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Development of models for incentivisation of recording in the beef and sheep breeding sectors

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Executive summary

- There is a strong case for industry good investment in genetic improvement. Commercial farmers with land ownership are the primary long term beneficiaries of higher industry rates of genetic progress. While bull and ram breeders, feedlotters, finishers and meat processors are key participants in the supply chain and facilitators of genetic progress, their ability to capture long term economic rents is limited by the highly competitive nature of what are effectively service businesses.
- Investment by government can be justified based on improved viability of rural economies and their contribution to the local communities as well as national GDP. In Australia, some benefits of genetic improvement may be captured by consumers, further justifying tax payer investment, although this depends on the extent to which domestic consumers have to compete with export markets for price and quality of animal products. A conventional economic view would be that the level of competition is quite high, and so domestic consumer benefits are likely to be modest.
- In the absence of industry good investment, market failure will inevitably lead to gross under-investment in genetic improvement.
- While breed group and/or breed society driven investment in genetic improvement is attractive, reliance on this approach alone would neglect large fractions of breeders within the Australasian sheep and beef sectors. This is because many breeds and breeder groups lack either the scale or the political will to drive more gene testing and phenotypic recording.
- Investment in subsidised genotype in isolation is not sustainable long term because it will undermine investment in the phenotyping that is required to sustain genomic selection. Any genotyping subsidies need to be closely linked to a requirement for ongoing, extensive (many traits), and high quality, phenotypic recording.
- While a centralized approach has been taken to phenotypic recording for the Australian sheep industry to date (i.e. the sheep information nucleus which has migrated to become the sheep resource flock), partnership investment models which make greater use of industry animals and phenotypes should be considered going forward, particularly if there is a reduction in overall funds available.
- The effective deployment of partnership investment models will depend on

  - A constraint on the level of administration required for both the party or parties distributing funds, and also the applicants.
  - Clear and transparent criteria upon which applications are judged.
  - A structure that manages redemption risk, so that funds committed to support phenotyping do not exceed revenues and funds available for investment.
- This report demonstrates an approach for ranking five mechanisms of incentivising trait recording. Four methods (Industry good investment, breed society investment, genotype price surcharge, and targeted discounted services) ranked similarly in the example. A fifth approach involving a free market system whereby breeders can buy and sell access to phenotypic data to be included in genetic evaluations ranked lower.
- Further development of approaches to classifying breeders according to data quality standards in Australia and development of these standards in NZ should be pursued vigorously as these will provide a valuable instrument for targeting industry good incentives for phenotypic recording.
- Prioritisation of traits for recording effort can be achieved using case specific selection index calculations using models that already exist in Australia and New Zealand. However, a more simple approach involves comparing the percent contribution of a trait to the index to the average accuracies of young male selection candidates in specific flocks or herds of interest.
- It is not clear that prioritisation of phenotype recording incentives to breeders with high current levels of genetic merit, high rates of genetic progress, and high existing genetic contributions to other breeders is appropriate. This is because of the potential loss of genetic diversity through effectively ruling out the competitiveness of competing bloodlines. Such approaches could also lead to alienation of significant numbers of breeders from objective genetic improvement approaches, thus limiting the extent of technology penetration.
- Future research is proposed to develop metrics of the value of phenotypes and genotypes in specific animals, although deploying outcomes of this research may be challenging, because of the complex nature of the optimal decision space, and the lack of overall control of what actually happens in highly fragmented breeding sectors. A major deficiency arises from the fact that existing equations for predicting the accuracy of genomic selection do not account for the number and size of relationships between selection candidate

and the animals with both genotypes and phenotypes (i.e. the training population).

- In the meantime, further development and formalisation of a tendering process to allocate partner funds to industry genotyping and phenotyping initiatives is suggested. This will require active effort to keep smaller breed groups and breeders engaged, and there will be benefits from encouraging individual breeders to form groups of sufficient scale to facilitate effective genomic selection.

Acknowledgments

We are grateful to Rob Banks, Brian Kinghorn and Julius van der Werf who participated in a number of useful discussions that lead to many of the incentivisation mechanisms and ranking criteria developed as part of this project. Sally Martin and Sam Gill provided the model and analysis on costs to breed rams in Australia. Wayne Upton provided the analysis on costs to breed bulls in Australia. Peter Parnell and Carel Tesling assisted with the provision of data and EBVs for the analysis of Australian Angus average bull sale prices and their relationships with herd average EBVs. Rob Banks provided data on sheep sales in Australia, and an anonymous NZ ram breeder provided details of prices received by individual ram for both maternal and terminal flocks.

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1. Overview

MLA and Ovita are both interested in how cost effective genomic selection will impact on genetic improvement of beef cattle and sheep in New Zealand and Australia. Ovita have contracted AbacusBio to undertake studies of how sheep and beef breeders benefit from genetic improvement. Subsequently, MLA has contracted Ovita who in turn has subcontracted AbacusBio to expand the focus of study in terms of the Australian sheep and beef industries.

A companion research project is also being undertaken in Australia by Sally Martin. This project is entitled “Valuing Data Quality" and aims to investigate the different forms of value that is placed on data quality in the sheep industry and in other breeds, and provide a recommendation on measures that can be used to value data quality.

2. Introduction

The recording of trait phenotypes such as live weight, calving records, and some ultrasonic predictors of carcase merit along with accurate monitoring of pedigree information form the cornerstone of genetic improvement strategies that rely on statistical genetic evaluation systems. However, these activities have associated costs, and their uptake is not universal. This becomes particularly evident when the number of pedigree registered bulls sold is matched against the industry requirement for breeding bulls.

New technologies offer both a threat and an opportunity to phenotypic and pedigree recording activities. The threat comes through an ability of some breeders to substitute their investment in recording with an investment in potentially lower cost DNA testing. If these breeders are able to capture a significant share of the market for bulls marketed as "genetically improved" using scientifically verified methods, there will be a disincentive for conventional breeders to continue recording at higher costs. This is a threat, because the future integrity of genomic predictors almost certainly depends on ongoing and substantial levels of trait recording. However, the opportunity comes through the potential for breeders to differentiate themselves as "performance recorders" and extract additional value from their performance recording over and above the traditional benefits of being able to capture a genetic improvement premium over the full cost of generating a sound fertile breeding bull to sale age. The balance between the threat and the opportunity will depend on the way structural and pricing mechanisms are put in place.

In Australia there has been a substantial focus on obtaining performance records for a wide range of traits including hard to measure traits in flocks and herds funded with significant investment from industry and governments. In New Zealand, the majority of data for genomic selection has come from traits recorded by sheep breeders, and the research investment has had more of a focus on developing the technology platform and obtaining genotypes on industry sires. In both countries, funds are limiting relative to the very large training population sizes that have near distance relationships with industry selection candidates required to obtain accurate genetic predictions of merit. Furthermore, there is a rapid transition in place whereby phenotypes are becoming relatively more scarce, and more expensive, relative to genotypes. Thus, there is a need to rationalise investment, and to leverage research investment with the recording efforts of industry breeders. This needs to be undertaken in ways that maximise the efficiency of the overall efficiency with which industry improvements in the rate and direction of genetic change are achieved.

This document presents an overview of key issues for incentivisation of recording. First the distribution of genetic improvement benefits are discussed, direct and direct beneficiaries are identified and the exploitation of interests of, and partnerships with, breed societies, group breeding schemes and large breeding organisations is analysed. Then the mechanisms of incentivation of phenotypic recording and the criteria for comparing them identified in a previous report are expanded. Based on these criteria and on additional studies into ram and bull price costs and trends, conclusions and recommendations about which mechanisms would be most appropriate are drawn.

