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Economic Analysis of the Selection Response in the NE Index line

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Summary and Implications

The objective was to estimate economic effects of 19 generations of selection for increased litter size in the NE Index line. Using realized biological data, 1,250-sow enterprises based on Index line and Control line females were simulated. Each system was closed to introduction of females and included pureline females mated to produce replacement pureline and F_1 gilts, and F_1 females mated to terminal cross boars to produce market progeny. Costs of production and income statements were produced using the reproductive, growth and carcass data from the NE Index (I) and Control (C) lines reported in the two preceding papers. Gross revenues were estimated using the SiouxPreme Packing Co. grid payment matrix. The production system based on Index sows produced 24,417 pigs per year with net income of $23.76 per pig. The output for the system based on Control sows was 20,166 pigs with net income of $16.73 per pig. Within each mating group, net revenue for pureline I pigs was $2.05 per pig more than for Line C pigs and net revenue for three-way cross pigs with 25% Line I genes was $2.89 per pig more than for terminal cross pigs with 25% Line C genes. However, net revenue for F_1 pigs with 50% Line C genes was $2.50 per pig more than for those with 50% Line I genes. Highly prolific lines such as Line I have a large effect on reducing production costs and increasing income. Crossbreeding is an effective way to utilize the enhanced reproductive efficiency of the Index line.

Background

The NE Index Line (Line I) was developed with selection only for increased litter size. It excels in reproduction. Its commercial value was demonstrated in the National Pork Producers Council Maternal Evaluation Project (MLE) that included GPK347 females, a cross of the Index line with a maternal line of DeKalb Choice Genetics. Return on equity for a system using GPK347 was 21.1% compared with 16.5% for the average of other lines in the MLE. Although this experiment produced economic data that led to increased use of the Index line in commercial production, it did not produce data to calculate the economic return from selection for litter size. To estimate the economic response, total production systems based on either Index or Control sows must be compared.

In this analysis data from the litters and pigs described in the previous papers were used to simulate a 1,250-sow farrow-to-finish enterprise to compare economic returns for breeding systems using either Line I or Line C females. The production system was closed to introduction of females and used artificial insemination to produce F_1 replacement gilts and terminally-sired market pigs.

Materials and Methods

Table 1 contains the number of litters per year along with mean reproductive performance for 1,250-sow units based on Line C and Line I females. In each case, it was assumed that the pure line was propagated within the system and semen from Danbred® USA Landrace or terminal sires was used to produce F_1 gilts and market pigs, respectively. The number of pureline females was set at 50 with 15 boars retained for breeding each generation to maintain rate of inbreeding in the pure line at approximately 1% per generation. The number of matings of I or C sows to produce F_1 gilts was determined by experimental estimates of farrowing rates and litter sizes, and imposed gilt selection rate and sow culling rates described below.

Production Assumptions

Annual sow and boar replacement rates were set at 30% and 33%, respectively. Female replacement rate corresponded with a policy of culling all open females and all females that had eight litters. A confinement production

Table 1. Reproductive statistics and estimated number of I and C sows necessary to maintain a 1,250-breeding sow operation.

Genetic Group[a]	% FR[b]	NBA[c]	DL[d]	Litters[e]	% oF total	Replacements	Market pigs
C	98.2	8.49	0.20	116	4	41	733
L x C	81.5	8.27	0.20	160	5.5	339	524
T(L x C)	86.5	10.37	0.20	2,635	90.5	-	18,909
Total				2,912	100	380	20,166
I	93.5	10.90	0.20	116	4	37	909
L x I	84.3	10.28	0.20	131	4.5	345	564
T(L x I)	88.9	12.11	0.20	2,664	91.5	-	22,944
Total				2,912	100	382	24,417

[a]C = Control, I = Index, L x C = Landrace x Control, L x I = Landrace x Index, T (L x C) = Terminal DH x (Landrace x Control) three-way cross, T (L x I) = Terminal DH x (Landrace x Index) three-way cross.
[b]FR = Farrowing Rate of gilts and sows designated for breeding.
[c]NBA = Number born alive per litter.
[d]DL = Death loss.
[e]Litters = Number of litters per year.

