The Economic Impact of Genetic Improvement

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Introduction

If the pork industry in the United States is to prosper, it is imperative that production efficiency of lean, quality, consumer-oriented pork products improve. The pork industry is one of several industries competing for a share of consumer market demand. Consumers, both domestic and international, have the option of purchasing numerous pork substitutes.

Due to rapid improvements in production efficiency, the retail prices of broilers and turkeys have risen less than pork prices. As a result, pork, the medium priced meat, lost sales to poultry in the more price sensitive markets and is competing with beef in less price sensitive markets.

As the pork industry matures, the most efficient producers continue to expand. The expansion of the more efficient producers causes profit margins to decrease. Thus, it is increasingly important that each pork producer carefully consider genetic options. Only progressive pork producers utilizing seedstock with superior genetic potential arising from strategic selection practices remain competitive.

Pork producers must exploit the power of genetic improvement programs in order to improve their production efficiency. While most commercial producers are aware of the dollar returns associated with investments in improved management, the majority fail to realize the substantial economic impact of genetic improvement.

Selection based upon performance data can be highly profitable for pork producers. Using proven selection techniques, it is possible to genetically improve economically important traits at the rate of about 2 to 3% per year. Improved efficiency of pork production results not only from genetic progress, but from advances in all areas of swine production: genetics, nutrition, physiology, management, and health. Longterm improvement of a commercial producer's swine herd, however, is dependent upon implementation of sound genetic improvement programs in seedstock herds. The 1936 Yearbook of Agriculture included a section addressing breeding problems in the swine industry. To quote, "There has been a growing realization among breeders and others that something more than records of ancestry, litter size, and show-ring winnings is required as a basis for truly effective selection of breeding animals." The same might be said to apply today.

Using Genetics to Improve Efficiency

Achieve genetic improvement of production efficiency by deciding which animals to mate (selection) and how to mate them (mating systems). Commercial swine production is based upon crossbreeding, the mating of animals from different breeds, due to the benefits of heterosis (hybrid vigor) and breed complementarily. Breed complementarily means using breeds in a crossbreeding program in such a way as to combine their strengths, e.g., using a breed with good lean tissue growth rate and feed efficiency to sire market hogs and breeds with superior reproductive performance as dams of market hogs. Heterosis, the difference in performance between crossbreds and the average of the parental breeds, is relatively large for traits associated with reproduction, moderate for growth rate, and low for feed efficiency and carcass traits. The mating of a E1 female to a sire of different breeding, for example, is expected to improve litter size about 8%, 21-day litter weight per female exposed about 28%, and days to 250lb. about 7%, relative to the pure-bred average. However, feed efficiency and carcass traits differ little from the pure-bred average.

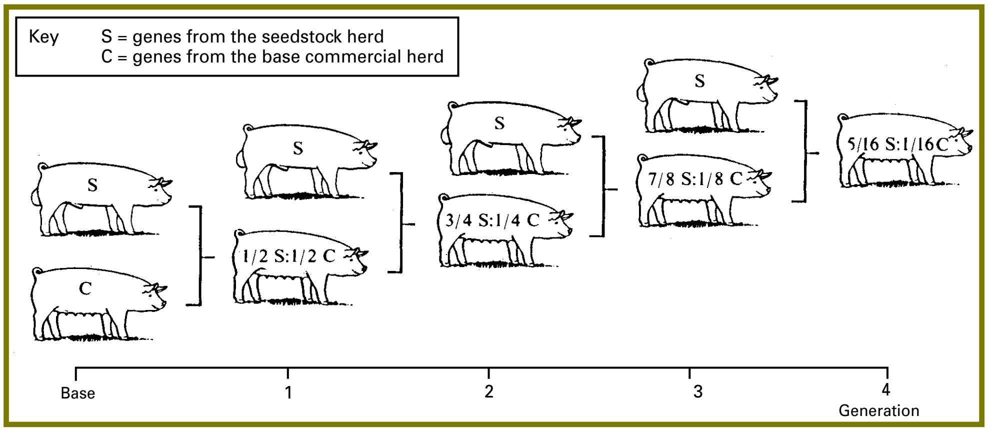

Figure 1. Dependence of the commercial herd upon the seedstock herd supplying boars.

