Report to

Australian Wool Innovation

Benefit Cost Analysis of AWI's Genetics & Genomics Investment

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BACKGROUND

BDA Group was commissioned by AWI to complete a benefit cost analysis (BCA) of their investment in the Genetics and Genomics Program. Investment in this area over 2010-13 was made under the On-Farm Strategy (1): Sheep Health, Welfare & Productivity; Program (1) Sheep Health, Welfare & Productivity; Sub-Program (iv) Genetics & Genomics. AWI has continued investment in this area under the current 2013-16 Strategic Plan.

The analysis was completed with the primary purpose of providing a robust assessment of the potential returns to Australian woolgrowers from that investment and forms part of the series of AWI investment evaluation reports. These analyses are publically available from AWI[1] and apart from reporting the return on investment to shareholders support the on-going process of strengthening investment planning and reporting across the organisation.

BACKGROUND

The underlying rationale for investment in genetics and genomics by AWI is to enable the Australian wool industry to increase the rate of genetic progress or gain across commercial flocks. This is possible because wool growers can exercise discretion over which animals are used as replacements in their flocks, both studs and commercial woolgrowers alike. In the main this is based on ram selection and to a lesser degree on the selection of replacement ewes. Industry profitability can also be increased through AWI investment if the cost associated with identifying replacement animals is reduced.

Principles of genetic progress are not new and indeed have been pursued by the Australian wool industry since its foundation. Investment by AWI then seeks to increase the rate of genetic gain for woolgrowers over and above that which is able to be achieved by the industry without AWI investment. The key factor that has driven genetic progress to date has been the identification of superior animals to use as replacements. All animals will have a unique contribution to make depending on their genetic makeup and the characteristic of the flock in which they will be used. Selection processes will accordingly seek to identify the superiority of one animal over another. This is the basis of genetic benchmarking and in this evaluation the focus will be on ram selection[2].

[1] http://www.wool.com/en/about-AWI/how-we-consult/measuring-performance.

[2] It is noted that this will underestimate potential gains as improved selection decisions for ewes – mainly in sheep studs –will accelerate genetic progress. Genetic progress can also be achieved through increases in the selection differential as a result of having a wider choice of selection candidates; a higher selection intensity as a result of selecting fewer animals as replacements across all candidates; and though reduction in the generation interval as result of decreasing the time between candidate selection and use in breeding programs.

The choice of a particular benchmarking approach by a stud breeder will depend on the value of that approach weighed up against any additional cost that would be incurred. To deliver a positive value to the stud breeder any "new" or improved approach would need to result in the selection of different animals as replacements than would otherwise be the case or reduce the costs associated with the identification of superior animals.

INVESTMENT

Investment made by AWI in the Genetics and Genomic Program over 2010 to 2013 totalled $3.6m ($3.8m in current dollars) including operational costs[3] and involved 13 separate projects. Investment was made in five key areas with the majority of investment made in the Information Nucleus Flock (48%) and the operation and improvement of MerinoSelect (46%).

1	INF (48%)	The Information Nucleus Flock (INF) was set up by the Sheep CRC to increase the accuracy of breeding values by analysing the DNA of young rams. In 2011AWI[4] decided not to support on-going investment in the INF, citing concerns that the previous INF investment had not yielded adequate benefits on Australian woolgrower's investment and that the project failed to adequately demonstrate a bridge to a commercial outcome. In response to the latter the Sheep CRC[5] stated that the bridge to a commercial outcome was through Sheep Genetics and improved accuracy of ASBVs (Australian Sheep Breeding Values[6]).
2	MS Improvement (46%)	Investment in this area supported the on-going operation and development of MerinoSelect (MS) as well funding support for research into matching genetics and reproduction systems and reproduction efficiency to improve the gains from genetic progress.
3	Bloodlines (<1%)	AWI and the NSW Department of Industry and Investment support the periodic publication of Merino Bloodline Comparisons which enables wool growers to benchmark the performance of current and potential

[3] Operational costs were estimated at 30 cents on every dollar contracted through individual projects.
[4] http://www.wool.com/Content/en-GB/genetics_genomics_summary_sheet_2012.pdf.
[5] http://www.sheepcrc.org.au/genetic/summary-of-progress-in-genomics-and-genetics/information-nucleus-program-best-investment-for-genetic-gain.php.
[6] ASBVs are estimated breeding values used in Sheep Genetics.

bloodlines across Australia. The last release was in July 2010 and investment over 2010 to 2014 also sought to reconcile poor correlations between Bloodline and Sheep Genetics Indexes.

