

Punting Lamb

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Abstract. We present in clear, readable terms how to understand the risky aspects of a ewe purchase decision. Expected lamb prices in the future are an important driver of ewe prices now. We derive easy methods of determining the relationship between future lamb prices and current ewe prices. This lends to an evaluation of rules of thumb showing that the 'bet' and the 'odds' are keys to good investment.
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Introduction

Farming is a caper in which the best operators occasionally make some really good money. Most of the time, most get through the tough times and, overall, make a living and enjoy doing so. The big decision problems come along both when times are tough, and when prospects are exciting with promise. Managing poorly and making some big decisions badly in good times can send farm businesses broke just as effectively as managing the tough times poorly.

Note the important difference between making good decisions and them being right or wrong decisions: good decisions use the best available information and sound logic to organise the information into a way that 'tells a sensible story', plus of course the decision-maker's own good intuition. Whether a good decision turns out to be the right decision or the wrong decision depends on many other uncertain and uncontrollable factors that farmers must live with and their business must survive, such as rainfall, prices, exchange rates, market access and so on.

Questions often asked by farmers considering decisions about farming lambs profitably are:

- How much should I pay for replacement ewes?
- What is the cost of owning ewes?

These are good questions. They are almost the right questions. They are not quite the right questions. Better questions are:

- What will be the effect of the price I pay for replacement ewes on lifetime profit from the investment in her?
- What is the risk of the investment being profitable or not?

To answer these questions it is necessary to draw on issues that are at the heart of economic theory: the value of capital and return to capital.

Capital

A farm business comprises fixed capital in the form of things used for production that have a medium and long-term life, such as land that is non-depreciable, and capital in the form of machinery and livestock that is depreciable. Variable capital consists of the inputs used in an annual production cycle, such as fertiliser, chemical, seed. (A different, and confusing, use of the word capital refers to finance: the fixed and variable capital inputs are financed by owners' equity and borrowings of financial capital.)

Replacement ewes are an investment in livestock capital.

The value of an item of capital

The value of an item of capital is determined by how much the use of it adds to net profit of the business. Suppose we have a lump of capital that does not depreciate or die, and it is certain to add $10 each year to farm profit in perpetuity. How much is the lump of capital worth? The answer is worked out as follows:

If I want to earn 10% p.a. on my investment in this lump of capital that gives a net return each year of $10 forever, then I would value the lump of capital at $100. This is because $10/$100 equals 10% return p.a. You want 10% return each year, therefore you would pay up to $100 for the source of the $10 net profit each year.

What about the annual costs of a capital investment? Suppose a lump of capital has a market value today of $100 and it has a five-year productive life and at the end of five years it will be worn out to a considerable extent and it is going to be worth in the market 25% of its original value today (i.e. in 2011 dollars). There are a couple of ways that we can estimate the annual cost of owning and using this lump of capital.

Calculating depreciation cost

The simplest is to estimate annual depreciation cost as follows:

Lifetime depreciation is opening value minus salvage value

Salvage value is opening value multiplied by salvage value %, that is $100x0.25=$25

Therefore, lifetime depreciation (in 2011 dollars) is $100-$25=$75

Annual depreciation cost is $75/5 years=$15 per year

This lump of capital also has another annual cost: this is the cost incurred by using the value of this capital in the way we are going to do so instead of investing the same amount into an alternative profitable use. The economic term for this is 'opportunity cost'. This is the net return given up from an alternative use, by instead using the capital on the farm.

The tricky bit in estimating this annual opportunity interest cost is that the amount of capital tied up each year in the farm use will be less each year if it is a depreciable asset and thus loses some of its value each year. A rough way to get around this difficulty is to estimate the annual opportunity cost as an annual *average* percentage of the *average* annual amount of capital tied up for the five years. The calculation is done as follows:

Calculating opportunity cost

Average annual capital value is opening capital value (in 2011 dollars) plus end of 5 year market Salvage Value (in 2011 dollars) / 2:

This is ($100+$25)/2=$62.5 capital tied up each year in the asset on average.