3. Who benefits

There are many participants in sheep and beef product supply chains, and the wide range of genetically influenced traits available to select for affect value right through the chain. Participants include commercial farmers, feedloters, meat processors, distribution companies and consumers, while the vast majority of investment, effort and risk to achieve genetic change come from the ram and bull breeding sectors. The share of the benefits among these stakeholders depends on the livestock species and on the operation of market forces within the supply chain which are often livestock production system, supply chain and country specific. This section discusses the likely beneficiaries of genetic progress within the Australasian sheep and beef industries.

Direct benefits

In New Zealand, it is widely accepted that commercial farmers are the primary direct beneficiaries of genetic progress in farm profitability. It is very unlikely that average real profit margins captured by NZ sheep and beef breeders (i.e. ram and bull sellers) have increased at all over the past two decades, despite the fact that considerable genetic progress has been achieved in indexes. This is the case also for Australian Angus bulls (Appendix 1 describes a detailed analysis of bull price data) for which prices are highly dependent on the prevailing market price for commercial animals, and quite independent of genetic indexes values (Figure A.1.1). In the absence of long term benefits from genetic progress accruing to bull and ram breeders, genetic improvement efforts must be driven by the need to remain in business, and to capture the revenue premiums associated with selling rams and bulls, relative to costs of generating them. Appendix 2 provides a summary of costs to breed rams and bulls, and these are compared with typical sales prices.

Within the New Zealand sheep industry, there have been substantial numbers of breeders who have departed the industry, and these have been replaced with larger, more technically focused, and business oriented, breeding businesses. The benefits captured by breeders were subject to a separate study[1], although analysis of individual ram prices from one New Zealand breeder is described in Appendix 3. A

Box 1. Estimated benefits of future genetic progress (NZ sheep).

A recent cost benefit analysis undertaken to identify the value of future sheep genetics research highlighted the likely tail-off in the value of current genetic progress as traits like litter size and ewe size approach their biological and economic optimums. New initiatives to develop new traits which address GxE interaction, incorporate the new genomic technologies coming on stream at lower prices, and improved adoption and penetration of progressive sheep breeding methods could add substantial additional value to that already being realised from genetic improvement. The aggregate benefits were estimated as NZ$740 M from 10 years of additional genetic progress over and above the status quo. Assuming NZ breeders average $300 profit per ram sold (see Appendix 2), and that breeders making genetic progress could increase their profit per ram by 10% per year in real terms such that in ten years, ram breeding was twice as profitable, then the present value captured by ram breeders at NZ$68 M would be less than 10% of the total value captured by commercial farmers.

[1] Maximising value Milestone 3.1: Assisting the breeder to recognise the value of using Ovita technologies

number of case studies assessing the impact of genomic selection on the NZ sheep industry demonstrated that breeders would benefit from its application more by increasing market share than by increasing sale prices of rams. Box 1. describes a hypothetical comparison between benefits expected to accrue to NZ sheep breeders from investment in research to underpin future genetic progress, and what might be a realistic upper limit to the proportion of benefits captured by the ram breeding sector.

A somewhat deeper understanding of the factors driving market influences on breeders was obtained by looking at the relationship between the average sales prices of bulls with the estimated breeding values and indexes of the herds. Considering the Australian Angus breed the higher the genetic value of the herd, the higher the sales volume and the higher the bull prices within a sale year (Figures A.1.2, A.1.3). However, these relationships were relatively weak, with other factors such as merit for an individual trait (Intra muscular fat), and number of bulls sold also contributing substantially to variation in average prices across sales. Increases in price over time within a sale were unrelated to the rate of increase in index trend. Rather, herds with the highest trends in sale prices and volumes tended to be those with herds that ranked highly for intramuscular fat.

In Australia, a series of studies by economists have indicated that Australian consumers are significant beneficiaries from genetic improvement, through greater consumption and/or through reduced prices[2]. However, these consumers' benefits may be drastically reduced if sheep and beef product prices are set by international prices, as appears to be the case.

The same studies demonstrate that intermediate businesses in the supply chain such as feedlotters and meat processors receive minimal shares of any genetic improvement gains because they face intense competitive pressures such that any gains get passed back through the supply chain. However, feedlots and meat processors can benefit through maintaining their position in the market and in some limited cases they are able to maintain a short to medium term lead on their competitors though capturing exclusive access to lines of animals for which they have contributed to their genetic improvement. This can be particularly attractive to meat processors if it helps secure access to stock in a highly competitive procurement market.

[2] Milestone Report 1. Development of models for incentivation of recording in the beef and sheep breeding sectors

Upstream and downstream GDP benefits

Studies in Canada, USA and Australia[2] recognise that revenues earned by beef farmers get spent on inputs which further stimulates the economy, including wages and profits earned by farm workers and owners and the substantial impacts that these earnings have on rural communities. They also recognise the significant employment and additional GDP turnover associated with meat processing and estimate a benefit multipliers in the region of 2.5 to 3.5. Although the violation of some assumptions used in these studies (e.g. that there are no input and output price changes as a result of genetic change), there are also arguments relating to the necessity of technical changes (such as genetic improvement) to maintain the international competitiveness of the industry. Without this competitiveness, and in the absence of alternative land uses of comparable profitability, current levels of regional economic activity that are underpinned by livestock industries such as sheep and beef cattle production may be lost in highly competitive global markets.

4. Mechanisms to incentivise recording

Milestone Report 1[3] of this project presented models for incentivisation of phenotypic recording in beef and sheep which can be considered from two important perspectives. Firstly, the perspective of revenue collection from external beneficiaries of performance recording and secondly the perspective of how performance recorders can receive rewards and incentives.

The five different mechanisms presented in that report are summarised here as:

1. Industry levy and Govt. support. This mechanism consists of an industry levy (e.g. MLA) together with government support for ongoing recording and new trait research on industry relevant animals (i.e. in industry herds on close relatives of leading industry sires, the BIN program being a classic example). The industry levy is applied based on the rationale that commercial farmers are likely to capture the largest share of the benefits generated from faster rates of genetic progress and therefore they should contribute financially to support recording. While they do this to some extent by paying premiums for improved bulls (see figures in appendix 1), this

[3] Development of models for incentivisation of recording in the beef and sheep breeding sectors- Models of royalties and incentivisation mechanisms - B SGN 0137 Milestone Report 1 - by Peter Amer Jan 2013.

has, and will continue to be, insufficient to motivate industry optimum levels of performance recording.

2. Breed society support. This model/mechanism relies on breed society support for recording and new trait research on industry relevant animals (e.g. BINs). The motivation for this breed society level of investment is that benefits will accrue across the entire breed from a more progressive image and from higher rates of genetic progress. Breed members can also benefit collectively if there is a reduced reliance on importation of genetic superiority which arises from more home grown genetic improvement through performance recording. This is because revenue historically shifting off-shore for semen purchases will now be captured by local breeders through either semen sales, or bull sales.

3. Surcharge on genotyping price. A surcharge on the genotyping price to reflect the benefits inherent in the DNA test from performance recording. This could take a multi-tier form, to reflect the investment made by some DNA test users in the value generated from their ongoing phenotypic recording. In this way, the DNA test royalty would be highest for test users with minimal or no recording, and lowest for breeders with extensive recording. However, a base royalty value might be applied to all tests under the assumption that breed wide investment in structures such as the BIN also provides benefits to performance recording breeders. While DNA test royalties would be a convenient method of generating revenue and can be structured in a multi tiered way to incentivise ongoing recording, it also needs to be recognised that the higher test costs will create a disincentive for their use, which will likely lead to lower uptake and lost opportunity for industry wide benefits.

