Proceedings of the 1991 Winter Simulation Conference
Barry L. Nelson, W. David Kelton, Gordon M. Clark (eds.)

THE FINANCIAL IMPACT OF BIOTECHNOLOGY ON HOG PRODUCTION: A DYNAMIC-STOCHASTIC CAPITAL BUDGETING SIMULATION APPROACH

Conrado M. Gempesaw, II
Catherine K. Halbrendt

Department of Food and Resource Economics
University of Delaware
Newark, Delaware 19717

ABSTRACT

The costs and returns associated with hog production vary according to regional location and type of operation. This paper evaluates the profitability of adopting a new technology, porcine somatotropin, by representative hog farms located in the six largest hog-producing states in the U.S. using a dynamic-stochastic capital budgeting simulation model. The results show that the simulated financial impacts of the new technology is not uniform across the different representative hog farms.

1 INTRODUCTION

Biotechnological improvements in the hog industry have allowed the production of leaner and more efficient animals and improved animal nutrition and disease control. For example, porcine somatotropin (PST) regulates the utilization of animal nutrients and increases both the decomposition of protein and breakdown of fat. PST improves the feed efficiency of hogs, producing a leaner product and reaches market weight faster. Past studies have shown that the growth rate of hogs can increase by as much as 33 percent, reach slaughter weight 11.6 days earlier, increase feed efficiency as high as 40 percent and reduce fat by as much as 32 percent (Meisinger 1989).

Recent studies have been conducted to evaluate the economic impact of PST on the hog industry. For instance, Lemieux and Richardson (1989) examined the financial performance of three representative Midwest grain-hog farms with and without PST adoption. They found that PST had a positive impact on farm financial returns only if producers were paid a premium price for the lean product.

This paper builds on past studies in two major technical areas. First, while all previous studies were based on annual data, this study uses monthly data. This procedure is more realistic and accurate in simulating hog production since the entire hog production cycle lasts less than one year. Production costs, mortality and other technological variables were then modelled on a monthly basis. Second, the technique used in this study to model PST is significantly different from past literature. The effects of PST along with individual production costs, market weight and output prices were specified as stochastic. Monte Carlo techniques using the triangular probability distribution were utilized to select the assumed variable values for every iteration. This procedure attempts to capture the uncertainty behind the assumed variable values rather than using point estimates which indicate perfect forecasts.

The objective of this study is to conduct a comparative financial analysis of farms adopting PST in the six largest hog-producing states in the U.S. using a dynamic-stochastic capital budgeting simulation model.

2 SIMULATION MODEL

AQUASIM, a comprehensive farm-level, dynamic and stochastic, multiple year, capital budgeting simulation model was developed from FLIPSIM V (Richardson and Nixon 1986) to simulate the production and financial performance of representative hog enterprises. The simulation model is programmed in Fortran code with more than 10,000 source statements. Options are available in the model to run either deterministic or stochastic analysis. A maximum of 300 iterations is available if the stochastic option is selected. At the end of each iteration, the model stores the results and reinitializes the representative farm to the original situation used at the outset of the first iteration. The user can select several different probability distributions when using the stochastic option. The probability distributions include the normal distribution, empirical distribution, triangular distribution, and the beta distribution. Upon completion of the desired number of iterations, the model performs a descriptive statistical analysis and computes for the mean, standard deviation, coefficient of variation, maximum and minimum values for 179 statistical output variables. The model output includes a ten-year proforma financial statement which includes the cash flow, balance sheet, and income statement along with various financial ratios. Additional production indicators given by the model include mortality rates, production numbers, average weight, stocking densities, and quantity transfers from one production unit to another.

Several features are available in the model that enable the user to realistically simulate the economic and production performance of hog farms. AQUASIM can simulate enterprises that produce products that are used as inputs in the next stage of operation. The model has the capability of simultaneously modelling products with different production time periods. These features are needed to simulate the farrow to finish hog operation where each group of sows had different production cycles. The model is also programmed to allocate the estimation of the variable costs through different time periods. For example, the costs of PST adoption will only be incurred during the last two months of a production cycle. These features are important considerations for cash flow and operating expense management.