4 AMSEA (4%)

The Australian Merino Sire Evaluation Association (AMSEA) overseas the publication of Merino Superior Sires which enables stud breeders to benchmark the performance of their own genetics against other studs.

5 Strategy (2%)

AWI periodically funds a number of projects to support their on-going investment planning for genetics and genomics research, development and extension as well the assessment of attitudes to different benchmarking methods and to support additional statistical analyses to strengthen existing performance data.

TABLE 1: AWI GENETICS & GENOMICS INVESTMENT: 2010/11 TO 2012/13: $'000

Investment	2010/11	2011/12	2012/13	Total
Project	$841	$1,199	$743	**$2,783**
Operational	$252	$360	$223	**$835**
Total	**$1,093**	**$1,694**	**$1,225**	**$3,618**

AWI's investment in the Genetics & Genomic program was undertaken in partnership with a range of agencies including the Sheep CRC, Sheep Genetics Australia[7], Meat & Livestock Australia, AMSEA and a number of government departments. In total, AWI's support accounted for, on average, some 53% of funding from all sources, including stud breeders who are the other major funder of MS. AWI direct investment support of MS over the evaluation period was $662,000.

7 Sheep Genetics Australia (SGA) operates under a partnership between MLA and AWI and also from income received from industry members as payment for provision of services – LambPlan and MerioSelect. SGA operate out of the Animal Genetics and Breeding Unit based in Armidale, which was established in 1976 by the NSW Department of Agriculture and the University of New England.

BENEFITS

Investment benefits will largely be generated from AWI's and partner investment in MS over the evaluation period as this was the main vehicle for delivering industry gains from research and development activities. While considerable investment was made outside of MS (for example the support of the Information Nucleus Flock) the pathway by which commercial wool growers would obtain benefits was through their participation in MS. Further, investments made in the support of other benchmarking programs were more marginal from an AWI investment perspective and these programs typically operate under a more industry pays structure than SGA.

In this evaluation the focus is on a period of investment over three years, 2010/11 to 2012/13 and benefits are considered in terms of gains made as a result of studs participating in MS over that period. Benefits that can be attributed to the AWI investment include:

1 benefits to MS participating studs;
2 flow-on benefits to commercial wool growing flocks as a result of increased rates of genetic progress in participating MS studs; and
3 longer term progress in development and implementation of genomic technologies[8].

Benefits to Participating MS Studs

While it might be possible to estimate a typical rate of genetic gain and value from participation in MS, difficulties lie in estimating the counterfactual, or what rate of gain would otherwise be achieved. While it is plausible that some stud breeders are able to achieve similar rates of genetic progress without using MS it is also plausible that some stud breeders would realise a significant increase in rates of genetic progress as a result of their participation in MS. Indeed, the difference between what stud breeders might achieve with and without MS will drive the adoption of MS through time as well as possible gains from a more cost effective data collection, management and analysis system. Given available evidence on the success of different approaches to breeding[9], it cannot be concluded that MS is the most appropriate breeding approach for all stud breeders, only that some stud breeders may prefer it over other approaches and realise a benefit from participation.

[8] Investment in genomics (largely through the Sheep CRC) had a commercialisation pathway through MS and hence any progress achieved will be reflected in benefits generated through MS. However, much of the investment in genomics involves basic research and it would be expected that research outputs achieved over the years 2010 to 2013 will increase scientific knowledge and hence contribute to the on-going research in this area. These potential outputs were not included in the evaluation.

[9] For example, AWI project EC193 – SARDI Demonstration Flock – showed that genetic progress could be achieved with different breeding approaches, including performance recording, visual classing and elite wools, and the profitability of one approach over another which will depend on the rate of gain achieved against its cost.

In the absence of robust information on the counterfactual economic models can be constructed to estimate, across all participants, the aggregate value they receive from participation in excess of the costs they incur, including MS participation costs, their own recording costs and any additional environmental costs[10]. The base assumption under such an economic model is that MS participants are able to determine the value of their participation and the costs of such. The economic model is described in Figure 1[11].

where:

- Supply of MS represents the service provided by MS and is given by the number of new animals included under MS each year.
- Demand for MS by stud breeders represents the number of new animals required by merino breeders each year to be entered into MS. The responsiveness of the demand (De) for new animals by merino breeders was assumed to be relatively inelastic [12](-0.5).
- P represents the price faced by merino breeders for each new animal included in MS. This price was estimated at $2.50 per animal[13].
- Q represents the number of new animals added each year to MS. In 2012 this was 130,000 animals.
- CS represents consumer surplus which is the total value to all MS participants from participation in MS in excess of the costs that they incur. This value was estimated at $325,000 a year[14]. Across three years the total value would be $975,000.
- PS represents producer surplus which is the total value to MS from delivery of the service to merino breeders in excess of the cost of delivering that service. As the supply of MS services is relatively elastic, in that changes in the number of animals entered has little impact on delivery cost, PS was assumed to be close to zero.

