Profit, cash, wealth and risk implications of changes to a prime lamb business in south-west Victoria

Jonathon Tocker[1,2], B Malcolm[2,3], J Heard[1,2], A Sinnett[3], C Ho[3] and R Behrendt[1,2]

[1]Agriculture Research Division, Department of Environment and Primary Industries, Hamilton, Vic, Australia.

[2]Red Meat Innovation Centre, Department of Environment and Primary Industries, Hamilton, Vic, Australia.

[3]Agriculture Research Division, Department of Environment and Primary Industries, Parkville, Vic, Australia.

Email: jonathon.tocker@depi.vic.gov.au

Summary. Over the next decade sheep farmers will experience rising real costs for key inputs, while real prices received for meat and wool are unlikely to rise on a sustained basis, meaning annual profit and debt servicing capacity will continue to be squeezed. Under these conditions continuing with business as usual will result in declining annual net incomes, reduced net cash flows and eroding of current wealth. Variability in seasonal conditions and changing farm family goals also add to the pressures faced by farm businesses. A case study of a prime lamb operation in south-west Victoria was analysed to inform the farm owner, and others in similar situations, about the relative merit of common choices for the challenges they face. The focus was on changes to the farm business that would increase profits from producing prime lamb, evaluating both the profit and the risk of making these changes. The biophysical, economic, financial and risk dimensions of the farm business were simulated to examine how changed farm systems were likely to perform under volatile seasonal, price and cost conditions over a seven year planning period. Each change was also analysed to estimate additions to wealth, debt servicing and the attractiveness of these options based on the degree of aversion to risk.

Four changes to the base farm were analysed: increasing stocking rate; increasing land area; increasing stocking rate and land area; and increasing lambing percentage. The changes increasing stocking rate and lifting lambing percentage involved less capital investment and used the extra capital invested the most efficiently of all of the changes. They offered attractive additions to wealth and had less total risk than the changes that involved borrowing to purchase and develop land. These two changes would be more attractive to decision-makers with a low to medium aversion to taking risk. Purchasing extra land, but not increasing its productivity had significant extra financial risk associated with servicing extra debt, and if there was no real capital gain, this would give the lowest addition to wealth over the seven years. Purchasing extra land and increasing the stocking rate on both the new and base farm area offered the greatest addition to end wealth for similar levels of business and financial risk as only purchasing extra land. This option would appeal to decision-makers in a position to take on a marked degree of additional risk and provide the opportunity to build considerable extra wealth. These results suggest the expansion in size of prime lamb businesses will be limited by the degree to which capital gain can be made on purchased land and the significant additional financial risk associated with the servicing of debt. Furthermore, analysis of factors contributing to variability of returns on capital indicated price of lamb was a substantial contributor to risk of the enterprise, suggesting sheep farmers and industry should seek solutions to mitigate this risk to their businesses.

Keywords: farm change, whole farm analysis, economics, finance, wealth, risk

Introduction

In the next decade, sheep farmers will experience rising real costs of key inputs such as labour, fertilizer, fuel and capital equipment. At the same time, prices received for sheep meat and wool will fluctuate around a trend that is more likely to be stable or declining rather than rising in real terms (Malcolm et al. 2005; ABARES 2012). Weather will continue to be volatile and changing, with climate data showing that since 1900 Australia has become warmer and rainfall in some regions has decreased but increased in others. Also the frequency of extreme hot periods and heavy rainfall events has increased (Hennessy et al. 2010). Taken together, the variability in seasonal conditions, and the likely rise in real costs and decline in real prices, means sheep farming net returns will continue to be squeezed unless farmers change how they operate (Rabobank 2013). If they do not change, and continue with business as usual for the next decade, sheep farmers will face declining annual profits, reduced net cash flows, and erode their current wealth.

The above situation would be true even if a sheep farmer had the same goals and objectives for the next decade as applied to the past, but few are in this position. The situation of farm families' change: young farmers seek to build their businesses, children grow and older farmers adjust priorities. Added to the inevitable cost-price squeeze and volatile seasonal conditions the usual imperatives of growing the business to support offspring and build wealth for retirement, and the scene is set for a decade of change for sheep farmers. This raises questions about which change, how much change can the business and the people in it bear, and what criteria to use to judge if a change is likely to be worth making.

Extensive research, development and extension has been directed at improving the profit of sheep systems in south-west Victoria (e.g. Saul and Dark 2003; Saul et al. 2011; Lewis et al. 2012; Morant 2011). Sheep farming systems have been analysed using biophysical modelling methods (e.g. MLA 2004; Warn et al. 2006; Thompson 2006; Young et al. 2010; Warn 2011). Some analysts estimate effects on activity gross margins, while others use more informative whole farm measures of profit to assess profitability (Heard et al. 2013). Assessing which change to implement to achieve goals of growth in wealth requires the whole-farm approach, where several key dimensions are considered - profit, cash, wealth and risk - to determine the viability of the family goals and the trade-offs involved (Malcolm et al. 2005). Analysing the trade-off between return and risk matters when making decisions about change, and the whole-farm approach is required (Heard et al. 2013).

In this study, for a prime lamb business located in south-west Victoria, the research question was about the relative merit of plausible potential changes to maintain and improve profit over the next decade, in the face of rising real costs, fluctuating, but not increasing real prices for output, and volatile weather conditions.

Method and approach

Systems simulation of the operation of a case study farm was used to compare the probable performance of the business over a medium term planning period (seven years) without any change, to the potential performance of the business with some plausible changes. The approach involved three key elements: a real case study farm; close involvement of an industry steering committee; and whole-farm modelling focussed on the technical, biophysical, human, economic, financial and risk aspects of the farm business (Malcolm et al. 2012)[1].

The steering committee was comprised of six local sheep farmers, two agricultural consultants, a sheep extension officer, a sheep scientist and agricultural economists. The steering committee provided direction about scenarios to analyse, assumptions to use in making changes to the farm system, and assisted in the interpretation of results. This ensured analyses' were subject to rigorous questioning with a range of well-grounded perspectives considered (Malcolm et al. 2012).

Using case studies of real farm businesses as they currently operate and as they could operate provides information about real world phenomena which facilitates improved understanding of these businesses and of the changes analysed for them (Armstrong et al. 2005; Ho et al. 2005; Malcolm et al. 2012). The case study farm was chosen by the industry steering committee subject to criteria representative of a typical prime lamb system for the region.

The biophysical component of the farm system was simulated 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 modelled subject to real historical rainfall variability (Moore et al. 1997; Freer et al. 2012). GrassGro® analyses of changes to farming systems (e.g. Clark et al. 2000; Clark et al. 2003; Robertson 2006; Warn et al. 2006; Graham and White 2010; Warn 2011) abound in the literature. Details of the physical characteristics of the base case study farm and prime lamb system that were simulated in GrassGro® for this research are shown in Table 1. The operation of the base farm system and each change was simulated using a distribution of rainfall over a 50-year period (1960 to 2009) to derive farm output and generate a distribution of possible production.

The biophysical outputs from GrassGro® were combined with price and cost information to produce annual whole farm budgets in Microsoft Excel, based on farm management economic principles, such as in Malcolm et al. (2005). Annual and cumulative farm profits, net cash flows, and balance sheets were constructed for the base farm with and without each change. Risk was incorporated using @Risk, an add-in software package to Microsoft Excel, which allows probability distributions to be defined for uncertain input variables and Monte Carlo sampling of these distributions (Palisade 2012). In addition to weather variability, probability distributions were defined for key prices and costs. These included lamb carcass weight ($/kg carcass weight (CW)), skins ($/hd), mutton ($/kg CW), replacement ewes ($/hd), wool (c/kg clean wool), supplementary feed ($/t) and fertiliser prices ($/t). The key percentiles and distributions for each variable are presented in Table 2. Justification for using each

[1] This approach was based and expands on previous economic research conducted for the Victorian dairy industry which compared options of change for case study dairy farms to maintain and improve profit in the face of volatile markets and weather, rising costs and declining or flat prices (Armstrong, *et al.* 2005; Ho *et al.* 2005; Heard *et al.* 2012; Malcolm *et al.* 2012).

distribution is presented in Table 3. Correlations between prices of lamb, mutton and replacement ewe prices were included (Table 4). Variable costs (Table 5) and fixed costs (Table 6) were estimated based on a combination of South West Farm Monitor Project figures (Tocker and Berrisford 2011), actual case study farm data and judgements of the members of the industry steering committee. Asset values (Table 7) and debt ($80,000) was based on that of the case study farm.

An annual 'cost-price squeeze' of 1% was imposed by having all costs increase annually by 1% in real terms. In the financial analysis, an expected annual inflation rate of 2% was added to all costs and prices. Interest of 5% (nominal) was earned on any annual surpluses of net cash flow over the planning period, and annual deficits of net cash flow were charged at 7% (nominal) interest. For the purposes of the analysis the farm was assumed to be purchased at the start of year one, run for the planning period of seven years and then assumed to be sold. A large number of iterations of runs of seven years of farming under a range of natural and economic conditions were analysed to form distributions of the range of possible profit, cash and wealth outcomes for the base farm and for each change.

Criteria for judging the merit of a change to a business

In farm management economics, key criteria for evaluating the merit of a change to a farm business are the potential size and variability of possible changes in annual and cumulative profit, net cash flows and wealth (Malcolm et al. 2005). The method used in this analysis to evaluate each change consisted of five components, which asked the following key questions:

(i) Will the change to the farm system make the business more economically efficient? Economic efficiency is indicated by return on capital, estimated by calculating the modified internal rate of return (MIRR) of an investment over a planned period (Malcolm et al. 2005). Judging whether a change will improve economic efficiency involves investigating whether the extra cash profit (benefit) from the extra capital invested (cost) to make the change is attractive, all things considered including risk, compared with investing a similar quantity of capital in another way. The MIRR in this analysis was calculated based on the real annual net cash flows over the planned period.

(ii) Will the change to the farm system build greater wealth by the end of the planned period than would be achieved by investing in something else, or by doing nothing different, after considering the additional capital required and the relative uncertainties about the prospective addition to wealth? Addition to wealth reflects the change in equity at the end of the planned period and is based on cumulative annual net cash flows from farming over the planned period (seven years in this case). Assets are purchased at the beginning of year one and sold at the end of year seven, with annual fixed debt servicing obligations (interest and principal) being paid and the balance of any remaining debt settled at the end of the seven years. Calculations are in nominal terms.

(iii) Will the change to the farm system be able to be financed? This is analysed by calculating how much extra debt will be incurred to make the change and then calculating future cash flows after servicing the assumed debt to see how likely it is that the changed business will be able to meet debt servicing obligations. All finance calculations are in nominal terms.

(iv) How will the change to the way the business operates over the planned period affect the exposure to business risks (volatility of weather, prices, yields) and financial risks (net cash flow after servicing debt), their relative contributions to total risk, and to what extent?

The variability of each change to the farm system was assessed using the statistical terms of standard deviation (SD) and coefficient of variation (CV).

Business risk was measured as the coefficient of variation of annual net cash flow after tax before principal and interest in a steady state year. Financial risk was measured as fixed debt servicing obligations (principal and interest) divided by annual net cash flow after tax, principal and interest in a steady state year, multiplied by business risk. Total risk is the sum of business and financial risk (Gabriel and Baker 1980). Calculations are in nominal terms.