4. Free market mechanism. A free market mechanism to reward phenotypic recording could be integrated into the genetic evaluation process. This would allow breeders to choose which novel phenotypic information would be included in their own personalised genetic evaluation. In this way, phenotypes could be chosen which would be most useful, but at a cost set by the phenotype owner who would look to balance return per access, against number of breeders utilising the phenotypes. This approach is appealing in that it works on free market principles, however, fundamental changes would be required in the way genetic evaluations are delivered, and breeders may have insufficient information to judge the value-add they would get from additional phenotypes.

5. Targeted discounts and services. For leading performance recording breeders. This would involve scientists working with progressive breeders to help them maximise their rate of genetic progress under the proviso that they would make their genetics, genotypes, and phenotypes available to other breeders. This model would be best funded by industry levy organisations to avoid tensions within the breed society.

Criteria for comparing mechanisms

It was proposed in Milestone report 1 that the assessment and comparison of the five mechanisms should be based on the following eleven criteria;

A. Expected genetic progress. Theoretically faster rate of genetic progress expected

B. Risk of genetic progress eventuation. Risk that extra rate of genetic progress may not eventuate

C. Requirement of complex research. The more complex research is needed to understand and deploy the model/mechanisms the more chances it has to be not properly implemented.

D. Industry disruption. Some models/mechanisms could be highly disruptive to existing industry leaders, and therefore could have some political consequences that could hamper its implementation.

E. Transition costs. Transaction costs in terms of difficulty and expense to administer may also vary among mechanisms

F. Net costs. In addition to transitional costs, net costs (to be met out of industry or governmental investment) may also be different among models/mechanisms

G. Improvement of data quality. Result in improved quality of data available for genetic evaluations and genomic selection

H. Accommodation of entrepreneurship. Ability to accommodate entrepreneurship and incentivise commercial genotype providers

I. Adaptation ability. Ability to adapt to substantial future changes to breeder recording practices and gene flow structures.

J. Redemption risk. If there is a static incentive, and a large number of breeders/animals qualify, the budget for incentivisation may be blown, particularly if revenue from royalties is less than anticipated. This could be resolved via a share system, whereby breeders who genotype and phenotype desired animals would be allocated shares, and these shares would be used as the basis for allocation of future royalty streams.

K. Transparency and equity. Recording incentivisation models/mechanisms may have different levels of support and costs for each specific stakeholder of the breeding system. If these are not explained clearly and simple could be considered "unfair" and generate rejection to the mechanism that at last could hamper or avoid its implementation.

Comparison of mechanisms

An example assessment of the five mechanisms proposed for recording incentivation based on the criteria identified has been undertaken as part of the development of this report. It should be considered as an example, as the proposed scoring could also be undertaken by key stakeholders with informed instruction on the proposed mechanism and the selection criteria, for example in a workshop setting. For the example, four of the five mechanisms had a very similar overall score, with the Free Market mechanism scoring lower than the others (Table 1). Justifying comments are provided as a supplement to the scores in the table. Despite the similar overall weighted score for the four mechanisms, each mechanism has its specific strengths and weaknesses across the evaluated criteria. Note that for the example, the mechanism scores on some criteria are more similar that on others. This means that final decisions on which mechanism to implement should evaluate more carefully the criteria in which the mechanisms differ more. These criteria were net costs, accommodation of entrepreneurship and redemption risk. The criteria in which mechanisms received very similar scores where improvement of data quality and adaptation ability.

Table 1. Assessment matrix of incentivisation mechanisms. Mechanisms are scored with a value between 1 and 9 for each criterion, with 9 being most favourable and 1 least favourable. Scores are combined into an average based on the weighting factors presented for each assessment criterion

Mechanism	Assessment criterion											**Weighted average total**
	A. Expected genetic progress	B. Risk of genetic progress eventuation	C. Complex research required	D. Industry disruption	E. Transition costs	F. Net costs	G. Improvement of data quality	H. Accommodation of entrepreneurship	I. Adaptation ability	J. Redemption risk	K Transparency and equity	
1. Industry levy & Govt. support	8	4	5	3	5	2	5	3	5	5	4	**4.8**
2. Breed society support	5	6	5	3	5	8	5	4	3	3	3	**4.8**
3. Surcharge on genotyping price	5	3	5	5	5	8	6	5	3	3	5	**5.0**
4. Free market mechanism	3	2	1	6	1	2	5	9	5	9	7	**4.3**
5. Targeted discount and services	5	4	5	4	5	7	7	4	5	3	3	**4.9**
Weighting factor	**0.2**	**0.1**	**0.1**	**0.05**	**0.05**	**0.1**	**0.1**	**0.1**	**0.05**	**0.05**	**0.1**	

Justification comments by Peter Amer for Table 1 example criteria scoring,

A. Industry levy and government support is the most likely approach that will generate the scale of investment required to achieve higher rates of genetic progress. The free market mechanism will require a lot of active initiative including investment by industry participants which may not eventuate.

B. Some breed societies have the option to drive change within their members in the interests of the breed. The free market mechanism has a high risk of failure of recorded and other breeders to engage.

C. The free market mechanism would require major modifications to genetic evaluation infrastructure.

D. The free market mechanism will be less obviously disruptive because of its free market nature. Industry levy and breed society support will need to negotiate carefully the influence of industry leaders who may be threatened by change.

E. The free market mechanism would require major modifications to genetic evaluation infrastructure.

F. Breed society support and genotype surcharges have significant self funding components. The free market mechanism would require major infrastructure changes to genetic evaluation systems.

G. Targeted services could be contingent on data recording and quality. As could genotyping discounts.

H. The free market mechanism has a clear advantage in terms of encouraging entrepreneurial initiative and opportunity.

I. The breed society support models and genotype surcharge may be less flexible in their ability to adapt to future industry changes.

J. Breed society support, genotyping surcharges, and discounted services run the risk of over commitment of investment that cannot be recovered from associated charges. The free market mechanism has minimal redemption risk.

K. The free market mechanism has the best equity outcome (potential reward for risk taking), while other mechanisms run the risk of alienating parts of the breeding industry due to decision making that is not full transparent.

5. Conclusions and recommendations; Practical application

While there is a strong case for industry level investment in phenotyping to support both conventional genetic improvement, and also genomic selection, this project has not yet clearly identified a single mechanism for incentivising the recording of phenotypes. A next step on from this project could involve one or more workshops with key stakeholders, to apply the criteria to the alternative mechanisms of incentivisation that have been introduced, to identify the best fit in various circumstances (ie. NZ vs Australia, sheep vs beef, large breeds or groups, vs smaller breeds or groups, vs individual breeders).

When incentivisation programs are targeting an increase in industry level genotyping for genomic selection purposes, an important conclusion from this project is that there would be benefits in the future, from linking the genotyping price to the level and quality of phenotypes recorded by the commercial users of genetic tests.

In the future, improvements in DNA test efficiencies with new lab technologies and increased scale of service, there is likely to be a switch away from any need to support genotyping, and instead the focus should switch to supporting phenotyping. While royalties attached to genotypes are an obvious mechanism to generate revenue for support of phenotyping, these royalties could act as a disincentive to the adoption of a technology which will drive genetic change for the benefit of commercial farmers. Thus, royalty mechanisms are best targeted at "phenotype free riders" i.e. those breeders with low cost systems which rely on genotyping as a substitute for phenotype recording effort.

