (Table 7).

Table 7. The probability of annual net cash flow being greater than annual principle and interest repayments, for an amortization loan at 15% interest rate, in the steady state years

Option	Fixed debt servicing obligations at 15% interest	Probability of NCF being greater than debt servicing obligations at 15% interest
Status Quo	$19,229	98% (7 year loan)
Scenario 1	$87,860	92% (7 year loan)
Scenario 2	$244,158	66% (15 year loan)
Scenario 3	$350,308	62% (15 year loan)
Scenario 4	$36,631	99% (7 year loan)

The financial analysis further illuminates the risk associated with each of the changes: financing matters (Malcolm, 2012). Considering the price and yield risk as in part three, and overlaying the financial implications for the business of each of the changes, further informs the decision maker about the choices. Even though a change may look attractive in terms of profit and risk, financial matters will be decisive. The capital required has to be able to be borrowed, and borrower and lender have to be confident the loan can be serviced. In this case, the options requiring substantial new capital investment exposes the business to rises in interest rates reducing the probability that the debt can be serviced in each year. If these options are taken up, some thought would be needed by the investor about what steps could be taken in the event of rising interest rates and periodic shortages of annual net cash flow.

4. Discussion of Results of Analysis of Development Options for Case Study

In the first research reported in this paper, 15 potential productivity improvements were analysed. The five changes that promised the highest mean addition to wealth, and the most rewarding for scientific efforts, were

- Higher weaning rate and higher stocking rate
- Increasing feed efficiency of ewes and increasing lamb turnoff
- Increasing ewe feed efficiency
- Increasing ewe longevity in flock and reducing ewe mortality
- Increasing stocking rate

In the second analysis reported in this paper, four alternative scenarios were analysed for ways a top prime lamb producer in south-west Victoria might continue earning competitive rates of return on total capital invested in the farm business. The options considered involved intensifying by increasing stocking rate or lambing percentage, expanding by buying an extra 240 ha or expanding and increasing stocking rate. Each option resulted in an expected increase in mean annual steady state operating profit and return on total capital of the business and also increased the variability of annual operating profit and return on capital. Each option had implications for wealth, and for exposure to business and financial risk of the business.

The farmer decision maker has information about potential changes to the farm system that can increase profit, return on capital and wealth. Each of the options – increase stocking rate, buying land, buying land and increasing stocking rate and increasing lambing percentage – has different effects on profit, return on capital and wealth, and importantly different implications for business risk and financial risk. The farmer decision maker is in the position of incorporating this information into their processes of weighing up what to do, if anything. This information about return and risk can be added to their knowledge from the past (experience) and intuition (experience and judgement and expectations), along with their feelings about bearing extra risk, all in light of the goals they are striving to achieve over the medium term planning period.

When considering the potential changes in profit, cash, wealth and the change in business and financial risk associated with each option, it is also important to ponder the chances (risk) of achieving the hope-for increases in options such as increasing stocking rate and lambing percentage. Whilst added costs associated with added risk has been counted in the analysis, there remains an element of chance about whether the targets for stocking rate and lambing percentage will be achieved. If there is more reasons to be more confident about achieving the higher stocking rate than the high lambing percentage, this has to be included in weighing up the choices.

If the farm owner's goal is to have the business in a strong equity position in 7 years or so, in order to have sufficient superannuation, or to make possible a succession plan, then they would need to weigh up the extra risk they would need to bear to build a larger equity, and settle on the choice with the balance of risk and end net worth that is a bet they are willing to make. From the viewpoint of best use of scarce capital in the case study business, increasing stocking rate and increasing lambing percentage had attractive returns to marginal capital, an important economic criteria. Increasing stocking rate had implications for business risk and financial risk as exposure to drought increased and as borrowings increased, but to a lesser extent than the option involving buying more land. Increasing lambing percentage was a low capital option which had the least implications for business risk and financial risk. Buying more land without also lifting the productivity of the land looked a relatively unattractive proposition in this case where it was assumed that no real capital gains occurred in land value; buying the land and improving it promises a better return to marginal capital and contribution to wealth than buying the land and not improving its performance. The options involving land purchase markedly increased both business risk and financial risk. Depending on the situation and goals of the farmer, if the land purchase opportunity came up, if the land was also improved, the addition to wealth is comparable to the increasing stocking rate and increasing lambing percentage options, and though risk is higher, it may be an attractive choice that fits longer terms aims to do with succession. If succession looms less large, but wealth in a decade or so is highly significant, then the less debt, less risk avenue of intensifying by lifting stocking rate and lambing performance might be more attractive than committing to buying more land and servicing greater debt.

