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THE EFFECTS OF PORCINE SOMATOTROPIN ON THE CONSUMPTION OF SOYBEAN MEAL

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The Effects of Porcine Somatotropin on the Consumption of Soybean Meal

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Introduction

The use of pork somatotropin has shown the potential to yield significant feed cost savings for hog producers (Apland and Cornelius, 1990). The savings result from improved growth rates for feeder pigs. PST use also results in significant changes in the optimal feed mix. Higher levels of protein are required in the ration when PST is used and, as a result, the consumption of soybean meal by hogs may be affected significantly. This study examines the potential effect of PST on soybean meal consumption by comparing least cost rations for different responses to PST with the situation where no PST is used. High, medium, and low response levels to PST are considered. A range of market prices for ingredients are considered as well as the substitution of other protein sources for soybean in the optimal feed mix. By controlling for these factors, it is possible to isolate changes in soybean use due to the adoption of PST.

Model

Two models were considered, the first allowed only corn and soybean meal as primary feed sources, the second included alternative protein sources. The models were set up in a linear programming framework and were designed to find rations for various stages of growth which minimize total feed cost per head. Minimum daily requirements for metabolizable energy, crude protein, lysine, calcium, and phosphorus were specified and limits placed on dry matter intake. The base model is described as follows.

Minimize: $\sum_{i=1}^{n_f} p_i Y_i$ Total Feed Cost [1]

Subject to: $-Y_i + \sum_{j=1}^{n_s} d_j X_{ij} \leq 0 \quad i=1 \ldots n_f$ Total Feed Use [2]

$\sum_{i=1}^{n_f} a_{1i} X_{ij} \geq b_{1j} \quad j=1 \ldots n_s$ Metabolizable Energy [3]

$\sum_{i=1}^{n_f} a_{2i} X_{ij} \geq b_{2j} \quad j=1 \ldots n_s$ Crude Protein [4]

$\sum_{i=1}^{n_f} a_{3i} X_{ij} \geq b_{3j} \quad j=1 \ldots n_s$ Lysine [5]

$\sum_{i=1}^{n_f} a_{4i} X_{ij} \geq b_{4j} \quad j=1 \ldots n_s$ Minimum Calcium [6]

$\sum_{i=1}^{n_f} a_{4i} X_{ij} \leq 1.15 b_{4j} \quad j=1 \ldots n_s$ Maximum Calcium [7]

$\sum_{i=1}^{n_f} a_{5i} X_{ij} \geq b_{5j} \quad j=1 \ldots n_s$ Phosphorus [8]

$\sum_{i=1}^{n_f} a_{6i} X_{ij} = b_{6j} \quad j=1 \ldots n_s$ Dry Matter Intake [9]

$Y_i,\ X_{ij} \geq 0 \quad j=1 \ldots n_s;\ i=1 \ldots n_f$ [10]

Where: n_s is the number of stages of growth

n_f is the number of alternative feeds

Y_i is the total per head use of feed i

X_{ij} is the daily per head use of feed i in stage j

p_i is the unit price of feed i

d_j is days on feed in stage j

a_{ki} is the content of nutrient k per unit of feed i
k=1: metabolizable energy
2: crude protein
3: lysine
4: calcium
5: phosphorus
6: dry matter

b_{kj} is the daily requirement of nutrient k in stage j
k=1: metabolizable energy
2: crude protein
3: lysine
4: calcium
5: phosphorus
6: dry matter

The objective function, equation 1, is total feed cost per pig, which is to be minimized. Constraint 2 defines the total use of each feed as the sum over all stages of daily use times the number of days in each stage. Constraints 3, 4, 5, 7 and 8 insure that minimum daily requirements are met for metabolizable energy, crude protein, lysine, calcium and phosphorus, respectively. Dry matter intake is fixed by constraint 9. Constraint 7 limits calcium intake to no more than 115% of the minimum daily requirement. For the model in which alternative proteins are used, additional constraints are placed on the intake of canola, meat and bone meal, and sunflower seed meal to avoid nutrient deficiencies or unpalatability of the feed mix. Canola meal was limited to less than 10% of fed weight in growth stage 1 and less than 20% of fed weight in growth stages 2 through 4. These limits are used to avoid nutrient deficiencies in the diet resulting from the overuse of canola. Meat and bone meal is limited to less than 5% of the fed weight of feed in growth stage 1, less than 20% for growth stage 2 and less than 30% for growth stages 3 and 4. These restrictions are used to avoid unpalatability of the feed mix. Sunflower meal is limited to less than 10% of fed weight for growth stage 1 and less than 20% for growth stage 2, and less than 30% for growth stages 3 and 4. These restrictions are used to restrict the fiber intake in the diet.