There are likely to be substantially reduced transaction costs (due to scale and dilution of application effort by wider benefits) associated with dealing with breed societies and larger breed groups. In this instance, models of proportional matching internal investment are likely to support user driven initiatives, and minimise the risk of "white elephant" projects. This approach has already been used widely to support genomics research in both the New Zealand sheep industry (Ovita) and to support the beef information nucleus projects (also referred to as progeny benchmarks).

For smaller breeders, a system whereby phenotype subsidies are paid to breeders recording scarce and/or hard to measure traits should be considered. AWI recently ran a program[4] offering a payment per phenotype for wool traits in Australia wether trials and a wider system along these lines could be offered in both New Zealand and Australia. A major issue with these sorts of programs is redemption risk, in that it is uncertain what the uptake of the subsidy will be in advance. For this reason,

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http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0004/48685/additional_trait_funding_procedures.pdf application and prioritisation procedures will be required and these are discussed further in the future work section below, as they apply to all modes of incentivisation with the exception of the free market system.

Methods to assist with prioritising traits for phenotyping incentivisation have been discussed in more detail as part of a separate report in this project[5].

6. Future work

Future work that would further assist this research project theme includes the development and further implementation of data quality standards and metrics, as these would be an extremely valuable tool in both allocating support for phenotypes and genotypes where necessary. For situations where it is politically acceptable to publicise these data quality levels, market forces and demand by commercial farmers for rams and bulls from high efficacy and integrity breeding programs will help motivate improved phenotype quantity and quality.

Ongoing research into two metrics of phenotype and genotype value would be useful. These would be based on an animal's relatedness to others in the population that already have genotypes and phenotypes and would answer the two questions below.

1. What would be the added value over BLUP prediction from using genomic prediction in this particular animal?

2. What would be the value to the wider population of a phenotype in this animal?

This research is not necessarily straight forward, and in particular is challenged by the multi-dimensionality nature of the decisions that need to be made as a result of the metrics. For example, the benefits of genomic selection might be high, if a major phenotyping exercise is undertaken in flocks containing relatives of a selection candidate, but otherwise not. Thus, there is a risk that this research will take a long time, and deliver outcomes that are complex to deploy in practice.

In the interim, we propose the development of partner funding systems that exploit existing industry investment by commercial breeders to record phenotypes and undertake genotyping. These systems will need to rely on a tendering/application

[5] Milestone 2 (contract E) Selection index tools for use in evaluating incentivisation 27-06-2013

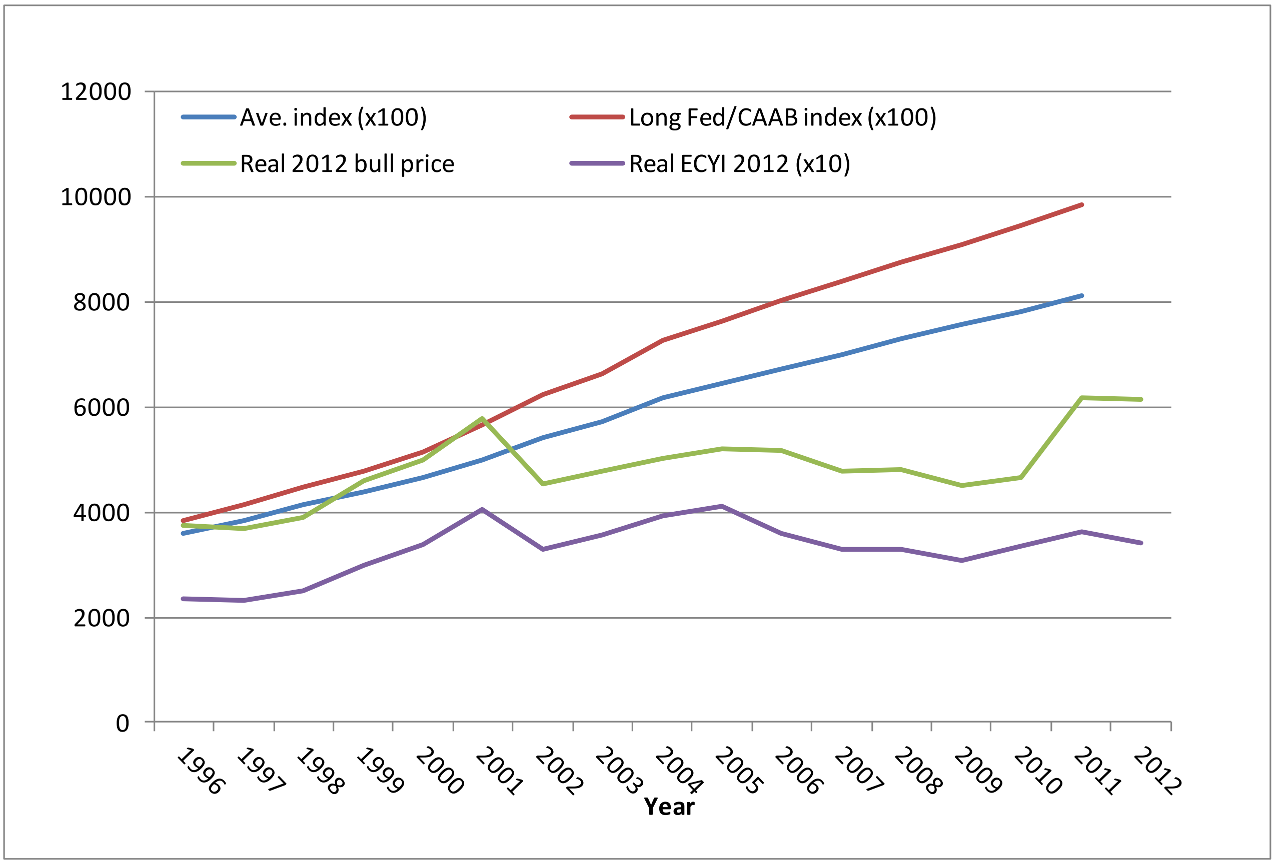
process, and active operational support will almost certainly be required to keep smaller breeder groups and individual breeders engaged. Where possible, smaller breeders should be encouraged to form groups to generate scale efficiencies, both in the process of application, but also this would likely improve the efficiency and effectiveness of genomic selection strategies which require a reasonable scale of somewhat related animals with phenotypes and genotypes to generate effective prediction accuracies.

7. Appendices

Appendix 1. Benefits of genetic selection. Evidence from bull price data

An extensive analysis of bull price and estimated breeding values using data from the Australian Angus breed society was undertaken to help inform this analysis, and to help better understand who gets the benefits of genetic improvement. Data on average bull prices and number sold from registered Angus herds were combined with Breedplan herd average estimated breeding values. The records retained for analysis were for 826 sales from 119 herds spanning between 2004 and 2012. Only herds with a minimum of three sales were included in the analysis, so as to facilitate an investigation into the rate of change in average bull prices relative to the rate of change in genetic progress for a range of traits of interest.