5. Conclusion

In the work reported in this paper, potentially good investments by researchers and sheep farmers for the next decade have been investigated. Some of the results confirm the common sense and intuition of experienced researchers and farmers, other findings are less obvious. Potentially attractive innovations such as earlier mating, increasing growth rates, increasing lamb feed efficiency, faster lamb turnoff, reducing animal health costs, increasing ewe fleece weight did not rank as highly in terms of profit and risk as the traditional, well known innovations to do with increasing stocking rate and ewe feed and reproductive performance. Though, all these changes looked to improve the profit of the *status quo* farm system.

For the case study farm, faced with a cost price squeeze, the worst choice of the five options for profit, cash and building wealth was to continue with business as usual. It was also the best choice if minimizing exposure to business and financial risk was the main criteria. Business as usual involved the least financial or business risk of all the options. Increasing stocking rate from 16 DSE/ha to 22 DSE/ha and lambing percentage from 129% to 145% promised attractive returns on marginal capital and additions to wealth, with sizeable increases in both business and financial risk, and with an element of doubt about consistently achieving these stocking rates and lambing percentages. Purchasing and developing more land, if there is no increase in real land values over the seven year planning period, added similarly to end wealth as increasing stocking rate and lambing percentage, with a marked increase in exposure to both business and financial risk.

Intensifying or extensifying a business that has very high equity inevitably means increasing the exposure to business and financial risk. Nothing ventured, nothing gained; more risk makes more growth possible, and also the threat of greater loss. For most farmers however, standing still is not an option.

Acknowledgements:

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<u>APPENDIX ONE</u>: Details of the scenario analyses of the pre-experimental modelling analysis

This section of the report contains a description of each of the scenarios analysed, including the costs which have and have not been included in the calculations. The effects of these scenarios on farm profit and risk are also presented and discussed in more detail.

- **Scenario 1: The base case**

This scenario represents the current farm system. Estimates of the annual and cumulative profit and risk of this farm system have been calculated using stochastic simulation. The farm owner/operator has confirmed that these estimates closely represent the historical performance of the farm. These estimates of profit form the basis for comparison with each of the scenarios evaluated below.

- **Scenario 2: Increased stocking rate**

The change to the farm system considered here is an increase in the stocking rate from 10 to 12 ewes per hectare. The benefits of this change will be an increase in the gross revenue from lambs and wool sold. Extra annual costs will be increased supplementary feed costs and increased husbandry and sale costs. These costs are all automatically included in the model.

Increasing the stocking rate involves increasing in the amount of livestock capital used on the farm. To compare scenarios with different amounts of capital invested, the opportunity cost of extra capital must be included in the analysis. This has been done here by assuming the extra ewes are purchased using borrowed funds and including the extra annual interest cost when comparing scenarios.

The extra annual depreciation cost associated with the extra capital investment in the extra 2,000 ewes is also included in this analysis through the calculation of livestock trading profit. An added cost of the extra labour which would be required to manage the extra stock has also been included. The increase in the labour cost is proportional to the increase in total sheep numbers (ewes and lambs). The effects on farm profit and risk of this change to the farm system are summarised below:

Scenario	Average annual net profit	% Change	Standard deviation	% Change
Base case	$384,000		$58,000	
Higher stocking rate	$494,000	29%	$72,000	24%

- **Scenarios 3 and 4: Increased weaning rate**

The weighted-average weaning rate across the entire flock is 130%. This overall average comprises the 148% weaning rate of the 7,800 ewes which are two or more years old, and the 71% weaning rate of the 2,200 one year old ewes. In this scenario the weaning rate of all ewes has been increased by 20%. The table below contains a summary of the weaning rate with and without the change. The benefits of this change are an increase in the number of lambs sold and an increase in total revenue from wool sales.

	Weaning rate	
Scenario	**2+ y.o ewes**	**1 y.o ewes**
Base case	148%	71%
Higher weaning rate	178%	85%

The extra annual costs associated with this change which are currently captured by the model are extra annual supplementary feed costs, extra animal husbandry and sale costs, and the annual cost of extra labour. The increase in the labour cost is proportional to the increase in lamb numbers on the farm.

The increase in supplementary feed costs is caused by the increase in whole-farm energy demand which occurs when the weaning rate is increased. This includes an increase in both the average per-head energy requirements of pregnant and lactating ewes, and the greater overall energy demand of weaned lambs.

