Factors Driving Sow Breeding Operations to Become Large

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Abstract

This study examines influences of economic and non-economic variables on sizes of U.S. sow breeding operations. Using a probit model and national survey data of U.S. hog operations, our findings indicate that location, facilities, specialization, breeding practices, and risk influence producers' decisions to choose breeding operations with 500 or more sows.

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Traditional farrow-to-finish operations of the 1960's and 1970's once located across the country, have given way to newer, more specialized, more geographically concentrated operations since the 1980's. On these specialized operations, time and energy is increasingly devoted to one phase of the hog production process. Within the past two decades, there have been noticeable changes in U.S. breeding herd operation size. From 1991 to 2003, the number of hogs kept for breeding declined by 21 percent, while the number of breeding sows per hog operation increased by more than 100 percent (NASS, selected years). Operations with more than 5,000 head produced higher annual litter rates than operations with less than 5,000 head (NASS, 2002). McBride and Key (2003) attribute this "improvement" in average litters farrowed per sow to "technical change in hog production, which includes improved genetics, nutrition, housing and handling equipment, veterinary and medical services, and management that improves the performance of hogs and the efficiency of the operation."

Changes have also been seen in the U.S. hog cycle. Normally measured as 3 1/2 to 4 years (Hayenga et al., 1985), lately the hog cycle has become shorter in length and also less volatile, as illustrated by the inventory data shown in figure 1 (NASS, 2002). The biological hog cycle covers the length of time it takes for the inventory of hogs to change, from breeding, gestation, farrowing, weaning, grow-out, and finally to slaughter. Because biology limits farmers' ability to quickly change production, there is a lag in inventory changes due to external factors such as price expectations, creating the cycling effect.

In addition to the changes in hog cycles, there have also been changes in pigs produced per sow per year and pigs per litter. The average number of pigs per year per breeding herd animal increased by 57 percent from 1979 to 2001, while the average pigs per litter increased by 29 percent (NASS, 2002). The higher a sow's ovulation rate, the more pigs she could possibly farrow. Large breeding operations are able to marginally improve litter rates by using sows that have higher ovulation rates and histories of farrowing large litter sizes as replacements for less productive sows (Christenson, 2003). Research has shown that substantial increases in litter size can be obtained through simultaneous improvements in both ovulation rate and uterine capacity (Christenson and Leymaster, 2002). The question of what are some of the factors contributing toward the increase in the size of sow operations in the United States is the foundation of the study reported here.

Although there are no known studies that examine factors influencing the size of sow breeding operations, several authors have used farm size or operation size as exogenous variables in theoretical models. In examining the relationships between farm size, specialization, and financial condition, Purdy et al. (1997) found that farms may capture product-specific economies of size by specializing. Key and McBride (2003) found that factor of productivity, particularly feed, labor, capital, and other inputs are all influenced by the size of operation. In a more recent study by Gillespie et al., (2004), the number of sows on an operation was used to examine the influence of farm size on technology adoption. It was found that the adoption of intensive breeding programs was positively influenced by the size of breeding operations. In contrast to these studies, our research examines the size of sow breeding operations as the dependent variable, and not as an exogenous, independent regressor.

The objective of this study is to uncover some of the factors influencing producers' choice of the size of breeding operations, particularly operations with less than 499 sows and operations with 500 or more sows. Some of the factors examined in this study include specialized hog operations, risk, farm demographics, breeding practices, and socioeconomic characteristics.

The remainder of the article is structured as follows. A description of the data is given along with a discussion of the econometric model. Exogenous variables are then be discussed along with their expected signs, followed by the results. The final section is a discussed along of the results and conclusions.

Data and Methodology

In 2000, surveys were mailed to 4,986 U.S. hog producers. A stratified random sample of hog producers subscribing to National Hog Farmer magazine generated the sample. Dillman (1978) was used as a guide in conducting the survey. Weighting variables were used to account for sample stratification as specified in Greene (2002). Information collected from the questionnaire included farm and financial characteristics, transaction costs, farmer attitudes toward risk, autonomy, and social capital. Twenty-one percent of the surveys were returned (1,031 surveys).

