Optimal Operation Scale of Hog Production for Farrow-to-Finish Farms

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ABSTRACT : This study analyzed the lowest production cost and the greatest profit to be obtained from marketing hogs to determine the optimal operation scale for family-owned farrow-to-finish farms. Data were collected from 39 farrow-to-finish farms with 500 to 5,000 inventories for two consecutive years, and treated with GLM and quadratic regression models using the REG procedure. Analysis results indicated that farms capable of marketing 2,933 and 3,286 hogs annually had the lowest production cost and the greatest profit, respectively. Further analysis attributed the lowest production cost or the highest return in farms with an optimal scale of 3,000 to a higher survival rate of the herd, as well as lower expenses in veterinary medicine, labor, utilities and fuel, transportation, and depreciation. A similar feed conversion efficiency was observed for all the farms studied. Obviously, the cost efficiencies were associated with the economy of the operation scale of hog production until it reached 3,000 hogs marketed annually for a family-run unit. Beyond the optimal scale of 3,000 hogs, good stockmanship was more difficult to maintain and the herd management deteriorated as increasing mortality confirms. It is conclude that, unless advanced management is applied, the operation scale should not expand beyond 3,000 hogs. ***(Asian-Aust. J. Anim. Sci. 2001. Vol 14, No. 9 : 1326-1330)***

Key Words : Farrow-to-Finish Operation, Production Cost, Economic Scale

INTRODUCTION

Hog production has evolved from relatively small, family-run operations to large-scale operations. Indeed, farrow-to-finish operations have increased in size globally due to cost efficiencies associated with economies of scale (Rhodes, 1995; Windhorst, 1998). Further improving production efficiency involves not only adopting advanced manufacturing, production and distribution methods, but also applying these methods as accompanied by changes in vertical coordination (Den Ouden et al., 1996). Vertical coordination includes contracting with producers for a particular product and integration, and large company producers establish production contracts with smaller growers to feed the hogs to market weight. Contracting and vertical integration, in addition to consolidation, can therefore create barriers to entry and reduce the amount and accuracy of publicly available market information, possibly distorting the manufacturing and marketing decisions of smaller, independent producers. In addition, structural changes towards vertical coordination associated with new technology and improved production efficiency causes an increase in the size of company producers and threatens the survival of individual farms striving for independence.

Facing integration and consolidation, small or family owned farrow-to-finish farms seek contracts with large Company producers to provide the labor and facilities and receive a fixed payment adjusted for production efficiency. Otherwise, they become more competitive by applying modern technology, management practices and expanded operations on a more economic scale. The extent to which economy of scale is manageable and remains competitive is uncertain and may vary with regional economic climate. Van Arsdall and Nelson (1985) suggested that at least 3,000 hogs marketed, or 200 sows, should be attained annually. An economic scale of 200 sows inventory in one region may not be applicable to other areas due to differences in technological availability and other economical and social determinants. Nevertheless, it provides a valuable reference for farmers in other areas who are competing in a global market under a free trade policy.

This study presents a novel approach to determine an optimal operation size for individual hog farms. In addition to examining how the operating scale of farrow-to-finish and production cost and profit are related, this study also derives the optimal inventory for a farrow-to-finish farm. Results presented herein should provide a valuable reference for private and small producers when planning their management practices.

MATERIALS AND METHODS

Thirty-nine farrow-to-finish units with an overall operation scale of 500 to 5,000 inventory were studied. The farms were family based, full-time producers with a minimum number of employees. Their hogs were sent to market when reaching 100 to 110 kg. Farmers in this study were instructed to fill out a questionnaire designed to reveal their monthly production efficiency, cost, and income. Consecutive recordings were taken for 12 months to ensure reliability and consistency of information supply. Data used for analysis herein are taken from those farmers who

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consistently recorded data for 24 consecutive months. Producers reported their information, including production figures, management cost, and income related to hog raising. Table 1 lists the detailed items on the questionnaire. Data recording initial value of assets included breeding stocks, buildings, machinery (feeding, washing and sanitary) as well as waste treatment equipment, in addition to other utensils such as air conditioners and refrigerators. Breeding stock were valued at US$ 650/boar and US$ 325/sow. Other investment costs were recorded according to its actual expense upon purchase.

The collected data were treated and fitted by the General Linear Model (GLM) to demonstrate production efficiency, production cost, income, and profit per 100 kg of pig liveweight. The extent to which operation scale affected performance, production cost, variable cost, fixed cost, and profit per 100 kg liveweight was analyzed by a quadratic regression model using the REG procedure of SAS statistical software (SAS, 1996). Mean values were compared with the Least Square Means test. The study applied following statistical models.

