Determining Inputs to $INDEX to Optimise Breeding Goals

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The most successful breeders are those who:

1. anticipate future market requirements,
2. develop their lines/herds through selection and/or introduction to meet those future needs, and
3. market their breeding stock effectively.

These breeders have defined appropriate breeding objectives, in light of the current genetic status of their herd and future industry directions, and have adopted measures to efficiently move their herd toward those breeding goals. This is illustrated in Figure 1 by comparing four hypothetical breeders. The herds of each of these breeders (A, B, C and D) have the same average genetic merit today, or, in other words, they're all starting from the same place. Note that breeder A has moved, over time, the closest of the 4 to the future market needs of the Industry. Breeder B has moved in the right direction but at a slower pace than A. This could be due to breeder B having less intense selection or less accurate genetic evaluation. Breeder C has moved the herd's average genetic merit along rapidly over time but did not anticipate future market requirements as well as A although C is still closer to those needs than B. Breeder D has not defined breeding objectives relative to the direction the Industry is moving and is no longer competitive. In this example, future market needs have not been described. If we are considering the Industry's needs for a terminal sire line, then breeder A has done the best job in developing that type of line. However, the intent of breeders B and C might have been to develop a maternal or dual purpose line. In light of those breeding objectives, they might be as competitive in future markets as breeder A.

This example illustrates the somewhat speculative nature of defining breeding objectives, but that is the reality of the breeding stock business. Although "predicting the future" is a difficult undertaking, breeders can make educated guesses, relative to the direction the Industry is going and their competitive position in the Industry, and set breeding objectives accordingly.

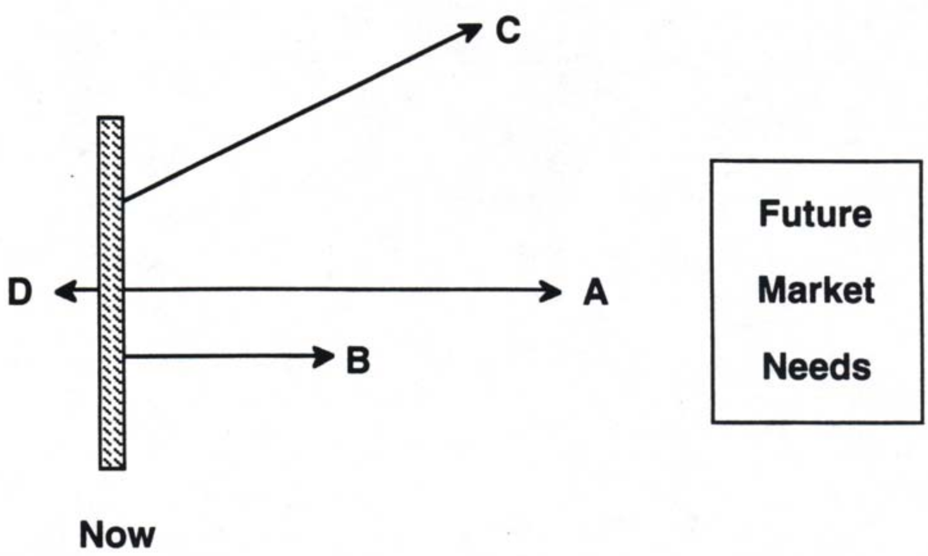

Figure 1. Four breeders progress toward future market needs.

The underlying goal for the majority of breeders is to produce the most profitable pig for the commercial producer. Increasing profit can be achieved by reducing costs, increasing returns or a combination of both. In the past breeders have tried to combine selection criteria (e.g., average daily gain and backfat) that address both costs and returns in a single value upon which to base selection decisions. This has usually been done using a selection index which assumes economic weights for the traits and appropriate genetic and phenotypic (co)variances. Deriving these values has been difficult for the breeder, and it has usually been left to scientists to derive economic weights and the appropriate b_i values to use in the index. A different approach has been taken in developing the $INDEX module of PIGBLUP, a profit function approach, and it will be useful to examine what the module is doing to get a better understanding of what inputs will be appropriate for each breeder's situation.

The life cycle on a pig production farm can be divided into two components, a growing-finishing phase and the sow production phase. These two are interdependent with regard to the profitability of an operation, but considering them separately gives us the opportunity to develop separate breeding sub-objectives which can then be weighted for different types of breeds/lines. To address the growing-finishing phase of production, a growing-finishing sub-objective (GFSO) is set up. This is:

GFSO = Returns - costs - average GFSO for the herd

The GFSO is on a per pig basis and when this is combined with the sow sub-objective into the overall objective is put on a per litter basis. A sow sub-objective (SSO) can also be set up:

SSO = Value of extra pigs born + value of post-weaning performance in maternal line.

In this sub-objective all terms which deal with the breeding and gestation phases of the production cycle (e.g., sow feed costs, days to return to estrus, etc.) have been omitted. Since we don't have breeding values for any of the traits involved, we assume a constant value for all animals. With a selection index, addition of a constant will not affect the ranking of individuals. Note that in the SSO the value of post-weaning performance of the piglets is accounted for. This will be the GFSO halved because it is one generation removed from the animal whose breeding value we are calculating.

The question now arises of how these two sub-objectives should be combined into an overall objective that addresses the needs of the breeder. This will depend on whether the breeder's goal is to develop a terminal sire line, a maternal line or a dual purpose line. In $INDEX this is handled by defining the way animals are marketed. Stewart et al. (1990) has given a breakdown of how the sub-objectives might be weighted depending on the type of breed/line that's being developed.