Table 2. Income statement for integrated breeding system based on Control and Index line females.[a]

	Control line			Index line		
	Line C	L x C	T(L x C)	Line I	L x I	T (L x I)
Gross revenue/pig sold, $	102.42	125.12	124.60	105.47	122.62	127.49
Less death loss cost/pig sold, $	1.62	1.62	1.62	1.62	1.62	1.62
Net revenue/pig sold, $	100.80	123.50	122.98	103.85	121.00	125.87
Variable costs/pig sold, $						
Feed costs, $	61.14	45.95	40.87	61.00	45.10	41.31
Labor costs, $	14.12	14.12	14.12	13.10	13.10	13.10
Veterinary, drugs and supplies, $	1.64	1.64	1.64	1.60	1.60	1.60
Utilities, $	2.28	2.28	2.28	2.22	2.22	2.22
Fuel and oil, $	0.41	0.41	0.41	0.40	0.40	0.40
Water costs, $	2.03	2.03	2.03	1.98	1.98	1.98
Building and equipment repairs, $	2.59	2.59	2.59	2.52	2.52	2.52
Transportation costs, $	1.39	1.39	1.39	1.35	1.35	1.35
Semen cost, $	—	17.38	1.58	—	13.10	1.32
Waste management, $	1.54	1.54	1.54	1.50	1.50	1.50
Marketing, $	4.10	4.10	4.10	4.00	4.00	4.00
Interest on variable costs, $	2.93	2.93	2.93	2.85	2.85	2.85
Total variable costs/pig , $	94.17	96.36	75.48	92.52	89.72	74.15
Contribution margin/pig, $	6.63	27.14	47.50	11.33	31.28	51.72
Fixed cost/pig sold, $						
Depreciation on buildings (15 yr), $	8.94	8.94	8.94	8.43	8.43	8.43
Depreciation on major equipment (10 yr), $	0.79	0.79	0.79	0.65	0.65	0.65
Depreciation on minor equipment (5 yr), $	0.20	0.20	0.20	0.16	0.16	0.16
Interest on buildings and major equipment	5.09	5.09	5.09	4.76	4.76	4.76
Insurance and taxes on buildings and major equipment, $	3.03	3.03	3.03	2.80	2.80	2.80
Professional fees, $	1.00	1.00	1.00	1.00	1.00	1.00
Maintenance cost (breeding stock), $	9.91	9.91	9.91	8.18	8.18	8.18
Total fixed costs/pig sold, $	28.96	28.96	28.96	25.98	25.98	25.98
Net return per/sold, $	-22.33	-1.82	18.54	-14.65	5.30	25.74
Number of pigs sold	733	524	18,909	909	564	22,944
Net return on total number of pigs sold, $	-16,367.89	-953.68	350,572.86	-13,313.47	2,991.30	590,663.91
Total net return, $			333,251.29			580,341.74
Rate of return on investment, %			12			18
Cash return/pig sold, $[b]	-12.40	8.11	28.47	-5.41	14.54	34.98

[a]L x C = Danbred® USA Landrace x Control, T (L x X) = Danbred® USA terminal Duroc-Hampshire x (L x C), L x I = Landrace x Index, and T (L x I) = Duroc-Hampshire (L x I).
[b]Cash return/pig sold = net return/pig sold plus all depreciation costs.

system including breeding and gestation facilities, farrowing facilities, nursery, and finishing facilities was modeled. The production system modeled mimicked the one used at the University of Nebraska Experimental Swine Farm in which pigs are weaned at 12 days of age and raised in a nursery until approximately 55 to 60 days when they are transferred to a finishing building. Once market weight was reached (250 lb) value was calculated based on the SiouxPreme Packing Co. payment matrix.

Breeding gilts and pureline boars were selected at approximately 180 days and transferred to the breeding and gestation building. Number of selected females and matings varied with fertility of the lines to produce 56 litters per week.

Income Statements

Costs of production were based on estimates of new construction/equipment costs that were depreciated over 15 years for buildings, 10 years for major equipment, and five years for minor equipment. These costs and those for additional fixed and variable inputs described in Table 2 were charged back to pigs on a per pig marketed basis.

New housing costs were set at $130 per pig space for the nursery, $175 per pig space for finishing, and $1,100 per breeding female space for breeding, gestation and farrowing. Other costs were obtained from a variety of sources including the 1999 Iowa State University Swine Report, the Maternal Line Genetic Evaluation Program Economic Analysis, and a local Nebraska producer.

Gross income was calculated on the SiouxPreme Packing Co. matrix that takes into account weight of the carcass and percentage lean estimated by TOBEC. Average market death loss was assumed to be equal for both Line I and Line C systems. Variable costs were then calculated and subtracted from net income to calculate an economic value known as contribution margin per pig marketed. Contribution margin is defined as net revenue per pig marketed minus variable cost per pig marketed. Fixed costs were calculated and subtracted from the contribution margin to give net return per pig marketed.

