ECONOMIC VALUES APPLIED TO BREEDING OBJECTIVES: A DECENTRALISED APPROACH FOR BREEDPLAN

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INTRODUCTION

Genetic evaluation procedures available to the Australian beef industry are among the most sophisticated in the world but no procedures are available which indicate the relative importance of various selection criteria. As evaluations become more sophisticated, thus improving the accuracy of selection for individual traits, the need becomes greater to provide overall direction to breeding programs. The breeding objective, when used to design a selection index, will provide direction by ranking prospective breeding stock on their potential to increase profit within a particular production system.

The beef industry has, in recent times concentrated on selection for weight or closely related traits, such as height. The National Beef Recording Scheme (NBRS) which began back in the 1970's provided the industry with ratios of weight at weaning and yearling for comparisons of contemporaries. In 1985 the NBRS introduced BREEDPLAN which uses a multi-trait mixed model procedure to provide comparisons of animals across management groups and across ages, and more recently across herds. The BREEDPLAN multi-trait (it is international convention to call this multi-trait when in fact it should be multi-record or criteria) model (Nicol et. al., 1985) calculates estimated breeding values (EBV) for three criteria, 200 day weight, yearling weight and final weight, with 200 day weight split into direct and maternal components. In 1988 the multi-trait model was extended to include birthweight, which had previously been treated by a single-trait model. Future improvements will include criteria for reproduction and carcase characteristics.

The aim of this project is to develop a farm-based program that calculates customised economic values for individual breeding herds and combines these with BREEDPLAN EBVs to give an index value for ranking prospective parents. A selection index can be calculated as the sum of the EBV's for individual selection criteria multiplied by their appropriate weightings (Graser pers com.).

CHOOSING THE 'RIGHT' ECONOMIC VALUES

Economic values for each trait in the breeding objective provide the link to weight the EBVs when using a quantitative method for making breeding decisions (Hill, 1981). In some nationally operated breeding schemes, scientists have estimated the extra profit from a unit change in a trait and used these values to rank the genetic potential of individual animals. This approach appears to have been adopted by ram breeders and buyers in New Zealand. These standardised weights when used in individual's herds have a number of problems;

The business of breeding and farming is serviced by, but not owned by government. A government bureaucracy which decides the economic values for an industry's breeding objective may be accused of usurping the private sector' s right to decide it's own destiny. It is the breeder's responsibility to make estimates of the important variables needed to calculate economic values. It is the function of the advisor to assist the breeder to make these estimates and to design models from which economic values can be derived. In the end it is the breeders who must choose whether or not to accept any such economic values for it is they who will either gain the profit or take the loss.

Product prices are a major source of error and here the breeder has to take a punt for there is no way in which the analysis of historical data can do more than help breeders make informed guesses about the direction of future prices. Inevitably the breeder will make forecasting errors which will result in breeding plans which will be sub-optimal to a greater or lesser extent.

Breeders have traditionally been reluctant to apply a single-valued assessment to all their animals because this may reduce their ability to sell some animals. In principle there is no reason why the bulls that a breeder has for sale should not be ranked on the basis of the breeding objective of each of his clients. This would mean that different bulls within the sale lot would have different values for different buyers.

Different sets of economic values have different implications for the degree of risk for the breeder. A set which results in large changes to one trait may be more risky than a set which results in lesser gains in several traits. Because each breeder has his own personal attitudes to risk, a centrally imposed set of economic values may not suit.

The beef breeding industry is made up of individual breeders who are all competing for the same market. A single index does not allow the individual breeder to use his skills to develop a competitive advantage.

Using customised economic values should result in greater confidence and use of recording information because of a higher level of participation by the breeder with external benefits to the industry overall.

Business and Breeding Structure

Modern business philosophy urges producers to assess the aspirations of their customers and to provide products which meet their aspirations. Applied to cattle breeding, the breeder sells bulls to commercial beef producers. He needs to derive economic values for their enterprises as the input to his breeding objective. The most appropriate economic values for a bull breeder will be those specific to the segment of the market for bulls which he has decided to target. Breeders will require customised indexes which take into account the different requirements of the bull buyers being targeted.

The breeder's purpose is to maximise his own profit by providing a product that will maximise the profits of his customers. Profits are gross returns less costs. The breeder needs to estimate the extra returns and the extra costs from a unit change in the traits which will be altered on the commercial enterprise of his customers. In other words he should estimate economic values for his customers herds not necessarily his own.

The Breeding Objective

Traits should be included in the breeding objective if they have a direct effect on the costs or returns for the herd (Gjedrem, 1972). To this end the following set of traits are being considered as those having a major effect.

Table 1: Suggested traits for a beef breeding enterprise.