While the extra supplementary feeding costs caused by the increase in the weaning rate are included in the evaluation of this scenario, any increase in supplementary feed costs which may be required to bring about this change are not included. This is because the method and cost of achieving the increase in the weaning rate are not yet known.

In scenario 3, no change to the number of ewes on the farm is made when the weaning rate is increased by 20%. As explained above, increasing the weaning rate causes whole-farm energy demand (or the whole-farm stocking rate) to rise. Accordingly, this scenario represents an increase in the efficiency of ewes <u>and</u> an intensification of the farm system.

McEarchen and Sackett (2008) found that the increase in the stocking rate which occurs when the weaning rate is increased generates a significant part of the overall benefit of this change. However, some producers may not wish to take on the extra risk associated with higher stocking rates, so ewe numbers may be reduced when this change is made even though doing this will reduce the benefit generated.

In scenario 4, ewe numbers are reduced so that whole-farm energy demand is the same in this scenario as in the base case. This requires reducing ewe numbers from ten to nine ewes per hectare. The results of this scenario therefore reflect the increase in ewe efficiency only. A slight increase in supplementary feed costs is included in the evaluation of this scenario because the timing of feed deficits shifts somewhat. The net effects of these scenarios on farm profit and risk are:

Scenario	**Average annual net profit**	**% Change**	**Standard deviation**	**% Change**
Base case	$384,000		$58,000	
Higher weaning rate higher SR	$539,000	40%	$67,000	16%
Higher weaning rate maintain SR	$467,000	22%	$59,000	2%

Of the ‘Higher stocking rate’ and ‘Higher weaning rate higher SR’ scenarios, the latter has the most beneficial effect on the risk-return profile of the farm: it generates a greater increase in profit and a smaller increase in risk. This occurs because the increase in livestock trading profit in the higher weaning rate scenario is achieved without running any more ewes. This limits the increase in risk which occurs because it reduces exposure to variation in replacement ewe prices, seasonal conditions and interest rates.

The 'Higher weaning rate maintain SR' scenario causes the largest increase in profit for the smallest increase in risk of all the scenarios analysed. Relative to the 'Higher stocking rate', this change generates a slightly smaller increase in profit, but a much smaller increase in risk. Comparing this scenario to 'Higher weaning rate higher SR' we see that as expected, reducing the number of ewes on the farm when the weaning rate is increased reduces the increase in profit generated by this change, but also reduces the increase in risk.

- **Scenario 5: Increased average lamb carcase weight**

The target liveweight for lambs at the time of sale is 50kg. This weight is determined by the preferences of buyers in the markets where lambs are sold. Hence, in this scenario an increase in the liveweight of lambs at the time of sale is not considered, instead the proportion of light lambs which reach this target weight at the time of sale has been increased from 70% to 100%.

The benefit of this change is that revenue from the sale of lambs increases. The proportions of lambs in each weight category with and without this change are shown in the tables below. These are indicative proportions which apply in 'normal' years (90% of the time). In 'bad' years fewer lambs make it to 50kg at the time of sale. While included in the actual analysis, the effects of lamb deaths after weaning and variation in the weaning rate have been excluded from the tables for simplicity.

Base case							
Total lamb sales - good year							
Class	Sale date	Proportion	Number	Weight (kg)	Dressing %	Sale value per head	Lamb sale revenue
Heavy lambs	15-Dec	30%	3,900	50	44%	$ 104.0	$ 405,600
Light lambs	15-Mar	70%	9,100	47	49%	$ 108.0	$ 982,800
Total average			13,000	48	48%	$ 106.8	$1,388,400
Light lamb sales - good year							
Class	Sale date	Proportion	Number	Weight (kg)	Dressing %	Sale value per head	Lamb sale revenue
Lights 50kg	15-Mar	70%	6,370	50	49%	$ 114.0	$ 726,180
Lights 40kg	15-Mar	30%	2,730	40	49%	$ 94.0	$ 256,620
Lights average			9,100	47	49%	$ 108.0	$ 982,800

More lambs to 50kg							
Total lamb sales - good year							
Class	Sale date	Proportion	Number	Weight (kg)	Dressing %	Sale value per head	Lamb sale revenue
Heavy lambs	15-Dec	30%	3,900	50	44%	$ 104.0	$ 405,600
Light lambs	15-Mar	70%	9,100	50	49%	$ 114.0	$1,037,400
Total average			13,000	50	48%	$ 111.0	$1,443,000
Light lamb sales - good year							
Class	Sale date	Proportion	Number	Weight (kg)	Dressing %	Sale value per head	Lamb sale revenue
Lights 50kg	15-Mar	100%	9,100	50	49%	$ 114.0	$1,037,400
Lights 40kg	15-Mar	0%	-	40	49%	$ 94.0	$ -
Lights average			9,100	50	49%	$ 114	$1,037,400