Selection is the process of choosing the individuals from within the herd, or from other herds, that will be used for breeding. The objective of selection is to improve the herd genetically by increasing the frequency of desirable genes and decreasing the frequency of undesirable genes. The potential for genetic improvement by selection is in the hands of seedstock producers. Commercial producers who obtain all their breeding stock from seedstock suppliers can genetically improve their herds consistently over time only when these suppliers are practicing a sound, consistent on-farm performance-testing and selection program. If the commercial producer is retaining his or her own replacement females, the impact of selection on these females is insignificant compared to the effect of long-term selection in the seedstock herd or herds supplying boars. Figure 1 illustrates the dependence of the commercial herd upon the genetic level of the seedstock herds(s) supplying boars. After four generations, only 6.25% of the genetics of replacement gilts trace back to the original base herd, and this contribution is halved every generation. Thus, even where the commercial producer retains his or her own gilts, the herd is dominated by genes from the seedstock source(s).

The combined effects of crossbreeding and selection on performance are illustrated in Figure 2.

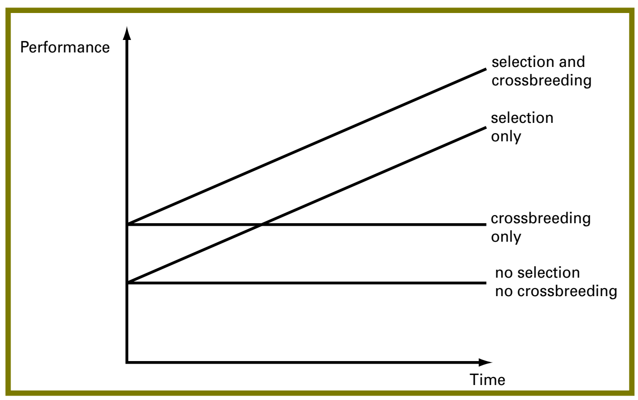

Figure 2. Combined effects of crossbreeding and selection on performance.

Sound Selection in Seedstock Populations

Improvement in commercial herds depend upon sound selection in seedstock populations to achieve longterm genetic progress for economically important traits. Performance data must be collected, and superior animals must be selected to reproduce within seedstock herds. The relative effects of selection of replacement gilts within the commercial herd on the commercial herd's genetic merit for litter size weaned (for example) are illustrated in Tables 1 and 2. Table 1, shows that boars purchased each generation from a seedstock herd make no genetic progress in litter size weaned. Replacement gilts are selected from the best third of the commercial two-breed rotation sow herd, based on the average of two litters. The genetic superiority of these replacement gilts is predicted to be around .25 pigs per litter. It can be seen that the breed mean in the commercial herd increases by this amount before plateauing after about six generations.

Thus, after six generations, no further improvement is possible because the unimproved boars introduced each generation constantly cancel out gains made by gilt selection. In addition, unlike genetic progress made in the seedstock herd, gains from selecting replacement gilts in the crossbred herd are not cumulative. If the commercial Figure 1. Dependence of the commercial herd upon the seedstock herd supplying boars. Figure 2. Combined effects of crossbreeding and selection on performance. 3 gilt selection is discontinued at any time, the genetic merit of the commercial herd declines to the unimproved level of the seedstock herd.

In contrast, consider the situation where the commercial producer is purchasing boars from a seedstock herd that is achieving genetic progress of .15 pigs weaned per litter each generation. The commercial unit, again operating a strict two-breed rotation, selects replacement gilts completely at random with respect to litter size weaned. The predicted results from this situation are shown in Table 2.

Generation	Genetic mean in herd supplying boars	Commercial Herd			
		Genetic superiority of replacement gilts	Breed mean	Heterosis	Herd generic mean
0	8.0	.25	8.00	8.00	8.64
1	8.0	.25	8.13	8.00	8.78
2	8.0	.25	8.19	8.00	8.84
3	8.0	.25	8.22	8.00	8.87
4	8.0	.25	8.23	8.00	8.89
5	8.0	.25	8.24	8.00	8.90
6	8.0	.25	8.25	8.00	8.91
7	8.0	.25	8.25	8.00	8.91

Table 1. Predicted results from selecting for litter size weaned in the commercial herd only.

