# Using a Computer Simulation Model to Teach the Interaction Between Production and Economics in Pork Production

**Raymond E. Massey and Duane E. Reese**

## Abstract

PORKSIM is an interactive computer model of pork production. It has been used for 3 years in an animal science lab to help students understand the interrelationships between production and economics. The components of PORKSIM and how it is used in the lab are described. The results of a student evaluation are provided to show that the laboratory use of PORKSIM was effective in helping students learn concepts and critically evaluate management decisions.

## Incorporating Computers

The importance of agricultural students to be familiar with computer applications and business knowledge is rising. Increasing numbers of departments of plant and animal science are encouraging their majors to take more business and economics courses.

Bekkum and Miller (1994) report the results of a 1989 survey of deans of academic programs in schools and colleges of agriculture. One of the 5 priority computing needs identified in the responses from the deans was the incorporation of computers into the curriculum. Over 60% of the deans reported that computerized agricultural applications were currently included in their curriculums.

Buchanan et al. (1994) indicate that Oklahoma State University animal science majors choosing the business option increased from approximately 10% to 30% after a curriculum revision in their department. Their revised curriculum encourages more hours in agricultural al economics and computers.

Students graduating in the areas of production science must be able to understand the impact of market forces on management decisions and, likewise, the impact of managerial decisions on firm profitability. Simply learning business and economic theory is not the ambition of these students. Their objective is an integrated systems analysis which allows them to consider market forces o n their particular production discipline. Understanding the interrelationships between production processes, management decisions an d economic forces fosters not only efficient production but sustainable, profitable production.

Often, the major difficulty with teaching systems is the complexity of the system. The plethora of interactions between pro and economics makes most systems unwieldy and conceptually taxing. Even if the systems interactions are known, assigning a student to mathematically examine a particular decision can be time consuming. A single error at the beginning of the analysis, carried through to the end, results in an incorrect analysis and frustrating experience for the student.

Every model of a system necessarily simplifies the relationships of the true processes (Naylor, 1987). The key to effective teaching models of systems is to identify and incorporate the critical factors necessary to provide a challenging and realistic learning experience.

Computer models which incorporate many of the physical and economic relationships of production can aid in the teaching of system by enabling students to analyze the system rather than process the mathematics. Benefits of simulation in educational experiences include: 1) decreasing the time necessary to work through the math and 2) results not initially thought of by the student appear . These two benefits combine to permit the student increased time available to think through the relationships within the system an d to evaluate why the unexpected happened.

## Production System

Pork production involves a complex interaction of physical processes, management decisions and external forces. Historically pork production courses focused almost entirely on the physical processes of reproduction, feeding, housing, etc. Though time was devoted to management aspects of production these were typically centered on physical standards such as number of pigs weaned per litter and feed conversion. Economics was outside the domain of the instructor and left to other courses the student was expected to take.

As production became more sophisticated, increased attention to management of facilities and production systems became critical. Fitting the animal to the facilities and the diet to the desired slaughter characteristics are examples of how management was addressed. Improved feed efficiency was assumed to yield potentially greater profitability but how

Massey is assistant professor, Agricultural Economics and Reese is associate professor, Animal Science, University of Nebraska-Lincoln, NE 68583-0714

much could be paid to gain increased efficiency while obtaining increased profits might not have been addressed.

As profit margins narrowed, the importance of market forces compelled producers and instructors to critically look at the interrelationship between production and profit. A major difficulty existed in the fact that the external market forces were constantly moving. As market hog prices were decreasing, feed prices might be increasing. A producer's response to a situation at one time may not be the right response to a similar situation at another time. As genetics, markets and inputs change so must the optimizing decision of the manager.

## PORKSIM: The Simulation Model

PORKSIM is a spreadsheet template which simulates the production, marketing and managerial interactions of farrow-to-finish pork production (Massey and Williams, 1992). It was peer-reviewed prior to its publication as a computer program.