Figure A1.1.[1] 1996-2012 evolution of Australian Angus bull prices, ECYI and average and CAAB indexes

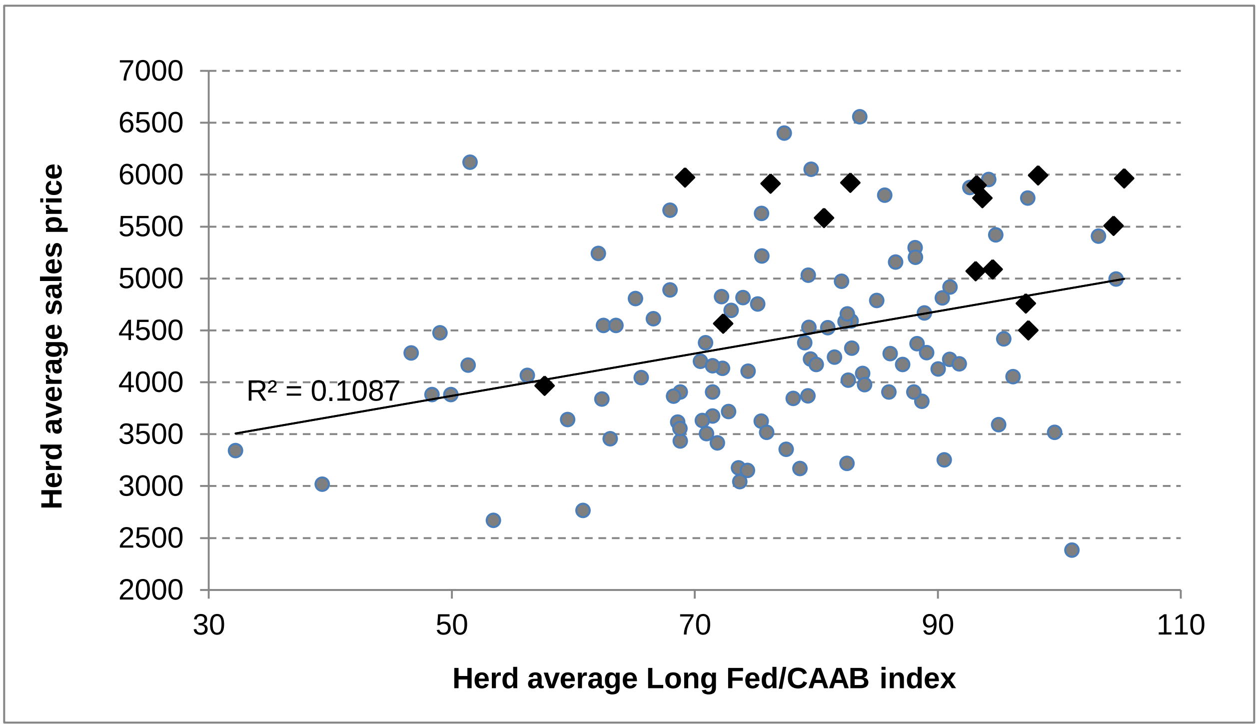


[1]Average index is a weighted average of the four main indexes published by Angus Australia. Long Fed/CAAB index is one of the four indexes, and which has a relatively high weighting on marbling in the breeding objective. Real 2012 bull price is

the price of bulls sold adjusted for the consumer price index to 2012 dollars, and Real ECYI is the Eastern Cattle price indicator for commercial cattle.

Figure A1.1 shows that after adjusting for inflation, the price of breeding bulls tracks much more closely to the price of slaughter animals than to the trend in genetic progress. Interestingly, there was a greater upward shift in the bull price for 2011 and 2012 than suggested by tracking the historic relationship with the commercial cattle price index. When this was pointed out to the board of the Angus Australia breed society, they suggested that a number of new buyers from Northern Australia had recently started competing for bulls in the Angus sales, and this had lead to an upward trend in price. A major shift in breed focus for the Northern cattle industry may have come about through ongoing disruption of the live cattle export industry.

Figure A1.2. Relationship between sale average bull price and herd average index values for Australian Angus breeders. Black diamond's refer to herds with high numbers (>70) of bulls sold

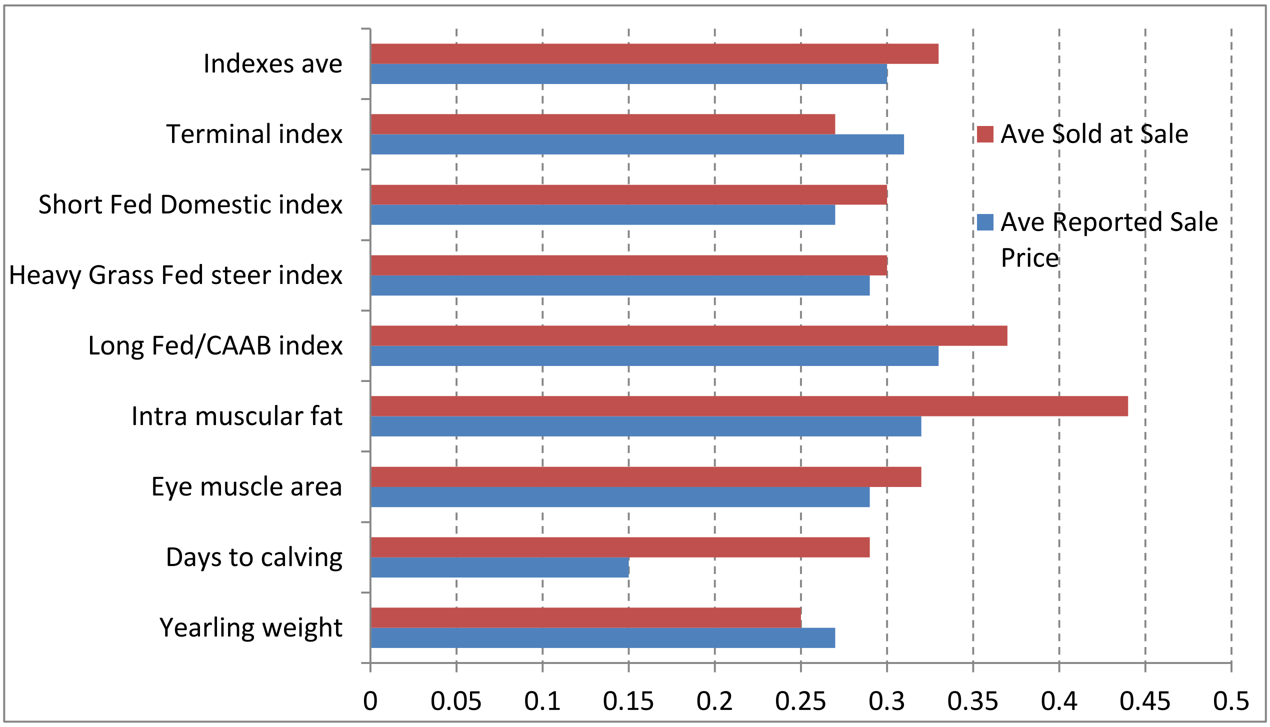


Genetic merit of herds is related to the average sale price of bulls and to the average number of bulls sold. These two aspects are also related to each other which makes it difficult to assess the influence of genetic values on each of them separately. Figure A.1.2 shows the positive relationship between sale average bull prices of Australian Angus herds and the herd average estimated breeding value using one of the four indexes routinely reported for the breed, the Long Fed/CAAB index.

However, this relationship is not that strong with 10.8% of the variance in herd average bull price explained by the index and a correlation between bull price and value of Long Fed/CAAB index of 0.37 (Figure A.1.3). Figure A.1.2 also shows how farms selling larger numbers of bulls (> 70) were also selling them at above average and or high prices and with no link between average price and the herd average Long Fed/CAAB index value.