In total, no more lambs are sold in this scenario than in the base case. However, revenue from the sale of lambs increases because the weighted average per-head sale value of light lambs rises when the proportion of light lambs sold at 50kg increases. Light lambs have a higher dressing percentage and hence a higher per-head value than heavy lambs, so increasing the proportion of lambs classed as heavy and sold at the time of weaning would actually reduce total lamb revenue.

The increased energy demand of light lambs when the average liveweight of these lambs rises is captured by the model in the evaluation of this change. No increase in the annual labour cost has been assumed in this scenario. The results of this scenario are below:

Scenario	Average annual net profit	% Change	Standard deviation	% Change
Base case	$384,000		$58,000	
More lambs to 50kg	$418,000	9%	$58,000	0%

The 'More lambs to 50kg scenario' has a relatively small effect on average farm profit because the quantity of lamb sold increases only marginally in this scenario. Specifically, the change increases the weighted-average liveweight of the 9,100 light lambs sold from 47kg to 50kg, a total increase of 6% or 27,300kg of liveweight lamb sold. While lamb sales represent the main source of revenue for this farm, the relatively small change in revenue per lamb sold generated by this change means the overall effect on farm profit is also relatively small. Changes in livestock trading profit and average supplementary feed costs for each of the scenarios are shown in the table below.

- **Scenario 6: Increase in ewe feed efficiency**

Animal energy requirements are calculated daily in the model and are based on equations published in Freer et al (2010). These equations are designed to calculate metabolisable energy requirements for maintenance, lactation, pregnancy, activity and liveweight/condition score changes, and are based on an 'average' animal of a given liveweight. This scenario was designed to investigate the impact on profitability of having animals with greater feed efficiency - animals that require less metabolisable energy for metabolic processes at a given liveweight.

To assess the effect of an increase in ewe feed efficiency on profitability, for this scenario it was assumed that ewes would require 80% of the metabolisable energy requirements of an 'average' animal. This in turn would allow stocking rate to be increased by 20% without an increase in feed demand. Labour costs were increased by 10% to account for increased stocking rate. The effect of an increase in ewe feed efficiency on year 5 average annual growth in equity is presented in the table below.

	Mean	% change from base farm	Standard deviation	% change from base farm
Base case	$ 384,000		$ 58,000	
Increase in ewe feed efficiency	$ 512,000	33%	$ 68,000	17%

Modelling suggests that increasing ewe feed efficiency by 20% will have a substantial positive effect (+ 33%) on average annual growth in equity. The benefits of this change will be an increase in the gross revenue from lambs and wool sold. Extra annual costs will be increased supplementary feed costs and increased husbandry and sale costs. Variation around this average is predicted to increase relative to the base farm system (+17%). With an increase in ewe (and consequently lamb) numbers, poor season event risk, replacement ewe price, lamb price and mutton price contributed most to variability in annual growth in equity for this scenario.

- **Scenario 7: Increase in lamb feed efficiency and turnoff**

Similar to scenario 6, we investigated the effect of increasing lamb feed efficiency on farm system profitability. For this scenario it was assumed that lambs would require 80% of the metabolisable energy requirements of an 'average animal' at a given liveweight. Under these conditions, lambs could be expected to reach target growth rates about 1 month earlier (both heavy and light lambs) and thus sale dates for each group of animals were brought forward (19 Nov instead of 15 Dec for 'heavy' lambs, and 2 Feb instead of 15 Mar for 'light' lambs). No other changes to the base farm system were made. The effect of an increase in lamb feed efficiency on year 5 average annual growth in equity is presented in the table below.

	Mean	% change from base farm	Standard deviation	% change from base farm
Base case	$ 384,000		$ 58,000	
Increase in lamb feed efficiency and turnoff	$ 395,000	3%	$ 54,000	-6%

Increasing lamb feed efficiency and turnoff with all else kept constant had a small positive impact on annual growth in equity. Results indicate that this scenario would also reduce variability in average annual growth in equity. This is primarily caused by a reduction in supplementary feed requirements relative to the base farm system. Earlier turnoff of lambs with improved feed conversion efficiency should lead to greater availability of forage for other livestock classes at key times during the year.