Data

Nutrient requirement parameters in the model varied with the animal growth stage. These stages are based on animal weight and are 40 to 50 pounds, 50 to 110 pounds, 110 to 170 pounds, and 170 to 230 pounds. The administration of PST was only considered in stages 2, 3 and 4. Days on feed and daily nutrient requirements were calculated for low, medium, and high responses to PST and also for no PST use. Parameters used in this study to reflect high, medium, and low responses to PST are derived from a statistical summary of published results of experimental trials. A detailed explanation of the methods used to estimate these parameters is presented in Apland and Cornelius (1990). A summary of these parameters are presented in Appendix Tables 1, 2, and 3. Appendix Table 1 summarizes hog feed use patterns by growth stage and PST response. In Appendix Table 2 the daily nutrient requirements for each stage of growth is recorded. The nutrient contents of ingredients used in the feed mix are recorded in Appendix Table 3.

To control for substitution effects due to relative price differences in ingredients, a number of price scenarios were considered for each model. Ingredient price parameters are derived as follows. For each ingredient, the mean of the mid-month price at Minneapolis/St. Paul for each month between January 1988 and December 1989 is used as the average price level. High and low price levels for each ingredient were taken as one positive and one negative standard deviation from the mean, respectively. A least cost ration was determined for each price scenario. Prices for each ingredient are presented in Table 1 (Feedstuffs, January 1988 - December 1989).

Table 1: Prices Parameters for Ingredients, Minneapolis/St. Paul

	Price Per Pound		
	Low	Average	High
Canola Meal	2.916	3.221	3.526
Corn	0.037	0.429	0.049
Meat and Bone Meal	0.116	0.132	0.148
Soybean Meal 49%	0.104	0.121	0.138
Soybean Meal 44%	0.097	0.113	0.130
Sunflower Seed Meal	0.048	0.056	0.065

Results

These results attempt to identify the effects of technological change resulting from PST use. In examining these effects it is necessary to control for other factors that may affect the use of soybeans. In this study two factors are considered. First is the difference in relative prices between primary ingredients, and second is the availability of alternative nutrient sources that substitute for soybean meal. Two sets of results are presented here. The first examines the effect of PST when no alternative protein sources are available, leaving only corn and soybean meal as primary ingredients. The second examines the effect of PST on soybean meal use when alternative protein sources are available. In each of these analyses, least cost rations for different PST response levels and alternative price scenarios are considered.

Soybean Meal Use when No Alternative Proteins are Available

In this analysis, only corn and soybean meal are considered as primary nutrient sources. This permits an examination of changes in soybean meal and corn use due to PST given alternative price scenarios.

Least cost rations for high, medium and low response levels to PST are derived for each possible price scenario. These are compared to the least cost ration where no PST is used. The total feed cost for each of these alternatives is presented in Table 2. The least cost rations for two price scenarios are presented in Tables 3 and 4. The first considers high soybean prices and low corn prices and is presented in Table 3. The second considers low soybean prices and high corn prices and is presented in Table 4.

Table 2: Total Feed Cost Per Head for Different Soybean Meal and Corn Prices.

Soybean Meal Price	Corn Price	No PST	-- Response to PST -- High	Average	Low	-- Response to PST -- High	Average	Low
		--- Total Feed Cost Per Head ---				Change From No PST		
High	High	41.47	35.91	38.53	41.90	-5.56	-2.94	0.43
	Medium	37.86	33.58	35.78	37.85	-4.28	-2.08	-0.01
	Low	34.23	31.24	33.03	35.71	-2.99	-1.20	1.48
Medium	High	40.15	34.03	36.66	39.96	-6.12	-3.49	-0.19
	Medium	36.53	31.70	33.91	36.87	-4.83	-2.62	0.34
	Low	32.91	29.37	31.16	33.78	-3.54	-1.75	0.87
Low	High	38.83	32.16	34.78	38.03	-6.67	-4.05	-0.80
	Medium	35.21	29.83	32.04	34.94	-5.38	-3.17	-0.27
	Low	31.59	27.49	29.29	31.85	-4.10	-2.30	0.26

Table 3: Least Cost Rations, High Soybean Price, Low Corn Price.