The contribution of each risky input to the variability in the returns on total capital invested (MIRR) for the base farm and each change was calculated using multivariate stepwise regression. Normalised regression coefficients associated with each input were calculated using @Risk, which indicate the change in standard deviation for an output for each unit change in standard deviation for a particular input (Palisade 2012). The change in standard deviation was then related to the percentage change in return on total capital (MIRR).

(v) How might the level of risk associated with each change and attitude to risk influence what change is implemented?

Stochastic efficiency with respect to a function (SERF) analysis was used to assess the attractiveness of each change for decision makers who have high, medium and low aversion to taking risk (Hardaker et al. 2004). This approach uses information about the risk-return trade-off as shown in the distributions of possible end equity/ wealth from each change. For a range of assumed degrees of aversion to risk, the SERF analysis uses certainty equivalent (CE) calculations to define which risk-return combination would suit decision makers best, for a range of degrees of aversion to risk.

CE values reflect the amount of benefits or gains measured in dollars that an individual would take for certain, rather than investing in a risky venture that offers a range of possible returns. The CE value can also be considered as the amount of gain (with no risk) that is regarded as being equally desirable to the option of investing in a risky venture with variable possible outcomes. The amount of benefits or gains that an individual would take for certain rather than take on a risky investment, depends on the distribution around the mean of the expected returns from the risky investment. It also depends on their aversion from, or preference towards, risk. In SERF analysis, the interpretation is: for a defined attitude to risk, the choice with the highest CE value from a set of risky choices is the best bet for the decision-maker with that particular attitude to risk.

The case study farm

The case study farm was a prime lamb operation located in south-west Victoria, with an average rainfall of approximately 730 mm and farm area of 560 ha. The farmer was a second generation owner/operator and operated the business using family labour plus some casual labour. Over the years, the area of the farm and livestock carried had increased. Total farm capital was $3.7 million (Table 7). Debt was minimal and equity was at 98%. Inside the next decade the owner planned to hand over to the next generation.

The soils on the farm comprised three different classes with different pasture types being grown on the different areas. On the rocky barrier country (312 ha), there was wallaby grass and subterranean clover, while the black flats (168 ha) grew phalaris and strawberry clover. The open country (80 ha) had perennial ryegrass and subterraneum clover. The annual carrying capacity was estimated to be approximately 14.5 DSE/ha (dry sheep equivalents per hectare) on the barrier country, 15 DSE/ha on the black flats and 21.5 DSE/ha on the open country. Across the whole farm, the average annual carrying capacity was estimated to be 16 DSE/ha. This carrying capacity involved feeding approximately 40 tonnes of supplementary feed each year.

The sheep activity comprised 3,000 Coopworth Composite ewes, with 1,000 of the ewes mated to a maternal sire and the remainder mated to a terminal sire. The feed requirements of this type of ewe producing lambs, most of which were sold within the year, was rated at 2.4 DSE/ewe/year, stocked at 6.6 ewes/ha. These ewes produced around 3.3 kg of clean wool each year, with an average fibre diameter of 32 micron. Ewe flock numbers were maintained by retaining around 700 replacement Coopworth Composite ewe lambs each year.

Lambs were born in mid-July and weaned in early December. Typically around 3,900 lambs were marked each year, which was 129% of the number of ewes joined. Allowing for the retention of replacement ewe lambs, around 3,000 lambs were usually sold each year. Total carcass weight of lamb sold was around 62,000 kg. The usual 25% light lambs were sold as stores in early December at approximately 34 kg liveweight and the remaining 75% heavier lambs were progressively sold at approximately 44 kg liveweight to a supermarket chain throughout December.

A budget of the steady state annual operation of the base farm in year four of the seven year planning period is outlined in Table 12. Expected average annual operating profit for the farm was $148,000, with a standard deviation of $75,000. Net profit after interest costs and tax was $113,000.

Change options

The steering committee identified a range of changes that had the potential to help achieve the family's goals. Four opportunities that were technically feasible and potentially acceptable to the owner were defined. These opportunities were: (i) Intensifying by increasing stocking rate on the base farm from 16 to 20 DSE/ha; (ii) Expanding by increasing land area of the base farm from 560 to 800 ha; (iii) Intensifying and expanding by increasing stocking rate from 16 to 20 DSE/ha across an enlarged farm area of 800 ha; and (iv) Intensifying by increasing lambing percentage from 129% to 145% (Figure 1). The assumptions underlying the operation of these changes are detailed below. Further details about each change are shown in Table 8 – 11.

Change 1: Increasing stocking rate

The steering committee judged that the reasonably good performance of the base farm could be improved further by increasing pasture production and consumption. This could be done by increasing soil fertility on the black flats and open country, with more tightly managed grazing, which would enable an increase in stock carried, while maintaining adequate pasture cover. The average level of supplementary feeding on the base farm would be increased in proportion to the extra animals carried. Average annual stocking rate over the whole farm increased from 16 DSE/ha to 20 DSE/ha.

Increasing soil fertility involved lifting the average soil Olsen P level across the black flats and open country from 7 to 12 by applying 169[2] t of superphosphate fertiliser in year one. The Hamilton long-term phosphate experiment suggests that an Olsen P for pasture production of around 15 can produce 12.5 t DM/ha annual pasture production (Cayley et al. 1998; Saul and Dark 2003). Increasing the average soil Olsen P of the black flats and open country and increasing annual pasture production to at least 11 t DM/ha was considered realistic. This quantity of pasture grown would enable an average stocking rate of 24 DSE/ha on these areas without depleting soil or pasture resources. Soil fertility and stocking rate were progressively increased from 6.6 to 7.5 ewes per ha in year one, up to 8.5 ewes per ha in year two and thereafter (Table 8).

The total cost for fertiliser, additional livestock and subdivision of paddocks (fencing and water system) more precisely according to land class and pasture type for improved grazing management was $344,000 (Table 10). All new investment was funded by borrowed funds (Table 11).

Variable costs (animal health, shearing, freight, selling costs, supplementary feed and maintenance fertiliser application) increased directly with stocking rate. Fuel and vehicle running costs and general repairs and maintenance increase slightly too, though not in direct proportion to stocking rate increases. Extra labour costing $15,000 per annum required during the busy times was also included (Table 10). It was assumed the steady state with these changes would be achieved by year three.

Change 2: Increasing land area

The second change investigated was buying 240 ha of the same type of land within a 20 km radius of the home block, with similar carrying capacity to the existing farm, and with similar proportions of soil types, pastures and fertility. This land was purchased for $4,660/ha and carried 16 DSE/ha, the same as the base farm. An extra 1,580 sheep were purchased costing $145/head and $230,000 in total. No extra plant was purchased. Variable costs increased in proportion to the number of DSEs. Fixed costs increased slightly and labour increased by $15,000. The steady state with this change was assumed to be achieved by year two.

Change 3: Increasing stocking rate and increasing land area

Opportunity three reflects a combination of changes one and two: increasing stocking rate from 16 to 20 DSE/ha on the base farm and purchasing 240 ha of additional land similar to the existing farm and increasing its stocking rate from 16 DSE/ha to 20 DSE/ha, all up farming 800 ha at a stocking rate of 20 DSE/ha. As per change one, stocking rate was increased by lifting Olsen P soil fertility levels from 7 to 12 on the black flats and open country land areas. This involved applying 241 t of superphosphate fertiliser in year one. Additional infrastructure required included extra fencing and expansion of the water system. The total cost of extra investment in land, capital fertiliser, livestock and improvements was $1.8 million (Table 10). Variable costs increased in proportion to DSEs and fixed costs increased too. An additional labour unit costing $40,000 per annum was employed. The owner/ operator allowance was also increased by $10,000 per annum to reflect the increase in management demands arising from the increase in size, complexity and risks of the expanded farm business. Steady state with this change was assumed to be achieved by year three.

Change 4: Increasing lambing percentage

The final change considered was increasing lambing percentage on the base farm. Growing more pasture and subdividing paddocks for improved ewe nutrition and stock control increased the number of lambs marked from ewes mated from 129% to 145%. Biophysical modelling suggested that such an increase in lambing percentage was achievable with the additional pasture production, without substantially increasing supplementary feed levels in most, reasonably typical years. Increasing pasture growth was assumed to be achieved by raising the Olsen P soil fertility levels from 7 to 9 on the black flats and open country land classes, which required capital application of 56 t of superphosphate fertiliser. Additional fencing and expansion of the water supply was required, and in total an extra $72,000 in capital was invested.

[2] Fertilizer capital application of 10 kg of Phosphorus per hectare in excess of maintenance is required to increase Olsen P by 1 unit; Saul and Dark 2003.

Some additional fuel and vehicle costs and labour for the busy times was also required. Steady state with this change would be achieved by year two.

For each of the changes, all capital development was funded using borrowed funds. For the financial analysis, an amortised seven year loan at 7% interest (nominal) was assumed for the base farm and the low capital development changes (one and four). A fifteen year amortised loan at 7% interest (nominal) was assumed for the high capital development changes (two and three). Annual fixed debt servicing obligations (interest and principal) for the base farm and each of the four changes is given in Table 11.

Results

Each change was analysed to compare profit and efficiency (economics), additions to wealth (wealth), debt servicing (finance), in light of the volatility of performance and degree of aversion to risk of the investor (risk).

Mean and standard deviation values for income, variable costs, overhead costs, operating profit and net profit for the base farm and each change in a steady state year is presented in Table 12.

Economic analysis (i): return on marginal capital

Real return on marginal capital invested (marginal real MIRR) was calculated for each change. The potential distributions of possible returns for each change, indicating variability of annual returns around the average over many runs of seven years of farming is given in Figures 2 – 5. Investing $344,000 and increasing stocking rate (change one), and investing $72,000 and lifting lambing percentage (change four), generated the highest returns on marginal capital, with 17.0% and 11.4% respectively (Table 13). Much less capital was invested in these changes compared to investing $1,348,000 to buy more land (change two) and $1,840,000 to buy more land and develop it (change three). Respectively, changes two and three generated returns on marginal capital of 7.2% and 8.7%. However, both increasing stocking rate and lifting lambing percentage on the base farm had large variations in returns around the average, relative to buying land and intensifying it, as indicated by their large SDs and CVs (Figures 2 and 5 compared with Figures 3 and 4, and Table 13).

The results for marginal capital invested in each change show that as profit and returns on marginal capital increased, so too did risk (Table 13). This is consistent with the general business phenomenon where higher returns on extra capital invested are achieved only by taking higher risk (Parry et al. 2000).

Economic analysis (ii): return on total capital

The marginal real MIRR tells how well the extra capital invested performs for each change. It is instructive to check how the extra capital invested in the business contributes to the annual return on the total capital in the business. This is especially so when comparing different choices that involve different amounts of capital. The real MIRR was calculated for seven years of operation of the base farm and for each change to compare the annual returns on total capital and the variability.

The real MIRR plotted against SD for each choice is shown in Figure 6 and the mean real annual return on total capital and SDs are given in Table 14. Continuing to farm without changing the system does not improve the economic efficiency of capital invested in the business. All changes resulted in annual average returns on total capital increasing to similar levels of economic efficiency of around 5%. All four changes to the base farm system showed the promise of producing higher annual profit and returns to total capital than the status quo system.

Compared with the base farm, increasing stocking rate and increasing land area (change three) gave the highest real return on total capital (MIRR), but also had the greatest variability associated with return, as measured by SD (Figure 6). Increasing stocking rate, increasing lambing percentage and increasing land area each had similar returns to capital, but each had different variability around return.