The simulation model generates detailed statistical results regarding the financial viability of the hog representative farms. At the end of each iteration, values for the key financial variables are calculated. If the farm experiences a negative cash flow or does not meet the various specified solvency and liquidity standards during the planning horizon, financial deficits are automatically covered by obtaining a loan secured by existing net worth available to the farm at the point. If the farm avails of this option but still cannot cover the cash flow deficit, the farm is declared insolvent and the model ends the simulation process.

Five simulation output variables are used in this study to measure the financial impact of porcine somatotropin on hog production. The probabilities of economic survival and economic success provide bottom-line measures of the general economic viability of the representative hog enterprises. The probability of economic survival is defined as the probability that the farm will remain solvent during the entire ten-year planning horizon. To remain solvent, the farm needs to maintain at least a 10 percent equity to asset ratio over the planning horizon. The probability of economic success is defined as the probability that the farm will have a positive after-tax net present value. The after-tax net present value (NPV) is defined as the present value of the producer's annual cash withdrawal plus the present value of the change in net worth minus the present value of annual off-farm income. Cash withdrawals equal family living expenses plus income and self-employment taxes. An 8 percent after-tax discount rate was used to calculate the NPV for the representative farms. The internal rate of return (IRR) is defined as the discount rate that equates the NPV to zero. The average net cash farm income (NCFI) is the average net cash farm income received by the producer over all years simulated. NCFI equals total farm revenues minus all cash production expenses, interest payments, labor costs and other miscellaneous costs.

3 DATA ASSUMPTIONS

Representative farms from the six largest hog-producing states in the U.S. were identified in this study. The six states are Iowa, Illinois, Minnesota, Indiana, Nebraska, and Missouri. These states produce over two-thirds of U.S. hog production. Two types of hog production operations are examined, i.e., the farrow to finish operation (FAFO) and the feeder to finish operation (FEFO). The feeder to finish operation accounts for over 20 percent of total hog production and needs to be evaluated separately. For the FEFO farms, it was assumed that feeder pigs were purchased every four months, resulting in three cycles of hog production annually. In the FAFO farms, it was assumed that the producer had new sows three times a year. Each sow farrowed twice a year for two years before it was sold in the market. The hog production cycle took ten months from breeding to market weight size. Five representative farm data sets (Iowa, Minnesota, Indiana, Nebraska, and Missouri) were constructed to represent the FEFO farms. Illinois was not included due to unavailability of accurate data for this type of operation. For the FAFO farms, six representative farm data sets were developed for analysis.

The input data required by the simulation model are categorized in two groups: main data and option data. The main data requirements include the initial investment cost for land, building, machineries and equipment, long-term and intermediate-term loan, interest rates, depreciation schedules, cash withdrawals, and other financial variables needed to generate fixed investments. The option data requirements include the various costs of production such as feed, medicine, energy, hired labor, cost of the new technology, survival rates, hog weight and output market prices. These variables were all specified as stochastic using the triangular probability distribution. The input data were taken from various Cooperative Extension publications on hog production from the respective states identified.

Table 1 shows the general production and financial characteristics of the farrow to finish representative farms. The Illinois and the Indiana farms were the two largest farms in production capacity, with the Missouri farm having the smallest capacity. The total financial assets of the representative farms range from a low of $239,100 for the Missouri farm to a high of $385,600 for the Illinois farm.

Table 1: Production and Financial Characteristics of Regional Farrow to Finish Hog Farms

Variables	Illinois	Minnesota	Nebraska	Indiana	Missouri	Iowa
Number of Sows Farrowed Per Year	180	100	100	150	96	110
Annual Pork Production (cwt)	6,605	3,894	3,309	5,601	2,975	3,567
Total Assets ($000)	385.6	324.6	259.6	375.6	239.1	324.1
Debt to Asset Ratios:						
Long Term	0.25	0.24	0.30	0.50	0.40	0.50
Intermediate Term	0.50	0.50	0.45	0.50	0.40	0.50

The general production and financial characteristics of the feeder to finish representative farms are presented in Table 2.