			------- Response to PST -------		
		No PST	High	Medium	Low
Total Feed Cost ($)		34.23	31.24	33.03	35.71
		------ Total Feed Use Per Head (lb) ------			
	Corn	615.3	395.8	466.7	524.7
	Soybean Meal 49%	78.3	111.0	110.6	114.3
	Calcium Carbonate	6.0	4.7	5.3	5.8
	Dicalcium Phosphate	2.1	1.7	1.5	1.4
	Vitamin Premix	3.7	2.8	3.1	3.5
	Tallow	0.0	4.6	0.0	0.0
Soybean Meal as Percent of Total		11.09	21.32	18.83	17.61
		-- Daily Corn and Soybean Meal Use (lb) --			
Stage 1 (40-50 lb)	Corn	2.484	2.484	2.484	2.484
	Soybean Meal	0.488	0.488	0.488	0.488
Stage 2 (50-110 lb)	Corn	5.226	4.306	4.679	4.900
	Soybean Meal	0.627	1.021	0.956	0.917
Stage 3 (110-170 lb)	Corn	5.869	4.901	5.342	5.481
	Soybean Meal	0.823	1.321	1.243	1.219
Stage 4 (170-230 lb)	Corn	7.001	4.757	5.486	5.900
	Soybean Meal	0.800	1.640	1.512	1.440
	Tallow	0.000	0.167	0.000	0.000

Table 4: Least Cost Rations, Low Soybean Meal Price, High Corn Price.

		No PST	Response to PST: High	Medium	Low
Total Feed Cost ($)		38.83	32.16	34.78	38.03
		Total Feed Use Per Head (lb)			
	Corn	613.7	394.8	465.2	523.1
	Soybean Meal 49%	78.4	111.1	110.8	114.7
	Calcium Carbonate	7.2	5.4	6.4	7.0
	Dical Phosphate	2.1	1.8	1.5	1.4
	Vitamin Premix	3.7	2.8	3.1	3.5
	Tallow	0.0	4.6	0.0	0.0
Soybean as Percent of Total		11.11	21.36	18.88	17.65
		Daily Corn and Soybean Meal Use (lb)			
Stage 1 (40-50 lb)	Corn	2.476	2.476	2.476	2.476
	Soybean Meal	0.489	0.489	0.489	0.489
Stage 2 (50-110 lb)	Corn	5.213	4.292	4.664	4.885
	Soybean Meal	0.628	1.023	0.958	0.919
Stage 3 (110-170 lb)	Corn	5.852	4.882	5.324	5.462
	Soybean Meal	0.824	1.324	1.247	1.222
Stage 4 (170-230 lb)	Corn	6.984	4.757	5.468	5.882
	Soybean Meal	0.801	1.640	1.515	1.443
	Tallow	0.000	0.167	0.000	0.000

While the cost of administering PST is not known given the current state of technology, a summary of total feed costs for all possible corn and soybean price scenarios (Table 2) show some promising results. Without including the cost of administering PST, high and medium responses to PST result in a reduction in the total feed cost. When the response to PST is low, there is a small cost saving or small cost increase depending on relative prices for corn and soybean. Given these cost patterns and a sufficiently low cost of administering PST, farmers would adopt the use of PST if they can achieve average or high response levels and may even do so at low response levels depending on the relative prices for corn and soybean.

From Tables 3 and 4, it is clear that the use of PST causes an increase in soybean use and a decrease in corn use for both price scenarios. The magnitude of these differences changes with the level of response to PST. Soybean use increases from 78 pounds to between 110 and 114 pounds while corn use decreases from 615 pounds to between 524 and 395 pounds.

Comparing price scenarios, there is an increase in the level of soybean use and a decrease in corn use as the price of soybeans decreases relative to corn. Considering that these are the extreme values for the relative prices of these ingredients, the change in ingredient mix for the least cost ration is very small. For all possible PST responses, the difference in total soybean meal use due to differences in relative price is less than a pound.