10 These costs include additional feed and management costs as a result of physically different animals run – such as higher body and fleece weights.

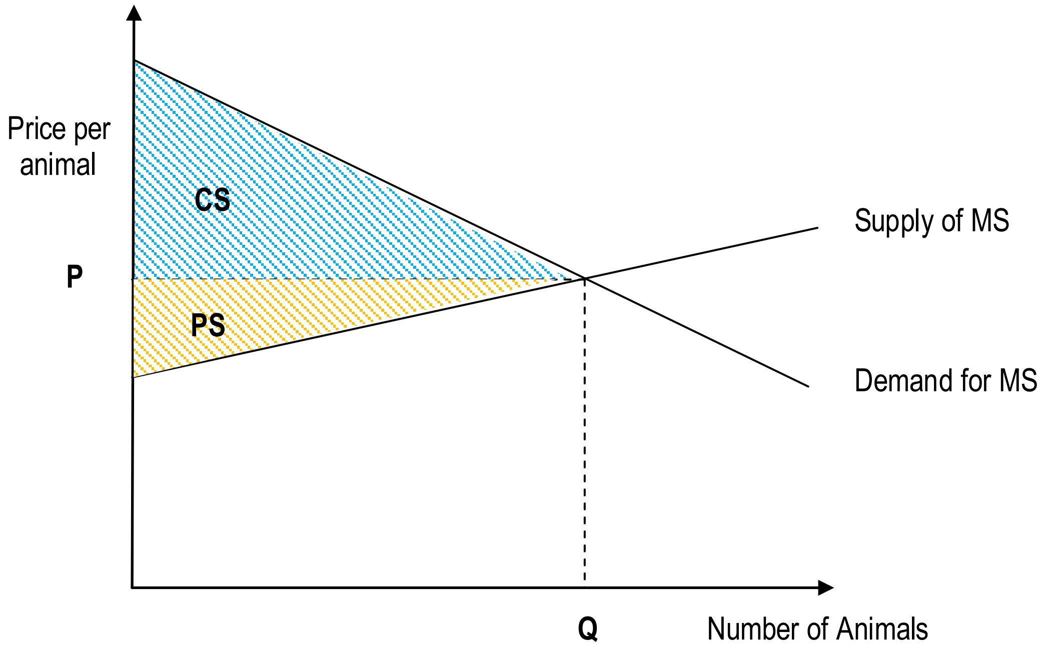
11 An economic model based on a partial equilibrium model as outlined by Freebairn,J. (1992), "Evaluating the Level and Distribution of Benefits from Dairy Industry Research", *Australian Journal of Agricultural Economics*, 36 (2), 141-165 was used to estimate consumer and producer surplus assuming current observed prices and quantities represented an equilibrium position.

12 While no estimates were available an inelastic demand was assumed given that there are no substitute services in the market and that the cost of participation is a relatively small share of a stud's total operating cost. Demand reflects benefits that are realised by individual stud breeders and could include gains from increased genetic progress or more efficient data management as well as additional costs incurred in realizing gains such as, possibly, increased costs of data measurement.

13 This was based on a cost of $1.80 per new animal plus an average flock subscription of $412.5 per participating stud and $121 per flock for the second or more flocks within the same stud (and an average of 535 animals entered per flock).

14 Given by the equation $CS = 0.5Q[(P/Q)(1/De)-P]$

FIGURE 1: ECONOMIC MODEL FOR THE ANNUAL SUPPLY AND DEMAND FOR MS SERVICES.



Flow-On Benefits to Commercial Woolgrowers

Apart from the value of participating in MS realised by stud merino breeders there is also a flow-on benefit to commercial woolgrowers as a result of increased genetic progress in the studs from which rams are purchased. The size of this flow-on benefit will be based on the increased rate of genetic gain achieved by studs though their participation in MS, the number of studs increasing their rate of genetic progress and the economic value of that gain (albeit lagged).