Trait	Related trait(s)
Number of stock for sale	reproductive rate .
Sale weight - direct	could be live or carcase,
Sale weight - maternal	depending on selling system
Maturity rate	days to reach slaughter suitability - fatness
Carcase value	carcase muscle score
Maintenance cost of cow herd	mature cow weight
Longevity	

The Purpose of Selection.

Selection, in most herds, is for two purposes, that of improving the future herd and of improving the current herd (sometimes referred to as culling). The ranking of breeding animals to maximise economic progress in the future herd may be quite different to the ranking of animals to maximise the economic performance of the current herd. Time at which traits are expressed will vary for the future and current herd and this will change the discounting that needs to be applied to the economic value for the different purposes. EBV's are appropriate for ranking animals for the future herd as these contain a measure of heritability while the value that is appropriate for the current herd should use repeatability. For example when a cow has produced at least one calf the maternal component of weaning weight is important because it provides some information about the expected performance of the cows next calf but it also gives a better estimate of maternal ability of her daughters. The record of calf weaning weight needs to be multiplied by the repeatability to give an estimate of the performance of the cow's next calf but by the heritability of maternal 200 day weight to estimate the likely performance of the cows daughters.

STEPS TOWARDS IMPLEMENTING A SELECTION INDEX FOR BEEF CATTLE

The steps taken by this group towards implementing selection indexes for the beef industry in Australia are:

1. Decide the target audience
2. Decide what traits to include in the breeding objective
3. Develop a method for calculating economic values
4. Develop a method to calculate weightings for selection criteria
5. Develop a format for presentation of information to breeders

The Target Audience

Three audiences for the selection index programme were defined; Breeders using BREEDPLAN figures for selection within their own herd, breeders selecting replacement breeding stock on BREEDPLAN figures from other herds and breeders selecting breeding stock on records other than BREEDPLAN. The first development work targeted those breeders using BREEDPLAN for selection within their own herd and many of the references in this paper will be specific to this audience.

Traits

The first model we used to calculate economic values had a breeding objective with only three traits namely, weaning rate, yearling weight and mature cow weight. This model was recognised as rather simplistic but it served to test the feasibility of collecting the appropriate data to allow us to calculate the economic values for individual herds.

A more complete breeding objective must contain an expanded set of traits such as those in table 1.

Calculating Economic Values

The economic value of a trait is the extra profit per cow per year from a unit increase in a trait when adopting the optimal policy for coping with extra consequential feed requirements. Ideally the economic value should be estimated as the first derivative of the fully specified production function with respect to the trait input (Melton, Heady and Willham, 1979).

When developing an applied farm-level program for estimating economic values such a production function is not available. Instead the change in profit from a small increment in a trait is estimated using partial budgeting (Rae, 1977). When the increment is small this procedure will give the same result as the partial derivative. This requires the beef producer to estimate the extra revenue and extra costs for his beef enterprise in the event that such trait improvements are possible.

One dilemma in estimating the extra costs of a unit change in a trait is the degree to which unused resources can be relied on to meet these costs. As breeding is a long run operation, we have assumed that most of the slack in the farming system will be taken up by the time the improved animals come on stream.

We have taken a medium term outlook in setting up the farm-level program. That is, breeding is an activity that will generate benefits well into the future and it was considered that beef breeders would emphasise future benefits. Discounting procedures were used to allow for the delay in the diffusion of the impact of a trait through the herd.

An economic value is calculated for each trait included in the breeding objective and for each feed costing option within each trait. The 'best' economic value for each trait is taken as the highest valued option (table 3).

In developing our procedure for calculating economic values we took a number of decisions about the method we should use. Five elements of our approach are discussed in detail, namely;

a. partial budgeting
b. cost calculation
c. feed costs
d. prices
e. discounting

a.Partial budgets Partial budgeting is a farm management tool for examining the value of an activity which has been proposed as an addition to a business. Usually, though not always, the budgeter assumes that the managerial decisions which go with the proposed activity are optimal. If he is not sure about this he works out partial budgets for several versions of the proposed activity to see which is best.

In using the computer program designed to make the necessary calculations on farm, the beef breeder is asked to estimate the extra or marginal returns and costs from an increase in a trait. This is done in a budgeting framework by considering only those parts or items of the budget that change.

However for breeders who are unsure about costs we have made available the option of using default values from industry sources. The budgeting process involves identifying and costing all the activities carried out on each class of animal from birth to sale. The costs are specific to various enterprise types (e.g. yearling steer production) in different regions. If the program is to be used in a wide diversity of locations then local default values will be required.

b.Cost calculations Extra costs, required for the partial budgeting, imply that we should be calculating marginal costs. However as we are taking a medium to long term perspective for this breeding program the marginal costs are assumed to equal average costs. Average costs are calculated for various classes of animals e.g. weaner, yearling and breeding cow. Costs include materials, labour and capital for both management and marketing.