Table 2: Production and Financial Characteristics of Regional Feeder to Finish Hog Farms

Variables	Minnesota	Nebraska	Indiana	Missouri	Iowa
Number of Feeder Pigs Purchased/Year	750	1,242	1,500	1,993	1,575
Annual Pork Production (cwt)	1,776	2,835	3,381	4,408	3,586
Total Assets ($000)	64.6	92.1	134.7	173.6	137.7
Debt to Asset Ratios:					
Long Term	0.25	0.25	0.10	0.25	0.10
Intermediate Term	0.25	0.25	0.10	0.25	0.10

The Missouri farm was assumed to purchase the largest number of feeder pigs per year while the Minnesota farm had the lowest number of feeder pigs purchased annually. The total financial assets of the representative feeder to finish hog farms range from a low of $64,600 for the Minnesota farm to a high of $173,600 for the Missouri farm. For planning purposes, all initial variable costs of production were assumed to increase by an average of 3-5 percent annually. Similar inflation rates were specified for the asset values. Interest rate for long-term debt was set at 12 percent while intermediate-term debt and operating loan interest rate was set at 12.5 percent. PST was assumed to be adopted during the last 2 months prior to the hogs reaching market weight. Following Meisinger (1989), the hog producers were assumed to sell the hogs at a higher average weight by keeping the hogs over the regular production cycle rather than selling them early. The weight gain per day due to PST adoption was set around 12-18 percent while feed cost was specified to decrease about 18-22 percent to accomodate the increase in protein during the 60 days of PST administration. The PST cost per hog was assumed to be between $5.50-6.60. The adoption rate was set at 20 percent in the first year, 40 percent in the second year and 90 percent from the third year onwards. Each representative farm was simulated over a ten-year planning horizon under a base scenario of no PST adoption and another scenario with PST adoption. The other scenario was based on the adoption of PST with a price premium set at $2.80-$3.20 per hog. Projected values for hog output prices were collected from WEFA agricultural price forecasts.

4 DISCUSSION OF RESULTS

The simulation results are presented based on the five output variables discussed previously. Table 3 presents the base scenario results for the FAFO farms with no PST adoption.

Table 3: Base Scenario, No PST, Farrow to Finish Farms

Variables	Illinois	Minnesota	Nebraska	Indiana	Missouri	Iowa
Chance of Survival(%)	100.00	100.00	100.00	100.00	100.00	100.00
Chance of Success (%)	84.00	74.00	0.00	72.00	0.00	30.00
Internal Rate Return (%)	7.86 (1.25)	7.45 (0.92)	3.01 (1.47)	7.49 (1.89)	3.59 (1.37)	5.66 (1.57)
Net Farm Income($000)	32.32 (6.59)	25.58 (4.14)	6.13 (4.06)	22.33 (6.75)	7.16 (3.21)	12.84 (4.38)
Net Present Value($000)	37.88 (34.9)	15.72 (22.2)	-63.21 (21.1)	21.88 (35.0)	-46.96 (16.5)	-15.14 (22.6)

**Numbers in parenthesis are standard deviations.

Under the base scenario, all the six representative hog farms reported 100 percent chance or probability of economic survival. This means that all farms met the minimum financial ratios required to be solvent over the ten-year planning horizon. However, in terms of the probability of economic success, the Nebraska and Missouri farms recorded zero chances of attaining at least 8 percent rate of return. The Illinois farm recorded the highest probability of economic success (84%). The Illinois, Minnesota, and Indiana farms attained an average of over 7 percent internal rate of return. The net cash farm income of the representative FAFO farms ranged from a low of $6,130 per year for the Nebraska farm to a high of $32,320 per year for the Illinois farm. Only three farms, Illinois, Minnesota, and Indiana managed to post positive average after-tax NPVs.