- **Scenario 8: Increased ewe and lamb efficiency and turnoff**

The effect of increased ewe and lamb feed efficiency (scenario 6 and 7 combined) on the profitability of the farming system was investigated. For this scenario it was assumed that ewes would require 80% of the metabolisable energy requirements of an 'average' animal. This in turn would allow ewe stocking rate to be increased by 20% without an increase in feed costs. Labour costs were increased by 10% to account for increased stocking rate. It was assumed that lambs would require 80% of the metabolisable energy requirements of an 'average animal' at a given liveweight. Under these conditions, lambs could be expected to reach target growth rates about 1 month earlier (both heavy and light lambs) and thus sale dates for each group of animals were brought forward (19 Nov instead of 15 Dec for 'heavy' lambs, and 2 Feb instead of 15 Mar for 'light' lambs).

	Mean	% change from base farm	Standard deviation	% change from base farm
Base case	$ 384,000		$ 58,000	
Increase in ewe and lamb feed efficiency and turnoff	$ 531,000	38%	$65,000	12%

This scenario had a marked impact (+38%) on year 5 average annual growth in equity relative to the base farm system. Increased ewe stocking rate without a concurrent requirement for increased supplementary feed costs for these animals meant that the farming system could generate more wool and breed more lambs, thus increasing gross farm income. Increased lamb production and decreased age to turnoff would ensure that more feed is available for other livestock classes at key times of the year, thus reducing supplementary feed costs. Variation around this average is predicted to increase relative to the base farm system (+12%). With an increase in ewe (and consequently lamb) numbers, poor season event risk, replacement ewe price, lamb price, mutton price and wool price contribute most to variability in annual growth in equity for this scenario.

- **Scenario 9: Decrease in ewe mortality**

The effect of decreased ewe mortality on system profitability was considered. The benefits of this change would include a decrease in the number of replacement ewes required to be purchased in each year. In this analysis we assumed an increase in labour cost to account for costs associated with improved ewe survival, although in practice this may not be the case.

In the base farm system, ewe mortality was assumed to be 3% per annum in a 'good' year (currently 9 years in 10) and 6% per annum in a 'bad' year (currently 1 year in 10). To test the effect of decreased ewe mortality on farm system profitability, ewe mortality was reduced to 1% in 'good' years and 3% in 'bad' years. Labour costs were increased by 10% to account for possible costs associated with this change. No other changes were made to the system.

	Mean	% change from base farm	Standard deviation	% change from base farm
Base case	$ 384,000		$ 58,000	
Decrease in ewe mortality	$ 408,000	6%	$52,000	-8%

Decreasing ewe mortality had a small positive (+6%) effect on average annual growth in equity relative to the base farm system. This scenario also generated lower variability around the mean (-8%) than the base farm system. This was due largely to reduced exposure to replacement ewe costs. This scenario would generate small benefit from increased cull sales. Relative to the base farm system, this scenario generated a small increase in supplementary feed requirements, due to the current timing of purchasing replacement stock. Poor season event risk, replacement ewe price, lamb price and mutton price influenced the variability of this system.

- **Scenario 10: Increase in ewe longevity (and average mortality)**

The effect of increased ewe longevity was considered. In the base farm system, productive ewes are kept until approximately 5.5 years of age, having been joined 5 times over their lifetime. The benefit of increasing ewe longevity would be to decrease the number of replacement ewes required to be purchased in a given year. In this analysis, at least for the time being, no account has been made of increased costs associated with this change, such as possible increased animal health costs associated with older animals, or an increased cull rate as animal age increases.

To test the influence of increased ewe longevity on farm profitability, we assumed that ewes were kept until 7.5 years of age – that is, joined 7 times over their productive lifetime. Average annual cull rate for the flock was reduced from 20% per age group to 14% per age group.

	Mean	% change from base farm	Standard deviation	% change from base farm
Base case	$ 384,000		$ 58,000	
Increase in ewe longevity (+average mortality)	$ 430,000	12%	$55,000	-2%

Increasing ewe longevity from 5 joinings to 7 joinings had a more positive impact on average annual increase in equity than reducing ewe mortality. This was primarily due to the reduced requirement for replacement ewes in each year. This system was most sensitive to poor season event risk, lamb price, replacement ewe price, pasture growth rates in early autumn and mutton price.