PORKSIM consists of seven tables which detail the major aspects of pork production (Table 1). The user can enter descriptive assumptions regarding production, marketing and financial aspects of the system under study.

All of the tables are interrelated so that a change in one works through the entire pork production system. For example, a change in number of pigs weaned per sow per litter (PORKSIM 1 input) has an immediate effect on the number of pigs weaned per sow per year (PORKSIM 1 output), the number of pigs marketed per year (PORKSIM 2 output), amount of feed fed and the total cost of production (PORKSIM 3 output).

PORKSIM 1 through 3 each occupy one screen on the computer monitor and has the returns above all costs (profit) at the top. By changing one or more of the descriptive assumptions on the input (left) side of these tables, the returns above all costs will show the resulting impact on profitability. In this manner the user can quickly view the impact of various management and marketing decisions.

PORKSIM 1 requires input concerning conception rates, litter size, death loss and breeding herd management. Breeding herd management includes such things as breeding on first or second heat after weaning, purchasing or raising replacement gilts and number of boars used. Primary output observable in PORKSIM 1 concerns breeding performance of the modeled swine herd.

PORKSIM 2 requires input concerning desired feed efficiency, mortality rate from weaning to market, weight of animals sold and /or purchased and the labor requirement per farrowing female. Results of PORKSIM 2 show the total hundredweight of feed consumed, the total number and weight of hogs markets, and the estimated total number of hours of labor required.

PORKSIM 3 is used to quantify the marketing and economic aspects of the swine enterprise. Dollar estimates of input (feed and animals bought) and product (animals sold) prices are required in the Input side. The Output side details total sales and several per hundredweight cost estimates (such as feed cost per cwt., capital costs per cwt., etc.)

**Table 1. PORKSIM tables**

1. Reproduction Input and Results
2. Production Input and Results
3. Costs and Returns
4. Investment and Operating Costs for Facilities, Machinery and Equipment
5. Enterprise Budget for a Farrow to Finish Swine Production System
6. Feed Consumption Computation
7. Facilities Use Schedule

PORKSIM 4 allows for customizing the facilities to whatever is appropriate for the lesson. Entering the purchase price and expected life of facilities allows the program to determine fixed costs such as depreciation and taxes. Complete confinement to complete dirt lot production systems can be modeled.

PORKSIM 5 through 7 provide more exhaustive output, with no opportunity for input by the user. These tables can be used to provide insight into results which are not at first obvious.

PORKSIM 5 is an enterprise budget for the entire pork production system. It lists the operating and fixed costs and revenue, by various categories. The specific amount spent on inputs such as feed and labor can be quickly known with this table. The Return s Above Total Operating Costs and the Returns Above All Costs Except Overhead, Risk and Management are provided to give an idea of t he amount of return above certain costs for an individual year. The returns do not take into account income taxes which must be paid.

PORKSIM 6 details the feed usage for specific animal groupings and the amount of specific feed ingredients in the feed. The feed usage is a function of the "desired" overall feed efficiency entered in PORKSIM 2. The feed to the breeding herd is based on the pounds of feed fed per day and days on feed. The residual amount of feed required to achieve the desire overall feed efficiency is allocated to starter, grower, and finishing rations.

PORKSIM 7 estimates the facilities usage and days individual groups of animals will be in specific stages of the production cycle. Formulas required to derive days in PORKSIM 7 are based on the Pork Industry Handbook Circular PIH-113, Calculating Swine Schedules (Jones et al.). The facilities use schedule can be used to alert the user when the number of sows farrowing at one time exceeds t he number of farrowing crates. The user then is faced with the decision to decrease the number of sows, decrease the time each animal occupies a farrowing crate or to purchase additional crates until the facilities are not over-utilized.

