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THE DISTRIBUTION OF RISK AND REWARD IN EXTENSIVE LIVESTOCK IMPROVEMENT SYSTEMS, THEIR CONSEQUENCES AND POSSIBLE RESPONSES

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SUMMARY
A range of players or sectors make investments into genetic improvement in the extensive livestock industries, but overall returns are heavily dependent on decisions made by bull- (and ram-) breeders. They in turn rely on sales of genetic material to cover their own investments and maintain profitability. Some broad-scale characteristics of the investments and of the markets for genetic material are reviewed, leading to the observation of very high uncertainty in those markets. This uncertainty is almost certainly acting as a brake on genetic progress, and some possible approaches to reduce the uncertainty are considered. Such approaches will aim to improve efficiency of the market for genetic material, and will need to be designed to be robust, transparent and simple and cheap to apply.

INTRODUCTION
For any livestock improvement system, return on investment must be satisfactory both to maintain profitability and to fund further improvement. For single, vertically-integrated enterprises, this should be straightforward in terms of accounting and response, and the same conclusion likely applies for breeding enterprises in multi-vendor situations, provided that they have enough scale and market share. For multi-enterprise industries, such as beef cattle and sheep in Australia, things may not be so straightforward. Discussion of opportunities, and research, is often quite sensibly focussed on technical questions, which can ultimately be summarised as how to achieve higher accuracy of selection for a given investment and with possible constraints on inbreeding. Increasingly however, and especially when there is a mix of public, collective and private investment, some focus is on how to improve investment return: in simple terms, how to increase the rate of genetic progress?

In livestock industries such as beef cattle and sheep, investment in genetic improvement can be grouped into two categories: performance recording, and research, development and extension. The returns ultimately accrue as increased value of sales of products and margins distributed in some way through the value chain, or at worst reduced rate of decline in the real value of these things. Who makes the investments, and what returns they receive, could have important effects.

This paper focusses on these distributions of risk and reward, and explores whether they might be affecting rates of genetic progress, and if so, what responses might be considered. This paper focusses on the beef industry, but the limited available evidence suggests similar patterns apply in sheep.

RATES OF PROGRESS ACHIEVED
Previous reports of genetic progress being achieved in the beef and sheep industries indicate that:

a) Averages are consistent with, or higher than, those achieved in other countries (Swan 2009, these proceedings)
b) There is wide variation in rates within and between breeds (Johnston, 2007).

Adoption rates, estimated as proportion of sires entering the market either with BVs themselves, or sired by animals with BVs, are moderate to high.

Together, these observations suggest that the technologies and the forms in which they are offered/provided, enable very satisfactory genetic progress. Given the opportunity costs of genetic progress being slower than potential, it is reasonable to ask what causes the difference.

INVESTMENTS AND RETURNS

Data collection and availability of total investments and returns is limited, but some high level approximations can be used. Table 1 summarises estimates for the beef industry for the decade leading to the end of the Beef CRC.

Table 1: Estimated annual investments in Research, Development and Extension/Adoption and Implementation in the Australian beef industry, 2002-2012

Stage	Estimated Annual Investment ($m)			Funding Source %		
	Cash	In-kind	Total	Breeders	Producer levies	Gov'ts
Strategic research	$7.48	$8.10	$15.58		6%	94%
Applied RDE	$1.00		$1.00		50%	50%
Extension to breeders	$0.50		$0.50	42%		58%
Implementation	$2.50		$2.50	50%		50%
Routine evaluation	$0.60		$0.60	100%		
Data collection in studs	$3.75		$3.75	100%		
	$15.83	**$8.10**	**$23.93**			

The key observation from this summary is that overall investment is substantial, and it is sharply divided between pre-implementation Research, Development and Extension/Adoption, borne predominantly by tax-payers and producers, and implementation, which is borne predominantly by breeders. This raises the question of how returns flow to the different investors.

In the case of estimated returns, there are 3 sources (breed, herd, and within-herd):

- Estimates of returns to sectors, using Equilibrium Displacement modelling (Zhao et al, 2000). These estimate that the distribution of returns from improved productivity, or marketing (which can be treated as a proxy for improved product quality) is approximately 30% to producers, and approximately 67% to domestic and international consumers (Table 2). Note that the form such benefits (to either the consumer, or ultimately the producer and breeder) take when consumers essentially pay the world price may not be clear, and some of the estimated consumer benefits may accrue to local land values, to the benefit of domestic producers.

Table 2: Distribution of Returns (%) by sector R&D investment into improved production or improved demand (Zhao et al, 2000)

Sector	Beef	
	Production Research	Promotion Research
Producers	24-34	20-30
Feedlots	0.1-0.2	0.3
Processors	1	1
Retailers	4	4-7
Domestic Consumers	50-55	50-65
Overseas Consumers	8-9	5-12

- Data from breed societies on bull sales, at the breed and herd level.
    - Breed level: at the time of writing, only a very limited sample of such data has been analysed: average prices for Angus bulls across years, and average prices for Angus studs

within a year. The former analysis suggests a relatively constant relationship between the average price across all bulls sold in a year and the prevailing price for young cattle. The ratio of average bull price in dollars to Eastern Young Cattle indicator in c/kg across the period 1996-20104 is 10.8:1. Using a standard carcase weight and number of lifetime progeny, this ratio equates to 5.4% of total on-farm earnings per bull (and therefore approximately 1.6% of total value chain income per bull).

