PigEV – a new tool to derive economic values for pigs

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Greater flexibility to setup breeding objectives in pigs

The breeding objective defines the selection emphasis placed on individual traits based on the economic importance of each trait. In PIGBLUP, the $Index defines the breeding objective based on the profit function developed by Stewart *et al*. (1990). The profit function was based on two main equations quantifying a sow herd sub-objective (SHSO) and a growing-finishing sub-objective (GFSO). Information required in the PIGBLUP $Index module included economic inputs outlining payment details and cost structures, performance levels in key characteristics of pig production and marketing weighting as outlined by Long (1991) during an earlier AGBU Pig Genetics Workshop.

The number of traits considered in genetic evaluations has increased over time and the bio-economic model developed by de Vries (1989) was used by Cameron and Crump (1999) to derive economic weights for the main performance traits based on production and market parameters relevant for Australian conditions at the time. However, breeders require greater flexibility in the setup of company-specific breeding objectives for a wider range of traits. This need has now been met by the development of PigEV which is a tool that allows users to define breeding objectives in pigs using their own input parameters in regard to cost structures, performance and marketing information.

PigEV - concept

Bio-economic models are a common tool to derive economic values. However, often a large amount of time is invested in detailed definition of biological interactions and their associations with input and output prices, with minimal influence on the final breeding objective (Amer, 2006). Therefore, separate models for individual trait groups relevant for the growing pig and the sow were developed that capture only relevant biological interactions and their economic implications. Specific equations for individual traits can be readily modified if further refinements seem warranted.

PigEV is a spreadsheet with a number of worksheets, which capture all of the assumptions and calculations required to derive economic values for traits of the growing pig and the sow. PigEV generates a summary table of economic values as well as multiple formatted tables of intermediate calculations and assumptions. These can be readily pasted from the spreadsheet into reports and other documents as required. Inputs are divided into those that are required to customise the breeding objective to a particular situation or operation, versus those that either have minimal impact, or alternatively act as biological constants which are not expected to change over time, or across farms.

Economic values quantify the change in profit for a trait while keeping other traits in the breeding objective constant. PigEV includes sub-models for each trait of the growing pig and the sow that quantify profit both before and after changing each trait by one unit. Input parameters include production and price assumptions for growing pigs, sows, replacements and piglets as well as operational costs including costs of facilities, depreciation and discount rates. The general assumptions relevant for each trait of the growing pig and the sow are outlined below.

PigEV- traits of the growing pig

The main traits of the growing pig affecting profitability are feed conversion ratio or feed intake, growth rate, survival rate and carcase characteristics that affect the market value of pig carcases. The traits of the growing pig described below are direct traits of all growing pigs including those destined for slaughter and replacement gilts.

1. Accounting for feed costs of the growing pig

Feed costs until age at slaughter can be accounted for by considering feed conversion ratio (FCR) or feed intake (FI) in the breeding objective. The economic values for these traits assume that average daily gain, or age at slaughter, are part of the breeding objective when evaluating the economic value of FCR or FI. It is further assumed that feed eaten from birth to slaughter is measured in kg. The price of feed eaten by growing pigs must have units which correspond to the measure in the FCR or FI trait definition (e.g. kg dry feed or kg wet feed). This should be a weighted average price for feed over the entire life of the pig. Slaughter age is assumed to be the range across which FCR and FI apply.

The estimated breeding value is available for FCR or FI in the test period (FCR_T, FI_T). Therefore, FCR_T or FI_T need to be adjusted for the fact that they have a genetic relationship with FCR or FI through the lifetime of the pig. Adjustments are made using genetic regressions, based on the assumption that no trait other than FCR_T or FI_T has a predictive genetic correlation with FCR or FI other than indirectly via their correlations with FCR_T or FI_T. Note that this conceptual approach could be used to help determine the optimal time during the growth phase to test pigs for FCR or FI.

The economic value for FCR is derived from the changes in feed costs over the lifetime of a growing pig per unit change in FCR, which correspond to the price of feed eaten and live weight of the growing pig at slaughter.

The economic value for FI is based on the number of days until slaughter and price of feed eaten.

2. Computing of daily non-feed costs per pig from weaning to slaughter

Daily non-feed costs are used in economic values for average daily gain, weaning weight and post-weaning survival of growing pigs. It is assumed that all finishing costs excluding feed costs and grower pig price, plus a normal profit margin on finished pigs are all proportional to number of days from weaning to slaughter. Non-feed costs per day in the growing period from weaning to slaughter were derived from the revenue of the pig at slaughter minus marketing and feed costs, and the price of the weaner pig divided by the number of days of the growing period.

3. Economic value for average daily gain

Average daily gain is defined as lifetime average daily gain quantified in grams per day. The improvement in lifetime growth rate is used to translate extra weight for age into savings in days at the end of the finishing period. It is assumed that change in profit is linear for an improvement in growth rate during the finishing period.

The economic value for average daily gain differs depending on whether FCR or FI is part of the breeding objective. The economic value for FCR captures the reduction in feed costs due to higher average daily gain. This reduction in feed costs due to higher growth rate is not implicitly captured in the economic value for FI.