Increased Rate of Genetic Gain

While the rate of genetic gain realised by a stud from participation in MS compared to what they would have otherwise achieved is unknown (as there may be a wide range across members) an estimate can be derived from an assessment of increased accuracy that could be realised on including additional data (from relatives) into the breeding value estimate. Accuracy of a ram's estimated breeding value can be increased if the accuracy of the parent estimated breeding values are increased.

Julius van der Werf[15] notes that the accuracy of an estimated breeding value depends on the source of information used. Increasing the accuracy of the sire estimated breeding value (from 50% to 90%) can increase the accuracy of an estimated breeding value by 16% (points) assuming this is the sole source of information used. Through MS the progeny of parents is continually updated as year on year drops are added to the database. With increased progeny numbers the accuracy of the estimated breeding

[15] Julius Van der Werf course notes UNE Gene422 – 2. Principles of Estimation of Breeding Values.

value is increased and hence the accuracy of the estimated breeding value for progeny in any year drop, from which animals will be selected.

The 16% would be a maximum as the accuracy of the estimated breeding value can increase with addition of other data such as own performance and half siblings. In this case the heritability of the trait impacts on the accuracy of the estimate and hence the gain from improving the parent accuracy is diminished. In essence, the 16% measures the average increase in genetic gain achieved across all MS participants and as noted previously this is unknown. Nonetheless, for the purpose of this evaluation the maximum gain in accuracy is assumed[16].

Participation in MS delivering a 16% increase in the accuracy of ram estimated breeding values will deliver a 16% increase in the average rate of genetic progress[17]. This gain would be realised over four years based on the replacement rate of rams into the ewe breeding flocks and lagged by two years from first entering MS (one generation interval).

Adoption

MS started in 2005 and flock numbers reached 237 in 2012/13. There was a substantial increase in participating flocks in July 2012 as a result of the incorporation of the database for Dohnes. Over 2012/13 28 new flocks joined MS and 11 left[18]. The extent to which the maximum gain would be realised will depend on the period of time participating studs (and flocks) had been a member of MS, noting that every year some new members join and some existing members leave. These details were derived from records held by AWI and are presented in Table 2.

TABLE 2: YEARS OF MEMBERSHIP: NUMBER OF FLOCKS: BY YEAR

Years Membership	2010/11	2011/12	2012/13
1	13	14	28
2	12	13	25
3	11	12	22
4	133	139	162
Total	**169**	**178**	**237**

16 This is because the reported payoff under this assumption is negative and hence there is little gain from considering a lower increase in accuracy. Sensitivity analysis on the assumed increase in accuracy is examined in the final section. The extent that this increase is passed on to commercial flocks might also be lower as the accuracy associated with describing the genetic superiority of a team of animals using breeding values will be higher than for the individual animals themselves.

17 Rate of genetic progress is a function of the accuracy of an estimated breeding value, the selection intensity, the variation in the population for a trait of interest and the generation interval. Julius Van der Werf (course notes UNE Gene422 – 2. Principles of Estimation of Breeding Values) suggest that the rate of genetic progress {using estimated breeding values] is proportional to the increase in accuracy of the estimates..

18 Data supplied by Sheep Genetics

For the evaluation it was assumed that 133 flocks would have reached the maximum gain of 16% by July 2010 (the start of the evaluation period) and the operation of MS over 2010 to 2013 would have enabled them to maintain this increased rate of genetic progress. For the flocks joining in 2012 only one year's participation in MS is considered, with the increased rate of genetic progress capped at 4% (based on a one year selection decision for replacements rams). Other flocks would have realised a gain of less than 16% in any given year depending on when they joined.

Value of genetic gain

Information from Genetic Trends for sires entered in Merino Super Sires (1991 to 2012) can be used to estimate the baseline genetic gain that has occurred in the past across the wool industry. Changes in major traits are detailed in Table 3. The annual gain realised was estimated at 47 cents per ram, or 23.5 cents per ewe mated.