- Herd level: the regression of herd average bull price in 2014 (adjusted for season and state) on herd average merit for $Index for the 2012 drop, in Angus herds across Australia is = ($ 17.26 x Herd Average Merit) – 1813, with an r-squared of 6.6%. Certainly this is a small sample, but there are two interesting aspects in these numbers: firstly, that the regression – the amount paid to the breeder per $Index point, is close to half the proportion of the value-added per bull received by the commercial producer, meaning that the bull-buyer is on average sharing the "rewards" from genetic improvement with the bull breeder; and secondly, that there is a great deal of variation around the regression, meaning that there is considerable uncertainty for the breeder about how much reward he/she will receive for the genetic improvement generated and offered for sale.
- Data from samples of individual bull sales: Van Eeenannam (pers. comm.) analysed data from individual stud sales for Angus studs for regression of price on index value, within stud, and found regressions ranging from $80-160 per index point, with r-squared values in the range 20-26%. Similarly, analysis of data from 8 Angus studs for the 2016 selling year reveal regressions of sale price on $Index across studs averaging $88 extra per $Index point (range $34 to $134) and r-squared averaging 19% (range 7% to 32%). The data for these sales also show very variable but sometimes strong relationships of price with weight of sale day (not shown).

Some caution is needed in considering the meaning of these results:

- it is likely that buyers of Angus bulls have the most appreciation of BREEDPLAN information, reflecting the focus on the technology and its extension over many years,
- the price data includes stud and herd bull sales, in varying proportions across studs, but this is likely to bias upwards both the across-herd and within-herd regressions of price on merit,
- the studs for which individual regressions have been investigated could be realistically described as technology leaders, and so their clients may not be representative of the average bull-buyer.

IMPLICATIONS

Overall investment into genetic improvement in the beef industry can be categorised into "pre-commercialisation" investment (R&D, extension) and commercialisation or implementation investment. The former creates potential for genetic progress and hence wealth generation, the latter converts potential into reality.

The distribution of the investment into these 2 categories almost perfectly maps to 2 categories of investors: the former to tax-payers and commercial producers acting collectively, and the latter to bull breeders. In general analyses of return on investment in genetic improvement show very favourable long-term and industry- or community-wide returns. However, such outcomes are completely dependent on the behaviour of the breeding sector, or more precisely on the large number of heterogeneous agents who comprise it: – how much they invest, how they invest and how they make selection decisions. Those decisions all ultimately depend on the returns obtained from selling genetic material – and more particularly on both the expected level of return and the uncertainty about that expectation.

The limited analysis of sale results for Angus cattle has two main messages. First, there is a relatively stable relationship between overall average price of bulls and the current price of commercial cattle. It is as if the market estimates and applies some function of steer price in determining the price it is willing to pay for bulls. Second, there is some variation around this overall average, related to herd merit and animal merit within herd. So, the market can be said to be paying for genetic merit, albeit with very wide variation about how much it pays. And further, there is very wide variation around the across- and within-herd regressions, indicating considerable uncertainty for the bull breeder. This has most relevance to genetic improvement in relation to the across-herd regression of average price on merit. The low r-squared implies that obtaining a reliable return on investment in (additional) herd recording and faster genetic progress cannot be guaranteed.

In these circumstances, it is not unreasonable to expect under-investment (the utility value of an investment being its expectation minus a function of its uncertainty, and the uncertainty in this case is clearly high), and potentially some excess caution in decisions relating to breeding direction and selection differential. Both these responses limit the overall returns, for all investors. Accordingly, there would be value in industry and community consideration of strategic mechanisms to reduce the uncertainties. Note that this does not relate to industry and community support for RDE – those investments are to create potential. The mechanisms needed are to in some way reduce the uncertainty and/or improve the returns – which can almost be considered as modifying the implicit license under which the knowledge and tools of genetic evaluation and improvement are made available to the breeding sector, which in turns supplies a service called genetic improvement.

Currently, the rest of industry incentivizes the breeding sector via the market for genetic material, which the data reviewed here suggests to have very low efficiency in its signalling – there is a lot of noise in the market, as reflected by the low and variable r-squared values. One approach to changing the terms of the transaction between breeders and the rest of the value chain, developed in the grains industry of this country, is to collect an end-point royalty on production, and funnel that back to breeding companies. This levy can be used to offset breeding program costs. This approach goes part way towards solving the problem, but the link between returns and genetic merit is still filtered through market perceptions and knowledge informed by a system of variety comparison. This is essentially almost equivalent to funding breeders for their recording costs, although it does not deliver that specificity. This still leaves the returns for better breeding decisions uncertain. It would be worth considering whether other or additional mechanisms could be developed that more directly reward genetic merit, and thus increase the r-squared in relationships between price and merit.

These ideas may seem impractical or anti-market, but in fact groups of interested players or their agents define rules of operation for many markets. Leaving genetic improvement, and the wealth it can generate, solely to an imperfect market has only one merit, and that is that it is easy.

CONCLUSION

Markets for genetic material (beef in this case) are the means by which incentives for genetic improvement are delivered, and hence by which returns on investment generated. These markets appear to be very noisy despite signs of underlying rationality. Mechanisms to reduce that noisiness are worth investigation, as such reduction should improve incentives and hence overall returns.

REFERENCES

Johnston, D.J. (2007) *Proc. Assoc. Advmt. Anim. Breed. Genet.* **17**:8

Swan, A.A., Brown, D.J., and Banks, R.G. (2009) *Proc. Conf. Assoc. Anim. Breed Genet.* **18**: 326.

Swan, A.A., Banks, R.G., Brown, D.J., and Chandler, H.R. (2017) *Proc. Conf. Assoc. Anim. Breed Genet.* **22** *(in press)*

Zhao, X., Mullen, J.D., Griffith, G.R., Griffiths, W.E. and Piggott, R.R. (2000) Economic Research Report No. 4, NSW Agriculture, Orange.