The merit of some specific genetic traits were also found to contribute to the variation of herd average sale prices and numbers of bulls sold(Figure A.1.3). The intramuscular fat estimated breeding value was the most important in this regard being just as important as the complete Long Fed/CAAB index for the herd's bull price and even more important for average numbers of bulls sold. Also of note that the days to calving trait contributes much more strongly to variation in sales volumes than to variation in sales price.

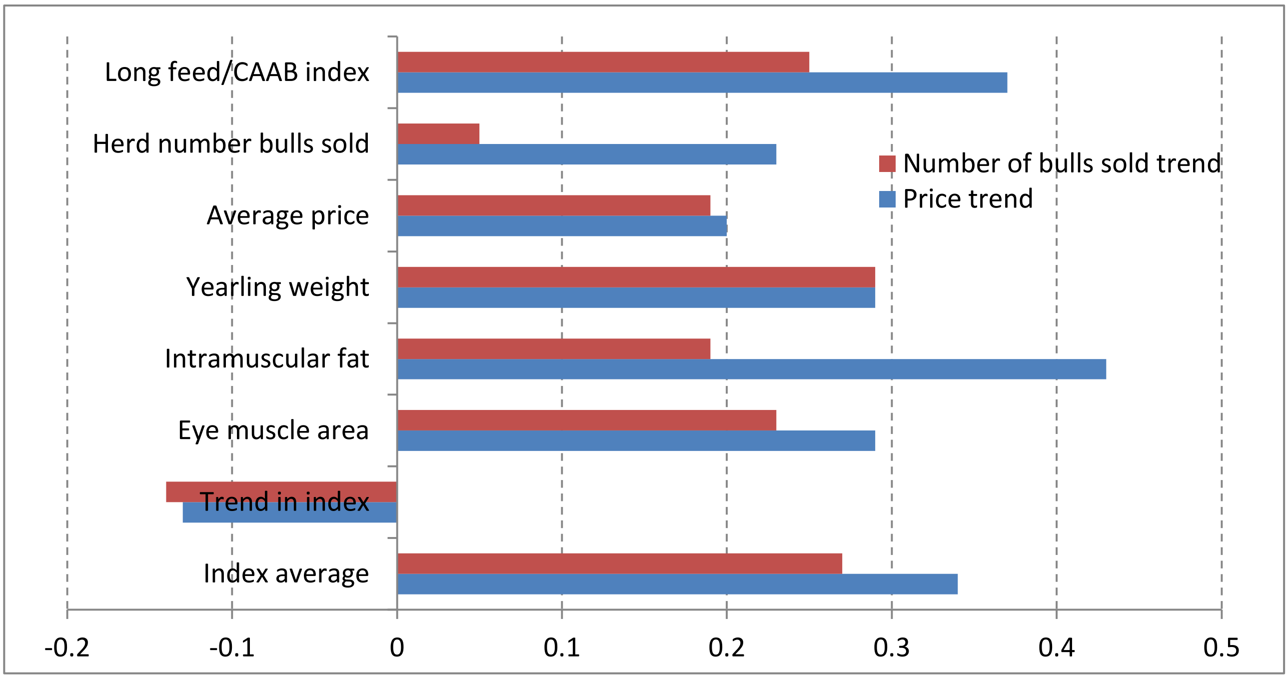
Figure A.1.3.[6] Correlation between the average reported Australian Angus bull sale price and the average number of bulls sold at sale with the genetic values of different traits. The correlation reported for days to calving has been shown as a positive correlation, when in reality the correlation was of equal magnitude but negative.



[6] Reference of data

Figure A.1.4 shows the relationship between trend of bull prices and numbers of bulls sold with different indicators of genetic merit and some individual traits. Increases in price over time within a sale were unrelated to the rate of increase in index trend but were related with the herd average value of the index itself and with the herd average value of some favourable traits (intramuscular fat). Herd average merit for yearling weight was the main factor explaining variation in the positive trend of sales volume. Scarcity of bulls with good estimated breeding values for intra-muscular fat could explain the stronger link between merit for this trait with a positive trend for sales price, rather than with increased sales volume.

Figure A.1.4.[7] Correlation between the trends of Australian Angus bull prices and the number of bull sold per herd with the genetic values of different traits, the average price of the bull and the number of bulls sold in the herd



These results highlight that improvements in market share are potentially a stronger incentive to breeders to make genetic progress in traits, than improvements in price, although both factors are clearly important. In fixed price - private treaty approaches to sales common within the New Zealand ram breeding industry, the potential to gain market share is likely to be an even more important motivating factor driving genetic improvement. This is because it is harder for breeders to increase prices substantially above perceived market rates without losing clients. The breeder to

[7] Reference of data

breeder market which tends to generate premium prices at auction tends to be less prominent in the sheep industry, with NZ sheep breeding programs relying less on use of purchased outside genetics (ram swapping and sharing among members of breeder groups is much more common). This is likely to be a further factor contributing to market share as the main motivator for investment in genetic improvement in the NZ sheep industry.

Appendix 2. Costs to breeders to generate sires relative to average prices received

The following four sections (A2.1 to A2.4) summarise the results of detailed studies of costs and returns of generation of breeding bulls and rams in Australia and New Zealand. Costs are grouped in categories and net returns are given per stud sold and also calculated for an average size breeding farm. A more detailed breakdown is provided for New Zealand bulls in section A2.5.

An average sized breeding bull and sheep farm would generate between $70,000 to $100,000 return to the breeders. This is comparable to the profit that might be expected from any other business involving risk, skill, knowledge, and advanced investment before a return is realised. In addition when a breeder can capture either a premium over market average, or can increase the scale of the breeding operation, the opportunity to increase profitability is substantial. For example, an Australian Angus bull stud which can sell 120 bulls at an average price of $6000 (per bull, the return to the breeding business increases from $70,000 (profit of 50 bulls sold at $4000) to ($6000-$2800) x 120 = $384,000 (profit of 120 bulls sold at $6000). Thus, for a breeder striving to make this shift, there is a strong incentive to invest in whatever it takes to achieve it. This may involve investment in recording and genetic improvement in objective traits, but it is also likely to require a significant investment in marketing and other activities that lift the profile of the breeding business.

Costs of recording, breed registration, and contributions towards genetic evaluation costs for bulls and rams are not high relative to the revenues received by the studs. For example, Breedplan costs of $100 per bull sold plus an extra $100 per bull sold for trait recording and labour is only a modest fraction ($200/$4000) = 5% of the price paid by the purchaser. Corresponding recording, registration and genetic evaluation costs to breeders are somewhat lower in absolute terms for sheep, but a much higher proportion of the sale price because of lower unit values of rams compared with bulls in the market (i.e. recording costs are 19% of sale value in Australian fine wool rams with wool testing costs and 8.6% in New Zealand dual purpose rams).

The opportunity cost of not being able to sell a male for slaughter makes up a modest proportion of the sale price of breeding bulls (23% and 20% in the cases of Australian Angus and New Zealand bulls respectively) and a not so high but still important part of the total costs of generating breeding rams (16% and 19% for New Zealand and Australian rams respectively). This could explain the strong link between the commercial steer indicator price and Angus bull sale average prices over years (Figure A.1.1). The costs of devalued unsold bulls will also increase with a higher market price, and the opportunity cost of the extra feed (to get retained males up to stud sale weight) would also be greater when the commercial lamb and steer price is higher. Similarly, on the demand side, farmers will bid harder for bulls they like when they are more financially well off.