Respondents to the survey were asked, "Do you have breeding sows in your operation? If yes, approximately how many?" This dependent variable was separated into two size categories, operations with 499 sows or less (SIZE 2) and operations with 500 or more sows (SIZE 1).

A binomial probit analysis was used to determine the size of sow breeding operation most likely to display characteristics described by certain exogenous variables. The probit model follows a normal distribution and can be expressed as (Greene):

$$\Pr(Y = 1) = \int_{-\infty}^{\beta'\chi} \phi(t)dt = \Phi(\beta'\chi). \tag{1}$$

A weighted average and marginal probabilities were calculated for the choice of alternative sow breeding operation (see Greene, 1997 and 2000 for specific details). Now that we have identified the model, what are some of the potential factors influencing producers' decisions to choose one size breeding operation over another?

Expected Signs of Exogenous Variables

Specialized operation is a discrete (0, 1) variable identifying farms with only sow breeding (farrow-to-wean) operations. Growth in the average size of hog operations has been more pronounced among specialized operations (McBride and Key, 2003). Most of the specialized operations are larger than the average hog operation and are involved in some type of production or marketing contract. It is expected that producers who run farrow-to-weaning operations will be more likely to run operations with 500 or more sows.

Labor quality is a continuous variable that measures a producer's perception of the quality of labor used in the hog operations. Producers were asked to rate their labor from 1 to 10, 1 being low quality and 10 being high quality. It is hypothesized that those who rated their labor quality higher will choose breeding operations with 500 or more sows.

In-door facility is a discrete variable that indicates whether the producer raises breeding sows in a confined facility. It is hypothesized that producers who used in-door facilities are likely to choose breeding operations with 500 or more sows.

The variable *risk prone* is an indicator of a producer's feeling toward risk. This risk assessment is the result of the following question: "Relative to other investors, how would you characterize yourself? Possible answers include: "I tend to take on substantial levels of risk in my investment decisions, I tend to avoid risk when possible in my investment decisions, and I neither seek nor avoid risk in my investment decisions." For this study, we were interested in knowing whether the producer tends to take on substantial level of risk in investment decisions. It is hypothesized that the risk prone producers would choose breeding operations with 500 or more sows.

Two geographical variables were defined: *Iowa* and *Delta States* (Arkansas, Louisiana, and Mississippi). Although Iowa is the largest hog producing state, we thought it would be interesting to analyze. It is expected that sow breeding operations in Iowa will likely be those that have 499 or less breeding sows. Hog production in the Delta States has increased significantly in recent years. The growth of hog production in this region has been partly attributed to producers' willingness to accept contracts since there were relatively few independents who would view its introduction as a threat to autonomy, given the few alternative markets for hogs. Thus, it is expected that the Delta States producers will likely choose breeding operations with 500 or more sows.

Intensive breeding and *artificial insemination* are discrete variables that represent two of the many breeding practices available to hog farmers. Intensive breeding increases the number of sows bred and the number of times the sows are bred, while artificial insemination enables producers to control the breeding of animals. We hypothesized that producers adopting intensive breeding and artificial insemination practices will likely choose breeding operations with 500 or more sows.

It is expected that younger (*age*) or beginning producers will likely choose a 500 or more sow breeding operation. Older producers will less likely concern themselves with expanding production and are likely to be producers who run operations with 499 or less breeding sows due to their tendency to adjust and downsize their production and management responsibilities in preparation to exit the industry. Boehlje (1992) identifies this point as the third stage in the family life cycle, where producers exit and intergenerational transfer of property takes place.

The final variable, *Bachelor's Degree* is an indicator of educational background. Producers who completed a 4 or more year college program are hypothesized to choose operations that have 500 or more sows.

Empirical Results

Of the 1,031 complete surveys returned, only 944 were usable. A total of 531 of the 944 observations raised breeding sows. Approximately 16 percent of the 531 observations had 500 or more sows, while 84 percent had less than 500 sows. The means and standard deviations associated with the exogenous variables are shown in Table 1. Binomial probit results are shown in Table 2. In the binomial probit analysis, all of the variables were significant at the 10% or 5% level with the exception of Bachelor's

Degree, age of the producer, and quality of labor used in production. No serious multicollinearity problems were found based on the Pearson Correlation coefficient. However, heteroskedasticity was found and was corrected using a model with Multiplicative Heteroskedasticity. The percentage correctly predicted by the probit analysis was 86.8, while the McFadden's likelihood ratio index (or Pseudo R^2) was 0.6156.