Comparing variability (SD) relative to mean return enables a fairer comparison between risk and return of the base farm and each change (CV). The changed systems did not increase business risk above the level already present for the base farm. The CV of return on total capital was 40% for the base farm, higher than the CVs for changes one, two, three and four (Table 14, Figure 7). Without considering the significantly different amounts of capital involved, and just focussing on risk and return on capital, buying extra farm land and developing it and the base farm dominates all other changes as it promises a higher return on capital for similar or less business risk. The changes of increasing land area, increasing lambing percentage and increasing stocking rate all had similar returns to capital and similar variability in returns relative to mean returns. Continuing to operate the base farm had the highest variation relative to the lowest mean return on total capital invested.

Contribution of Variables to Total Volatility of Performance

Analysing the components that make up the variability associated with each change, reveals the contribution that each uncertain input variable has on the volatility of return on total capital invested (MIRR) for the base farm and each change. The contribution to risk of individual variables (lamb price, mutton price, skin price, wool price, year, fertiliser price and supplementary feed price) is shown in Figures 8 - 12. For the base farm, a change in lamb price of one standard deviation, with all other variables held constant, caused a 1.3% increase in real MIRR (mean MIRR of 4.0%). In contrast, a one standard deviation change in supplementary feed price, with all other prices/ variables held constant, caused only a 0.1% change in real MIRR (Figure 8).

Lamb price was the most significant cause of business risk in each of the changes investigated. Mutton price and skin price generally were the next most influential, followed by wool price and year. 'Year' represents the quantities of inputs used and outputs produced by the farm, with variations in these quantities primarily caused by differences in rainfall from year to year. As for supplementary feed costs, fertiliser price changes also had negligible influence on the variability of return on total capital.

Judging these investment choices based on economic efficiency and business risk, alone, is not sufficient. Finance too matters: the implications of the changes for net cash flow, debt servicing and wealth are equally important, and need to be evaluated.

Financial analysis: addition to wealth

For the base farm and each change, addition to wealth (increase in equity) was assessed. Addition to wealth is estimated as cumulative nominal annual net cash flow after interest deductions, from seven years of farming, with farmland, livestock and plant purchased at the beginning of year one with equity and debt, and sold at the end of year seven, with all debt repaid. Asset values were adjusted by 2% inflation each year. This was done for the base farm and for each change giving total increase in wealth at the end of year seven (Table 15).

Interest charges in annual net cash flows has major impact on the cumulative net cash flows generated by each choice. After accounting for the cumulative net cash flow after interest generated from farming and adjusting asset values for inflation, which negated some of the interest cost for the high capital development options, change three, increasing stocking rate and land area generated the highest addition to end wealth with $1,974,000. This was $452,000 above the end wealth generated by the base farm, which was the least favourable of all of the choices. The next most favourable change was lifting lambing percentage, closely followed by increasing stocking rate on the base farm. Increasing land area generated the least to end wealth above that of the base farm.

These results show that borrowing to increase land, without also increasing the productivity by increasing stocking rate, was not expected to be a good use of the farmers' equity as other opportunities, such as increasing stocking rate and land area, or increasing stocking rate or lambing percentage on the base farm.

Like in the economic analysis, as the potential for additional wealth increases, so too does the variability (Table 16). Based on mean increase in wealth, the base farm had the lowest SD with $463,000, followed by increasing lambing percentage, then increasing stocking rate, and increasing land area. Increasing stocking rate and land area together had the highest SD. The variability relative to the mean (CV) shows that increasing lambing percentage had the lowest coefficient of variation at 29%, then followed by the base farm, increasing stocking rate on the base farm, and buying more land. Buying and developing land had the highest CV with 42%.

Financial analysis: debt servicing capacity

The distribution of the range of possible nominal annual net cash flows before interest in a steady state year can be used to calculate, for defined terms of debt, the probability that principal repayments and interest will be met. The situation is: 'This is the amount of capital required to make this change happen. If the farmer took out an amortised loan for this amount for a certain number of years, how likely is it that annual net cash flows will be sufficient to meet annual debt servicing obligations'.

If the farmer took out seven year loans for the lesser capital choices (base farm, increasing stocking rate and increasing lambing percentage on the base farm), then farm annual net cash flow in the steady state exceeded debt servicing requirements in 96%, 90% and 98% of years respectively. If taking out fifteen year amortized loans at 7% nominal for the choices requiring larger capital investments (buying land, buying land and intensifying), farm annual net cash flow in a steady state year exceeded fixed debt servicing obligations in 78% and 79% of years respectively (Table 17).

If the nominal interest rate was 15% per annum, the mean annual net cash flows in the steady state generated from the base farm, increasing stocking rate or increasing lambing percentage, would still be greater than principal and interest repayments required most of the time (Table 18). For the choices involving higher capital investment where land is purchased, the higher nominal interest rate of 15% per annum means that for half the time the mean annual net cash flow in the steady state will not cover debt servicing obligations. Under prolonged high interest rates the investment would not be financially feasible.

Risk analysis: business risk and financial risk

Business risk, measured as the coefficient of variation of net cash flow before interest for a typical one year period, was lower for each of the changes, compared with the base farm (Figure 13). The additional investment of each change into improving the performance of the base farm generated higher mean annual net cash flows, before interest, than the base farm with no change. While the SDs for each change were also greater, in proportion to their respective means the CVs were smaller, and therefore business risk is less. However, as shown in Figure 13, the difference in business risk between the base farm and each of the changes was not large.

Compared with business risk, there was a large difference though in financial risk between choices. Financial risk captures the relationship between annual net cash flow after tax, principal and interest for a typical one year period and fixed debt servicing obligations relative to business risk. The results showed that the greater the borrowings the higher the financial risk (Figure 13). However, for changes two and three, while change three involved more debt (Table 11) its level of financial risk was similar to change two. This is because each change is generating similar mean annual cash flows in proportion to debt, as well as having similar levels of business risk. This does not mean though that both are equal choices, because for the same risk, buying more land and intensifying it and the base farm generates a greater return on capital and end wealth than just buying more land.

Risk analysis: incorporating attitude to risk

Using stochastic efficiency with respect to a function (SERF) analysis, certainty equivalent (CE) values were calculated for the possible end wealth accumulated for running the base farm and each change (Table 16). The CE values for the base farm and each change at five levels of aversion to risk (lowest, low, medium, high and highest) are shown in Figure 14.

The ranking of choices changes depending on the decisions-makers' degree of aversion to risk. At the lowest level of aversion to risk (risk taker), the ranking of CE values indicated that a decision-maker would prefer approximately $1,877,000 for sure in exchange for the risky distribution of cumulative benefits generated from increasing stocking rate and land area (which had a mean of $1,974,000 and a SD of $833,000). This means, for a decision-maker willing to take on a relatively high degree of risk, buying extra land and increasing the stocking rate was the best choice. Conversely, for the most risk averse decision-maker (risk avoider), the ranking of CE values indicates that the most appropriate choice was increasing lambing percentage.

The CE rankings suggest that for the most risk averse decision-makers, continuing with the base farm system would be preferable to buying more land. For a decision-maker with a medium degree of aversion to risk increasing stocking rate, or increasing lambing percentage have the highest CE values and therefore are theoretically the most appropriate choices based on SERF analysis.

Discussion

The decision-maker is in the position of incorporating information about choices of farm changes into their processes of deciding what to do, if anything, about changing their business to achieve goals such as maintaining and growing wealth in the coming decade. Information about the returns and risks of the choices the farmer faces can be added to their knowledge from the past (experience) and intuition (experience, judgement and expectations), along with their feelings about bearing extra risk, all in light of the importance they place on the goals they are striving to achieve over the medium-term planning period. The risk preferences of the farmer, their goals and their stage of life will influence the decision the farmer makes. If the farm owners' goal is to have the business in a strong equity position in seven years or so, in order to have sufficient superannuation, or to make possible a succession plan, as well as have a business that is economically sustainable, then they would need to weigh up the extra risk they would need to bear to build such a business and settle on a choice that has a balance of risk and acceptable net worth, and is a bet they are willing to make (Malcolm et al. 2005).

Unavoidably, decision makers have to make assumptions about future levels of key parameters, such as likely extra carrying capacity, timing of increases in carrying capacity, rainfall, prices for wool and sheep meat, interest rates and so on. Some parameters are risky because they are volatile real-world phenomena. There may also be risk because the assumptions about key input-output relationships used to simulate the operation of the system are not known for sure. Research and increasing knowledge of farming systems has enabled a better understanding of the interactions and response functions between components within various situations. Likewise, past distributions and expert opinion inform judgements about the range of possible prices and costs in the future planning period.

For the case study farm, and based on the assumptions included in this study, the worst choice of the five options for profit, cash and building wealth was to continue with business as usual, unless the decision-maker was highly averse to any more risk, in which case buying more land was less favourable than continuing with the status quo. Increasing stocking rate from 16 DSE/ha to 20 DSE/ha and lifting lambing percentage from 129% to 145% on the base farm offered attractive returns on marginal capital and additions to wealth, with increasing stocking rate being slightly more risky than the base farm, and increasing lambing percentage slightly less. These changes would appeal more to decision-makers with a low to medium aversion to taking risk. Purchasing more land but not increasing its productivity added the least to end wealth and had a marked increase in exposure to financial risk. Purchasing extra land and increasing the stocking rate promised the greatest addition to end wealth, but also had high financial risk, and thus may appeal more to decision-makers willing to take on more risk.

Increasing stocking rate and increasing lambing percentage required the least extra capital investment and increased return to total farm capital above that of the base farm. These two choices promise a high return on extra capital invested. While costs associated with added risk have been counted into the analysis, there are still issues to do with the increasing management complexity and the degree to which producers can successfully apply the management strategies required to achieve the increased production targets. Increasing stocking rate through increased application of phosphorous fertiliser is a well proven and demonstrated technology (Trompf et al. 1998; Cayley et al. 1999; Saul and Kearney 2002). There is also potential to increase lamb marking percentages on farms through the management of ewe condition score (Trompf et al. 2011), and use of management strategies to improve lamb survival (Hinch and Brien 2014). The increased lambing percentages assumed in this paper have also been demonstrated in local farm systems research for the ewe type run on the base farm (EverGraze 2014). However, there is still some risk that higher stocking rates and lambing percentages may not be consistently achieved. On an individual basis, sheep farmers would need to assess how confident they are about achieving the higher stocking rate or higher lambing percentage, when weighing up the choices.

The financial analysis illustrates the risk associated with each of the changes, and that financing matters (Malcolm 2011). Considering price and yield risk and overlaying the financial implications of each of the changes for the business further informs the decision-maker about the choices. Even though a change may look attractive in terms of profit and risk before financing considerations, financial matters will be decisive. The capital required has to be able to be borrowed, and borrower and lender need to be confident the loan can be serviced under most of the range of circumstances that are likely to apply. In this case, the opportunities requiring substantial new capital investment increased financial risk by exposing the business to rises in interest rates, increasing the variability around the mean of net cash flow after debt servicing and reducing the probability that the debt can be serviced each year. If any of these changes were taken up, some thought would be needed by the investor about what steps are needed in the event of rising interest rates and periodic deficiencies of annual net cash flows.

Increasing stocking rate has implications for business risk and financial risk as exposure to drought increases and as borrowings increase, but to a lesser extent than buying more land. Increasing lambing percentage was a low capital change 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 where it was assumed that no real capital gains occurred in land value; buying the land and improving it promised a better return to marginal capital and contribution to wealth. The changes involving land purchase markedly increase financial risk. This may though, be an attractive choice that fits longer term aims to do with succession. The decision-maker would need to have a willingness to take on extra risk to buy the extra land and lift its stocking rate. If succession looms less large, and if the decision-maker has a medium or higher degree of aversion to risk, but wealth in a decade or so is still highly important, then the less debt, less financial risk avenue of intensifying by lifting stocking rate and lambing performance may be more attractive than committing to buying more land and servicing greater debt.