The reason this scenario does not have less variability around the mean than decreasing mortality is because the range of possible values in this scenario is wider, and hence the variation around the mean is larger. This occurs because increasing longevity increases profit by much more than reducing the mortality rate, so the increase in the upside of the distribution (P95) generated by this scenario is much greater than the increase in the upside which occurs when the mortality rate is decreased. Conversely, the increase in the downside of the distribution (P5) which occurs (relative to the base case) is relatively similar in both these scenarios.

Scenario	**P 5**	**change**	**P 95**	**change**	**95-5**	**change**
Base Case	236,413		442,740		206,327	
Decreased ewe mortality	274,146	37,733	462,838	20,098	188,692	-17,635
Increased ewe longevity	279,081	42,668	479,958	37,218	200,877	-5,450

This is an example of the danger associated with using the standard deviation of the distribution as a measure of risk. Increasing longevity causes the greatest decrease in risk of these scenarios – ie this scenario has the higher P5 value (the worst outcome that occurs in 20 years) of the two scenarios, but because it causes an even larger increase in the P95 value (the best outcome in 20 years), it does not reduce the standard deviation of the distribution.

The analysis indicates that farm profit is less exposed to variation in replacement ewe prices when ewe longevity is increased than when the mortality rate is decreased. Given that we purchase fewer replacement ewes in the increase longevity than the decrease mortality scenario, this is exactly what we would expect to see. However, this alone is not enough to reduce the overall variation in the growth in equity. This is because decreasing the mortality rate reduces exposure to the 'poor season event risk' variable. This occurs because the occurrence of 'bad' years has smaller consequences for farm profit in this scenario, as the number of ewes which die in these years is smaller.

As mentioned above, the effect of these changes on the downside of the distribution of the annual growth in equity (P5) is similar. However, because increasing the longevity of ewes causes a much larger increase in livestock trading profit (by reducing replacement ewe costs) than reducing mortality rates, the upside (P95) of the distribution of annual growth in equity is much higher in the increased longevity scenario than when mortality is reduced.

- **Scenario 11: Decreased ewe mortality plus increased ewe longevity**

The effect of decreased ewe mortality coupled with increased ewe longevity on farm profitability was considered. In this scenario, ewe mortality was reduced to 1% in 'good' years (9 years in 10) and 3% in 'bad' years (1 year in 10). Labour costs were increased by 10% to account for possible costs associated with this change. Productive ewes were kept until 7.5 years of age. All else was kept constant.

	Mean	% change from base farm	Standard deviation	% change from base farm
Base case	$ 384,000		$ 58,000	
Increase in ewe longevity (+decreased mortality)	$ 454,000	18%	$51,000	-10%

The combination of decreased ewe mortality plus increased ewe longevity had a strong positive effect (+27%) on average annual growth in equity. This system was again most sensitive to poor season event risk, lamb price, replacement ewe price, pasture growth rates in early autumn and mutton price.

- **Scenario 12: Increase lamb growth rate and reduced age to turn-off**

The influence of increased lamb growth rates and consequent reduced age to turn-off on profitability was considered. In the base farm system, 'heavy' lambs were sold at 128 days of age, and 'light' lambs sold at 217 days of age. In this scenario, age to turn off was reduced by 20% for both classes of lambs such that heavy lambs were sold at 102 days of age, and light lambs sold at 174 days of age.

This shift implied that higher daily growth rates were achievable for each group of lambs. This increase in daily growth rate required an increase in daily metabolisable energy intake during the period the lambs were growing. However, it also meant that whole of flock metabolisable energy requirements were reduced once the lambs were sold, which could provide a benefit in terms of greater feed on offer entering a potential feed gap in autumn months.

	Mean	% change from base farm	Standard deviation	% change from base farm
Base case	$ 384,000		$ 58,000	
Increased lamb growth rate and reduced age to turn off	$ 395,000	3%	$56,000	-4%

Increasing lamb growth rates and decreasing the time to turn-off had a small positive (+3%) effect on average annual growth in equity relative to the base farm system. This scenario also generated slightly lower variation (-4%) around the mean. This is due largely to making better use of spring pasture growth coupled with earlier lamb turnoff dates, reducing reliance on purchased supplementary feeds. Poor season event risk, replacement ewe price, lamb price, mutton price and wool price contributed to variation around the mean in this scenario.

- **Scenario 13: Improvements in fleece weight and/or reductions in fibre diameter**

The effect of improvements in fleece weight, reductions in fibre diameter (as price received for wool) or a combination of both increased fleece weight and increased wool price on system profitability was investigated. The average fleece weight of ewes was increased by 20%, keeping all else constant. Then, wool price was increased by 20%, keeping all else constant. The combination of increased fleece weight (+20%) and increased wool price (+20%) was also tested.