Table 1. Contents of monthly management data of surveyed pig farms

Production	Management	Income
Inventory	Initial assets	Extension
Boar number	Livestock value	Marketing
Sow number	Building value	Culling sales
Others	Machinery value	Others
Farrowing no.	Investment in wastage treatment	
Pig born alive	Other equipment	
Litter size at weaning	Variable costs	
Extension no.	Feed	
Marketing no.	Veterinary medicine	
Culling no.	Labor*	
Death no.	Utilities and fuel	
	Transportation	
	Miscellaneous	
	Fixed costs	
	Interest	
	Depreciation**	

* Labor cost included family labor cost and hired labor cost. Family labor cost was calculated at US$ 1,290 per man monthly or US$ 806 per woman monthly. Hired labor cost was paid monthly.

** Depreciation was estimated from initial assets to include livestock value, building value, machinery value, wastage treatment, and other equipment. Livestock value was divided for three years, building value was divided for fifteen years, other investment value estimated over US$ 6,450 was divided for seven years, between US$ 3,225 to 6,450 was divided for five years, and less than US$ 3,225 was divided for three years.

Model 1

$$y_{ijk}=\mu+F_i+Y_j+\varepsilon_{ijk}$$

where y_{ijk} denotes the individual performance of i^{th} farm, j^{th} year, and k^{th} observation; μ represents the overall mean; F_i is the effect of farm; Y_j denotes the effect of year; and ε_{ijk} represents the random error of each observation.

Model 2

$$y = a + b_1x + b_2x^2 + e$$

where y denotes the value of production cost and profit per 100 kg of marketing hogs; a represents intercept; x is farm scale; b_1 and b_2 denote parameters of the regression equation, and e corresponds the random error.

RESULTS

Table 2 summarizes the production efficiency of 39 farrow-to-finish farms with inventories from 500 to 5,000 head. This table reveals that, during a two-year study period, producers experienced two different economic environments for hog raising. The early stage was favorable as the price ratio of hog income/feed was 7.5. However, the next year was discouraging as the ratio dropped to 6.0 mainly due to a 19.95% increase in feed price and 3.65% decrease in hog price. On the other hand, the parameters of production efficiency measured remained almost unchanged, including overall feed conversion ration and culling rate of sows. However, the average herd size of sows slightly increased from 147 to 154, and the overall survival rate of the herd significantly declined from 87.27% to 83.50%. In addition, the analysis of production cost in this same table revealed that feed price increased 19.95% during the second year of the study, subsequently elevating the feed portion in total production cost from 62.11% to 67.44%. This elevation, together with a 3.65% decrease in hog price, led to a 46.4% decrease in profit despite a slight drop of operating and fixed costs in the second year (table 2). This table clearly reveals that the survival rate was significantly reduced when the hog income/feed price ratio was lowered.

Figures 1A and 1B present the regressions of mean production cost and profit in a 2-year study against farm operation scales indicated by annual volume of hogs marketed, respectively. The curve fittings indicate that the expansion of the operation from 500 hogs marketed annually would progressively lower production cost until it reached a theoretical minimum value at a marketed volume of 2,933 according to the regression y (production cost)=214-47.5x+8.1x^2 ($r=0.60$, $p<0.001$). Further increasing the operation scale, however, would increase production cost (fig. 1A). Accordingly, the profit gained from raising a 100 kg hog also continuously increased from

Table 2. Analysis of production efficiency, cost and profit of 100 kg hog liveweight from farms (n=39) with operation scale from 500 to 5,000 head from 1995 and 1996

Items	Overall	Year 1995	Year 1996	SEM	△%
Breeding sows / farm	151	147	154	2	4.76*
Total pigs[(1)] / farm	1,529	1,503	1,554	25	3.39
Hogs marketed / farm / yr	2,018	2,000	2,035	32	1.75
Feed price (US$/100 kg)	28.88	26.26	31.50	0.18	19.95**
Feed conversion ratio (F/G)	3.35	3.33	3.37	0.04	1.20
Culling rate of sow (%)	36.01	34.19	37.83	1.51	10.65
Survival rate of pig (%)	85.39	87.27	83.50	0.91	-4.32**
Feed cost, US$	103.35	94.97	111.73	1.61	17.65**
% of production cost	64.56	62.11	67.44	0.50	8.58**
Variable cost, US$	135.96	128.33	143.58	2.04	11.88**
% of production cost	85.35	83.93	86.67	0.40	3.08**
Fixed cost, US$	23.33	24.57	22.09	0.77	-10.09*
% of production cost	14.65	16.07	13.33	0.40	-16.54**
Production cost[(2)], US$	159.29	152.90	165.67	2.36	8.36**
Income, US$	192.26	195.83	188.69	0.75	-3.65**
Profit, US$	32.97	42.93	23.01	2.05	-46.40**

[(1)] Excludes breeding stocks

[(2)] Production cost = Variable cost (Feed cost + operating cost) + Fixed cost.