Conclusion

This study has assessed some typical options to increase the wealth of a prime lamb business. Those that intensify the business and increase the level of output from the existing base farm using a modest investment of capital were the most favourable in terms of generation of wealth balanced with the degree of risk. A key issue that would affect the success of these options would be the increase in management complexity and the degree to which farmers may achieve the change in practice. The results of this study also show that the expansion of the size of prime lamb business will be limited by the degree to which capital gain can be made on purchased land and the significant additional financial risk associated with the servicing of debt. In addition, analysis of factors contributing to variability of returns on capital indicated price of lamb was a substantial contributor to risk of the enterprise, suggesting sheep farmers and industry should seek solutions to mitigate this risk to their businesses. An extension of this work into other enterprise mixes and across different climate scenarios would build greater understanding about the risk and return of common choices of change that exist for sheep farmers.

Acknowledgements

We acknowledge the valuable interest, time and effort contributed to this project by the members of the project steering committee: Peter Small, Anthony Fleetwood, Philip Gough, Alex Robinson, Matthew Crawford, Matthew Tonnisen, Lisa Warn, James Whale, Ralph Behrendt and Peter Bailey. The time and effort given the project by the case study farmer and inputs of various Department of Environment and Primary Industries scientists into aspects of the project are also acknowledged gratefully. This work was supported by funding from the Department of Environment and Primary Industries, Victoria.

References

ABARES 2012, 'Agricultural commodity statistics 2012', Australian Bureau of Agricultural and Resource Economics and Sciences, Canberra, Australia.

Armstrong D, Ho C, Doyle P, Malcolm B, Gibb I and Brown S 2005, 'Analysing drought impacts and recovery options by adapting a dairy farming systems modelling approach', *Australian Farm Business Management Journal,* 2(1): 11-16.

Cayley JWD, Hannah MC, Kearney GA and Clark SG 1998, 'Effects of phosphorus fertiliser and rate of stocking rate on the seasonal pasture production of perennial ryegrass-subterranean clover pasture', *Australian Journal of Agricultural Research,* 49(2): 233-248.

Cayley JWD, Kearney GA, Saul GR and Lescun CL 1999, 'The long-term influence of superphosphate and stocking rate on the production of spring-lambing merino sheep in the high rainfall zone of southern Australia', *Australian Journal of Agricultural Research,* 50: 1179-1190.

Clark SG, Austen EA, Prance T and Ball PD 2003, 'Climate variability effects on simulated pasture and animal production in the perennial pasture zone of south-eastern Australia. 1. Between year variability in pasture and animal production', *Australian Journal of Experimental Agriculture,* 43: 1211-1219.

Clark SG, Donnelly JR and Moore AD 2000, 'The GrassGro decision support tool: its effectiveness in simulating pasture and animal production and value in determining research priorities', *Australian Journal of Experimental Agriculture,* 40: 247-256.

EverGraze 2014, 'Sheep systems for maximising profit from perennials at Hamilton EverGraze proof site', from *http://www.evergraze.com.au/library-content/hamilton-key-message-livestock-systems-for-maximising-profit-from-perennials/*

Freer M, Moore AD and Donnelly JR 2012, 'The GrazPlan animal biology model for sheep and cattle and the GrazFeed decision support tool', *CSIRO Plant Industry Technical Paper*.

Gabriel SC and Baker CB 1980, 'Concepts of business and financial risk', *American Journal Agricultural Economics,* August: 560-564.

Graham P and White A 2010, 'Sheep enterprises - what are the differences?', *Australian Farm Business Management Journal*, 7(1): 33-42.

Hardaker JB, Huirne RBM, Anderson JR and Lien G 2004, *Coping with risk in agriculture*, 2 edn, CABI, Oxfordshire, United Kingdom.

Heard JW, Leddin CM, Armstrong DP, Ho CKM, Tarrant KA, Malcolm B and Wales WJ 2012, 'The impact of system changes to a dairy farm in south-west Victoria: risk and increasing profitability', *Animal Production Science*.

Heard J, Malcolm B, Jackson T, Tocker J, Graham P and White A 2013, 'Whole farm analysis versus activity gross margin analysis: a sheep farm example', *Australian Farm Business Management Journal*, 10: 16-29.

Hennessy KJ, Whetton PH and Preston B 2010, 'Climate projections', in C Stokes and M Howden (ed.), *Adapting agriculture to climate change: preparing Australian agriculture, forestry and fisheries for the future,* rev. edn, CSIRO, Melbourne, Australia, pp. 13-20.

Hinch GN and Brien F 2014, 'Lamb survival in Australian flocks: a review', *Animal Production Science*.

Ho C, Nesseler R, Doyle P and Malcolm B 2005, 'Future dairy farming systems in irrigation regions', *Australian Farm Business Management Journal*, 2(1): 59-68.

Lewis C, Malcolm B, Farquharson R, Leury B, Behrendt R and Clark S 2012, 'Economic analysis of improved perennial pasture systems', *Australian Farm Business Management Journal*, 9(2): 37-56.

Malcolm B 2011, 'Financing matters', *Australian Farm Business Management Journal*, 8(1): 11-18.

Malcolm B, Ho CKM, Armstrong DP, Doyle PT, Tarrant KA, Heard JW, Leddin CM and Wales WJ 2012, 'Dairy Directions: a decade of whole farm analysis of dairy systems', *Australasian Agribusiness Review,* 12: 39-58.

Malcolm B, Makeham J and Wright V 2005, *The farming game: agricultural management and marketing,* 2 edn, Cambridge University Press, Melbourne, Australia.

MLA 2004, 'Economic analysis of sheep production systems', report prepared for MLA (Meat and Livestock Australia) by: Hassell and Associates Pty Ltd., Sydney, Australia.

Moore AD, Donnelly JR and Freer M 1997, 'GrazPlan: decision support systems for Australian grazing enterprises. III. Pasture growth and soil moisture submodels, and the GrassGro DSS', *Agricultural Systems,* 55(4): 535-582.

Morant A 2011, 'EverFarm - Strategic Decisions Milestone Report June 2011 - EverGraze - Case Study Farm - Corinda-Vale', Department of Primary Industries, State of Victoria, Australia.

Palisade 2012, @Risk - Risk Analysis Add-in for Microsoft Excel version 6.1.1. Palisade Corporation: Ithaca, New York, USA.

Parry J, Black C and Bennett A 2000, *Fundamentals of finance: Financial institutions and markets, personal finance, financial management*, Pearson Education New Zealand Limited, Auckland, New Zealand.

Rabobank 2013, *The future of farming: the rise of the rural entrepreneur*, AB Publishing, London, United Kingdom.

Roberston SM 2006, 'Predicting pasture and sheep production in the Victorian Mallee with the decision support tool, GrassGro', *Australian Journal of Experimental Agriculture,* 46: 1005-1014.

Saul G and Dark P 2003, 'Making informed decisions on phosphorus fertilisers: results from the Hamilton long-term phosphate experiment', Department of Primary Industries, State of Victoria, Australia.

Saul GR and Kearney GA 2002, 'Potential carrying capacity of grazed pastures in southern Australia', *Wool Technology and Sheep Breeding,* 50(3): 492-498.

Saul G, Kearney G and Borg D 2011, 'Pasture systems to improve productivity of sheep in south-western Victoria. 2. Animal production from ewes and lambs', *Animal Production Science,* 51: 982-989.

Thompson A 2006, 'Morelamb Quality Pastures', Department of Primary Industries, State of Victoria, Australia, and Meat and Livestock Australia, Sydney, Australia.

Tocker J and Berrisford T 2011, 'Livestock Farm Monitor Project: Results 2010/11', Department of Primary Industries, State of Victoria, Australia.

Trompf JP, Gordon DJ, Behrendt R, Curnow M, Kildey LC and Thompson AN 2011, 'Participation in Lifetime Ewe Management results in changes in stocking rate, ewe management and reproductive performance on commercial farms', *Animal Production Science,* 51: 866-872.

Trompf JP, Sale PWG, Saul G, Shovelton J and Graetz B 1998, 'Changes in practices and decisions resulting from the paired-paddock model used in the Grassland's Productivity Program', *Australian Journal of Experimental Agriculture,* 38: 843-853.

Warn L 2011, 'Hamilton EverGraze proof site: impact of changing management regimes on profitability', Mackinnon, The University of Melbourne, Australia.

Warn L, WebbWare J, Salmon L, Donnelly J and Alcock D 2006, 'Analysis of the profitability of sheep wool and meat enterprises in southern Australia', Sheep CRC, Australia.

Young JM, Thompson AN and Kennedy AJ 2010, 'Bioeconomic modelling to identify the relative importance of a range of critical control points for prime lamb production systems in south-west Victoria', *Animal Production Science,* 50: 748-756.

Appendix

Table 1. Details of the physical characteristics of the farm and prime lamb enterprise modelled in GrassGro®.

General farm systems information

Total farm area	560 ha
Weather Station	Penshurst

Soil		Paddock 1 Barrier country Area 312 ha Stony rises (Um 6.21)		Paddock 2 Black flats Area 168 ha Dark cracking clays (Ug 5.16)		Paddock 3 Open country Area 80 ha Hard neutral brown soils (Db 2.22)	
		Top soil	Sub soil	Top soil	Sub soil	Top soil	Sub soil
Cumulative depth	(mm)	150	1000	200	1400	300	1000
Field capacity	(m^3/m^3)	0.43	0.30	0.50	0.45	0.24	0.30
Wilting point	(m^3/m^3)	0.25	0.20	0.33	0.31	0.13	0.20
Bulk density	(Mg/m^3)	1.10	1.70	1.10	1.30	1.60	1.70
Saturated conductivity	(mm/hr)	100	3.00	1.00	0.30	30	3.00
Initial water	(m^3/m^3)	0.15	0.23	0.15	0.23	0.15	0.23
Soil evaporation	($mm/d^{1/2}$)	3.30		3.50		3.30	
Steepness		Gentle		Level		Gentle	
Fertility (scalar 0 to 1)		0.75		0.70		0.70	

Pasture		Paddock 1 Barrier country		Paddock 2 Black flats		Paddock 3 Open country	
		Austrodanthonia (Wallabie grass)	Sub clover Leura	Phalaris	Sub clover Leura	Perennial Ryegrass	Sub clover Leura
Phenological stage		Vernalizing	Senescent	S. Dormant	Senescent	S. Dormant	Senescent
Live DM	(kg/ha)	0	0	0	0	0	0
Standing dead DM	(kg/ha)	4002	2000	4000	2000	4002	2000
Litter DM	(kg/ha)	500	200	500	200	500	200
Below ground DM	(kg/ha)	200	0	300	0	200	0
Max. rooting depth	(mm)	300	100	400	100	700	100
Seed DM	(kg/ha)		400		400		400

Farm system

Livestock

Breed	Border Leicester (Coopworth Composite is not an option in GrassGro®)
Standard reference weight	65.0 kg
Greasy fleece weight	4.10 kg
Fibre diameter	32.0 microns
Fleece yield	70%
Ram breed	Border Leicester (On farm it's $^1/_3$ joined to a maternal sire $^2/_3$ to a terminal sire (Dorset))
Death rate : adults	6%
Death rate : weaners	7%

Management Policy : ewe management

Stocking rate (base farm)	6.6 ewes/ha
Shearing date	15-Nov
Replacement rule	Self-replacing; CFA stock aged 6-7 years

Reproduction

First join at		1-2 years
Mating date		15-Feb
Conception at CS 3	(1)	52%
	(2)	43%
	(3)	5%
Birth date		13-Jul
Castration		Yes
Weaning date		10-Dec
One ram per		85 ewes
Keep rams for		3 years
Sell young ewes		Between 10 Dec and 30 Dec sell any animals at 44 kg or heavier. Sell any remaining animals regardless of weight on 30 Dec.
Sell young wethers		Between 10 Dec and 30 Dec sell any animals at 44 kg or heavier. Sell any remaining animals regardless of weight on 30 Dec.