	Mean	% change from base farm	Standard deviation	% change from base farm
Base case	$ 384,000		$ 58,000	
Improvements in fleece weight or increase in wool price	$ 412,000	7%	$59,000	1%
Increased fleece weight plus increased wool price	$ 448,000	17%	$ 59,000	1%

Improving fleece weight by 20% or fleece price by 20% had a positive (+7%) influence on average growth in equity, with very little impact on variability around the mean (1%). Intuitively, increasing both fleece weight and wool price by 20% had a more marked positive effect (+17%), while still generating very low variability around the mean (1%). Wool price ranked slightly higher in terms of contribution to variance in these scenarios when compared with the base farm system, however poor season event risk, replacement ewe price and lamb price were more closely correlated with overall growth in equity in this scenario.

- **Scenario 14: Improved animal health or reduced animal health costs**

Animal health costs can be a significant proportion of variable costs in a lamb production system. The effect of reducing animal health costs on farm profitability was investigated. Costs associated with lamb marking, crutching, drenching, inoculating and jetting were reduced by 20% and the resulting farm profitability calculated assuming all else remained constant (base farm conditions).

	Mean	% change from base farm	Standard deviation	% change from base farm
Base case	$ 384,000		$ 58,000	
Reduced animal health costs	$ 394,000	3%	$58,000	0%

Reduced animal health costs had a small positive (3%) effect on average annual growth in equity. As animal health costs vary directly with animal numbers, there was no change in the variation around growth in equity for this scenario. As for the base farm system, poor season event risk, replacement ewe price, lamb price, mutton price and wool price were key determinants of growth in equity for this scenario.

- **Scenario 15: Join ewes at 12 months rather than 2 years old**

In this scenario, the change to the farm system investigated is joining ewes at 7 months of age rather than at 2 years. To explain how this scenario has been represented in the model, some explanation of the base case is required. Specifically, in the base case replacement ewes are purchased at approximately 10 months old, and joined at 12 months old. Ewes are retained on the farm for 5 lambs and then sold.

Lambs which are joined at 12 months old are assumed to have a much lower fertility rate than the ewes which are at least 2 years old. The table below contains the weaning rates which apply to these two classes of ewes.

	Weaning rate	
Scenario	**2+ y.o ewes**	**1 y.o ewes**
Base case	148%	71%

The one year old ewes which are joined in the base case of this farm can be used to represent the 7 month old lambs joined in this scenario, since the lower weaning rate of younger ewes is already represented. There may be some further differences in terms of energy requirements, but the effects of these differences on farm profit will be small. The alternative scenario of only joining ewes at two years old can be represented by not joining the one year old ewes currently in the flock.

This is what has been done here, and so the representation of this scenario is the reverse of the other scenarios, with the 'base case' scenario corresponding to the situation where 7 month old ewes are joined and the 'mating at 2 years' scenario corresponding to the situation where ewes are not joined at this age.

The effects of this change to the farm system on farm profit and risk are generated in several ways. First, by not joining 1 year old ewes but instead carrying them for a year, a smaller proportion of the total ewe flock are joined, and hence a smaller number of lambs are sold. This reduces farm profit relative to the base case. However, because the energy requirements of the whole flock are reduced when the proportion of ewes joined is decreased, the stocking rate can be increased from 10 to 10.4 ewes per hectare without increasing the supplementary feed cost, which somewhat offsets the effect on profit of the decrease in the number of lambs sold.

Also, fewer replacement ewes are purchased in this scenario than in the base case, because ewes are only culled after their first joining, hence unlike in the base case, one year old ewes are not culled in this scenario.

This scenario can result in a net increase or decrease in farm profit, depending on the relative magnitude in the decrease in livestock trading profit caused by the reduction in the number of lambs sold, and the increase in livestock trading profit caused by the reduction in the value of replacements purchased. Assuming the price of lambs is the same in both these scenarios, the reduction in livestock trading profit caused by selling fewer lambs depends only on the decrease in the number of lambs weaned in this scenario. Conversely, the effect of the decrease in the value of replacements purchased depends on the change in both the number and price of replacements.

As explained above, the decrease in the number of replacement ewes purchased is caused by the reduction in the number of 1 year old ewes that are culled in this scenario. The price at which replacement ewes are purchased may also be lower in this scenario than in the base case, because less-developed ewes could be purchased if they are going to be carried on the farm for a year before being joined, compared to the situation where they are joined shortly after purchase. However, it may be the case that the same price is paid for ewe lambs regardless of whether they are going to be joined immediately or not. Which of these situations applies determines whether this scenario causes an increase or decrease in farm profit.