Soybean Meal Use when Alternative Proteins are Available

In this analysis, a number of alternative high protein ingredients are permitted in the feed ration. They are canola meal, meat and bone meal, soybean meal with 44 percent protein, and sunflower meal. These are in addition to the corn and soybean meal with 49 percent protein used in the first analysis. The feed cost for all combinations of high, medium and low prices for both soybeans and alternative protein sources is presented in Table 5. As is clear from this table, allowing alternative proteins in the least cost ration causes a significant decrease in the cost of feed. This decrease ranges between 4 and 21 percent depending on the PST response and relative prices. The least cost ration for the two extreme price scenarios were selected, and the results presented in Tables 6 and 7. Results for the scenario where soybean prices are high and all alternative protein source prices are low is presented in Table 6. Results for the scenario where soybean prices are low and alternative protein prices are high are presented in Table 7. These results show once again that there is a significant decrease in the amount of corn and an increase in the amount of soybean meal in the least cost ration when PST is administered. It is interesting to note that both high protein (49 percent) and low protein (44 percent) soybean meal are used in the least cost ration for medium and high response levels to PST and that the proportion of high protein soybean meal increases as the response to PST improves. This result is attributable to the decline in intake resulting from the increased response to PST, which encourages the use of ingredients with higher nutrient concentrations. Sunflower seed meal is a significant substitute for soybean and corn under both of the price scenarios considered here. The proportion of soybean in the least cost feed mix decreases from between 11.09 and 23.06 percent when no soybean meal is used to between 0.85 and 10.27 percent when PST is used. When compared to the

Table 5: Total Feed Cost Per Head for Different Soybean Meal and Alternative Protein Prices.

Soybean Meal Price	Alternative Protein Price	No PST	Response to PST High	Response to PST Average	Response to PST Low
		Without Alternative Protein			
High		37.86	33.58	35.78	37.85
Medium		36.53	31.70	33.91	36.87
Low		35.21	29.83	32.04	34.94
		With Alternative Protein			
High	High	33.71	29.51	31.07	33.65
		(10.96)[a]	(12.12)	(13.16)	(11.10)
	Medium	32.41	28.35	29.77	32.21
		(14.40)	(18.45)	(20.19)	(14.90)
	Low	31.06	27.02	28.26	30.48
		(17.96)	(19.54)	(21.02)	(19.47)
Medium	High	33.62	28.91	30.56	33.17
		(7.96)	(8.80)	(9.88)	(10.03)
	Medium	32.32	27.76	29.27	31.74
		(11.52)	(12.43)	(13.68)	(13.91)
	Low	31.01	26.61	27.97	30.30
		(15.11)	(16.06)	(17.52)	(17.82)
Low	High	33.52	28.11	29.98	32.69
		(4.80)	(5.77)	(6.43)	(6.44)
	Medium	32.23	27.17	28.76	31.27
		(8.46)	(8.91)	(10.24)	(10.50)
	Low	30.93	26.02	27.47	29.84
		(12.15)	(12.77)	(14.26)	(14.60)

[a] The number in parentheses below each cost is the percentage decrease in cost when alternative protein is available.

Table 6: Least Cost Rations, High Soybean Price, Low Alternative Protein Price

			No PST	Response to PST High	Response to PST Medium	Response to PST Low
Total Feed Cost ($)			31.06	27.02	28.26	30.48
			Total Feed Use Per Head (lb)			
		Canola Meal	0.0	0.0	0.0	0.0
		Corn	535.2	333.6	396.6	446.5
		Meat/Bone Meal	3.8	21.8	21.2	22.3
		Soybean Meal 49%	0.0	6.4	2.7	0.0
		Soybean Meal 44%	2.0	8.3	7.1	6.4
		Sunflower Seed Meal	147.2	129.7	146.4	162.1
		Calcium Carbonate	6.7	0.1	0.9	1.4
		Dicalcium Phosphate	0.0	0.0	0.0	0.0
		Vitamin Premix	3.7	2.8	3.1	3.5
		Tallow	0.0	11.4	2.1	0.0
Soybean Meal as Percent of Total			0.3	2.9	1.7	1.0
Alt. Proteins as Pct of Total			21.2	29.5	28.9	28.7
			Daily Corn and Protein Use (lb)			
STAGE 1	(40-50 lb)	Corn	2.335	2.335	2.335	2.335
		Meat/Bone	0.143	0.143	0.143	0.143
		Soybean 49%	0.000	0.000	0.000	0.000
		Soybean 44%	0.228	0.228	0.228	0.228
		Sunflower	0.289	0.289	0.289	0.289
STAGE 2	(50-110 lb)	Corn	4.618	3.829	4.134	4.314
		Meat/Bone	0.072	0.252	0.250	0.249
		Soybean 49%	0.000	0.000	0.000	0.000
		Soybean 44%	0.000	0.228	0.170	0.135
		Sunflower	1.131	1.032	1.090	1.125
STAGE 3	(110-170 lb)	Corn	4.963	4.122	4.441	4.542
		Meat/Bone	0.000	0.264	0.198	0.170
		Soybean 49%	0.000	0.019	0.000	0.000
		Soybean 44%	0.000	0.000	0.000	0.000
		Sunflower	1.663	1.813	1.916	1.948
STAGE 4	(170-230 lb)	Corn	6.108	3.730	4.525	4.920
		Meat/Bone	0.000	0.248	0.244	0.257
		Soybean 49%	0.000	0.218	0.096	0.000
		Soybean 44%	0.000	0.000	0.000	0.000
		Sunflower	1.618	1.916	2.032	2.129
		Tallow	0.000	0.410	0.075	0.000