Maintenance feeding rule		
Main flock	Feed in paddock. If animal condition falls to 2.0 during 1 Jan to 31 Dec, feed to maintain condition of the thinnest animals.	
Weaner flock	Feed in paddock. If animal condition falls to 2.0 during 1 Jan to 31 Dec, feed to maintain condition of the thinnest animals.	
Supplement	Oats, whole	
	Proportion of mix	100%
	Dry matter content	90%
	Dry matter digestibility	73%
	ME:DM (MJ/kg)	12.4
	Crude protein (%)	10%
	Rumen degradable protein (%)	80%

Grazing rotation

To model the enterprise over the three pasture and soil classes a fixed grazing rotation was selected - whereby the grazing rotation involved 5 days in paddock 1; 3 days in paddock 2; 2 days in paddock 3. This grazing rotation represents appropriate levels of pasture covers, growth rates and stocking rates for each pasture and soil class.

Table 2. Distribution types and key percentiles for specified prices and costs.

Variable	Distribution type	Min	5%	95%	Max	Average	Standard deviation
Lamb meat price ($/kg cwt)	Gamma	1.77	3.42	5.92	None	4.55	0.77
Skin price ($/hd)	Pert	0.22	3.85	19.70	25.97	11.44	4.83
Mutton price ($/kg cwt)	Triang	0.30	0.99	4.35	5.20	2.59	1.01
Replacement ewe price ($/hd)	Lognorm	0.00	101.00	199.00	None	145.00	30.00
Wool price ($/kg clean)	BetaGeneral	3.27	3.43	5.88	6.53	4.51	0.76
Supplementary feed ($/t)	Lognorm	0.00	165.00	359.00	None	250.00	60.00
Fertiliser (super) ($/t)	Lognorm	0.00	303.00	401.00	None	350.00	30.00

Table 3. Justification of specified price and cost distributions used in the analysis.

Variable	Detail
Lamb meat price ($/kg cwt)	@Risk Fit Distribution function based on consumer price index adjusted Eastern States Trade Lamb Indicator data (2003-2013). Lamb dressing percentage 45%
Skin price ($/hd)	@Risk Fit Distribution function based on consumer price index adjusted skin prices from the Hamilton sale yards (2000-2013).
Mutton price ($/kg cwt)	@Risk Fit Distribution function based on consumer price index adjusted Victorian mutton price data (2003-2012). Mutton dressing percentage 48%
Replacement ewe price ($/hd)	@Risk Fit Distribution function used, based on expert opinion (project steering committee of farmers, consultants and research scientists).
Wool price ($/kg clean)	@Risk Fit Distribution function based on consumer price index adjusted southern micron guide for 32 micron wool (2003-2012). Assume 85% of clean fleece value across entire wool clip to take account of discounted lines (bellies/pieces/locks).
Supplementary feed ($/t)	@Risk Fit Distribution function used, based on expert opinion (project steering committee of farmers, consultants and research scientists).
Fertiliser (super) ($/t)	@Risk Fit Distribution function used, based on expert opinion (project steering committee of farmers, consultants and research scientists).

Table 4. Price correlations used in the @Risk analysis.

Price correlations	Lamb meat price	Mutton price	Replacement ewe price
Lamb meat price	1		
Mutton price	0.9	1	
Replacement ewe price	0.9	0.9	1

Table 5. Variable costs used in the analysis.

Variable costs				
Animal health		$/application	No. applications	$/head
Broadspectrum	ewes	$0.65	2	$1.30
	lambs	$0.33	3	$0.99
Narrowspectrum	ewes	$0.45	1	$0.45
Dipping	ewes	$1.16	1	$1.16
Fly control (long acting)	weaners	$1.55	1	$1.55
Vaccination (6 in 1)	ewes	$0.27	1	$0.27
	lambs	$0.27	1	$0.27
Marking	lambs	$1.55	1	$1.55
Scanning	ewes	$0.80	1	$0.80
		Total	ewes	$3.98
			weaners	$1.55
			lambs	$2.81

Labour			$/head	
	Shearing	ewes	$5.89	
		hoggets	$5.89	
		rams	$8.50	
	Crutching	ewes	$1.04	
		lambs	$1.04	
		rams	$1.95	
Wool costs / Shearing supplies				
		Wool tax	2%	of wool income
		Commission, warehouse, testing charges	$39.00	/bale*
		Wool cartage	$18.00	/bale*
		Wool packs	$13.00	/bale*
				*assume average wool bale is 200 kg
Livestock selling costs				
		Livestock cartage	$1.90	/hd
		Commission on sheep sales	4.50%	
		Levies (yard dues, MLA levy, and RLPB rates)	1.90%	
Other	(annual costs)			
		Other costs (general)	$0.35	/hd
		Fuel & vehicle	$8,400	
		Repairs & maintenance	$11,800	
		Pasture maintenance	$7,300	
		Fertiliser application rate	0.0008	t P/dse; 8.8% P per tonne of super.
		Ewe standard value	$145	/hd
		Ram purchase value	$900	/hd
		Effective tax rate	15%	
		Inflation on income	2.0%	
		Inflation on costs	2.0%	
		Cost price squeeze	1.0%	

Table 6. Fixed costs used in the analysis.

Fixed costs	
Labour	$0
Depreciation	$14,000
Rates	$5,000
Administration	$9,000
Other *(Electricity, Insurance, etc)*	$6,700
Operator's allowance	$60,000

Table 7. Value of assets for the base farm.

Value of Assets	Purchase	Salvage
Owned land	$2,900,000	$2,900,000
Livestock	$700,000	$700,000
Plant and Equipment	$105,000	$21,000
Fodder	$8,000	$8,000
Total	$3,713,000	$3,629,000

Table 8. Additional changes to physical characteristics of the farm and prime lamb enterprise for each change modelled in GrassGro®.

			Change 1	**Change 2**	**Change 3**	**Change 4**
			Increase stocking rate	Increase land area	Increase stocking rate and land area	Increase lambing %
Fertility	Year 1	Paddock 1	0.80	0.75	0.80	0.75
(scalar 0 to 1)		Paddock 2	0.80	0.70	0.80	0.80
		Paddock 3	0.80	0.70	0.80	0.80
	Year 2 onwards	Paddock 1	0.80	0.75	0.80	0.75
		Paddock 2	0.95	0.70	0.95	0.80
		Paddock 3	0.87	0.70	0.87	0.80
Stocking rate	Year 1		7.5	6.6	7.5	6.6
(ewes/ha)	Year 2 onwards		8.5	6.6	8.5	6.6
Conception at CS 3		(1)	52%	52%	52%	15%
		(2)	43%	43%	43%	80%
		(3)	5%	5%	5%	5%
Grazing rotation	Year 1	Paddock 1	5	5	5	5
(no. days in each paddock)		Paddock 2	3	3	3	3
		Paddock 3	2	2	2	2
	Year 2 onwards	Paddock 1	5	5	5	5
		Paddock 2	4	3	4	3
		Paddock 3	2	2	2	2
No. of extra sheep required		Year 1	504	1584	2304	-
		Year 2	560	-	800	-

Table 9. Mean and standard deviation values of production parameters for the base farm and each change. The results represent mean and standard deviations based on GrassGro® modelling over 50 years of weather data (1960 to 2009) for the Penshurst area.

	Status Quo		**Change 1**		**Change 2**		**Change 3**		**Change 4**	
	Base Farm		Increase stocking rate		Increase land area		Increase stocking rate and land area		Increase lambing %	
Physical details	**Mean**	*Standard deviation*	**Mean**	*Standard deviation*	**Mean**	*Standard deviation*	**Mean**	*Standard deviation*	**Mean**	*Standard deviation*
Land area (ha)	560		560		800		800		560	
Rainfall (mm)	729	*114*	729	*114*	729	*114*	729	*114*	729	*114*
Feed budget - pasture grown (kg/ha)	7,837	*1,374*	9,600	*1,587*	7,880	*1,357*	9,555	*1,577*	8,588	*1,463*
Feed budget - animal intake (kg/ha)	4,592	*256*	5,964	*347*	4,600	*255*	5,958	*346*	4,864	*232*
Average stocking rate (DSE/ha)	15.7	*0.7*	20.2	*0.9*	15.7	*0.7*	20.2	*0.9*	16.5	*0.6*
- paddock 1 av. stocking rate	14.6	*0.7*	16.9	*1*	14.6	*0.7*	16.9	*1*	15	*0.8*
- paddock 2 av. stocking rate	14.9	*0.6*	23.5	*1.1*	14.9	*0.6*	23.5	*1*	16.2	*0.6*
- paddock 3 av. stocking rate	21.7	*1.4*	26.4	*1.4*	21.7	*1.4*	26.4	*1.5*	23.5	*1.2*
Supplementary feed (t)	41	*77*	52	*96*	60	*111*	74	*138*	33	*67*
Average No. adults over the year (Mature & 1-2 y.o. Females)	3,190	*17*	4,114	*20*	4,559	*24*	5,875	*26*	3,193	*19*
Lamb marking % (lambs per ewe)	129%	*12%*	130%	*13%*	129%	*12%*	129%	*13%*	145%	*11%*
Total No. of lambs sold	3,007	*343*	3,908	*469*	4,300	*475*	5,568	*663*	3,477	*295*
Lamb Production - Total Kilograms Carcass Weight	62,063	*7,209*	81,801	*10,025*	88,873	*10,135*	116,483	*14,221*	73,865	*6,635*
Lamb Production - Kilograms Carcass Weight per Ha	111	*13*	146	*18*	111	*13*	146	*18*	132	*12*
No. kilograms of wool produced per ha	22.2	*0.9*	29.3	*1.2*	22.3	*0.8*	29.2	*1.2*	22.6	*0.9*

Table 10. Additional costs and investment required for each change (in real dollars).