If the opportunity cost of the capital is 5% real (no inflation) then we charge an opportunity interest cost of 5% real on the $62.50, giving annual average opportunity cost of $62.50x0.05=$3.12

Total annual cost of the $100 capital invested for 5 years is $15 depreciation plus $3.12 opportunity cost, giving $18.12 (in 2011 dollars) each year for the $100 lump of capital.

So far we have dealt with two concepts: the value of capital being determined by what it adds to net profit each year and the cost of depreciable capital being the sum of annual average depreciation and annual average opportunity interest cost.

Buying Replacement Ewes for Lamb Production

Cost of ewes

Some 'lumps of capital' not only depreciate but they also die. The calculation of the cost of owning a ewe (or the cost per head of owning a number of ewes) is as follows:

Calculating ewe ownership costs

1. Price paid for ewe = $100 (2011 dollars)

2. Salvage value of CFA ewe after fifth lamb, aged 6yo = $25 (2011 dollars)

3. Percentage of original flock that have not died during the 5 years = 90%

4. Annual depreciation and death cost = $100 purchase price – (90% of ewes left for salvage x $25 salvage value) = ($100-$22.50)/5 = $77.50/5 = $15.50 depreciation and death cost per year.

5. Annual opportunity interest on average capital:

Average capital is ($100+$25)/2=$62.5

Opportunity interest cost is 5% real (= to 8% nominal with 3% inflation)

Total annual opportunity cost is $62.5x0.05=$3.12 per year (in real dollars, no inflation)

Total death, depreciation and opportunity cost = $15.50+$3.12=$18.62/ewe purchased.

There is a further cost associated with deaths of ewes – the loss of production subsequently. This cost is the same regardless of the price paid for the ewes. Calculations of some typical costs of replacement ewes and returns from lamb sales reveal:

- Death losses matter. Losses reduce annual income as fewer lambs are sold each year from the initial investment in ewes, and the end of life salvage value too is reduced as there are fewer ewes remaining to be sold. But, *these death losses affect costs to the same extent irrespective of the initial capital investment, so they are equally important at all replacement ewe prices.*
- The higher the price paid for the replacement ewes, the higher the lifetime depreciation and death cost, regardless of lost production from deaths.

Lamb prices and net returns

The annual profit from a flock of ewes or a lamb business is determined by costs and income. The price paid for ewes determines their annual cost. Income is set by the prices received for the lamb output produced. While ewe quality is partly responsible for different prices paid for ewes at any time, a general rise in profitability of producing lamb will see prices across the range of ewe qualities move upwards accordingly, with the prices paid for higher quality ewes (greater productive potential over their lifetime) most likely rising at a greater rate than ewes of lesser quality.

The key point is that changes in the profits expected derive mostly from changes in the prices expected to be received for lambs. Thus, in valuing replacement ewes, much thought has to go into the expected income from lambs over the lifetime of the ewes.

Current lamb prices reflect world supply and demand conditions, with swings in both supply and demand determining prices at any time. If favourable change in demand occurs, caused by say favourable movements in exchange rates or changes in market access or growth in demand from rising incomes or changes in tastes in markets, then the key consideration is whether the change reflects a short-term aberration from the medium-term conditions, or is it something more stable and enduring, perhaps for the life of the planned investment in replacement ewes.

To consider the risk associated with lamb prices, and other risks of farming too, a more detailed analysis than the methods outlined above, which are based on single value 'best guesses', is useful. A comprehensive way to account for risky future lamb prices is explained below, and some results presented of analysing the questions about prices to pay for replacement ewes considering death and depreciation costs *and* all the possible prices for lambs.

A more comprehensive analysis that accounts well for risky lamb prices, and other risks too

This is the century in which we will understand risk better. For now, an improvement on the back of the envelope plus intuition approach demonstrated above is to construct a whole farm budget using a spreadsheet (which can be thought of as a big calculating machine on a computer). Using this method the analyst can use probabilities in the budgets to work out both returns and risks.