TABLE 3: TRENDS IN GENETIC GAIN: 20 YEARS

Trait	Absolute Change	Annual Change	Annual Economic Value
HCFW [a]	4.0%	7 gm	+0.7 cents
HFD [b]	0.7 um	0.035 um	+10.5 cents
HSS [c]	0.85 n /kt	0.04n /kt	+0.56cents
HSL [d]	3.2mm	0.16mm	+3.0 cents
HWT [e]	3.9kg	195gm	+32 cents

a) Based on 3.5 kg and 1,100 cents per kg
b) From base of 21 um, 100 cents per 1 um finer (net of fees and levies) and 3.5 kg clean
c) 4 cents per 1 n / kt increase and 3.5 kg clean
d) 5 cents per 1 mm increase and 3.5 kg clean
e) Based on $1.80 per kg lwt

Assuming a 75% weaning rate in commercial wool flocks and rams run at 2%, the increased value associated with [permanent] genetic progress would be $8.95 per ram used each year or $112 in present value terms[19] per ram over a 25 year period and allowing a 2 year lag. A 16% gain attributed to MS would deliver an extra $17.92 per ram used. This value overstates the increase in profit in commercial flocks as there would be an increased feed demand associated with higher body and fleece weights. This cost was estimated at 7% of the gain[20], and hence the increased profit per ram would be $16.67.

The total increased value of the genetic gain delivered through MS depends on the number of rams sold[21]. Based on 173 flocks for three years and 70 flocks for one year (achieving only a 4% increase in accuracy), the total value of the genetic gain was estimated at $0.7m.

[19] Discount rate used was 5%.
[20] Based on estimates derived for development of AWI's 2010 to 2013 Strategic Plan.
[21] It was assumed that around 20,000 rams were sold from participating MS stud in 2013.

PAYOFF

In this section the estimated pay off on the AWI investment is reported. Measures are reported in Table 4. It was estimated that the AWI investment, including the operation of MS, has generated benefits to Australian wool growers of $1.5m in present value terms. This represents a loss to Australian woolgrowers on the funds invested by AWI in the Genetic & Genomics program over 2010 to 2013.

TABLE 4: INVESTMENT PERFORMANCE MEASURES

Measure	Result
Present Value of Benefits	$1.5m
Present Value of Costs	$3.3m
Net Present Value)	-$1.8m
Benefit Cost Ratio	0.45

Sensitivity analysis was undertaken on the assumed flow-on benefits to commercial woolgrowers for the AWI investment to break-even. It was estimated that accuracy would need to increase by 56% (points) if investment benefits were to equal investment costs.

This would imply that participating studs in MS would need to have a very low level of accuracy in their estimation of an animal's breeding value prior to joining MS and hence a very low rate of genetic progress. This assumption would not be reasonable to make across all MS participants given that some of the major selection traits (micron and fleece diameter) are highly heritable and genetic progress is able to be achieved through other breeding approaches.

CONCLUSION

The main reasons for the loss on funds invested by AWI include the funding of the INF and low adoption of MS by studs given the financial support provided for its operation and improvement. While the return to Australian woolgrowers from the investment has been negative, this does not imply that MS does not generate value for participating wool growers. In fact, the MS operation was assessed to be profitable, delivering some $325,000 a year in benefits to participating members in excess of MS operating costs (which were $551,000 in 2012/13 and some $322,950 recovered through member charges). Further, additional gains are also realised by commercial woolgrowers who source rams from participating MS stud breeders (around $247,000 a year).

A number of important observations can be made from the evaluation of AWI's investment in the Genetics & Genomics Program from 2010 to 2013 which will have relevance for evaluation of future investment in genetics and genomics by AWI.

1 The first observation is that MS can operate as a commercial entity with private benefits able to be appropriated by participants and the cost of providing the service effectively priced.

2 There is a market failure as a result of flow-on benefits (from increased rates of genetic gain) being captured by commercial woolgrowers who purchase rams from participating MS studs, because the value of this benefit is not directly reflected in ram prices. Purchase decisions are based on the relative distribution of genetic superiority of animals across studs in any given year and not the absolute. Selection decisions will largely be made on the basis of the assessed breeding value of an animal rather than the accuracy of that assessment in any given year. It is also recognised that for some specific traits, for example resistance to worm burdens, price premiums might exist as the superiority of one animal over another is clearly evident and hence there would be no market failure for these traits.

3 Although there might be market failure this alone does not justify the investment of AWI funds. The sufficient condition for investment is that the benefit of overcoming this market failure needs to be greater than the cost of the intervention. Consequently, the decision by AWI to invest in MS in the future should be based on an assessment of the cost of the investment weighed against the incremental increase in genetic progress achieved by participating MS studs – not the absolute genetic progress achieved.

4 Finally, any future investment by AWI in genetics and genomics needs to consider different options for either increasing the rate of genetic progress through time or reducing the costs associated with benchmarking an animal's performance in studs across all breeding approaches. While improving MS might be a viable strategy, investment options involving other breeding approaches should also be considered.