Respondents involved in a specialized farraow-to-wean operation were associated with an increased probability of choosing breeding operations with 500 or more (SIZE 1) sows relative to operations with 499 sows or less (SIZE 2). Raising animals indoors in a weather controlled environment was associated with an increased probability of choosing SIZE 1 sow breeding operations relative to SIZE 2. These results show that producers who specialized in sow breeding and use controlled environment facilities were more likely to choose larger breeding operations.

Using artificial insemination to impregnate animals was associated with an increased probability of choosing SIZE 1 breeding operations relative to SIZE 2. Producers who employed an intensive breeding program had a greater likelihood of becoming SIZE 1 breeding operations. The more breeding technology incorporated into the farm production, the more likely it was a SIZE 1 breeding operation. This is consistent with results of Gillespie et al.

Delta States producers were more likely to choose SIZE 1 breeding operations, while producers in Iowa were likely to choose a SIZE 2 breeding operation. As expected, having a risk prone attitude toward investment decisions was associated with an increased probability of choosing a SIZE 1 breeding operation.

Conclusions

Results of this study lend insight to the different characteristics that describe large and small breeding operations. As greater specialization and concentration continue in the U.S. hog industry, findings from this study provide illumination to the impacts that production facilities, risk, breeding practices, and production locations have on its breeding sow operations.

Producers who have production sites in the Delta States were more likely to run breeding operations with 500 or more sows. External factors such as the costs land and labor and emerging vertically coordinated firms may be partially responsible for this finding. These producers are also more apt to use artificial insemination, and adopt an intensive breeding program. In addition, large breeding operations are more likely to adopt indoors climate controlled facilities and thus reduce mortality rates and chances of disease outbreaks. Research shows that some of the major changes in the past two decades that have helped propel the hog industry to its new level have been technological innovations, particularly breeding and genetics, reproductive management, nutrition, health, housing, and environmental management (Boehlje, 1992).

Results also reveal that Iowa producers were less likely to run breeding operations with 500 or more sows. Possible reason for this finding may stem from Iowa rich feed supply and comparative advantage of finishing animals.

Although age, college education, and labor quality were not significant in this binary choice model, other related studies have sighted the importance of one or more of these variables (Davis, 2002; Gillespie and Eidman, 1998, and Gillespie et al., 2004).

Previous research has also shown the producer's choice of business arrangement to be influenced by the size of an operation (Davis and Gillespie, 2004). Thus, in addition to the variables discussed in this study, it may be inferred that the growth of U.S. sow breeding operations may depend on producers' willingness to adopt a business arrangement or strategic alliance that reduces price risks and transaction costs.

References

Boehlje, Michael. "Alternative Models of Structural Change in Agriculture and Related Industries." Agribusiness: An International Journal. 8 (1992): 219-231.

Christenson, Ron K. Personal Communication. United States Department of Agriculture, Agricultural Research Service, U.S. Meat Animal Research Center, Clay Center, Nebraska, April 2003.

Christenson, Ron K. and K.A. Leymaster. (2002) "Correlated Responses in Gravid Uterine, Farrowing and Weaning Traits to Selection of Pigs for Ovulation Rate or Uterine Capacity. United States Department of Agriculture, Agricultural Research Service, U.S. Meat Animal Research Center, Clay Center, Nebraska.

Davis, Christopher, G. AFactors Affecting the Selection of Business Arrangements by Hog Farmers in the United States.@ Unpublished Ph.D. dissertation, Louisiana State University, July 2002.

Davis, Christopher, G., and Jeffrey M. Gillespie. "Factors Affecting the Selection of Business Arrangements by United States Hog Producers". Unpublished Staff paper, December 2004.

Dillman, D.A. "Mail and Telephone Surveys: The Total Design Method." New York:

Wiley, 1978.

Gillespie, Jeffrey M., Christopher G. Davis, Noro C. Rahelizatovo. "Breeding Technology Adoption in Hog Production." Journal of Agricultural and Applied Economics. 36 (April 2004): 35-47.