The most appropriate costs for a breeder to use are those of his 'average client'. The average client is difficult to define and even more difficult to estimate costs for. Those breeders who can define the average client are often reluctant to request information on costs, so they rely on cost estimates from their own operation, excluding costs that would obviously not be relevant to commercial production e.g. artificial insemination.

c.Feed costs Feed costs are difficult to calculate for extensive production systems. Land, labour and capital associated with feed are difficult to apportion to any segment of the herd. The partial budgeting approach allows us to side-step some of these problems.

We assume that the producer is stocking his property at optimal level with respect to both expected profit and risk. Further, we adopted the philosophy that the stocking pressure should remain equivalent to that of the herd before change implying that the current herd requirements are regarded as a fixed cost and only the extra feed required needs to be costed as part of the economic value for those traits which change feed requirements.

The second assumption that affects feed pricing is the seasonal distribution of feed through the year. In areas that have a seasonal pattern of rapid feed growth at a particular time of the year (e.g. a 'spring flush') it is assumed that there is surplus feed and if not eaten, the extra feed will simply be wasted. The costs of extra feed required at this time is assumed to be zero. Conversely there is a period of the year where the feed requirement of the herd closely matches the feed available and any extra requirement during this period must be paid for in full. This period of feed short-fall, which we refer to as the 'pinch period', will vary in length according to the production system and the environment. A producer who uses all available feed with a production system such as buying-in extra steers during the flush or conserving the extra as hay, can nominate a pinch period of 365 days.

Given that during the pinch period extra feed requirements need to be accounted for, we have used four main ways to cost feed.

1. Cow numbers can be reduced proportional to the feed requirement increase. Costs incurred with this option will be the reduced number of cows contributing to the income of the herd.

2. Some of the future sale stock can be sold off before the pinch period. The cost of this option is the foregone income compared with the original system where sale stock were carried through to normal sale time.

3. Agistment can be bought at the going rate.

4. Feed can be purchased at the market price.

The breeder is able to nominate which of the options is appropriate for his clients production system, e.g. there are a number of producers for whom the agistment option is not available and hence is not considered for that herd.

d.Beef prices We suggest that breeders average prices received over the last two years as a forecast of future prices. If this forecast is unrealistic the breeder can input the future prices which he feels are nearer the mark.

Another issue considered was whether aggregate national beef production would increase due to trait selection, in which case the price of beef may decline due to the interaction of demand and increased supply. In technical terms the beef price would be adjusted by a factor that included the effect of the price elasticity of demand and the share of total beef output which could be attributed to the breeder's bulls. Because this share of the beef market is small the adjustment will be negligible. This would generally lead to a lower beef price. However, the present program was developed to estimate economic values for individual beef breeders or producers and it was assumed that this decision framework would not, by itself, influence aggregate beef output. Therefore prices are not adjusted for the effects of increased supply.

e.Discounting The economic value for each trait is discounted (using an interest rate of 7%) to present value according to the timing of the genetic contributions from the selected animals. Herd dynamics especially factors such as age at first joining influence the diffusion coefficient as does the interaction of the trait with sex of the selected animal.

Weighting the Selection Criteria

To calculate an index for selection of animals including various measures of economic importance, correlated with the true breeding values for the traits in the breeding objective, relative economic values (EV) must be estimated. Using EBVs for n traits from a multi-trait genetic evaluation model the index can then be calculated as;

$$\sum_{i=1}^{n} (EBV_i * EV_i)$$

Frequently EBVs will not be available for all traits in the breeding objective as no direct measurements or records are available for these traits. In this case two options are available to weight the selection criteria;

a. Calculate EBVs for those traits as a linear function of other traits' EBVs using the genetic covariance matrix between traits.

b. Absorb the economic values for traits with missing EBVs into the other traits using the same covariance matrix.

For both options, the resulting index should be the same.

Our approach follows the second method and the first-generation program includes the traits and measurements shown in Table 2 with their variances and genetic correlations. The operator specifies which traits have EBVs.

Table 2: Traits, variances and genetic correlations used to calculate the weightings for EBVs.

Trait	Genetic Variance	Correlation 1	2	3	4	5	6	7
1. Calving Percentage	0.8	-	0.10	0.10	-0.10	0.09	0.08	0.10
2. Birth Weight	6.0		-	0.68	0.00	0.60	0.50	0.45
3. 200Day Growth	52.0			-	0.00	0.60	0.50	0.50
4. 200Day Milk	68.0				-	0.00	0.00	0.10
5. Yearling Weight	315.0					-	0.70	0.60
6. Final Weight	560.0						-	0.70
7. Mature Weight	750.0							-

Presenting Information to Breeders

Using economic values calculated from the information supplied by the breeder weightings are calculated for the selection criteria for which he has EBVs. These weightings are then multiplied by the EBVs and summed to give an index value for each animal. The index values are used to rank selection candidates for their worth to the herd.