A2.1. Cost and return of generating a breeding bull in Australia

Summary of more detailed calculations undertaken by Wayne Upton based on a spreadsheet model he had developed.

- Average price per bull = **$4000**
- 450kg steer = **$900**
- 350kg further LW gain @7kg DM per kg = 2.5tonnes of feed @ $450 per tonne = **$1300**
- 1 cull bull per 3 bulls sold at a loss of $600 = **$200**
- 4 recorded cows with society and Breedplan costs per bull sold @ $25 = **$100**
- Sales commission = **$300**
- **Total costs** per bull sold = **$2800**
- **Net Return** per bull sold = $4000 - $2800 **= $1200**
- 50 bulls sold @$4000 - $2800 = **$70,000** return to the breeder from the stud business

A2.2. Cost and return of generating a breeding bull in New Zealand

Summary of calculations undertaken by Natalie Howes of AbacusBio.

- Average price per bull = **$4500**
- 450kg steer = **$900**
- 350kg further LW gain @10kg DM per kg = 3.5 tonnes of feed @ 16.8 cents per kg of DM = **$588**
- 1 cull bull per 10 bulls sold at a loss of $300 = **$30**
- 6 recorded cows with society and Breedplan costs per bull sold @ $20 = **$120**

- Sales commission @ 10%= **$450**
- **Total costs** per bull sold = **$2088**
- **Net Return** per bull sold = $4500 - $2088 **= $2412**
- 50 bulls sold @$4500 - $2088 = **$120,000** return to the breeder from the stud business

A2.3. Cost and return of generating breeding rams in Australia

Summary of calculations undertaken by Sally Martin

- Average price per ram = **$650**
- Opportunity cost per ram (average profit per ram of commercial flock) = **$73**
- Breeding costs per ram = **$231**
    - IA and semen cost per ram = $7 + $22 = $29
    - Rams cost per ram = $30
    - Embryo transfer cost per ram = $20
    - SG animal fees and membership cost per ram = $11
    - Measurement and classing per ram = $70 + $4 = $74
    - Marketing cost per ram = $77
- Production costs (feed, health care, labour, professional services, transport, selling, shearing and crutching)= **$87**
- **Total costs** per ram sold = **$391**
- **Net Return** per ram sold = $650 - $341 **= $259**
- 300 rams sold @ $650- $341 = **$77,700** return to the breeder on the stud business

A2.4. Cost and return of generating breeding rams in New Zealand

Based on the detailed study of Sise et al.[8].

[8] Sise, J., Linscott, E.M. and Amer, P.R., 2011. How do sheep farmers benefit from new technologies*?. Proc. Assoc. Advmt. Anim. Breed. Genet.,* 19: 239-242.

- Average price per ram = **$745**
- Average processor return per ram sold = **$88**
- Fixed costs per ram sold = **$ 77**
- Variable costs (feed, labour and professional services) per ram sold = **$ 267**
- Total cost of technology = **$22**
- **Total costs** per ram sold = **$454**
- **Net Return** per ram sold = $745 - $454 = $**291**
- 300 rams sold @ $745 - $454 = **$87,300** return to the breeder from the stud business

A2.5. Example of detailed comparison calculation for costs and returns of generating breeding bulls in New Zealand

A model has been constructed to examine the costs of raising bulls from slaughter age to sale for breeding. The model assumes a base farm set up with 300 breeding cows weaning 0.9 calves per breeding cow, post-weaning survival of 0.98 and assuming that 20% of bulls are not fit for sale. Results are then scaled to express costs per bull sold.

Costs include the loss of income from bulls sales to the meat processor (that would have been received if the ram lambs had been slaughtered instead of retained), and the additional costs associated with feed and management of the growing bulls including, ultrasound testing, BVD test and fertility test. Allowance is made for costs associated with a bull breeding business such as management, pedigree recording and professional services including marketing and stock agents commission.

Costs associated with breeding bulls for sale

A2.1 depicts the average costs of raising bulls from slaughter age (20 months) to sale (24 months) on the model farm, where fixed costs account for 20% of the expenditure per breeding ewe, with the other major costs associated with lost processor income (42%), feed (31%) and commission fees (14%). A complete breakdown of the costs for a stud with 300 breeding cows is provided in Table A.2.[9].

Figure A2.1. Average costs per breeding cow associated with bull breeding, assuming 0.27 bulls/breeding cows are retained for sale, with stock agent commissions on 80 bulls sold

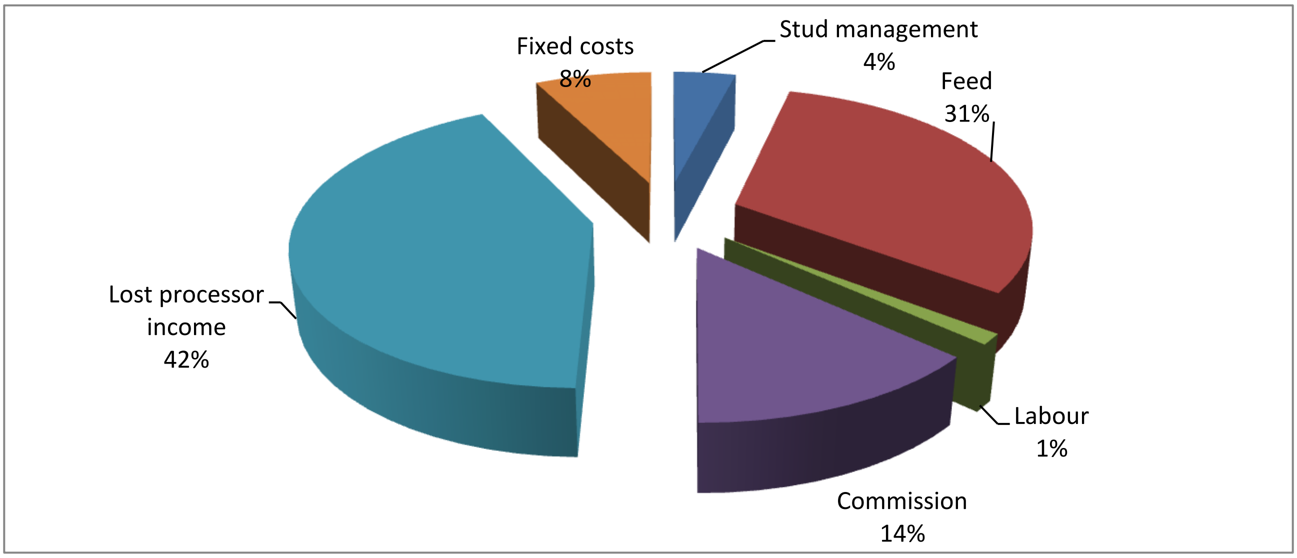


Table A.2.1. Breakdown of fixed and variable costs associated with bull breeding, assuming 0.27 bulls/breeding cow are retained for sale, with stock agent commissions on 80 bulls sold

Fixed costs		**Variable Costs**	
Pedigree recording	$ 6,000	Stud management(b)	$ 12,480
Marketing	$ 5,000	Feed	$ 97,782
Stud management	$ 12,480	Labour	$ 3,849
		Commission	$ 42,400
		Additional labour	$ 13,838
		Lost processor income	$ 131,812
Total Fixed	**$ 23,480**	**Total Variable**	**$ 302,160**

[9] Note that the cost of stud management is apportioned equally to the fixed and variable cost components, allowing it to be reflected in the variable costs/bull sold.