Gillespie, Jeffrey M. and Vernon R. Eidman. "The Effect of Risk and Autonomy on Independent Hog Producers' Contracting Decisions." Journal of Agricultural and Applied Economics. 30 (July 1998): 175-188.

Greene, William. Econometric Analysis. Third & Fourth Edition. Prentice-Hall, Inc. 1997 & 2000.

Hayenga, Marvin, V. James Rhodes, Jon A. Brandt and Ronald E. Deiter. The U.S. Pork Sector: Changing Structure and Organization. Iowa State University Press, Ames. First Edition, 1985.

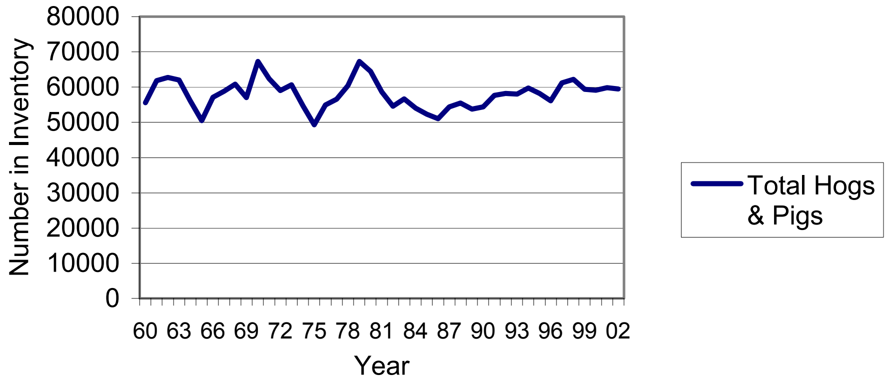
McBride, W.D., and Nigel Key. 2003. "Economics and Structural Relationships in U.S. Hog Production." AER No. 818. U.S. Department of Agriculture. Economics Research Service. February.

Purdy, Barry M., Michael R. Langemeier, and Allen M. Featherstone. "Financial Performance, Risk, and Specialization." Journal of Agricultural and Applied Economics. 29 (July 1997): 149-161.

U.S. Department of Agriculture. Agricultural Statistics 1965 - 2004. National Agricultural Statistics Service. U.S. Government Printing Office, Washington: 1965- 2004.

U.S. Department of Agriculture. National Agricultural Statistics Service. 2002. "U.S. Hog Breeding Herd Structure." September.

Figure 1: The U.S. Hogs and Pigs Cycle, 1960 - 2002



Source: NASS, Agricultural Statistics 1961 - 2002.

Table 1: Exogenous Variables Mean and Standard Deviation Estimates.

Variable	Measurement	Mean	Standard Deviation
Labor Quality	Continuous	5.78	2.90
Specialized Operation	(0-1)	0.02	0.13
Production in Delta States	(0-1)	0.01	0.10
Production in Iowa	(0-1)	0.32	0.47
Artificial Insemination	(0-1)	0.28	0.45
Intensive Breeding	(0-1)	0.28	0.45
In-door Facility	(0-1)	0.60	0.49
Investment Risk	(0-1)	0.23	0.42
Producer’s Age	Continuous	47.03	12.76
Bachelor’s Degree	(0-1)	0.26	0.44

Table 2: Probit analysis results of sow breeding operations.

Variable	Coefficient	Standard Error
Constant	-0.437**	0.046
Farm Characteristics		
SPECIALIZED OPERATION	0.101**	0.029
IN-DOOR FACILITY	0.130**	0.030
Effects of risk and producer practices on choice of operation size		
INVESTMENT RISK	0.305**	0.149
LABOR QUALITY	0.000	0.000
INTENSIVE BREEDING	0.153**	0.031
ARTIFICAL INSEMINATION	0.106**	0.028
Effects of location on choice of operation size		
IOWA	-0.053*	0.029
DELTA STATES	0.178**	0.065
Effects of personal characteristics on choice of operation size		
PRODUCER'S AGE	-0.000	0.000
BACHELOR'S DEGREE	0.027	0.025

** indicates significance at the 0.05 level. * indicates significance at the 0.10 level.
% Correctly Predicted: 86.8; McFadden's likelihood ratio index: 0.6156; Chi-Squared = 198.48**