Good information about the 'bet' and 'the odds' are the keys to good investment. This method of incorporating the odds into the arithmetic of the budget makes for a better informed punter. Note though, such an approach is doing nothing investors don't ordinarily do, except, usually, lacking information, they use implicit judgements and intuition.

Whole farm budgeting using the computer spreadsheet and probabilistic values instead of single values for key variables like price of lambs and ewes, cost of grain and fodder, exchange and interest rates, rain or no rain and so on, explicitly incorporates some of the unknowns into the calculations. As long as the information used to frame the market is good, better information is available to the decision-maker.

A spreadsheet model has been constructed to find the value of replacement ewes. The idea of this model is that a ewe's value is equal to the present value of the net profit generated in each year of the ewe's productive life. As explained above, annual net profit is the difference between income (lamb and wool sold) and costs (feed, depreciation, opportunity cost).

Using this model, simulation is used to calculate the risks and returns generated by investing in replacement ewes at a range of prices. In each simulation the computer picks the values to be taken by risky variables (like lamb, wool and feed prices) from the range of possible values for those variables. The computer then works out the net present value of investing in a ewe at a particular price if those values of the risky variables occurred. The computer repeats this process hundreds of times for each ewe price we consider and records the results, giving us an idea of the risk and return associated with paying these prices.

To make sense of the information produced by a spreadsheet model like this one, the assumptions used in constructing the model must be understood. In particular, the likelihood of particular values of the risky variables in the model occurring must be clear. Table 1 contains a description of the risky variables which have been included in the spreadsheet model.

The lamb price per head is the average price per head received for all lambs sold in a particular year. This number is determined by the per-kilogram liveweight price of lamb in each weight class, the proportion of lambs sold in each weight class and the dressing percentage. A skin value of $14 per lamb has also been included. Given the distribution specified in Table 1, the per-head price of lambs will be between $90 and $130 60% of the time, or 6 years in every 10. Prices lower than $90 and higher than $130 will each occur 2 years in every 10. The low ($60) and high ($170) values in the table each occur 1 year in every 20.

Other important assumptions of the model are that ewes are purchased as one-year-olds, and are sold after having five lambs, including one in the first year. Annual deaths of 3% and culls of 5% have been assumed when determining the distributions for per-ewe annual weaning rate. For example, if the average weaning rate per pregnant ewe is 150%, then the average weaning rate per ewe over the whole flock is 150% x (100% - 3% ewe deaths) x (100% - 5% dry ewes) = 138%. This calculation is the basis of the 'Lambs per ewe' distributions in Table 1.

The generally lower average fertility of younger ewes is included in the model by the different distributions of lambs per year for 1.5 and 2+ y.o. ewes. Distributions of lambs per ewe have been used here to capture the effect of weather and other random events which alter the number of lambs sold per ewe from year to year, including variation in lamb deaths.

The average annual cost of energy per ewe is assumed to be around $58 p.a. This cost reflects the price of supplementary feed if the farm was already fully stocked, or the value of surplus feed produced. Overhead costs (labour, administration) are assumed to be $20 per ewe.

Total animal health and sale costs (including lamb costs) are assumed to be another $18 per ewe p.a. (shearing, drench, levies, freight). Depreciation costs have been represented using a salvage value for ewes, and the opportunity cost of capital is included by discounting annual net profits by 8% p.a. real.

There are many ways to represent risk using simulation models, and the method used here is to calculate the probability of the investment earning a rate of return of at least 8% pa real. This is considered to be a 'satisfactory' rate of return on such an investment, but each person may have their own threshold rate. The higher the threshold rate of return used, the lower will be the probability of achieving it at all ewe prices paid.

The returns on investing in replacement ewes are represented by net present value (NPV). This is the value today (in 2011 dollars) of the cumulative net profits generated over the productive life of the ewe. This number is calculated by discounting future net profits at 8% pa real. This means that if the NPV is zero, then the investment has earned a rate of return of 8% real. If the NPV is greater than zero, this means the investment has generated 'extra' profits beyond the 8% real which is paid to the owners of capital. These extra profits accrue to the owner of the asset. Some results obtained from a simulation analysis using these numbers are presented in Table 2.