Profit drivers for a bull breeding business

Revenue for a stud bull breeder is primarily driven by the number of bulls sold per breeding cow and sale price. Table summarises the costs and expected returns of raising bulls from slaughter age to sale on the model farm, under the following assumptions;

- 106 of the 135 calves weaned are retained for sale at 24 months of age, with 26 bulls remaining unsold for breeding.
- 30% of bulls sold to commercial buyers are sold at a premium price of $6,000 each whilst the remaining 70% are sold at a standard price of $5,000 each.

Table A.2.2. Total sale value and costs of raising bulls for sale to commercial farmers, for a herd with 300 breeding cows, with 106 bulls retained for sale and 26 remaining unsold and sent to the processor at 25 months of age

Commercial bull sales	Total no of bulls sold	80
	n sale bulls unsold	26
	Average price per bull	$ 5,300
	Total value	$ 424,000
Processor sales	Total no of bull sold	48[10]
	Average price per bull	$ 1,199
	Total value	$ 57,609
Gross return to breeder		**$ 481,609**
Expenses	Fixed	$ 23,480
	Variable	$ 302,160
	Variable/breeding cow	$ 1,007
	Variable/bull sold	$ 3,777
	Total Expenses	**$ 325,640**
Net return to breeder		**$ 155,969**
Net return/breeding cow		$ 520
Net return/bull sold		$1,950

[10] The death rates between weaning to slaughter age are 98%, with a total of 3 bulls assumed to have died between weaning and 20 months.

Under this model, the net return to the breeder per breeding cow is $520, with a net return per commercial bull sold of $1,950.

Case study 1

Assuming that breeders want to sale all bulls for slaughter at 20 months and just retaining 2% of bulls for own use.

Table A.2.3. Case study 1: Comparison of model farm breeder to breeder selling bulls to processor for slaughter

		Farm Model	**Case study 1**
Commercial bull sales	Total no of bulls sold	80	0
	n sale bulls unsold	26	4
	Average price per bull	$5,300	0
	Total value	$424,000	0
Processor sales	Total no of bull sold	48[11]	128
	Average price per bull	$ 1,199	$ 1,240
	Total value	$ 57,609	$ 158,720
Gross return to breeder		**$ 481,609**	**$ 158,720**
Expenses	Fixed	$ 23,480	$ 23,480
	Variable	$ 302,160	$ 79,742
	Variable/breeding cow	$ 1,007	$ 266
	Variable/bull sold	$ 3,777	$ 623
	Total Expenses	**$ 325,640**	**$ 103,222**
Net return to breeder		**$ 155,969**	**$ 55,495**
Net return/breeding cow		$ 520	$ 185
Net return/bull sold		$ 1,950	$ 434

This compares favorably with the option presented in farm model, where under the same breeding parameter assumptions, the additional net returns to the breeder that sell 60% of the available bull for breeding is higher than if the breeder sell all the bulls produced to the processor.

[11] The death rates between weaning to slaughter age are 98%, with a total of 3 bulls assumed to have died between weaning and 20 months.

Appendix 3. New Zealand sheep breeder pricing structure

Data were available from a large New Zealand sheep breeder with a pricing system based on index. This breeder is very progressive with active engagement in performance recording of new traits and rapid update of genomic technologies. These data were analysed to determine the extent to which pricing (by private treaty) was linked to genetic merit, both within and across years. Data were available separately for dual purpose and terminal sire flocks. Results are presented in Tables A3.1 and A3.2 for maternal and terminal flocks respectively.

Table A.3.1. Maternal rams sales statistics, over four years for a large progressive New Zealand sheep breeder (DPO denotes a NZ standard selection index with units of cents per ewe lambing in flock on an EBV basis)

Year	**Number sold - flock rams**	**Number sold to other breeders**	**Mean price** ($/ram)	**Mean DPO index** (NZ cents)[1]	**Correlation between price and index**	**Percent of variation in price explained by index**	**Slope of price on index**
2007	182	1	844	1448	0.20	0.04	0.15
2008	203	0	856	1588	0.38	0.14	0.31
2009	244	0	835	1726	0.46	0.21	0.36
2010	300	2	935	1943	0.57	0.32	0.36

[1]Index trend for rams sold, not for the whole flock.

The genetic merit of the maternal rams sold was increasing by 160 cents per year, which is at the upper end of what could be expected for a maternal sheep flock in New Zealand, and which cannot benefit from importing sires of substantially higher merit than those bred in the home flock. For the first three years, ram prices were static as determined by the private treaty selling structure with fixed prices in bands of index merit. In the fourth year, ram prices were increased by $100 per ram. In October 2010, lamb prices were in a recovery phase after a downward dip in 2009, and at that point they were forecast to increase with a very positive outlook for lamb prices. In addition to the results shown, an additional premium of $100 per copy of a major gene which increases meat yield and confirmed by genetic testing was charged. The relationship between price of rams sold and index merit is quite strong in this flock within a year for the three most recent years (i.e. $.31 to $.36 per DPO index cent of superiority within a year). The index units are expressed per ewe lambing, but can be translated approximately to a per lamb born basis by multiplying by .694. Thus, if a ram has 300 lambs born in an average lifetime (100 ewes mated for an average of 2 years and 1.5 lambs born per ewe mated), then the buyer of superior rams on offer benefits by 300 lambs x 1 cent x .694 x 1/2 = $1.04 for every 1 cent of genetic superiority in the purchased ram, but only pays $.31 to $.36 per DPO index cent to capture this. The increase in market share of this ram breeding business needs to be interpreted with caution, because a high merit flock was purchased and integrated into the breeders own ram selling business in the initial period of the data series. Maternal type rams are sold to other breeders at a premium price which is $3000, and other "recording intensive" breeders are selling elite rams to other breeders for a premium price of $5000.

Table A.3.2. Terminal rams sales statistics, over four years for a large progressive New Zealand sheep breeder (TSO denotes a NZ standard selection index with units of cents per lamb born on an EBV basis)

Year	Number sold - flock rams	Number sold to other breeders	Mean price ($/ram)	Mean TSO index (NZ cents)[1]	Correlation between price and index	Percent of variation in price explained by index	Slope of price on index
2001	44	0	282	143	0.49	0.24	1.02
2007	76	0	476	490	0.36	0.13	0.23
2008	99	1	465	703	0.35	0.12	0.29
2009	84	2	530	662	0.40	0.16	0.41
2010	123	3	543	791	0.43	0.19	0.15

[1]Index trend for rams sold, not for the whole flock.

Table A3.2 shows results of analysis of data from the same breeder, but which corresponds to the terminal sire flock. The same lift in ram prices can be observed in 2009 as was observed within the maternal flock (i.e. an increase by approximately 15%). Sales of rams to other stud breeders of terminal sires attained less of a premium ($1500 for terminals versus $3000 for maternals), and the index trend appears more erratic. The relationship between ram pricing and index for terminals is comparable to that observed for maternals, but also more variable over years (average of $0.27 for every index cent increase in superiority). Because the terminal sire index is already expressed per lamb born, then the benefits to the ram buyer are 300 progeny born x 1 cent x 1/2 equals $1.50 of benefits per index cent, for which the ram buyer has been paying a premium of only 27 cents. The increase in numbers of rams sold observed, in particular since the 2001 data reflects the success of the breeder in making genetic progress and establishing a reputation as selling high genetic merit rams.