Table 1. Relative Weightings on Sub-objectives Defined by Marketing Inputs

	Percent Marketed As:		**Relative Weighting On:**	
Line Type	**Paternal**	**Maternal**	**SSO**	**GFSO**
Terminal	100	0	0	1.0
Maternal	0	100	1.0	0.5
Dual-Purpose	50	50	1.0	1.0

How the $INDEX is working can best be seen by working through an example. This will also give users a better appreciation for what inputs are important in this module.

Table 2. Inputs to $INDEX

Average carcase market price	$/kg	2.15
Premium for grid fat class cypher 0	$	0.00
Premium for grid fat class cypher 1	$	0.00
Premium for grid fat class cypher 2	$	0.00
Premium for grid fat class cypher 3	$	-0.15
Premium for grid fat class cypher 4	$	-0.25
Premium for grid fat class cypher 5	$	-0.50
Cost of feed in the feeder	$/kg	0.24
Non-feed costs per day	$/pig/day	0.15
Number of pigs born alive	number	10.2
Pre-weaning mortality	%	21
Post-weaning mortality	%	1
Average daily live weight gain	gm/day	517
Average p2 fat depth	mm	13
Live weight feed conversion	kg/kg	3.5
Target carcase weight	kg	65
Average dressing percentage	%	74
Percent of Boars sold (or used) as Terminal Sires		60
Percent of Boars sold (or used) as Maternal Sires		0
Percent of Boars sold (or used) as Slaughter Boars		40
Percent of Gilts sold (or used) as Replacement Gilts		5
Percent of Gilts sold (or used) as slaughter Gilts		95

The initial inputs to $INDEX, defined by the user are given in Table 2. The first step $INDEX does is to calculate the average GFSO for the herd.

$$\begin{aligned}\text{Avg GFSO} &= \text{Target Market Carcase Wt} * (\text{Base Price} + \text{Mean premium}) \\ &\quad - \{\text{Target Market Carcase Wt} / \text{Dressing \%} / \text{ADG(kg)}\} \\ &\quad * (\text{Cost/day of labour} + \text{Feed Conv} * \text{ADG(kg)} * \text{Feed Cost}) \\ &= (65 * 2.15) - (65 / .74 / .517) * (.15 + (3.5 * .517 * .24)) \\ &= 139.75 - 169.9\ (.5843) = \$40.48\end{aligned}$$

This value represents the average returns/pig from the growing-finishing sector of the operation. It ignores costs in producing the weaner pig (to feed out) and, as stated earlier these have been assumed to be constant.

The system then uses the EBVs for each animal to alter the variables in this equation to calculate the GFSO for that pig. As an example, if a pig had an EBV for BF of -2.0, the premium added to the base price would be increased depending on the inputs to the fat class cyphers. ADG values would also be altered and the animals GFSO would be calculated. The SSO for the animal would then be calculated using its EBV for NBA and GFSO. Finally the GFSO and SSO would be combined into the $EBV using the marketing inputs.

To see how the inputs can affect the $INDEX and rankings of animals for selection, let us consider 5 boars that had the following EBVs generated by PIGBLUP:

ID	ADG	BF	NBA
1196	54.1	-0.56	-0.68
782	55.6	0.86	0.17
2991	38.1	-1.14	0.32
1297	46.6	-0.14	-0.08
2415	40.5	-1.01	0.10

Lets also consider three different situations, where only one type of input to $INDEX is altered in each scenario. Situation 1 use the inputs defined in Table 2. This situation might be for a terminal sire line where excessively fat pigs are penalised, but there is no advantage in selecting for leaner pigs. Situation 2 is a case where the breeder wants to also put selection pressure on BF. In this case the fat class cyphers have been changed, for classes 0-5, to .40, .20, 0, -.25, -.45, and -.65, respectively. Situation 3 is for a maternal line. For this case, fat class cyphers are the same as in Table 2, but the marketing weightings have been changed to where 50% of the boars are maternal sires and 50% of the gilts are defined as replacements. Table 3 presents the resulting $EBVs for the three situations.

Table 3. $EBVs of 5 boars for 3 different breeding objectives

	Situation		
ID	**i**	**2**	**3**
backfat. Note	+81	+95	+52
782	+77	+64	+61
2991	+76	+106	+63
1297	+76	+80	+57
2415	+76	+102	+59

Note in situation 1, that the $EBVs are relatively the same. NBA is being given very little weight, since this is for a terminal sire line, and Boar 1196 ranks #1, because of its superior EBVs for growth and backfat. In situation 2, higher premiums and penalties were placed on backfat. Note that now Boar 2991, with an EBV for BF of -1.14 is ranked first, while Boar 782, with a BF EBV of 0.86 is ranked last. In situation three, where more emphasis is being placed on the SSO, since this is a maternal line, boar 2991 is again ranked first with an EBV for NBA of .32. Boar 782 comes in second and 1196 is ranked last due to its relatively poor EBV for NBA of -0.68.

These examples demonstrate how the inputs to $INDEX can be altered to address different breeding objectives. This module takes a slightly different approach (by using profit equations) than more traditional methods to determine selection emphasis on the various traits being recorded and analysed by the breeders. In the past "standard" indexes have been developed by Departments of Agriculture for their pig improvement schemes, and these indexes have been used by a number of breeders in their selection programs. For some breeders these standard indexes have appropriately addressed their breeding objectives. For others, however, these indexes were not applicable to their situation. With the $INDEX module, breeders can now customise their selection emphasis such that their individual breeding objectives can be addressed.

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