As can be seen from Table 2, the price paid for ewes has a very significant impact on the risk and return of investments in these assets. In particular, the probability of earning a satisfactory rate of return on investment is less than 50% at prices of around $190 per ewe. Furthermore, the average net present value (at 8% real return) of the investment becomes negative around $190 per ewe.

This does not mean that prices greater than $190 per ewe should never be paid. In fact, there is still a fairly good chance that the investment will be profitable at this price. However, as the price paid for ewes increases, everything else needs to go relatively well for the investment to generate a satisfactory return.

Another way to look at the information produced by the simulation model is provided in Figure 1, where the net present values of investments in ewes at a range of prices are displayed. There are two important points to take from this graph. First is that average net present value declines as the ewe price increases. Second, there is a fair amount of variation in net present values at all ewe prices, such that even at relatively high ewe prices, there is still a chance of earning a good return on the investment. However this chance is smaller than at lower ewe prices.

The main determinant of the rate of return earned by the investment in replacement ewes is the price received for lambs over the productive life of the ewe. To illustrate this point, we run the simulation model again, but now with a per-head lamb value distribution of $80 to $200, with a most likely value of $120 (instead of $60 to $160, with a most likely value of $110). The results are summarised in Table 3.

With these higher lamb prices, buying replacement ewes is a much more attractive proposition. Risk, as measured by the probability of achieving a satisfactory rate of return is much lower for all ewe prices relative to when lamb prices were lower. Furthermore, the profitability of the investment, as measured by the average net present value of the investment is now much higher for all ewe prices.

It is important to note that the two distributions of lamb prices used in this analysis represent different expectations about lamb prices over the next 5 years. As we can see, changing these expectations has a big effect on the estimated risk and return of investing in replacement ewes. If your expectations of lamb prices in the next few years are different from the distributions which have been used here, the risk and return of investing in ewes will be different too.

When making farm investment decisions, the implications of these decisions for the whole-farm system are important. However, while whole-farm analysis of ewe replacement decisions is possible, the results from such an analysis can be difficult to interpret, because they depend on other aspects of the farm system more than just the replacement price of ewes, which is what we are interested in here.

Accordingly, what we have presented here is a 'partial' analysis, which means that only the extra costs and benefits associated with the investment in replacement ewes are considered. This allows us to focus on the most important aspects of this decision. Whole-farm considerations such as the availability of feed and labour have been implicitly assumed to be unconstraining.

And the point is?

Relating *current* prices and net profits to the value to place on ewe replacements is not the correct approach. The correct way to value ewe replacements is to think hard about the prices and net profits you can expect to get for lambs from your system in the *medium term*. This figure is a better guide to how much to invest in replacement ewes than current prices. The common farmer way of thinking: 'if things are good they can only get better and if things are bad they can only get worse', is precisely the wrong way to think about investment.

A combination of high annual and total death and depreciation costs as a result of high initial capital values, along with falls in asset values that happen when expected income flows decline, accompanied by low lamb prices sometime during the life of the ewe, if it happens, can be disasterous for a business. High prices are 'cured' by high prices – in economic terms, high prices induce a supply response and unless demand continues to increase correspondingly, prices must fall.

What to do when your competing bidders expect lamb prices to stay at $125/head or higher for the next five years and are prepared to pay higher prices for replacement ewes than you can justify because you think lamb prices will fluctuate and will have an average price over the next five years that is less than $125/head?

The winning bid always goes to the most optimistic bidder. If you genuinely believe the current and near future lamb prices are a short-lasting 'spike' then it does not make sense to buy high priced replacement ewes that will be a depreciation and death cost burden to your business for the next 4 years.

And furthermore – averaging the capital invested!