	Change 1		Change 2		Change 3		Change 4	
	Increase stocking rate		Increase land area		Increase stocking rate and land area		Increase lambing %	
Variable Costs								
Fuel & vehicle	$1,500		$3,000		$5,000		$1,000	
Repairs & maintenance	$1,500		$3,000		$5,000		$0	
Pasture maintenance	$0		$3,000		$5,000		$0	
Fixed Costs								
Labour	$15,000		$15,000		$40,000		$5,000	
Depreciation	$0		$3,000		$5,000		$0	
Rates	$0		$2,500		$2,500		$0	
Administration	$0		$1,000		$1,000		$0	
Other *(Elec, Insurance, etc)*	$2,000		$2,000		$2,000		$0	
Operator's allowance	$0		$0		$10,000		$0	
Assets	Purchase	Salvage	Purchase	Salvage	Purchase	Salvage	Purchase	Salvage
Owned land	$0	$0	$1,118,000	$1,118,000	$1,118,000	$1,118,000	$0	$0
Livestock	$154,000	$154,000	$230,000	$230,000	$450,000	$450,000	$0	$0
Fencing and water systems	$131,000	$79,000	$0	$0	$188,000	$113,000	$53,000	$32,000
Capital Fertiliser	$59,000	$59,000	$0	$0	$84,000	$84,000	$19,000	$19,000
Total	$344,000	$292,000	$1,348,000	$1,348,000	$1,840,000	$1,765,000	$72,000	$51,000
Debt								
Opening Debt	$344,000		$1,348,000		$1,840,000		$72,000	

Table 11. Starting equity, borrowings, and annual fixed debt servicing obligations (principle and interest) – with an amortised seven year loan at 7% interest (nominal) for the base farm and low capital changes (1 and 4) and a 15 year amortised loan at 7% interest (nominal) for the high capital changes (2 and 3).

	Status Quo	Change 1	Change 2	Change 3	Change 4
	Base Farm	Increase stocking rate	Increase land area	Increase stocking rate and land area	Increase lambing %
Starting equity	$3,633,000	$3,633,000	$3,633,000	$3,633,000	$3,633,000
Total borrowings	$80,000	$424,000	$1,428,000	$1,920,000	$152,000
Annual fixed debt servicing obligations	$15,000	$79,000	$157,000	$211,000	$28,000

Table 12. Mean and standard deviation values for income, variable costs, overhead costs, operating profit, net farm income and net profit for the base farm and each change in a steady state year, as modelled on GrassGro® production data.

Steady State Year (Mean & Standard Deviation)										
	Status Quo		**Change 1**		**Change 2**		**Change 3**		**Change 4**	
	Base Farm		Increase stocking rate		Increase land area		Increase stocking rate and land area		Increase lambing %	
	Mean	*Standard deviation*	**Mean**	*Standard deviation*	**Mean**	*Standard deviation*	**Mean**	*Standard deviation*	**Mean**	*Standard deviation*
Gross Income										
Lamb sales	$319,299	*$63,458*	$420,610	*$84,495*	$456,939	*$89,842*	$598,151	*$120,065*	$377,022	*$69,178*
Cull ewe sales	$51,363	*$18,178*	$66,937	*$23,762*	$73,524	*$26,082*	$95,299	*$33,778*	$50,798	*$17,930*
Wool sales	$47,535	*$8,226*	$62,881	*$10,961*	$68,200	*$11,772*	$89,628	*$15,661*	$48,425	*$8,408*
less: Replacement ewe/ram purchases	$11,013	*$86*	$14,201	*$92*	$15,738	*$110*	$20,268	*$111*	$11,005	*$83*
Inventory change	$123	*$2,806*	$117	*$3,018*	$102	*$3,309*	$145	*$3,434*	$113	*$2,619*
Other farm income	$0	*$0*	$0	*$0*	$0	*$0*	$0	*$0*	$0	*$0*
	$407,307	*$68,411*	$536,343	*$90,060*	$583,026	*$97,182*	$762,954	*$129,483*	$465,354	*$73,195*
Variable Costs:										
Animal health	$21,788	*$1,189*	$28,220	*$1,651*	$31,151	*$1,656*	$40,223	*$2,307*	$23,397	*$1,038*
Shearing labour	$33,964	*$1,853*	$43,990	*$2,573*	$48,558	*$2,581*	$62,700	*$3,597*	$36,472	*$1,617*
Shearing supplies	$5,447	*$297*	$7,055	*$413*	$7,788	*$414*	$10,056	*$577*	$5,849	*$259*
Freight and cartage	$5,767	*$315*	$7,470	*$437*	$8,246	*$438*	$10,647	*$611*	$6,193	*$275*
Selling costs	$24,351	*$1,329*	$31,540	*$1,845*	$34,815	*$1,851*	$44,955	*$2,579*	$26,150	*$1,160*
Other	$2,243	*$122*	$2,905	*$170*	$3,207	*$170*	$4,141	*$238*	$2,409	*$107*
Supplementary feed	$11,367	*$21,631*	$14,277	*$26,706*	$16,693	*$31,445*	$20,645	*$38,430*	$9,295	*$18,726*
Fertiliser (super)	$28,901	*$2,777*	$37,224	*$3,619*	$41,336	*$3,961*	$53,155	*$5,162*	$30,422	*$2,863*
Fuel & Vehicle	$8,655	-	$10,200	-	$11,745	-	$13,806	-	$9,685	-
Repairs & maintenance	$12,158	-	$13,703	-	$15,248	-	$17,309	-	$12,158	-
Pasture maintenance / development	$7,521	-	$7,521	-	$10,612	-	$12,673	-	$7,521	-
	$162,161	*$19,584*	$204,106	*$24,018*	$229,399	*$28,495*	$290,309	*$34,176*	$169,552	*$17,476*
Total Gross Margin										
- total	$245,145	*$74,891*	$332,237	*$98,101*	$353,627	*$106,908*	$472,645	*$141,695*	$295,802	*$78,016*
- per DSE	$28	*$8*	$29	*$8*	$28	*$8*	$29	*$8*	$32	*$8*
- per Ha	$438	*$134*	$593	*$175*	$442	*$134*	$591	*$177*	$528	*$139*
Overhead Costs:										
Labour	$0	-	$15,455	-	$15,455	-	$41,212	-	$5,152	-
Depreciation	$14,424	-	$14,424	-	$17,515	-	$19,576	-	$14,424	-
Rates	$5,152	-	$5,152	-	$7,727	-	$7,727	-	$5,152	-
Administration	$9,273	-	$9,273	-	$10,303	-	$10,303	-	$9,273	-
Other	$6,903	-	$8,964	-	$8,964	-	$8,964	-	$6,903	-
	$35,751	-	$53,267	-	$59,964	-	$87,782	-	$40,903	-
Owner/Operator Allowance	$61,818	-	$61,818	-	$61,818	-	$72,121	-	$61,818	-
Operating Profit (EBIT)	$147,576	*$74,891*	$217,152	*$98,101*	$231,845	*$106,908*	$312,742	*$141,695*	$193,081	*$78,016*
Interest & Lease Costs:										
Current loan interest cost	$3,520	*$190*	$3,520	*$190*	$3,520	*$190*	$3,520	*$190*	$3,520	*$190*
New loan interest cost	$0	*$0*	$15,152	*$1,751*	$83,628	*$5,537*	$113,708	*$8,540*	$3,185	*$416*
	$3,520	*$190*	$18,672	*$1,737*	$87,148	*$5,532*	$117,227	*$8,538*	$6,705	*$370*
Net Farm Income	$144,056	*$74,889*	$198,480	*$97,291*	$144,697	*$105,372*	$195,515	*$138,610*	$186,376	*$78,018*
Tax Payable	$31,047	*$11,220*	$38,831	*$14,755*	$30,727	*$15,743*	$39,722	*$20,805*	$37,363	*$11,653*
Net Profit / Change in Equity	$113,009	*$66,623*	$159,650	*$86,587*	$113,970	*$94,084*	$155,793	*$123,931*	$149,013	*$68,487*

Table 13. Mean real marginal modified internal rate of return (MIRR) and associated statistical measures for each change.

Option	Mean Real Marginal MIRR	Standard Deviation	Coefficient of Variation
1. Increase stocking rate	17.0%	26.6%	156%
2. Increase land area	7.2%	6.5%	91%
3. Increase stocking rate and land area	8.7%	5.8%	66%
4. Increase lambing percentage	11.4%	56.0%	491%

Table 14. Mean real modified internal rate of return (MIRR) on total capital invested and associated statistical measures for the base farm and each change.

Option	Mean Real MIRR	Standard Deviation	Coefficient of Variation
Base Farm	4.0%	1.6%	40%
1. Increase stocking rate	5.1%	1.8%	36%
2. Increase land area	5.0%	1.6%	33%
3. Increase stocking rate and land area	5.7%	1.9%	32%
4. Increase lambing percentage	5.1%	1.7%	34%

Table 15. Total increase in wealth (mean) and marginal increase in wealth (mean) for the base farm and each change at the end of year seven (future value), made up of cumulative net cash flows after interest from farming and 2% per annum inflation of assets values.

Option	Cumulative Net Cash Flow (after interest) from 7 years Farming *(nominal)*	Adjustment of Assets by 2% p.a. Inflation *(nominal)*	Increase in Wealth after 7 years *(nominal)*	Difference in Wealth Effects between Options and Base Farm *(nominal)*
Base Farm	$1,148,000	$374,000	$1,522,000	
1. Increase stocking rate	$1,463,000	$358,000	$1,821,000	$299,000
2. Increase land area	$1,145,000	$544,000	$1,689,000	$167,000
3. Increase stocking rate and land area	$1,453,000	$521,000	$1,974,000	$452,000
4. Increase lambing percentage	$1,467,000	$359,000	$1,826,000	$304,000

Table 16. Mean total increase in wealth and associated statistical measures for the base farm and each change.

Option	Mean Increase in Wealth	Standard Deviation	Coefficient of Variation
Base Farm	$1,522,000	$463,000	30%
1. Increase stocking rate	$1,821,000	$590,000	32%
2. Increase land area	$1,689,000	$657,000	39%
3. Increase stocking rate and land area	$1,974,000	$833,000	42%
4. Increase lambing percentage	$1,826,000	$522,000	29%

Table 17. The probability of annual net cash flow being greater than annual principal and interest repayments, for an amortization loan at a 7% interest rate (nominal), in the steady state years.

Option	Fixed annual debt servicing obligations at 7% interest	Probability of annual NCF being greater than debt servicing obligations at 7% interest
Base Farm	$15,000	96% (7 year loan)
1. Increase stocking rate	$79,000	90% (7 year loan)
2. Increase land area	$157,000	79% (15 year loan)
3. Increase stocking rate and land area	$211,000	78% (15 year loan)
4. Increase lambing percentage	$28,000	98% (7 year loan)

Table 18. The probability of annual net cash flow being greater than annual principal and interest repayments, for an amortization loan at a 15% interest rate (nominal), in the steady state years.

Option	Fixed annual debt servicing obligations at 15% interest	Probability of annual NCF being greater than debt servicing obligations at 15% interest
Base Farm	$19,000	95% (7 year loan)
1. Increase stocking rate	$102,000	86% (7 year loan)
2. Increase land area	$244,000	48% (15 year loan)
3. Increase stocking rate and land area	$328,000	47% (15 year loan)
4. Increase lambing percentage	$37,000	98% (7 year loan)

Figure 1. Changes investigated for case study farm.

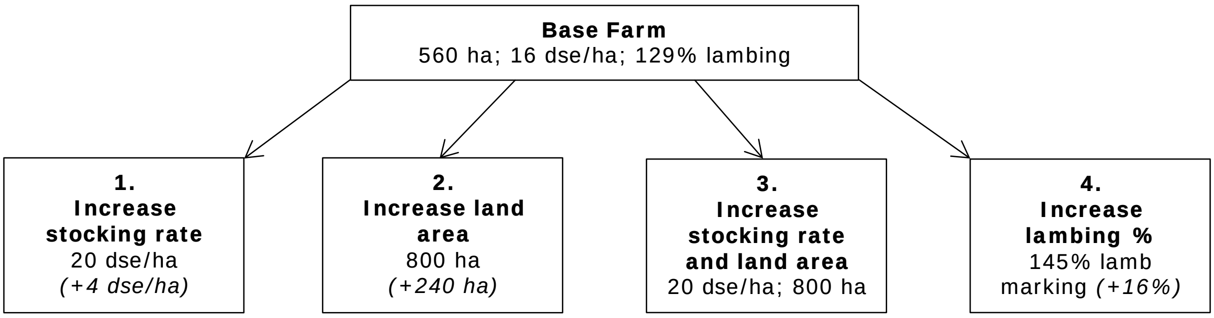


Figure 2. Real return on extra capital invested (marginal modified internal rate of return [MIRR]) from increasing stocking rate.

