The economics of hog production in Arizona

THE ECONOMICS OF HOG PRODUCTION IN ARIZONA

by

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ABSTRACT

Production of hogs in Arizona has increased rapidly in recent years, with much of this growth observed during a period of extremely good prices for slaughter pork. Future increases will be dependent on favorable prices and costs of production being competitive with producers in the midwest.

The principle objective of this study was to determine the costs of producing pork in Arizona, and to examine the effects on these costs of increasing the sow herd.

Data were obtained in personal interviews with 33 farrow to finish hog operators. These data were analyzed to examine the general characteristics of the industry, and in determining the technical coefficients used in setting up synthetic models for various size farrow-to-finish hog operations.

Results of the analysis indicate reductions in costs per unit of output are available to producers as the sow herd is increased to 600 sows. Beyond this point the analysis indicates that further cost reductions do not appear, and even some diseconomies may be witnessed between the 600 and 1,000 sow operations.

In general, costs of producing pork in Arizona, although somewhat higher than for most midwest producers, are competitive. But, production increases to meet

projected demand will most likely occur as a result of improved marketing alternatives, rather than from lower costs of production.

CHAPTER I

INTRODUCTION

Production of hogs in Arizona has increased rapidly in the past ten years, with significant growth noted since 1965. United States Department of Agriculture figures show that production increases in Arizona have occurred at much faster rates than the remainder of the United State (Table 1). Total pigs produced in 1960 were 36,000 whereas in 1970 they had increased to 126,000.

Approximately 90 per cent of the total number of hogs produced are marketed, with the remainder consisting of gilts held as replacements for cull sows. Assuming market weights of 220 pounds, Arizona produced 27.72 million pounds of pork in 1970, of which 24.95 million pounds were marketed. About 70 per cent of the marketed weight is consumed (17.47 million pounds).

Based on national per capita consumption levels of about 64 pounds, Arizona is producing approximately 15 per cent of the quantity demanded (113.28 million pounds). Population projections for Arizona are 2.10 million by 1975 and 2.75 million in 1985, compared with 1.77 million in 1970.[1] Expansion of the hog industry in Arizona could

1. United States Bureau of the Census, Statistical Abstract of the United States: 1969 (90th edition), Washington, D. C., 1969.

Table 1. Comparisons of Production of Hogs in Arizona and U. S. as a Per Cent of the Previous Year, for the Years 1960-1970

Year	No. of Sows		Per Cent of Previous Year		Total Pigs Produced		Per Cent of Previous Year	
	Arizona	U.S.	Arizona	U.S.	Arizona	U.S.	Arizona	U.S.
	--(Thousands)--				--(Thousands)--			
1960	2.50	6,323			36	88,387		
1961	3.00	6,498	120.0	102.8	36	93,142	100.0	105.4
1962	3.00	6,596	100.0	101.5	35	94,318	97.2	101.3
1963	3.00	6,611	100.0	100.2	39	95,022	111.4	100.8
1964	3.00	6,118	100.0	92.5	41	88,367	105.1	93.0
1965	2.85	5,448	95.0	89.0	41	78,940	100.0	89.3
1966	3.35	6,030	117.5	110.7	53	87,563	129.3	110.9
1967	4.60	6,205	137.3	97.1	74	91,310	139.6	104.3
1968	6.00	6,399	130.4	103.1	95	94,217	128.1	103.2
1969	6.60	6,053	110.0	94.6	105	88,948	110.5	94.4
1970	7.65	7,038	115.9	116.3	126	102,319	120.0	115.0

Source: Arizona Crop and Livestock Reporting Service, Agricultural Statistics, U. S. Department of Agriculture, 1960-1970.

occur at even faster rates than in the past, if the total future demand is to be met by in-state production and if production costs are competitive with other areas.