Table 7: Least Cost Rations, Low Soybean Price, High Alternative Protein Price

		No PST	Response to PST: High	Medium	Low
Total Feed Cost ($)		33.52	28.11	29.98	32.69
		Total Feed Use Per Head (lb)			
	Canola Meal	0.0	0.0	0.0	0.0
	Corn	534.2	353.3	401.6	441.0
	Meat and Bone Meal	0.0	0.0	0.0	0.0
	Soybean Meal 49%	0.0	29.0	15.5	0.0
	Soybean Meal 44%	5.9	24.1	21.6	29.1
	Sunflower Seed Meal	147.2	95.1	133.4	162.1
	Calcium Carbonate	0.0	0.0	0.0	0.0
	Dicalcium Phosphate	0.0	0.0	0.0	0.0
	Vitamin	0.0	0.0	0.0	0.0
	Tallow	0.0	6.4	0.0	0.0
Soybean Meal as Percent of Total		1.0	10.4	6.5	4.6
Alt. Proteins as Pct of Total		21.1	18.7	23.3	25.6
		Daily Corn and Protein Use (lb)			
STAGE 1 (40-50 lb)	Corn	2.293	2.293	2.293	2.293
	Meat/Bone	0.000	0.000	0.000	0.000
	Soybean 49%	0.000	0.000	0.000	0.000
	Soybean 44%	0.374	0.374	0.374	0.374
	Sunflower	0.289	0.289	0.289	0.289
STAGE 2 (50-110 lb)	Corn	4.601	3.767	4.072	4.253
	Meat/Bone	0.000	0.000	0.000	0.000
	Soybean 49%	0.000	0.000	0.000	0.000
	Soybean 44%	0.073	0.484	0.424	0.389
	Sunflower	1.131	1.032	1.090	1.125
STAGE 3 (110-170 lb)	Corn	4.963	4.061	4.392	4.500
	Meat/Bone	0.000	0.000	0.000	0.000
	Soybean 49%	0.000	0.000	0.000	0.000
	Soybean 44%	0.000	0.290	0.201	0.173
	Sunflower	1.663	1.813	1.916	1.948
STAGE 4 (170-230 lb)	Corn	6.108	4.593	4.823	4.857
	Meat/Bone	0.000	0.000	0.000	0.000
	Soybean 49%	0.000	1.063	0.542	0.000
	Soybean 44%	0.000	0.000	0.000	0.261
	Sunflower	1.618	0.646	1.579	2.129
	Tallow	0.000	0.236	0.000	0.000

situation where no PST is administered, the quantity of sunflower seed meal used is higher for the low PST response level and lower for the medium and high PST response levels. This, again, reflects the need for more concentrated protein sources as the response to PST improves. Tallow is used when the response to PST is at the high or medium level reflecting the need for a highly concentrated energy source as the response to PST improves and intake declines.

Changes in the least cost ration resulting from changes in the price of soybean meal relative to alternative proteins can be examined by comparing Tables 6 and 7. As the soybean meal price decreases relative to the price of other protein sources, the following adjustments occur. There is a decrease in the use of corn for no PST and low PST response levels and an increase in the use of corn for medium and high PST response levels. In the case of no PST and low PST response levels, this reflects the increased use of soybean as a metabolizable energy source. In the case of medium and high PST responses, this reflects the replacing of sunflower seed meal and tallow with corn and soybean as protein and energy sources. It is interesting to note that the substitution of corn and soybean meal for sunflower seed meal only occurs in stage 4 of the growth cycle, while substitution of soybean meal for corn and tallow occurs at all stages of the growth cycle. There is also the substitution of soybean meal for meat and bone meal as the price of soybean meal decreases relative to meat and bone meal. In addition to an increase in the total amount of both high and low protein soybean meal used, the amount of high protein (49 percent) soybean meal used increases faster than that for low protein (44 percent) soybean meal when the response to PST is medium or high.