It is sometimes thought that by buying an asset at a range of values and therefore keeping the average value of the total investment at a reasonable level gets away from the problems caused by paying too much for an asset. This is flawed thinking. Even though it is a common rationalisation made by investors, especially in the share market, value-averaging is still a classic case of investors fooling themselves to make things look better than they are or have been.

Each lump of capital invested has an alternative potential use at the time the investment is made. Once investments in livestock capital are made, they are sunk for some time at least. The original sum invested has incurred the opportunity cost - if the price paid for replacement ewes is so high as to then earn a net return less than the opportunity earnings foregone elsewhere, then no amount of adding up all the other bits of capital and averaging the total value will change the loss incurred by the high priced investment (even if self-delusion does make the investor feel better about the world of investment and all its pitfalls).

Rules of Thumb

A common rule of thumb used when buying replacement ewes is "to get your money back in two years". That is, the highest price to pay for ewes today is twice what you expect lamb prices to be over the next two years.[1] The economic sense of this rule can be evaluated using the net present value (NPV) model of investing in ewes which is described above.

There are several ways to represent the rule of thumb in the model. One way is to assume that future lamb prices are unpredictable, so that all we know when buying a replacement ewe is the current lamb price. Then, the highest price paid for the ewe in the first year is simply double the lamb price in the first year, and all future lamb prices (i.e. those received in the next 4 years) are drawn from the distributions of possible values for these prices.

Another way to think about the rule is that the highest price to pay for a ewe today is twice the price of lambs which is expected to be received over the life of the ewe. If farmers were able to perfectly predict lamb prices we could represent this by having a constant lamb price throughout the life of the ewe which was equal to the lamb price in the first year. However, this representation would hugely overstate the extent to which lamb prices can be predicted.

In fact, the rule of thumb is likely to be based on both risk and return. The reason for

[1] This is based on the assumption that one lamb is sold per ewe each year. Alternatively, the rule could be to pay up to twice the expected lamb income in the next two years, which would take into account the weaning rate and the price of lambs. For simplicity, we shall assume one lamb is sold per ewe each year.

wanting to get your money back in two years is at least partly because future lamb prices are unknown, hence we should not assume lamb prices can be predicted perfectly when representing the rule in the model. This means there is still a chance, even when the rule is followed, of paying the "wrong" price for ewes. This price is not necessarily wrong in the sense that it was a bad decision to pay this price, but wrong in the sense that it resulted in a negative return on the investment because of an unexpected fall in lamb prices. The question is, given the unpredictability of lamb prices, is the risk and return of investing in replacement ewes any better when the rule is used than when it is not?

No forecast

In this section the rule of thumb is represented in the model by setting the price paid for ewes equal to twice the current lamb price. In all subsequent years, lamb prices are drawn from the independent, random distributions specified Table 3. This is effectively assuming that farmers do not attempt to predict lamb prices when buying ewes, but just look at the current lamb price. If we run this model for the distribution of possible lamb prices we get the results in Table 4.

The average profitability of investing in ewes using this rule is relatively low – as indicated by the negative average net present value. Furthermore, the risk of the investment failing to make a satisfactory return is also relatively high – as indicated by the 1 in 4 chance of making a return greater than 8% real.

However, these results are generated across the whole distribution of possible lamb prices. The average lamb price in this distribution is $112, which implies an average ewe price of $224. This explains why the 'average' results presented in this table are relatively poor, and leads us to the question of whether there are some lamb/ewe price combinations for which the rule of thumb is a good guide for making this investment decision.

To work this out, we can examine the internal rates of return of the investments which arise when this rule is used at different lamb prices. These results are summarised in Figure 2.

This output tells us that the rule works best at relatively low lamb prices, and gets progressively worse as lamb prices increase. However, all this output really represents is the decrease in average IRR which occurs as the ewe price rises. Even though (using the rule) high ewe prices are only paid when lamb prices are high, we are only guaranteed to get the high lamb price for the first year. When all the other years of lamb prices can vary, paying high ewe prices is generally not sufficiently compensated for over the productive life of the ewe. This result is consistent with the results presented above where no rule was used.