Table 2. Student evaluations of PORKSIM. (N=17)

**PORKSIM Ease of Use**

1. Changing input values was:
   a. Very Simple 24%
   b. Simple ..... 53%
   c. Difficult ..... 24%
   d. Very Difficult ..... 0%
2. Viewing the results of a change was:
   a. Very Simple ..... 24%
   b. Simple ..... 65%
   c. Difficult ..... 12%
   d. Very Difficult ..... 0%
3. Moving through the program was:
   a. Very Simple ..... 6%
   b. Simple ..... 65%
   c. Difficult ..... 29%
   d. Very Difficult ..... 0%

**Realism of PORKSIM**

4. PORKSIM appeared to realistically model modern pork production practices.
   a. Strongly Agree ..... 0%
   b. Agree ..... 41%
   c. Mildly Agree ..... 41%
   d. Mildly Disagree ..... 12%
   e. Disagree ..... 6%
   f. Strongly Disagree ..... 0%
5. PORKSIM effectively linked production practices with economics.
   a. Strongly Agree ..... 6%
   b. Agree ..... 29%
   c. Mildly Agree ..... 41%
   d. Mildly Disagree ..... 18%
   e. Disagree ..... 6%
   f. Strongly Disagree ..... 0%

**Teaching Effectiveness of PORKSIM**

7. PORKSIM helped me to think through the exercise.
   a. Strongly Agree ..... 0%
   b. Agree ..... 35%
   c. Mildly Agree ..... 24%
   d. Mildly Disagree ..... 35%
   e. Disagree ..... 6%
   f. Strongly Disagree ..... 0%
8. PORKSIM did so much of the work that I was not forced to think though the exercise.
   a. Strongly Agree ..... 0%
   b. Agree ..... 0%
   c. Mildly Agree ..... 6%
   d. Mildly Disagree ..... 59%
   e. Disagree ..... 24%
   f. Strongly Disagree ..... 12%
10. PORKSIM improved the teaching impact of this lesson over what it would have been if done on paper.
    a. Strongly Agree ..... 12%
    b. Agree ..... 24%
    c. Mildly Agree ..... 35%
    d. Mildly Disagree ..... 12%
    e. Disagree ..... 12%
    f. Strongly Disagree ..... 6%
11. PORKSIM allowed me to spend more time concentrating on the objectives of the lesson and less time on the mathematical calculations involved in the lesson.
    a. Strongly Agree ..... 12%
    b. Agree ..... 41%
    c. Mildly Agree ..... 24%
    d. Mildly Disagree ..... 6%
    e. Disagree ..... 12%
    f. Strongly Disagree ..... 6%

## The Systems Experience

PORKSIM has been was used to teach students in a senior pork production class. The objective of the lesson was to give the students an opportunity to consider pork production from a systems approach. The interaction of various aspects of production and management on profitability were explored. Conversely, the impact of market prices on management decisions was examined.

The lab assignment consisted of four parts, each presenting a different managerial problem (Reese, 1993). The problems addressed were 1) factors affecting of nonproductive sow days; 2) facility utilization; 3) feed efficiency and feed costs per pound of gain; and 4) low hog prices. The students were given a base line model which they modified to observe the effect of different management decisions. After each problem the computer model was returned to its base line assumptions and the next problem was addressed.

As an example of how PORKSIM was used to assist the students, Part 1 of the lab assignment will be discussed. The stated objective was: "to discover what factors affect nonproductive sow days (NPSD)." NPSD was defined in equation form so that the students understood that gestation length, lactation length and litters per sow per year were the critical concerns. The assignment was to "demonstrate two methods of increasing NPSD by changing information in PORKSIM 1. Describe below the two methods you used, and record the returns/cwt above all costs for each method. Also explain what you have learned about ways to decrease NPSD and its relationship t o profitability."

The students could easily increase lactation length (age at weaning) in the program and see the effect on profitability. They could also decrease the number of litters per sow per year by changing any one of several management decisions (i.e. breed first o r second heat) to determine its impact on profitability.

In an effort to promote critical thinking skills, the students were instructed to view the other tables in the program to see the effect of their decisions on other areas such as scheduling and number of animals sold. While viewing these tables it often occurred that one of their decisions had affected another part of the production process in a way they had not anticipated. For example, the production schedule in PORKSIM 7 often revealed scheduling difficulties. This gave the students the opportunity to see that compromises occur in making management decisions and then to manipulate the model until a feasible solution was reached.