△%: Percentage differences between two years, * $p<0.05$; ** $p<0.01$.

marketing 500 annually up to an optimal scale of 3,286, as derived from fitting regression of y (profit) = $-16+39.2x-6.0x^2$ ($r=0.65$, $p<0.001$). Moreover, the profit is lower if this margin is surpassed. Obviously, fig. 1A and fig. 1B reveal that a private farrow-to-finish unit should market its inventory around 2,500 to 3,000 heads.

Originates of the least production cost of farms with optimal scale were revealed by comparing the parameters of production efficiency and cost analysis of 8 farms with capacity to market 2,500 to 3,000 hogs to those around 1,200 (n=13) or beyond 3,500 (n=5) farms. Figure 1B illustrates these selected farms which are grouped by open squares, while table 3 summarizes the results of comparison. This table reveals that an optimal operation of 2,500 to 3,000 could obtain an averaging 13.7 hogs produced/sow/ year, i.e., higher than 12.9 and 13.2 of 1,200 and beyond 3,500, respectively. Furthermore, optimal farms exhibited a higher herd survival rate of 87.8%, as compared to 85.0% and 84.8% of 1,200 and 3,500 hogs, respectively. Notably, the three types of farms displayed similar feed efficiency and feed price paid. The >3,500 hogs farms, when compared to those of 2,500 to 3,000 scale, could market their hogs at a higher price. However, the margin was completely offset by a higher expense of veterinary medicine and labor costs (2.7 and 1.0, respectively). In addition, hogs in farms of above 3,500 shared a higher depreciation cost (US$ 2.1) and other costs, including those of utilities, and fuel, and transportation (US$ 3.8). All of these higher shares contributed to the lower profit to raise a 100 kg hog in farms of >3,500 than in the 2,500 to 3,000 inventory. On the other hand, the 1,200 scale farms market their hogs at a price similar to those of 2,500 to 3,000. However, their higher feed, labor and depreciation cost rendered the hog production less profitable than those of the 2,500 to 3,000 inventory (table 3).

DISCUSSION

The impetus for structural change in a large scale operation in hog production has been the emergence of profit opportunities associated with emerging technologies and managerial techniques in addition to consumer demand. Large-scale operations are better able to adopt capital-intensive innovations and require less labor, but need more specialized skills such as artificial insemination and computer operation. A continuing series of advance in technology and management has created of a science of hog raising in large production units operated by specialized staff. Therefore, the prospect of significant profits obtained by those who adopt new technologies and practices would impel farms to continue developing more of their own.

Lower production costs and higher profits can be obtained on a larger farm scale (Taylor et al., 1992; Sidor and Danova, 1997; Kwak et al., 1998; Huang et al., 1999; Hurley et al., 1999). Large scale operation, however, does not ensure economic success in family-run or individual-owned hog farms. Among production units studied, those beyond an optimal inventory of 2,500 to 3,000 can produce the volume and quality of hogs. However, they offered few

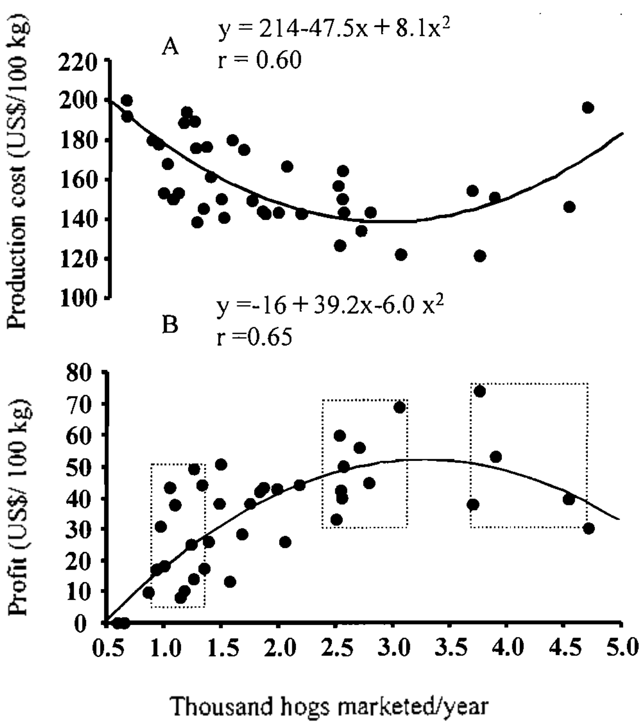

Figure 1. Curve fitting of production cost (A) and profit (B) with annual volume of hog marketed ranging from 500 to 5,000 head. Regression lines were y (production cost)= $214-47.5x+8.1x^2$ and y (profit)=$-16+39.2x-6.0x^2$. The minimum cost of production estimated from regression A was US$ 144/100 kg hog and obtained in farms marketing 2,933 hogs annually. The maximum profit generated from regression B was US$ 49/100 kg hog could obtained in farms with marketing capacity of 3,286 hogs. Farms enclosed by open squares are those selected to represent 3 different scales of 1,000 (small), 2,500 to 3,000 (optimal), and above 3,500 (oversized) for a further detailed comparison.