Table 4 presents the simulation results for the PST adoption scenario. The financial performance of all the FAFO farms substantially improved. At least four farms generated 100 percent chance of economic success. These four farms - Illinois, Minnesota, Indiana, and Iowa generated internal rates of return over 12 percent. The Iowa farm gained the highest improvement in returns from the use of PST. The net cash farm income of the Iowa farm increased from an average of $12,000 under the base scenario to $38,000 under the PST adoption scenario, a threefold increase. Except for the Nebraska farm, all the other farms managed to attain a positive average after-tax NPV over the ten-year planning horizon. The provision of the premium price along with the increase in weight per hog, allowed the representative farms to compensate for the higher cost of production due to the use of PST.

Table 4: PST Adoption Scenario, Farrow to Finish Farms

Variables	Illinois	Minnesota	Nebraska	Indiana	Missouri	Iowa
Chance of Survival(%)	100.00	100.00	100.00	100.00	100.00	100.00
Chance of Success (%)	100.00	100.00	36.00	100.00	78.00	100.00
Internal Rate Return (%)	12.09 (1.22)	13.64 (0.73)	6.58 (1.31)	13.27 (1.36)	7.83 (1.29)	13.36 (0.99)
Net Farm Income($000)	58.03 (8.86)	55.15 (5.03)	16.59 (4.36)	47.25 (7.37)	18.30 (4.05)	38.97 (4.57)
Net Present Value($000)	180.86 (45.7)	196.30 (26.7)	-7.34 (22.7)	160.01 (39.3)	15.57 (21.2)	129.02 (23.7)

**Numbers in parenthesis are standard deviations.

Table 5 presents the financial simulation results for the FEFO representative farms under the base scenario of no PST adoption. As explained previously, the Illinois farm was not included in the FEFO representative farms due to lack of accurate data. In general, the FEFO farms are not as profitable as the FAFO farms. None of the representative FEFO farms earned more than 4 percent internal rate of return. This caused the chance or probability of economic success for these farms to be zero. Only the Minnesota and Indiana farms managed to earn positive average annual net cash farm income. This is also reflected in their 100 percent chance of economic success. All farms registered negative average after-tax NPVs with the Nebraska farm generating the lowest NPV over the ten-year period.

Table 5: Base Scenario, No PST, Feeder to Finish Farms

Variables	Minnesota	Nebraska	Indiana	Missouri	Iowa
Chance of Survival(%)	100.00	98.00	100.00	96.00	98.00
Chance of Success (%)	0.00	0.00	0.00	0.00	0.00
Internal Rate Return (%)	2.92 (1.10)	0.59 (1.13)	3.73 (2.12)	3.19 (2.79)	1.10 (1.35)
Net Farm Income($000)	0.73 (1.87)	-5.39 (3.29)	0.17 (3.62)	-3.39 (5.74)	-2.27 (4.49)
Net Present Value($000)	-68.37 (9.9)	-101.2 (17.1)	-71.29 (18.8)	-88.57 (30.7)	-90.67 (23.6)

**Numbers in parenthesis are standard deviations.

The results for the PST adoption scenario for the representative FEFO farms are presented in Table 6.

Table 6: PST Adoption Scenario, Feeder to Finish Farms

Variables	Minnesota	Nebraska	Indiana	Missouri	Iowa
Chance of Survival(%)	100.00	100.00	100.00	100.00	100.00
Chance of Success (%)	24.00	26.00	94.00	58.00	4.00
Internal Rate Return (%)	8.47 (0.86)	9.66 (1.44)	13.28 (1.51)	11.52 (2.27)	5.10 (2.07)
Net Farm Income($000)	11.41 (2.09)	11.30 (3.38)	20.03 (4.34)	15.14 (6.23)	6.27 (4.66)
Net Present Value($000)	-8.03 (10.8)	-10.87 (17.5)	41.35 (22.5)	2.44 (32.9)	-39.69 (24.4)