Generation	Genetic mean in herd supplying boars	Commercial Herd			
		Genetic superiority of replacement gilts	Breed mean	Heterosis	Herd generic mean
0	8.00	0	8.00	8.00	8.64
1	8.15	0	8.00	8.00	8.64
2	8.30	0	8.08	8.00	8.72
3	8.45	0	8.19	8.00	8.77
4	8.60	0	8.32	8.00	8.99
5	8.75	0	8.46	8.00	8.14
6	8.90	0	8.60	8.00	8.29
7	9.05	0	8.75	8.00	8.45

Table 2. Predicted results for a commercial herd purchasing boars from a seedstock source with an effective selection program for litter size weaned.

Unlike gains made by selection of replacement gilts in the commercial herd, improved performance achieved by using genetically superior boars is cumulative. Table 2 shows that, after an initial delay, the genetic mean of the commercial herd is increased at the same rate as that of the seedstock herd, but lagging two generations behind.

Genetic improvement programs require both an understanding of, and a dedication to, performance testing and selection if they are to realize genetic progress. For such programs to be successful, they must include the following four features:

- complete, accurate performance records
- assessment of genetic merit for economically important traits (i.e., reproductive performance, growth
- rate, feed efficiency, and carcass merit), based on the individual hog's performance and that of its relatives.
- indexes weighting traits relative to their economic importance in alternative commercial crossbreeding
- systems (i.e., general-purpose, maternal and terminal-sire indexes); and
- consistent selection of the top indexing individuals to produce future generations.

These topics are covered in greater detail in subsequent fact sheets in this series. For seedstock herds to make consistent genetic progress, they must use a high percentage of superior performance tested boars, either from their own herds or from other herds with sound performance testing and selection programs. As a herd implements sound genetic programs and increases in genetic merit, there is a probability that untested boars or boars from unimproved herds l reduce the herd's genetic merit increases. A commercial producer cannot expect the genetic merit of either the seedstock producer's or his/her own animals to consistently improve unless the seedstock producer uses superior performance tested males and females exclusively in their herds. Commercial producers should therefore purchase seedstock from producers who use superior performance tested males and females exclusively in their herds.

Year	Seedstock herd levels[a] value at the start and end of each year	Average level	Commercial herd level[b]	Dollar value
0	0	0	0	0
1	.00-1.32	.66	.00	0
2	1.32-2.64	1.98	.33	33,000
3	2.64-3.96	3.30	1.16	116,000
4	3.96-5.28	4.62	2.23	223,000
5	5.28-6.60	5.94	3.42	342,000
6	6.60-7.92	7.26	4.68	468,000
7	7.92-9.24	8.58	5.97	597,000
8	9.24-10.56	9.90	7.29	728,000
9	10.56-11.88	11.22	8.59	859,000
10	11.88-13.20	12.54	9.90	990,000
cumulated subtotal for years 0 - 10 $4,356,000				
11	13.20-14.00	13.60	11.22	1,122,000
12	14.00-14.80	14.40	12.41	1,241,000
13	14.80-15.80	15.20	13.41	1,341,000
14	15.80-16.40	16.00	14.30	1,430,000
15	16.40-17.20	16.80	15.15	1,515,000
cumulated subtotal for years 0 - 15 $11,005,000				

Table 3. Profit potential for commercial producers when selection occurs within seedstock herds. [a]The seedstock herd improves at an annual rate of $1.32 from years 1-10 and $.80 from years 11-15. These values are approximately 70% of that expected if selection was based totally on the index. [b]The commercial herd profit difference per hog is equal to the average genetic level of the boars purchased and home-raised replacement gilts from the previous year. [c]Value of the seedstock producer's genetic selection program in improving the profit potential of commercial hogs produced by his boar purchasers each year. This value assumes that the seedstock producer sells 200 boars per year with 500 offspring per boar (100,000 total offspring per year).

Impact of Seedstock Selection on Commercial Swine Production

Impact of seedstock selection on commercial swine production genetic progress within seedstock herds is additive, accumulating from one generation to the next when consistent selection criteria are used. It has been estimated that a within-herd genetic evaluation program, selecting the top 5% of boars and 25% of gilts based on a general-purpose selection index, and a short generation interval (boars and sows averaging 12 and 18 months of age, respectively), could result in an annual improvement in profit potential of $1.88 per market hog. This total economic improvement is the sum of individual improvement in a number of sow productivity, growth, and carcass traits affecting profitability, each weighted by its relative economic value.