The breeding objective includes FCR. The economic value for average daily gain when FCR is part of the breeding objective is defined as the reduction in non-feed costs per pig due to savings in days until slaughter with higher growth rate.

The breeding objective includes FI. In comparison, the economic value for lifetime growth rate when FI is part of the breeding objective is higher because it accounts for both, the dilution of non-feed and reduction in feed costs with faster average daily gain.

4. Economic value for carcase fat depth

The economic value for carcase fat depth reflects the increase in returns per pig due to a lower proportion of pigs receiving a price penalty due to high fat depths. Conceptually it is possible to have a positive economic value for fat depth if a proportion of pigs receive a price penalty due to an extremely low fat depth. The proportion of pigs receiving a price penalty was computed as a function of the population mean and standard deviation of pigs. Therefore, changes in the mean as well as changes in the variability affect returns per pig (Hermesch, 2005).

PigEV – traits describing survival of pigs and sows

Survival of piglets, growing pig and sows are not only an important aspect of animal welfare but also affect profitability of pig enterprises. The traits considered include still born piglets, pre-weaning survival of piglets, post-weaning survival of growing pigs and sow longevity.

1. Economic value of farrowing survival

Farrowing survival is a trait of the sow expressed once per parity and defined as the proportion of live born piglets divided by the total number of piglets. The economic value of farrowing survival accounts for the opportunity cost of not having the piglet which is equal to the gestation cost of the sow associated with the stillborn piglet. In addition, the benefits of lower disposal costs of dead piglets are accounted for.

The value of the piglet itself cannot be counted because a sow with 14 piglets born alive and two piglets born dead would rank lower than a sow with 13 born alive and one piglet born dead. Both sows have 12 piglets born alive, and the value of a piglet itself is accounted for by the number of piglets born alive. The only extra costs associated with the extra dead piglet relate to feed requirements in gestation. Further, it is assumed that the lower pre-weaning survival and lighter weaning weight in the surviving piglets of the larger litter with two dead piglets are considered by including pre-weaning survival and average piglet weaning weight in the breeding objective.

2. Economic value of pre-weaning survival

The trait is defined as pre-weaning survival of piglets per piglet born, rather than the total count of piglets surviving until weaning from the litter. The proportion of surviving piglets until weaning is defined as a trait of the sow expressed once per parity. The economic value is derived from the value of an extra whole piglet surviving until weaning taking into account the cost savings due to the need to dispose of dead piglets. Most piglets die within the first few days after farrowing and average lactation feed costs for the additional surviving piglet can be ignored.

3. Economic value of post-weaning survival

Survival of the growing pig after weaning is defined as a binary trait of all growing pigs with values scored as 0 for pigs that died between weaning and slaughter and 1 for pigs that survived until slaughter. Piglets that died prior to weaning have a missing value. Two approaches were considered to derive economic values for post-weaning survival.

The cost saving approach assumes that a predictable death rate in the finishing system is anticipated and extra finisher pigs are purchased to make up for deaths. Thus, extra survival of growing pigs results in a savings in costs to purchase extra pigs. The economic value is based on the costs of the weaner pig, cumulative feed costs and non-feed costs from weaning until the average age of mortality and costs to dispose of a pig that dies post weaning.

The lost revenue approach assumes that a pig dying after weaning during the growing period results in lost revenue. Otherwise, the principle to derive economic values is the same as for the cost saving approach. The economic value is derived from the value of a pig at slaughter subtracting cumulative feed and non-feed costs from weaning until the average age of mortality and costs of disposing dead pigs.

4. Sow longevity

The economic value of longevity was defined as the marginal economic benefit of a sow achieving an extra parity during her lifetime. The trait is expressed on a per-sow lifetime basis, rather than a per parity basis. The economic value for a one-parity increase in sow longevity was estimated from the change in average profit per parity for a unit change in parities per sow when inter-parity survival of sows increased one percentage point. The calculation included a multiplication with the average number of parities per sow which ensures that the trait is expressed on a per sow lifetime basis.

The change in average profit per parity resulting from superior sow longevity is based on the cost of replacement gilts offset partly by average salvage returns from slaughter of cull sows and increased net returns per sow that arise through having an older sow herd on average (i.e. less lower performing young sows which wean less piglets in a herd with better survival).

PigEV – traits of the sow

The main traits of the sow profitability are the maternal genetic effect for average daily gain, number of piglets born alive, age at puberty and sow mature weight. All traits of the sow are expressed once per parity unless otherwise stated.

1. Economic value for the genes of the sow affecting lifetime average daily gain of progeny

The genes of sows affect the growth performance of their progeny and as such estimates of these genetic effects represent a trait of the sow. Two approaches were considered to derive economic values for traits quantifying the genetic effects of the sow on average daily gain of the growing pigs.

The maternal genetic effect of growth rate has the same economic value as growth rate when FCR is part of the breeding objective multiplied by the number of slaughter pigs per litter. There is no need to account for dilution of feed costs through faster growth rate, as neither FCR, nor FI have significant maternal genetic effects.