Results and Discussion

Net Revenue Per Pig Marketed

Income statements for production systems are in Table 2. Net revenue per

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pig marketed varied by line and cross, ranging from $100.80 per pig for Line I to $125.49 per pig for T (L x I). Pureline I and C pigs were predicted to have carcass value of 93% of the base price on the Sioux Preme matrix, F_1 L x I and L x C were predicted to have value of 102% of the base price, and three-way terminal crosses 103% of the base price. In the system based on Line I, net revenue was greater for three-way cross than for F_1 pigs ($125.87 vs $121.00 per pig). However, in the system based on Line C, net revenue per pig was greatest for F_1 pigs ($123.50) because their carcass weight was greater. Overall, three-way terminal cross Line I pigs had the most net revenue per pig.

Averaged across Line I and C systems, the increase in net revenue from pureline pigs to F_1 pigs was $19.93 per pig. There was a small additional increase of $2.18 from F_1 to three-way cross pigs. The terminal crossing systems that realized 100% heterosis and used the Danbred® USA lines selected for increased growth rate and percentage carcass lean had a large, positive effect on gross revenue per pig.

Variable Costs

Feed costs made up more than 50% of the total variable costs and therefore efficiency of feed use greatly affected variable costs per pig. Three-way cross pigs were the most efficient and reached market weight sooner than F_1 or pureline pigs. Pureline pigs took 31 days longer to reach market weight and had feed/gain ratios 0.59 units higher than three-way crosses. Line I pigs had an advantage of $0.55 per pig over Line C in feed costs.

Labor costs for breeding/gestation/farrowing/nursery were fixed for the size of the production unit and thus total costs for this labor was the same for systems using both Line I and Line C females. Labor costs for finishing pigs were calculated assuming a constant pig/worker ratio. Because more pigs were produced in the Line I system (Table 1), it needed one more employee for finishing, but produced 4,251 more pigs than the Line C system. As a result labor costs per pig were greater in the Line C system ($14.12 per pig) than for the Line I system ($13.10 per pig).

Semen costs differed among crosses and between Line I and C systems. There was no semen cost for pureline I and C production because these pigs were produced with natural service. Breeding costs for boars in pureline production were considered to be part of breeding herd maintenance costs included in fixed costs as described below. The cost of semen for L and T was set at $30 and $6 per dose, respectively, which made semen costs greater for production of F_1 pigs ($13.10 per pig for Line I system vs $17.38 per pig for Line C system) than three-way cross pigs. Semen costs were $1.32 per pig and $1.58 per pig for three-way cross Line I and C pigs, respectively. Semen costs were less for I than C because both farrowing rate and litter size were higher for I than C sows. In addition, waste management costs per pig marketed were less for Line I than C ($1.50 vs $1.54) because both required the same number of gestation/farrowing spaces, but Line I produced more pigs. The remaining variable costs expressed per pig marketed were also less in Line I because of its greater litter size.

Contribution margin per pig was higher in all three crosses for the system with Line I than the one with Line C. Averaged across the I and C systems, contribution margin for three-way cross pigs was $20.40 per pig more than for F_1 pigs, and the margin for F_1 pigs was $20.23 higher than for pureline pigs.

Fixed Costs

Depreciation costs were considered a fixed cost and were lower in the system with Line I because of the increased number of pigs marketed. However, the major difference in fixed costs between Line I and C systems was due to maintenance cost of breeding stock that included costs to maintain breeding boars, gilts and sows. This cost was $8.18 per pig for the Line-I system and $9.91 per pig for the Line-C system.

Net Return

Crossbreeding had a large effect on net return. Averaged across systems net return for F_1 pigs was $20.23 per pig more than for pureline pigs and return for three-way cross pigs was $20.40 per pig more than for F_1 pigs. Profitability for each group within the system and for the entire system was greater for the Line-I system than the Line-C system. The return for pureline I and C pigs was negative, $-14.65 per pig and $-22.33 per pig, respectively, because they grew slow, had poor feed conversion, and had substandard carcasses. Net return for F_1 L x I and L x C pigs was $5.30 per pig and $1.82 per pig, respectively. Net return for three-way cross T(L x I) pigs was $25.74 per pig vs $18.54 for three-way cross T(L x C) pigs.

Rate of Return on Investment

Net income for the system was calculated as the sum of the product of number of pigs times net return per pig for each of the three crosses within the Line I and Line C system divided by the total number of pigs within the system. The production system based on Index sows produced 24,417 pigs per year with average net income of $23.76 per pig. Output for the system based on Control sows was 20,166 pigs with net income of $16.73 per pig. There was an advantage of 6% in rate of return on investment for the system with Line I sows.

Conclusion

The system with Line I females marketed 3.4 pigs more per sow per year than the Line C system for an annual response to 18 generations of selection (the study used pigs from Generations 17, 18, and 19) of 0.19 pigs marketed per sow per year. The total difference in net return was $7.03 per pig. The annual response in net return from selection for increased litter size was $0.39 per pig marketed.

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