## Student Evaluations

PORKSIM and the lesson plan have been used for three consecutive years. In the third year (1993), the students were asked to complete a written evaluation of the usefulness of PORKSIM as a lab simulation model. The students were asked to evaluate the ease of using PORKSIM, the realism of PORKSIM in modeling the interrelationships of pork production and the effectiveness of PORKSIM a s a teaching tool. The responses of 17 of the 20 students enrolled in the class are summarized in Table 1.

Seventy seven percent of the students said the program was simple or very simple to change input values. Viewing the result s of a change was rated as easier with 89% saying it was simple or very simple. Moving from one table to another within the program was the least simple aspect of the program. Though 71% considered it simple or very simple, only 6% rated it very simple (compared to 24% for each of the first two questions). PORKSIM has been modified to make movement within the program simpler.

Eighty two percent of the students felt that PORKSIM realistically modeled modern pork production systems which they had al ready studied in class. This indicates that the production assumptions adequately model production processes, which the students we re probably most qualified to evaluate. Though the students were not business majors, 76% thought that the linkage between production and economics was realistic.

Of particular interest in this evaluation was the response of the students to the teaching efficiency of PORKSIM. Fifty nine percent of the students thought that PORKSIM helped them think through the exercise. Conversely, few (6%) thought that PORKSIM did so much of the work that they did not have to critically think. The effectiveness of the lessons were enhanced by using PORKSIM (71% strongly to mildly agreeing). The major reasons students cited for the effectiveness of PORKSIM was that it helped them see the connection between production decisions and economic consequences, it allowed the student to spend more time concentrating on the lesson objectives and less on the mathematical calculations and it displayed a change that they might have overlooked if they had no t used the program.

## Conclusions

The aid of computer models enhances the effectiveness of introducing systems analysis into production classes. Complex interrelationships can be observed and manipulated without undue concentration on the exact parameters of the relationships. The import ant lesson of whether one parameter negatively or positively impacts another parameter is reinforced by quick responses to change. The relative strength of the impact is revealed by the model rather than tediously processed by the student and a hand calculator.

PORKSIM is a useful tool in teaching a more complete pork production system. Its modeling of production, management and marketing allows students to experiment with different situations and managerial responses to those situations. Its flexibility in modeling different farrow-to-finish production systems allows it to be used in a variety of learning experiences.

As further integration of business and economics concepts into production courses occurs, computer models such as PORKSIM will fill an important spot. Fully understanding the marketing and economics of agricultural production will continue to be the domain of the agricultural economics/business departments. However, an understanding of the major interrelationships between production, economics and marketing is critical to students' education and facilitated by computer models.

## References


Bekkum, Victor A. and W. Wade Miller. Computer Proficiency for Undergraduate Students in Agriculture. *NACTA Journal*. 38:43-4 6, June, 1994.

Buchanan, David S., Charles A. Hibberd, J. Robert Kropp and W. Stephen Damron. Revision of the Animal Science Curriculum: Responding to Students, Industry Changes and Evolving University Guidelines. *NACTA Journal*. 38:9-14, June, 1994.

Massey, Raymond E. and Joseph E. Williams. PORKSIM: An Interactive Simulation Model of Pork Production. Oklahoma State University Ag. Exp. St. *Computer Software Series CSS-56*. Feb. 1992.

Naylor, T. H. *Computer Simulation Experiments with Models of Economic Systems*. New York: John Wiley and Sons, Inc. 1987.

Reese, Duane. Pork Management Systems Analysis. UNL Animal Science Swine Management Lab Exercise. Fall Semester, 1993.

Jones, Don D., L. Bynum Driggers, David B. Gerber, Kent A. Law and Ron Plain. *Calculating Swine Schedules. Pork Industry Handbook* PIH-113.