A better model

A fundamental problem with the analysis above is that the ewe price is assumed to be <u>always</u> twice the lamb price. This is not really the spirit of the rule, which is to pay <u>up to</u> twice the lamb price. If ewes can be purchased for less than this price then they will be. A more sensible approach to representing the rule of thumb is to let both lamb and ewe prices be random variables, and to calculate the return on investment generated for each combination of ewe and lamb prices. The effect of the rule on the risk and return of the investment can be analysed by excluding all situations where the ewe to lamb price ratio is greater than 2 from the distribution of IRR values generated by the investment, because these are circumstances when ewes would not be purchased.

When this is done, the average IRR of the investment across the whole range of possible lamb prices increases from 14% to 18%. Furthermore, the probability of earning a rate of return equal to at least 8% real increases from 46% to 69%. These results reflect the fact that when the rule is used, some of the instances where ewe prices are paid which are too high are eliminated from the distribution.

For example, when ewe prices are $280 and above, current lamb prices need to be at the highest 10% of all possible values for the rule to be satisfied (i.e. for lamb prices to be $140 and above). Because lamb prices this high are relatively rare, using the rule means high ewe prices are rarely paid, and as a result the poor returns on investment which frequently occur at these high ewe prices are avoided. Hence these results show the rule does provide some benefit.

However, it is important to remember that the performance of the investment depends on lamb prices over the productive life of the ewe, not just in the first year. Because it is only applied to the first year of lamb prices, it is possible that using this rule will mean that investments are made which turn out to be unprofitable, and that investments which would be profitable are not made. If no rule was used, the first of these situations would still occur because the future is unpredictable. However, the second situation only arises when a rule of thumb like this one is used. The results of this more realistic analysis are shown in Table 5.

There are several points to take from Table 5. First, given the distribution of possible lamb prices (low = $60, most likely = $110, high=$170), the rule is never used at ewe prices less than $120. This is because the ewe price can never be twice the lamb price until the ewe price reaches $120 per head, given that the lowest lamb price is $60. Second, using the rule gives better results than not the using the rule at ewe prices greater than $120 per head. This can be seen by the higher average IRR values in the "With Rule" column of the table.

Thirdly, the extent to which the rule is used increases quickly as the ewe price rises. For example, given the distribution of possible lamb prices, when ewe prices are $160 per head the rule is used in approximately 1 in every 17 possible deals. However, when the ewe price is $280 per head, the rule is applied in approximately 9 in every 10 possible deals, even though a high proportion of these deals are passed up when applying the rule.

Finally, the rule is by no means perfect. This can be seen by the proportion of deals which are passed up when the rule is used which would have earned an IRR of at least 8% real if they had gone ahead. For example, when ewe prices are $160, over 50% of the deals which are passed up would have earned at least 8% real. However, the average IRR earned on the investment when the rule is used is still higher than when it is not used at all ewe prices. This is because the average IRR of the deals which are passed up is much lower than the average IRR of the deals which go ahead, as shown in the final column of Table 5. This result reflects the fact that use of the rule means some good deals are passed up, it also means that relatively more bad deals are passed up, hence using the rule is better than not using any rule at all.

Conclusion

Financial capital has many uses. Theory says to use it in ways that earn the best returns. If doubt about the hype seems apt, don't buy. But, what alternative is there though, if other bidders do believe the high prices and profits are here for the duration? There can be merit in wait and see – not procrastinating but preparing to act smartly when the price is right. The livestock capital, and feed, can be used in other ways. Use the capital in other ways until the heat subsides a bit and the numbers and the odds come together to be a good bet. The more that buyers bet smart like this, the shorter will be the spike. Who bets?