The Affect of PST on Aggregate Soybean Use

Given the uncertainty associated with the transfer of PST use from a controlled experiment to farm practice, the consumer demand for pork produced with PST, the adoption of PST use by farmers, and the availability of alternative protein feed sources, it is difficult to draw aggregate inferences from the results presented above. However these results are useful for examining possible aggregate effects of PST on soybean use.

The least cost rations presented above show that if only corn and soybean meal are used as primary ingredients, then the use of PST will result in an increase in soybean meal ranging between 42 and 46 percent per feeder pig. If alternative proteins are included in the ration at present prices, then there is an increase in soybean use between 219 and 795 percent per feeder pig.

In translating these effects into aggregate changes in soybean meal use for the U.S., the first of these two scenarios is a more likely to occur because of the limited aggregate supplies of many of the alternative protein sources. For example, total sunflower seed meal production in the U.S. in 1989 was 297,000 metric tons (Oil Crops, Jan 1990). This would feed only 5.4 percent of the feeder pig population at the consumption levels prescribed by the least cost ration with alternative protein available. In addition, prices used for these ingredients are prices at the market and does not include transportation costs. Given the limited number of locations where some of these ingredients, such as meat and bone meal, are produced, the prices could be substantially higher at the farm.

If we consider that there were 82,916,000 barrows and gilts slaughtered in 1988 and that, on average, each of these consumed 78.25 pounds of soybean meal during their feeding cycle when no PST is used, then the total consumption of soybean meal by feeder pigs in the U.S. per year would be 6488 million pounds (Livestock and Poultry, Nov, 1989). If it is assumed that all hog farmers adopt PST and use the least cost ration developed here, aggregate increase in soybean meal consumption would be between 2725 million and 2984 million pounds. This would translate into an increase of between 56.5 million and 61.90 million bushels of soybean when a conversion factor of 48.21 pounds of meal per bushel of soybeans is used (Oil Crops, Jan 1990). Total domestic soybean production for the 1988 crop year was estimated to be 1,927 million bushels (Oil Crops, 1990). The increase in soybean meal use due to PST use would therefore represent between 2.93 and 3.21 percent of total domestic production.

While these figures provide a useful indicator of possible adjustments in the use of soybean meal for feeder pigs, there are many sector level adjustments that have not been accounted for. Some factors that would need to be considered are, the effect of a shorter growth cycle when PST is used, the adjustment in prices for ingredients when the demand for high protein ingredients increases, and the resulting adjustments in the production and use of ingredients. Further study of the adoption rates for PST, actual feed use, and sector level adjustments will be needed to confirm these estimates. The cost of administering PST also needs to be ascertained in order to evaluate the economic feasibility of PST adoption.

Summary and Conclusion

This study examines the effect of PST use on soybean meal consumption by feeder pigs. Data from experimental trials was used to estimate the effect of PST on feed consumption and pork production. Parameters for days on feed and daily nutrient requirements were calculated for different response levels to PST. These parameters were then used to calculate the least cost feed rations. In order to isolate the technological effect PST applications on the consumption of PST, it was necessary to identify the effect of two other factors. First was the effect of alternative protein sources as a substitute for soybean meal and second was the substitution effect due to changes in the relative price of ingredients. To control for these effects, two sets of least cost feed models were considered. The first used only soybean meal and corn as primary feed sources, while the second included some alternative proteins sources. Using these models, the least cost rations were calculated for a range of price scenarios and for each response level to PST.

The results of this analysis showed that in all the scenarios considered, the use of PST resulted in an increase in soybean meal use. When only corn and soybean meal were considered as primary ingredients, the use of soybean meal increased between 42 and 46 percent. When alternative proteins were available, the increase was between 219 and 795 percent. This large increase when alternative proteins were available was affected by large substitution effects that occurred between soybean meal and sunflower seed meal. Given the limited availability of many of the alternative protein sources considered, the first model was considered to be more realistic for aggregate analysis. The results of these least cost rations were then used to estimate the possible impacts of PST on aggregate soybean meal consumption. Using estimates for present feeder pig populations the feed ration figures were used to estimate the increase in total soybean consumption. Using these estimates and assuming that all feeder pig operations adopt PST, the increase in soybean use for the feeder pig operations in the US will be between 56.5 million and 61.90 million bushels of soybean.