In practice, however, genetic selection programs do not realize 100% of their genetic potential. Unavoidable death losses, the failure of some animals to meet minimum acceptable standards for soundness, and the need to plan matings to avoid a build-up of inbreeding. All serve to decrease selection response. Conservatively, a seedstock herd should realize 70% of the potential genetic improvement, i.e. S1.32 per hog per annum. While this may not seem to be particularly large, keep in mind that annual improvement accumulates within seedstock herds and is multiplied to many commercial pigs.

Table 3 shows the expected genetic merit of seedstock and commercial herds when selection in the seedstock herd is based on the general-purpose index. The annual rate of genetic progress expected for the first 10 years (6.7 generations) is $1.32 per hog. After 10 years of such selection, the hogs produced are expected to be born in larger, have heavier litters (.8 additional pigs and 7lb. heavier litters at 21 days), and have .12 inch less backfat, require .24lb. less feed per pound of gain, and reach market weight 12 days sooner, than unselected hogs. Assuming the annual rate of genetic progress decreased between years 10 and 15 to $.80 per hog, after 15 years of selection, the pigs produced are expected to be born in litters one pig larger and 9.2lb. heavier at 21 days than unselected litters. They are expected to have .16 inch less backfat, to require .32 lb. less feed per pound of gain, and to reach market weight 15.2 days sooner than unselected hogs.

The improved genetic merit of boars purchased from seedstock herds using a genetic evaluation program improves the profit potential for pork producers. The genetic merit of commercial herds parallel the genetic improvement with seedstock herds (Table 3). Assuming a purebred producer sells 200 boars per year, each having 500 commercial offspring (100,000 total offspring), the cumulative value of the selection program to commercial pork producers is substantial (Table 4). After 10 years, the expected increase in profit to commercial producers is $4.4 million. After 15 years, the increase in value of the commercial hogs is estimated to be about $11.0 million. Because the dollar returns from genetic improvement are so large, it is important that both commercial and seedstock suppliers have a good working knowledge of basic genetic principles and their application. The following articles in this series provide the reader with this knowledge. Guidelines for comprehensive data collection and processing programs are available to the seedstock industry. Pork producers should inquire as to the performance testing and selection program followed by their suppliers of breeding stock. Commercial producers should seek out seedstock producers who are using superior performance tested sires in their herds and purchase superior performing animals from these herds. The commercial producer must, however, be willing to pay a premium for genetically improved seedstock, thus offsetting the costs of performance testing and culling incurred by the breeder. Fortunately, such costs are low in comparison to expected financial returns (Table 4). The return to cost ratios are 70 to 1 after 10 years and over 100 to 1 after 15 years of genetic selection.

Year	Testing cost ($)	Total returns ($)	Return-to-cost ratio
5	31,000	714,000	23.0
10	62,000	4,356,000	70.3
15	93,000	11,005,000	118.3

Table 4. Testing costs and industry returns from implementation of genetic selection programs by seedstock producers. Assuming 2 boars sold per litter, 100 litters (800 pigs) tested per year at a cost of $6 per litter plus $7 per pig. Each boar produces 500 commercial progeny. Annual rate of genetic progress is assumed to he $1.32 per hog for the first 10 years and $.80 per hog thereafter.

Summary and Conclusions

Commercial swine producers will become more efficient, and improve the competitiveness of pork with other protein sources, especially when sound genetic selection programs are implemented within seedstock herds. Consistent genetic progress is possible only when superior performance tested boars are used by seedstock suppliers to produce breeding stock for their commercial customers. Genetic progress within seedstock herds is additive, and has a large impact on the efficiency of commercial production. Selection must take place in seedstock herds in order to genetically improve economically important sow productivity, postweaning performance,and carcass traits. For this reason, it isimportant that commercial producers purchase their breeding stock from suppliers who implement sound genetic improvement programs. Demand from commercial pork producers for seedstock suppliers using comprehensive genetic improvement program are, however, essential to stimulate their use, and to in turn improve the efficiency of pork production.

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