The breeder will receive a listing of the economic values for each trait in the breeding objective, a listing of the weightings for each measurement for which he has an EBV, the EBV values for each trait as well as a calculated index value (table 3).

ON-FARM EVALUATIONS

The computer program and methodology was tested on three herds using only three traits and a simplified herd model. In this first model extra benefits less the extra costs associated with the following three traits were calculated for the given units:

Weaning %: An increase in weaning rate per cow of 0.01.

Yearling weight: An increase of 1kg in the selling carcase weight.

Mature cow weight: An increase of 1kg in the mature weight of the breeding cow resulting in heavier culls and cull cast for age.

Herd Model

Our representative farm for commercial beef production consisted of an area sufficient to carry one beef breeding cow and her followers. The farm unit grows a surplus of grass for part of the year which is in excess of the demands of the 'herd'. In the so-called "pinch" period the rate of pasture supply was equal to or less than the rate of feed demand.

The commercial beef producer breeds and fattens stock. He carries the weaners through one pinch period and sells most of them as yearlings before the onset of the next pinch period. A few of the female yearlings join the herd as two year olds to replace culls and old cows cast for age. Culls are cows of any age which fail to get into calf or depart for other reasons. Output of this farm unit consists of a fractional 18 month yearling, a fractional cull cow, and a fractional cow cast for age.

The model of the farm unit can be altered appropriately to adjust for a wide range of circumstances simply by increasing or decreasing the length of the pinch period. If a breeder envisages his typical customer as an intensive producer with no feed slack in the system he simply specifies the pinch period lasting for 365 days in each year.

The First Herds

Three herds were surveyed in the first run of tests and while the task of collecting all the data was an arduous one, all properties were able to give answers to the necessary questions. The first two breeders were interviewed on-farm and it took approximately four hours to collect the required information. The third breeder was surveyed using a mail out questionnaire and with follow up phone calls he was able to supply the appropriate information.

Further the breeders surveyed recognised the value of the exercise and had no difficulty in interpreting the results produced by this first test.

Once breeders have faith in their customised index they may not need the individual EBVs for each trait or measurement. However we hold the view that the breeders own the information and are entitled to any estimates made using their data. The decision to suppress some or all of the information should be made by the breeder.

CONCLUSION

Beef breeders in Australia need a selection index which considers all traits of importance to beef production, weighted according to their relative economic values. This need is greater now that genetic evaluation procedures are becoming more sophisticated and more traits are being evaluated.

The diversity of production systems and market outlets dictate that economic values need to be customised for individual enterprises. Customised economic values will result in a selection index that is tailored to give maximum progress for individual breeders and allow the breeder to maintain control of his breeding programme.

When establishing their breeding objective bull breeders need to be aware of the aspirations of their bull buying customers. Buyers of bulls need genetic material to produce beef in their production environments. The bull breeder is really a marketer of genes so the breeding objective of his customers should have a major influence on his breeding programme.

References

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Table 3: Information print-out from the first model.

FEASIBLE FEED OPTIONS SELECTED WERE :

FEED OPTION 1 SELL MORE WEANERS AND LESS YEARLINGS
FEED OPTION 2 REDUCE TOTAL HERD SIZE
FEED OPTION 3 BUY EXTRA FEED FOR PINCH PERIOD
FEED OPTION 4 AGISTMENT - GRAZE OUT OVER PINCH PD

ECONOMIC VALUES

OPTION	SELL WEANERS	REDUCE COWS	BUY FEED	GRAZE OUT	SURPLUS CAPACITY	
	1	2	3	4	5	
Reprod.	1.077	1.302	1.265	1.610	1.685	BEST OPTION= 4 V*= 1.610
Sale weight	.264	.314	.305	.384	.401	BEST OPTION= 4 V*= .384
Mature wt.	-.112	-.186	-.062	.031	.057	BEST OPTION= 4 V*= .031

WEIGHTINGS FOR EBVs

BIRTH WEIGHT	.0236	
200-DAY DIRECT	.0293	
200-DAY MATERNAL	-.0075	N.B 200 day maternal has not received proper consideration as no economic value for the maternal component of sale weight has been calculated
YEARLING WEIGHT	.3916	
FINAL WEIGHT	.0203	

EBVs and index Values for Five Bulls

ID NUMBER	BIRTH WEIGHT	200 DAY MILK	GROWTH	WEIGHT	YRLG WEIGHT	FINAL MAT.VAL	200 DAY INDEX	B. WT.
86 21	-0.1	2	6	31	30		8.38598	
77 23	1.5	9	6	24	26	6	5.9464	
86 31		2	4	20	19		5.3985	
80 28	-1.3	4	6	21	21	3	5.39824	
82 21	-0.8		5	20	20		5.33414	