Appendix

Table 1. Risky variables in the simulation

Variable	Low value (1 year in 20)	Most likely value (10 years in 20)	High value (1 year in 20)
Lamb Price per head	$60	$110	$160
Lambs per ewe (1.5 y.o)	0.6	0.7	1.1
Lambs per ewe (2+ y.o)	0.8	1.4	1.8
Wool value per ewe	$10	$14	$20
Salvage value per ewe	$25	$50	$75
Feed price per tonne	$50	$70	$110

Table 2. Typical results from the simulation analysis

Ewe price per head	Probability of achieving a rate of return of at least 8% pa real, given the distribution of possible lamb prices and other variables*	Odds	Average net present value of a replacement ewe, discounted at 8% pa	Average Internal Rate of Return (IRR)	Comment
$70	99.7%	332:1 on	$106.8	76.6%	At these ewe prices, the investment earns at least 8% real on average
$100	97.6%	41:1 on	$79.0	42.6%	
$130	89.3%	8:1 on	$51.2	25.8%	
$160	71.0%	2:1 on	$23.4	14.9%	
$190	45.1%	1:1 even	-$4.3	7.1%	At these ewe prices, the investment earns less than 8% real on average
$220	21.7%	4:1 against	-$32.1	1.1%	
$250	7.8%	12:1 against	-$58.9	-3.7%	
$280	2.0%	49:1 against	-$87.7	-7.6%	

*The most important distributions are: Lamb price per head: low=$60, most likely=$110, high=$160; ewe salvage value: low=$25, most likely=$50, high=$75; lambs per 2+ y.o. ewe: low=0.8, most likely= 1.4, high=1.8

Table 3. Simulation results at higher lamb prices

Ewe price per head	Probability of achieving a rate of return of at least 8% p.a. real, given the distribution of possible lamb prices and other variables*	Odds	Average net present value of a replacement ewe, discounted at 8% p.a.	Average Internal Rate of Return (IRR)	Comment
$70	100%	- certain	$167.3	208.4%	At these ewe prices, the investment earns at least 8% real on average
$100	100%	- certain	$139.6	78.5%	
$130	99.4%	166:1 on	$111.8	49.4%	
$160	96.8%	30:1 on	$84.0	33.3%	
$190	88.4%	8:1 on	$56.2	22.4%	
$220	71.8%	3:1 on	$28.4	14.5%	
$250	49.4%	1:1 even	$0.7	8.3%	
$280	27.6%	3:1 against	-$27.0	3.2%	At this ewe price, the investment earns less than 8% real on average

*The most important distributions are: Lamb price per head: low=$80, most likely=$120, high=$200; ewe salvage value: low=$25, most likely=$50, high=$75; lambs per 2+ y.o. ewe: low=0.8, most likely= 1.4, high=1.8

Table 4. Application of the rule of thumb when the ewe prices if fixed at twice the lamb price

Ewe price per head	Probability of achieving a rate of return of at least 8% p.a real, given the distribution of possible lamb prices and other variables*	Odds	Average net present value of a replacement ewe, discounted at 8% p.a
2X the lamb price in year 0	26.7%	3:1 against	-$29.8

*The most important distributions are: Lamb price per head: low=$60, most likely=$110, high=$170; ewe salvage value: low=$25, most likely=$50, high=$75; lambs per 2+ y.o ewe: low=0.8, most likely= 1.4, high=1.8

Table 5. Application of the rule of thumb when lamb prices are a random variable

Ewe price per head	Average IRR (real)		Proportion of possible deals passed up	Proportion of passed up deals that would have earned >8% real	Average IRR (real) of passed up deals
	Without Rule	With Rule			
$70	94.6%	94.6%	0%	n/a	n/a
$100	45.9%	45.9%	0%	n/a	n/a
$130	28.0%	28.0%	0.1%	60.7%	13.1%
$160	16.6%	17.1%	6.0%	53.5%	8.9%
$190	8.6%	9.9%	23.5%	34.3%	4.1%
$220	2.4%	4.6%	47.8%	17.6%	-0.1%
$250	-2.6	0.5%	72.2%	7.8%	-3.7%
$280	-6.6%	3.0%	90.3%	2.9%	-7.0%

Figure 1. Relationship between net present value and replacement ewe price

Figure 2. Effect on internal rate of return of applying the rule of thumb at different lamb prices