The net impact on farm profit and risk of these effects is shown in the table below:

Scenario	Average annual net profit	% Change	Standard deviation	% Change
Base case	$384,000		$58,000	
Mating at 2 years (lower prices)	$418,000	9%	$52,000	-10%
Mating at 2 years (unchanged prices)	$359,000	-7%	$53,000	-9%

The 'Mating at 2 years (lower prices)' scenario was calculated assuming replacements could be purchased at $80 per head, rather than $120 per head in the base case. As shown in the table, if this can be done, whole farm profit increases in this scenario, indicating that the reduction in the cost of replacement ewes purchased is greater than the reduction in lamb sale revenue. However, the table also shows that if replacement ewes are purchased at the same price in this scenario and the base case, the value of the reduction in lambs sold is greater than the reduction in the cost of replacement ewes, hence whole-farm profit declines.

The results in the table show that this scenario is always risk-reducing, in the sense that it reduces the standard deviation of farm profit. This occurs because fewer replacement ewes are purchased in this scenario, hence farm profit is less exposed to variation in the price of replacement ewes.

APPENDIX TWO:

Table 1. Details and assumptions relating to the Lamb Directions South-West Case Study Farm

			Status Quo	Scenario 1	Scenario 2	Scenario 3	Scenario 4
			Base Farm (fully costed)	*1. Increase stocking rate*	*2. Increase land area*	*3. Increase stocking rate and land area*	*4. Increase lambing %*
Physical / Production Details (steady state year)							
Land area (Ha)			560	560	800	800	560
Rainfall			729	729	729	729	729
Feed budget	- pasture growth		7,800	9,500	7,900	9,500	8,600
(kg / ha)	- animal intake		4,600	6,500	4,600	6,500	4,900
Whole farm stocking rate (DSE/Ha)			16	22	16	22	17
	- Barrier Country		15	19	15	19	15
	- Black Flats		15	24	15	24	16
	- Open Country		22	32	22	32	23
Tonnes of supplementary feed fed			41	129	60	188	33
Average No. Ewes			3,200	4,600	4,600	6,600	3,200
Lamb marking %			129%	125%	129%	125%	145%
No. lambs sold			3,000	4,200	4,300	6,000	3,500
Lamb Production - Total Kg CW			62,100	87,200	88,900	124,300	73,900
Lamb Production - Kg CW per Ha			111	156	111	155	132
Wool Production - Kg per Ha			22	33	22	33	23
Prices / Costs			***Base***	***Additional***			
Prices	Lamb meat price		$4.55				
	Skin price		$11.44				
	Mutton price		$2.59				
	Replacement ewe price		$145				
	Wool price ($/kg)		$3.84				
	Ewe standard value		$145				
Variable Costs	Animal health	/hd	$3.40				
	Shearing labour	/hd	$5.30				
	Shearing supplies	/hd	$0.85				
	Freight and cartage	/hd	$0.90				
	Selling costs	/hd	$3.80				
	Other	/hd	$0.35				
	Supplementary feed	/tonne	$250				
	Fertiliser (super)	/tonne	$350				
	Fuel & Vehicle		$8,400	$1,500	$3,000	$5,000	$1,000
	Repairs & maintenance		$11,800	$1,500	$3,000	$5,000	$0
	Pasture maintenance		$7,300	$0	$3,000	$5,000	$0
Fixed Costs	Labour		$0	$15,000	$15,000	$40,000	$5,000
	Depreciation		$14,000	$0	$3,000	$5,000	$0
	Rates		$5,000	$0	$2,500	$2,500	$0
	Administration		$9,000	$0	$1,000	$1,000	$0
	Other *(Elec, Insurance, etc)*		$6,700	$2,000	$2,000	$2,000	$0
	Operator's allowance		$60,000	$0	$0	$10,000	$0
Assets		Owned Land	$2,900,000	$0	$1,118,000	$1,118,000	$0
		Livestock	$700,000	$244,000	$230,000	$578,000	$0
Plant & Equipment / Fencing & Water Systems			$105,000	$131,000	$0	$188,000	$53,000
		Fodder / Capital Fertiliser	$8,000	$59,200	$0	$84,700	$19,600
			$3,713,000	$434,000	$1,348,000	$1,969,000	$73,000
Debt	Loan		$80,000	$434,000	$1,348,000	$1,968,000	$72,000

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