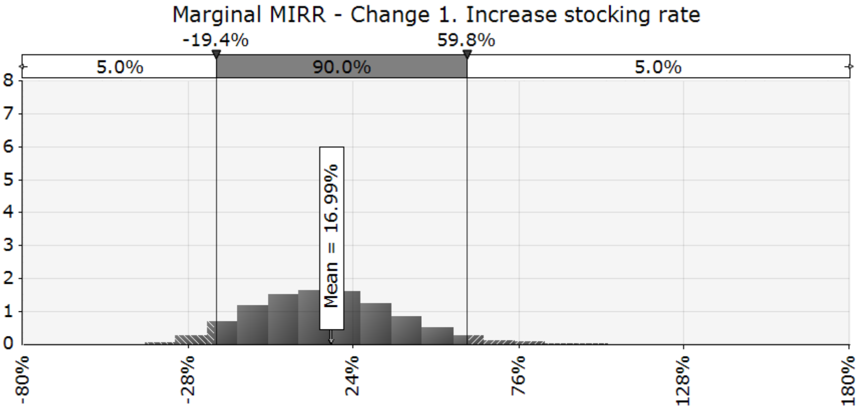


Figure 3. Real return on extra capital invested (marginal modified internal rate of return [MIRR]) from increasing land area.

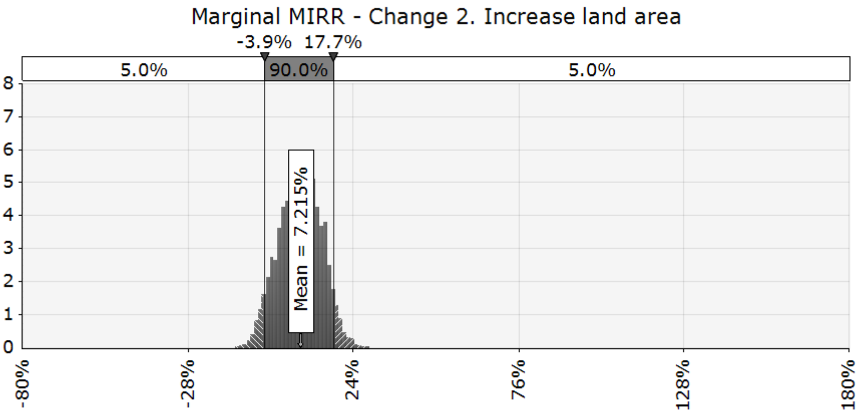


Figure 4. Real return on extra capital invested (marginal modified internal rate of return [MIRR]) from increasing stocking rate and land area.

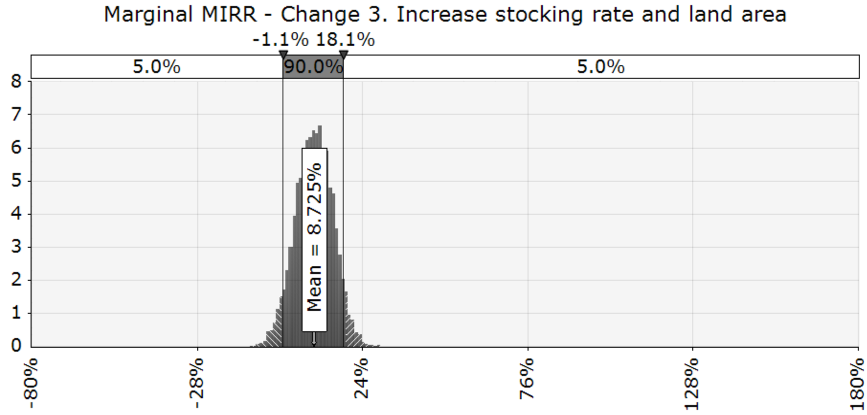


Figure 5. Real return on extra capital invested (marginal modified internal rate of return [MIRR]) from increasing lambing percentage.

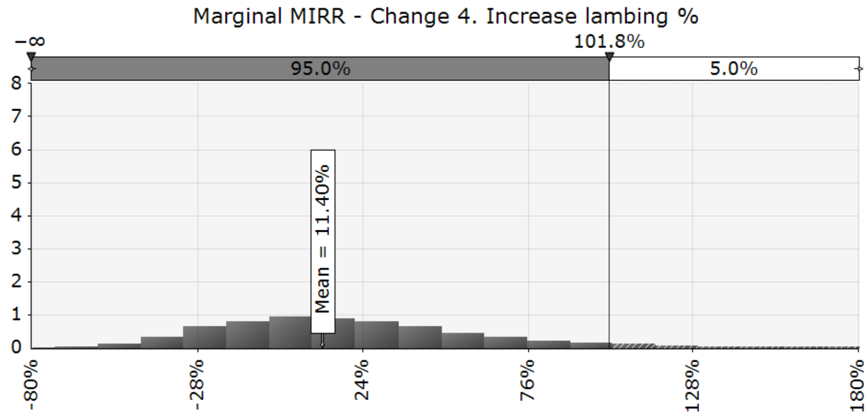


Figure 6. Real return on total capital invested (modified internal rate of return [MIRR]) versus variance in return for the base farm and each of the four changes in real terms.

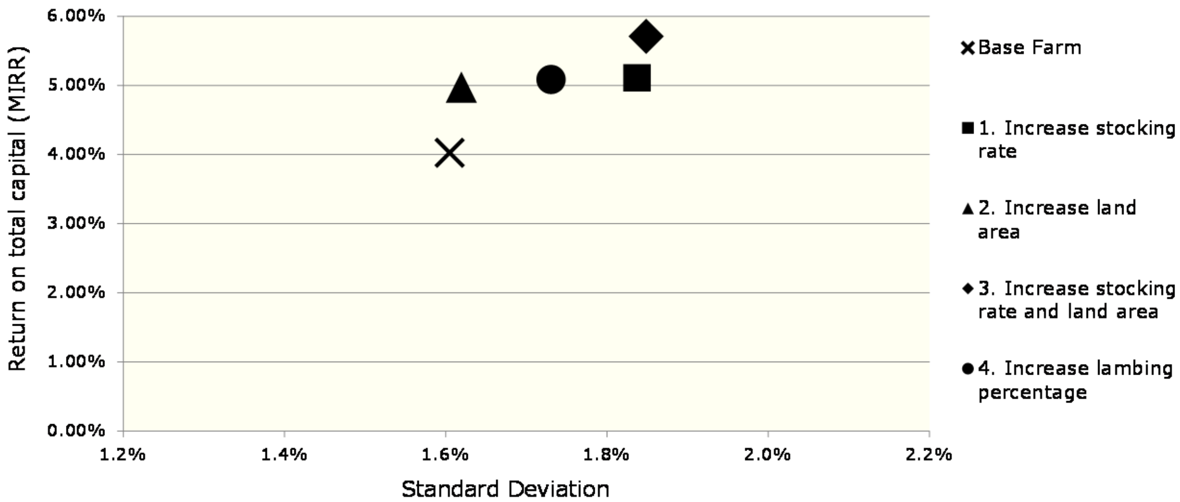


Figure 7. Real return on total capital invested (modified internal rate of return [MIRR]) versus coefficient of variation for the base farm and each of the four changes in real terms.

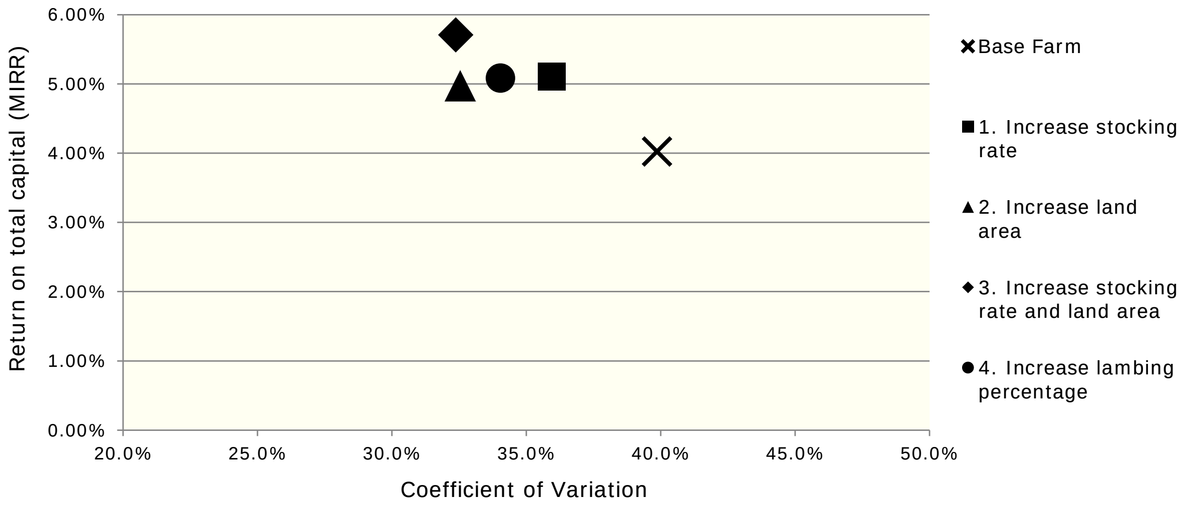


Figure 8. Influence of individual input distributions on real return on total capital invested (modified internal rate of return [MIRR]) for the base farm.

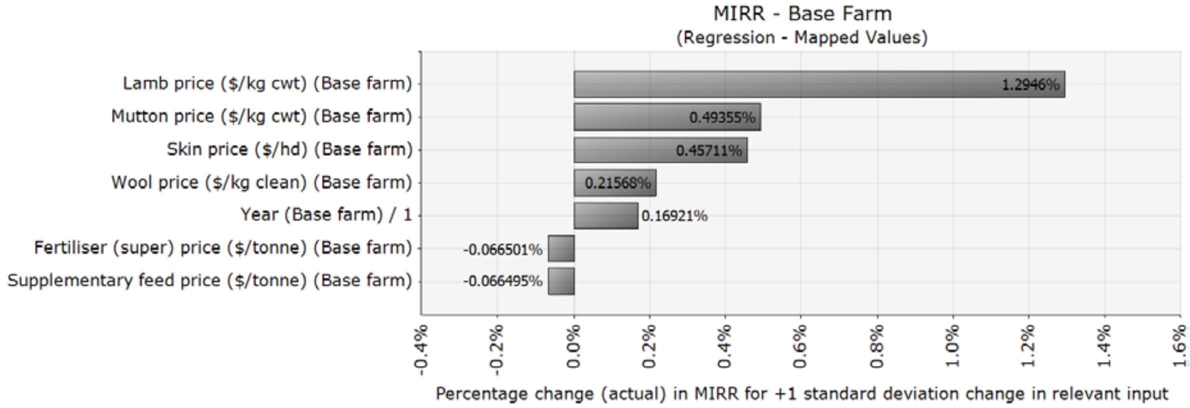


Figure 9. Influence of individual input distributions on real return on total capital invested (modified internal rate of return [MIRR]) for change 1, increasing stocking rate.