**Numbers in parenthesis are standard deviations.

The simulation results for the PST adoption scenario by the FEFO representative show a substantial improvement in their financial and economic performance. All the five farms managed to attain a 100 percent chance of economic survival over the ten-year planning horizon. Their chances of economic success also also showed a marked increase from the base scenario results. The Indiana farm obtained the highest increase in both the internal rate of return and net cash farm income measures. The IRR of the Indiana farm increased from 3.73 percent with no PST to a high of 13.28 percent under the PST adoption scenario. The Missouri and Nebraska farms also performed well relative to the other representative FEFO farms. All five farms reported positive net cash farm income over the ten-year planning horizon. In contrast, under the no PST adoption scenario, Nebraska, Missouri and Iowa generated negative average annual net cash farm incomes while Minnesota and Indiana barely managed to earn positive net cash farm incomes. In terms of the after-tax NPV, the Indiana and Missouri representative farms generated positive mean NPV values. The other farms reported negative mean NPV values but considerably lower than the negative mean NPV values reported under the no PST adoption scenario.

5 SUMMARY AND CONCLUSIONS

A dynamic-stochastic capital budgeting simulation model, AQUASIM, was used to evaluate the financial impacts of representative hog farms operating in six Midwestern states with and without PST adoption. Several interesting results were found in the analysis. First, the farrow to finish operations were found to be more profitable than the feeder to finish farms regardless of the technology assumption. A question could then be raised why over 20 percent of hog produced still come from the feeder to finish type of production structure. Second, among the farrow to finish farms, Illinois, Indiana, and Minnesota were found to be the most profitable farms. With the use of PST, the Iowa representative farm gained the highest increase in returns. Among the six farrow to finish farms, the Nebraska farm generated the least returns with and without PST. Third, among the feeder to finish farms, the Indiana and Missouri farms generated the most profits with and without PST adoption. The Nebraska farm earned the lowest returns without PST but was among the most profitable farms with PST adoption. The second and third issues raised here indicate that the financial impact of pork biotechnology adoption is not uniform across regional farms. This could be caused by the fact that these farms have different technological and production capabilities. Whatever the cause may be, these results imply that PST adoption is expected to increase competition among hog farmers. The use of PST may lead to overproduction thereby causing market prices to fall and, perhaps, squeezing profits. Fourth, despite the uneveness of the financial impacts of PST adoption among regional farms, the economic impact of biotechnology seems to benefit all the farms evaluated. The simulation results show that all the farms experienced a substantial increase in returns. These results, however, depend largely on consumer acceptance of meat products produced with growth promotants. This study has focused only on the farm-level costs and benefits of PST adoption. There is also a need to evaluate the corresponding consumer gains and losses due to PST adoption.

ACKNOWLEDGEMENTS

The authors acknowledge the research assistance of Vinay Varma, Budy Resosudarmo and J. Richard Bacon.

REFERENCES

Lemieux, C. and J. Richardson. 1989. Economic Impacts of Technology Adoption: The Case of PST. *North Central Journal of Agricultural Economics.* **11**:171-181.

Meisinger, D. 1989. Potential Economic Impact of Carcass Modifiers. *Journal of Animal Science.* **67**: 2150-2154.

Richardson, J. and C. Nixon. 1986. Description of FLIPSIM V: A General Firm Level Policy Simulation Model. Texas Agricultural Experiment Station Bulletin no. B-1528, Department of Agricultural Economics, Texas A&M University, College Station, Texas.

WEFA Group. 1991. U.S. Agriculture and World Trade: Executive Summary. Bala Cynwyd, PA.

AUTHOR BIOGRAPHIES

Conrado M. Gempesaw, II is an associate professor in the Department of Food and Resource Economics at the University of Delaware. His research interests are in agricultural finance and production economics. He is a member of the American Agricultural Economics Association.

Catherine K. Halbrendt is an associate professor in the Department of Food and Resource Economics at the University of Delaware. Her research interests are in international trade and biotechnology. She is a member of the American Agricultural Economics Association.