While these results provide a useful estimate for possible changes in soybean consumption due to PST, they should be used with caution. Many of the market level adjustments associated with the use of PST have not been included in this analysis. Further research is needed on to identify the cost of administering PST at the farm level, the consumer response to pork from pigs raised on PST, the spacial availability of alternative protein sources, and the effect of PST on the number of feeder pigs produced.

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Appendix Table 1: Summary of Alternative Scenarios Considered for the Response to PST

Scenario	PST mg/day	Stage	Beginning Wt (lb)	Ending Wt (lb)	Days Fed	Protein Fed (%)	Rate of Gain lb/day	Feed Conversion
No PST[a]	NA	1	40	50	9		1.14	2.37
No PST	NA	2	50	110	36	16	1.67	3.15
		3	110	170	33	14	1.80	3.35
		4	170	230	30	13	2.00	3.50
Low	4	2[b]	50	110	32	20	1.84	2.84
		3[c]	110	170	30	17	1.98	3.05
		4[d]	170	230	30	17	2.00	3.30
Average	4	2[b]	50	110	28	20	2.01	2.52
		3[c]	110	170	27	17	2.16	2.75
		4[d]	170	230	28	17	2.10	3.00
High	4	2[b]	50	110	24	20	2.18	2.20
		3[c]	110	170	24	17	2.34	2.45
		4[d]	170	230	26	17	2.20	2.70

[a] PST was administered only in stages 3, 4 and 5.

[b] For the 50-110 lb. weight range (stage 3), estimates of the response to PST are based on Steele, Campbell and Caperna; Caperna et al.; Campbell et al.; Evans et al.; and Ender et al.

[c] For the 110-170 lb. weight range (stage 4), estimates of the response to PST are based on Ender et al.; Knight et al.; Machlin; Goodband et al.; Baile, Della-Fera and McLaughlin; Bechtel et al., and Jones et al.; Bryan et al.; Newcomb et al.; Campbell and Taverner; Evock et al.; Etherton et al., 1987; Etherton et al., 1986; Chung, Etherton and Wiggins; McKeith et al.; Boyd, Wray-Cahen and Krick.

[d] For the 170-230 lb. weight range (stage 5), estimates of the response to PST are based on Boyd, Wray-Cahen and Krick; Azain et al.; Knight et al.

Appendix Table 2: Nutrient Requirements.

Stage	Metabolizable Energy (mcal/day)	Crude Protein (g/day)	Lysine (g/day)	Calcium (g/day)	Phosphorus (g/day)
	Without PST				
1	3.975	197.0	9.73	7.94	6.69
2	6.374	312.5	14.80	11.78	9.86
3	9.228	394.9	18.30	15.31	12.51
4	10.496	416.4	19.26	15.01	11.61
	With PST				
2	6.374	390.6	18.51	11.78	9.86
3	9.228	479.5	22.23	15.31	12.51
4	10.496	544.2	25.17	15.01	11.61

Appendix Table 3: Composition of Feeds, Per Pound as Fed.

Feed	Dry Matter	Metabolizable Energy	Crude Protein	Lysine	Calcium	Phosphorus
Canola Meal	0.930lb	1.315mcal	172.4g	10.3g	3.1g	5.3g
Corn	0.880	1.551	38.6	1.1	0.1	1.3
Meat and Bone Meal	0.940	1.034	230.9	13.1	42.6	20.8
Soybean Meal	0.900	1.535	220.0	14.2	1.2	2.9
Soybean Meal	0.900	1.461	199.6	13.2	1.4	2.9
Sunflower Meal	0.930	1.382	206.4	7.6	1.9	4.3
Calcium Carbonate	1.000	0.000	0.0	0.0	172.4	0.0
Dicalcium Phosphate	1.000	0.000	0.0	0.0	119.3	82.0
Vit/Min Premix	1.000	0.000	0.0	0.0	0.0	0.0
Tallow	1.000	3.581	0.0	0.0	0.0	0.0