additional advantages since higher expenses of veterinary medicine, utilities and fuels, and transportation per hog offset the attracted premiums (table 3). There is a positive correlation is known to exist between the survival rate of pigs and profitability (Holyoake et al., 1995). The studied farms above 3,500 showed fewer hogs were produced/sow/annually and there was lower survival rate, clearly indicating poor production management. This lower efficiency appears to be attributed to poor stockmanship, suggesting that neither a non-family laborer nor the owner could operate a system as efficiently as in the optimal operation of 2,500 to 3,000 hogs. Evidently, either an inventory of 3,000 hogs is the limit scale for a family to operate or the practice applied to a smaller scale is insufficient for a hog farm larger than 3,000 hogs.

Changes in the structure of hog production have been accompanied large changes in the demand for labor numbers and skills. That is emerging technologies and managerial techniques should be associated with a structural change in an operation larger than 3,000 hogs to aspire to greater profit opportunities. Our results clearly demonstrate that stockmanship was not only less well maintained during an unfavorable environment of higher feed price (table 2) but also in an inventory more than 3,000. These also suggest that large operations should adopt the latest advances in genetics and management practices that have significantly increased the number of hogs produced per sow annually. These advances have also reduced deaths and overall feed conversion rates, in addition to raised the prices received for hogs and lowered costs for feedstuffs. Present results further indicate that efficient producers must have access to new technologies and/or management skills; otherwise, the expansion of operation scale is not profitable.

Operations expansion to a family hog farm owner means not only taking larger financial risks, but also encountering difficulties to manage the innovations either by themselves or by employed labor in an efficient manner. Further improvements should be encouraged which company producers are normally willing to provide. Hog production has been industrialized and a further concentration of ownership and control may due to the inability of individual families to operate innovations. Consequently, the largest producers generally control many production units through ownership of some and contract production in others. Production through multiple units allows a company to greatly expand.

While studying the American hog industry, Van Arsdall and Nelson (1985) concluded that farms, marketing at least 3,000 hogs annually achieved economies of size. This is probably true for individuals having access to new technologies and the ability to use market information, and for those with equal or superior access to all inputs, including capital. These success factors are more readily to company or firm producers than family-run farms.

The principal determinants of the structure of the hog production farms include not only technological innovation, but also a favorable price ratio of hog to feed, labor availability and urban encroachment. In this study, a scale of 2,500 to 3,000 hog capacity is optimal, and may not necessarily apply to other regions; however, there may be a profit limit for family farms. Technological, functional, geographical and/or economic separation generates different optimal sizes for a particular area and period. Nevertheless, this study provides a model for a similar evaluation. Such an evaluation would provide a valuable reference for farmers to decide whether to seek integration or consolidation.

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Table 3. Comparison of production efficiency on different operation farm scales from 1995 to 1996

	Operation scales						
	2,500 to 3,000	1,200			3,500 to 5,000		
Traits	Actual	Actual	*△	*△%	Actual	*△	*△%
Farms	8	13			5		
Sows	194	91			312		
Hogs marketed	2,660	1,177			4,129		
Hogs / sow	13.7	12.9			13.2		
Survival rate (%)	87.8	85.0			84.8		
Feed efficiency	3.37	3.36			3.23		
Feed prices (US$/100 kg)	27.8	29.4			28.0		
Hogs (US$/100 kg)							
Marketing prices	195.0	193.3	-1.7	-0.9	200.5	5.5	2.8
Production costs	143.3	169.2	25.9	18.1	153.7	10.4	7.3
Variable costs	124.2	141.4	17.2	13.8	132.2	8.0	6.4
Feed	98.4	106.0	7.6	7.7	98.9	0.5	0.5
Labor	13.3	21.7	8.4	63.2	14.3	1.0	7.5
Veterinary medicine	6.0	6.1	0.1	1.7	8.7	2.7	45.0
Others	6.5	7.6	1.1	16.9	10.3	3.8	58.5
Fixed costs	19.1	27.8	8.7	45.5	21.5	2.4	12.6
Interest	1.9	4.7	2.8	147.4	2.2	0.3	15.8
Depreciation	17.2	23.1	5.9	34.3	19.3	2.1	12.2
Profits	51.7	24.1	-27.6	-53.4	46.8	-4.9	-9.5

*△ and △% are differences to farms of 2,500 to 3,000 scale.

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