Weaning weight as a trait of the sow should only be fitted if maternal genetic effects for growth rate are not included in the breeding objective. The economic value is based on the change in growth rate resulting from a change in weaning weight of the sow multiplied by the economic value for growth rate, litter size at birth and survival until weaning and during the post-weaning growth period.

However, the change in growth rate of the progeny resulting from a change in weaning weight of sows is difficult to define, because it effectively represents the environmental relationship between heavier weight at weaning due to maternal ability and the subsequent performance of progeny. Therefore, a phenotypic regression coefficient that incorporates the direct genetic relationship between weaning weight and average daily gain would be inappropriate, because maternal sow effects are operating differently, effectively as an environmental shift. Further thinking is required on how to define the regression coefficient to obtain the economic value for weaning weight of the sow and a custom data analysis may be required.

2. Economic value for number of piglets born alive

For a sow operation the economic value for number of piglets born alive was derived using two different assumptions about the long-term constraint on the size of the farming operation. Firstly, the constraint of a fixed number of piglets generated from the sow operation was assumed and secondly, a fixed number of sows were assumed. Both traits were defined as being expressed once per parity.

Fixed number of piglets. The economic value for an increase of one extra piglet born alive assuming a fixed number of piglets was calculated using the ratio of total costs per sow per year divided by the number of piglets born alive per year. The costs per sow per year included annual operating costs, annual capital costs, average parity feed costs and costs to purchase a replacement breeding gilt. It was assumed that no adjustment for litter size would be made when estimating breeding values for pre-weaning survival. Therefore there was no need to account for the fact that there will be higher pre-weaning mortality with larger litters in this economic value.

Fixed number of sows in the long term. The economic value is based on the assumption that extra piglets are generated for sale as weaners with larger litter size. Further, a slight allowance was made for higher lactation feed requirements for sows.

3. Economic value for age at puberty

The economic value for age at puberty measured in days is based on a one-day increase in feed costs for maintenance and non-feed costs per day for replacement gilts. Age at puberty is a trait of the replacement gilt.

4. Economic value for sow mature weight

The economic value of a one-kilogram increase in sow mature weight was based on four sub traits including extra capital required to accommodate the larger breeding sows, the cull value of the sow, sow maintenance feed costs per parity and the feed costs to rear heavier replacement gilts at age of first conception.

Capital investment for housing heavier sows. The economic value for the extra capital required to accommodate larger breeding sows was expressed per parity. Over the long term it was assumed that the capital requirements for sows were proportional to sow mature weight to the power of an exponent that takes a value between 0 and 1. Annualised capital costs for sows are computed assuming a full capital value of the sow facility, an inflation-free annual interest rate and an annual depreciation rate.

Cull value of sows. The economic benefit from heavier sows results from a higher cull value at slaughter expressed by sows once at slaughter. The proportion of sows that die on farm or are condemned at slaughter needs to be taken into account. The revenue obtained for the proportion of sows sent to slaughter is derived from the weight of sows at slaughter, dressing percentage and price per kg weight of cull sows.

Feed maintenance costs per parity. The economic cost of a one-kilogram increase in sow mature weight due to higher feed costs for maintaining larger sows was derived per parity and was based on the increase in energy requirements across all parities in the herd multiplied by the cost of feed energy utilised by sows.

Feed costs to rear larger replacement gilts. The economic value for additional feed costs to rear replacement gilts for a one-kilogram increase in mature weight was a trait for the replacement gilt. The cost of additional feed was calculated up until age at first conception of replacement gilts. The equation for this economic value included the change in cumulative feed requirements for gilts from weaning until first conception with a change in sow mature weight and the price per kilogram of feed.

Discounted expressions

The model accounts for difference in timing and frequency of types of traits. For example, the genes of a sire line boar mated to maternal sows are expressed early in the progeny for traits expressed in the growing pig. In comparison the genes of a maternal line boar are expressed later as only a proportion of his daughters become replacements, which go on to express genes for a number of maternal traits during their lifetime encompassing multiple parities. Finally genes affecting sow longevity are expressed with a substantial delay once daughters had the chance to express differences in sow longevity.

Uses of PigEV

The tool provides greater flexibility for pig breeders to setup specific breeding objectives for pig breeding programs. The number of traits has been extended to include multiple traits describing survival of pigs during the growing period as well as sow longevity. Further, methodology has been outlined to consider the effects of the genes of the sows on growth rate of their progeny. The approach is based on developing sub-models for individual traits, which is beneficial for the modification and extension of models should it be required in the future. Research into new traits used in pig breeding is continuing and further extensions of breeding objectives are likely.

The tool can also be used to evaluate the economic outcomes of implementing other, non-genetic products. The economic benefits of a superior husbandry practice may be evaluated by multiplying the improvement in each trait with its economic value. The sum of these products will have to be compared with the additional cost of the new technology to quantify the overall change in profitability resulting from adopting an alternative husbandry practice.

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