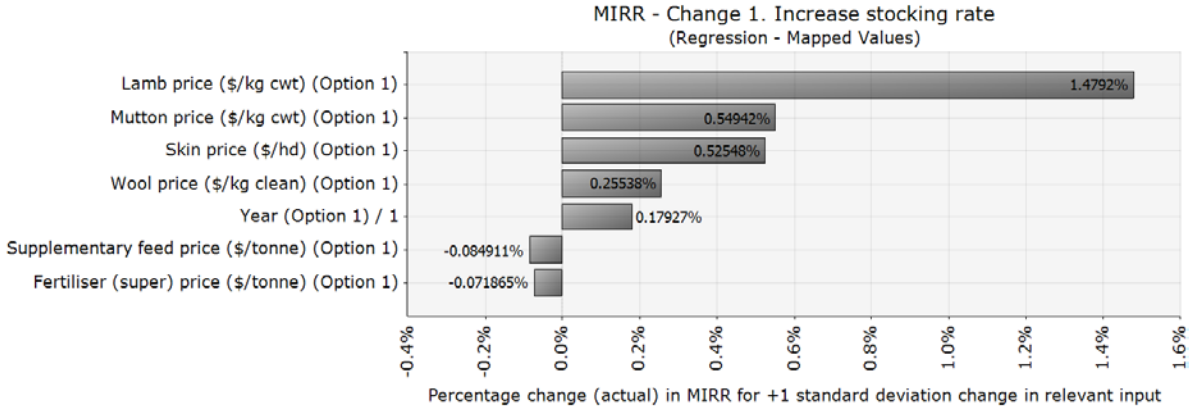


Figure 10. Influence of individual input distributions on real return on total capital invested (modified internal rate of return [MIRR]) for change 2, increasing land area.

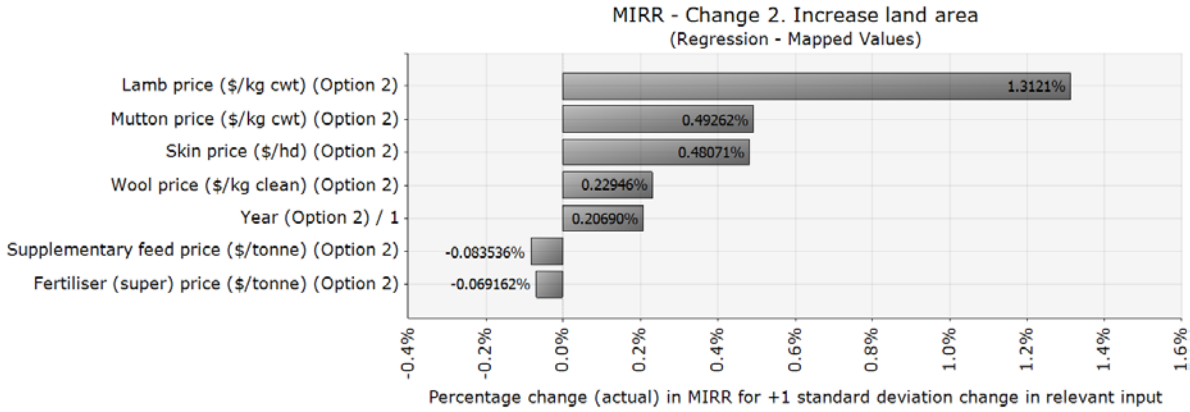


Figure 11. Influence of individual input distributions on real return on total capital invested (modified internal rate of return [MIRR]) for change 3, increasing stocking rate and land area.

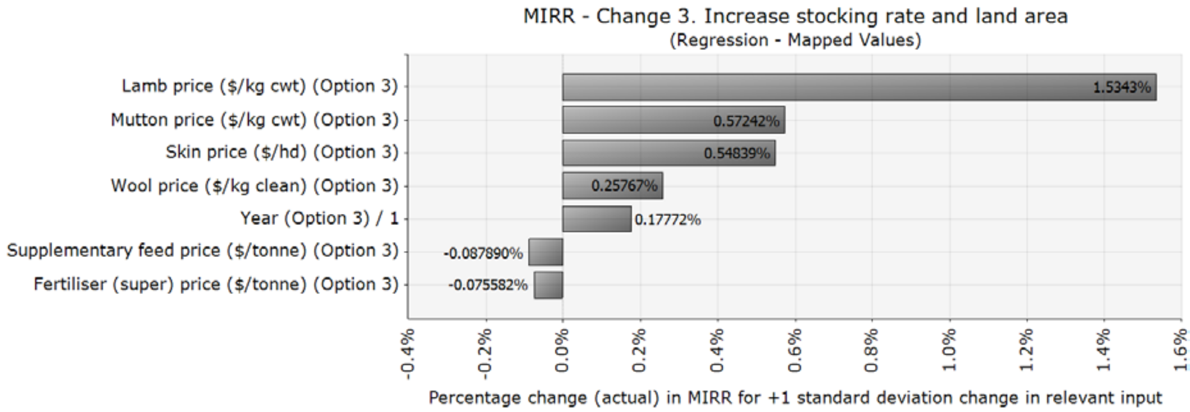


Figure 12. Influence of individual input distributions on real return on total capital invested (modified internal rate of return [MIRR]) for change 4, increasing lambing percentage.

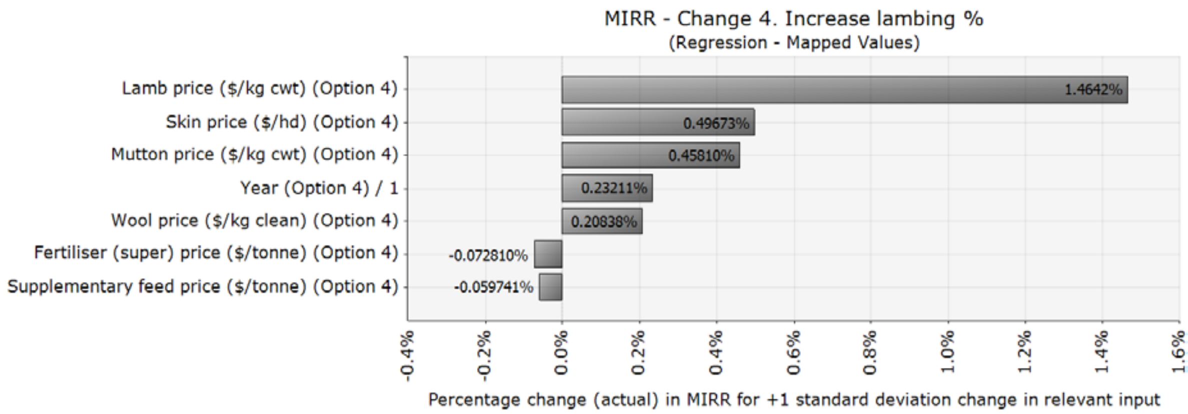


Figure 13. Sources of variability of annual net cash flows in a steady state year for the base farm and each change.

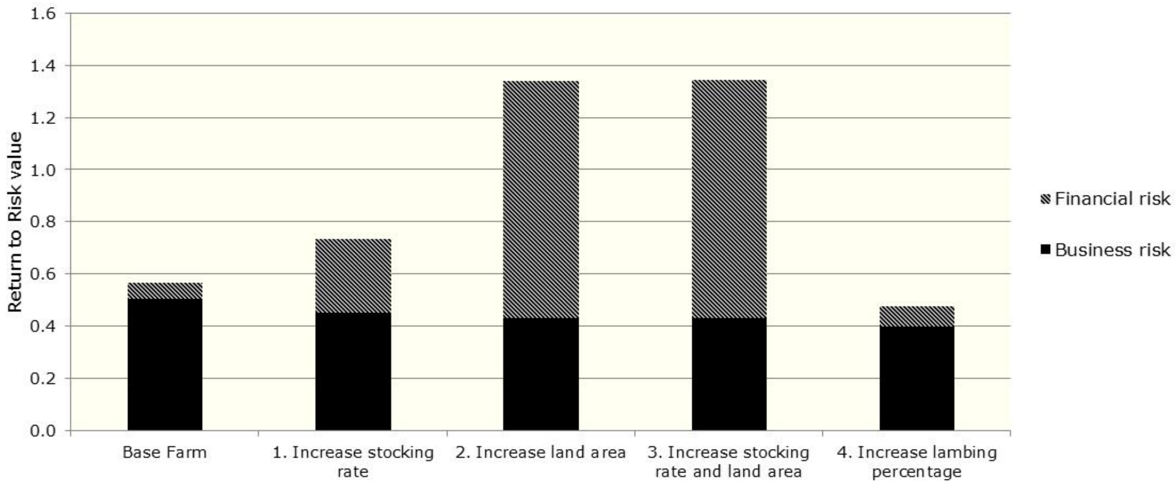
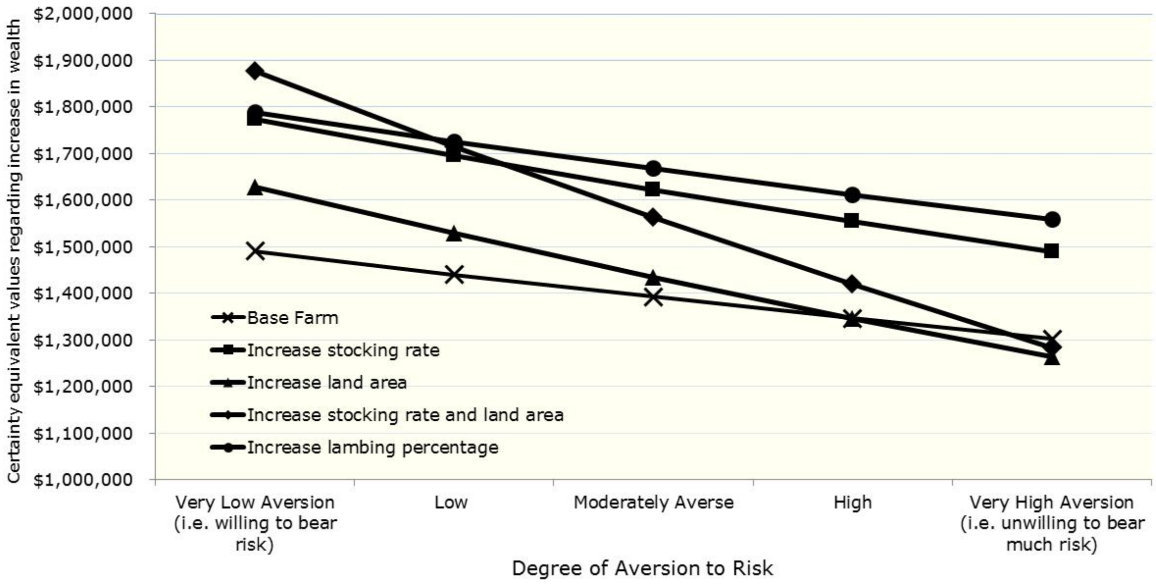


Figure 14. Certainty equivalent values regarding increase in wealth at different levels of risk aversion for the base farm and each change.



Authors' Certification

We, Jonathon Tocker, B Malcolm, J Heard, A Sinnett, C Ho and R Behrendt,

the authors of this paper have undertaken the necessary steps for ethical clearance, where necessary, to conduct the research projects that produced the results presented in this paper.

We also certify that this paper has not been published elsewhere before and that submitting it to *AFBM Journal* implies our concession in sharing copyright.

Date: 12 May 2014