Arizona producers, due to their relative closeness to local markets, receive a price advantage over midwest producers. In addition, reductions in cotton allotments may result in increased production of local feed for hogs, enhancing the possibility of producing hogs as an alternative to other enterprises.

Production economies may be available to Arizona producers in terms of climate. Producers in the lower elevation areas benefit from above freezing temperatures throughout the year. This reduces stress on pigs resulting from colder weather, and may provide an advantage over midwestern producers in terms of feed conversion rates during the winter months. In addition, the dry climate reduces the transfer of disease from operation to operation.

Information on production costs, conditions, and problems are needed by producers and potential investors in the industry. If expansion of present operations is to occur, information as to the existence of cost economies through size increases is desirable.

Objectives and Procedures

Information on cost economies are desirable to determine the competitiveness of Arizona hog production.

The major objective of this study is to examine the costs of production of pork in Arizona. This objective is supplemented by the following secondary objectives:

1. To examine the characteristics of the hog industry in Arizona at present.
2. To determine to what extent costs are affected as the size of an individual operation is increased.

Achievement of these objectives was dependent on data on the physical resources and management practices of various size hog operations. These data were obtained by personal interviews with hog operators throughout the state, conducted during the summer and fall of 1970. Cost data were obtained for the production period July 1969 to July 1970. These data on costs were analyzed to determine the general characteristics of the industry.

The procedure followed in evaluating the cost-size relationships was the economic engineering synthesis approach. This technique simulates production under as near optimal conditions as possible. Selected size groups were chosen and examined. Budgets were constructed using technical coefficients extracted from the better producers in the survey, supplemented by knowledge of individuals in the Animal Sciences and Agricultural Engineering Departments of The University of Arizona. Above average management and

production techniques were assumed, as it was felt these were the critical ingredients for long-run decision-making.

In order to properly analyze the costs of producing pork, it is necessary to be familiar with the theoretical cost concepts presented in the following section. Characteristics of the operations observed will be presented in Chapter II, followed by the empirical analysis of costs in Chapter III. Chapter IV provides a summary and conclusions resulting from the analysis. Detailed information involving the basic data used in setting up the final budgets is presented in Appendix A.

Theoretical Concepts Underlying Analysis of Cost Economies

Costs and Time

"Cost economies or diseconomies refer to phenomena which cause unit costs to decrease or increase respectively as size of the plant and output are expanded."[1] In examining economies to size one is interested in determining the nature of the average unit cost curves.

Economies to size may result from two alternative size adjustments. One involves changing the proportions of the factor mix, the other involves an adjustment in scale of plant. In agriculture, the relationship between these

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1. Earl O. Heady, Economies of Agricultural Production and Resource Use, Prentice-Hall, Inc., Englewood Cliffs, New Jersey, January, 1960, p. 361.

adjustments, unit production costs, and optimum size is best explored through the concepts of the short-run and the long-run.

The Short-Run. Jacob Viner defines the short-run as "a period which is long enough to permit any desired change of output technologically possible without altering the scale of plant, but which is not long enough to permit any adjustment of scale of plant."[1] The short-run is characterized by having one or more fixed resources which do not vary as output is altered.

The short-run average cost (SRAC) curve is theoretically a "U" shaped curve. Average costs per unit decline as variable factors are added to fixed factors, up to a minimum point. Beyond this point as variable factors are added in increasing proportion to the fixed factors the curve moves upward. Thus, the SRAC curve traces out the effects of adding additional variable inputs to a given set of fixed resources.

A set of hypothetical SRAC curves are shown in Figure 1. Each SRAC curve represents a given scale of plant. $SRAC_6$ and $SRAC_2$ are identical in scale of plant, but due to better efficiency in resource use firm two is

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1. Jacob Viner, "Cost Curves and Supply Curves," A. E. A. Readings in Price Theory, Vol. VI, edited by George J. Stigler and Kenneth E. Boulding; Richard D. Irwin, Inc., Homewood, Illinois, 1952, p. 202.

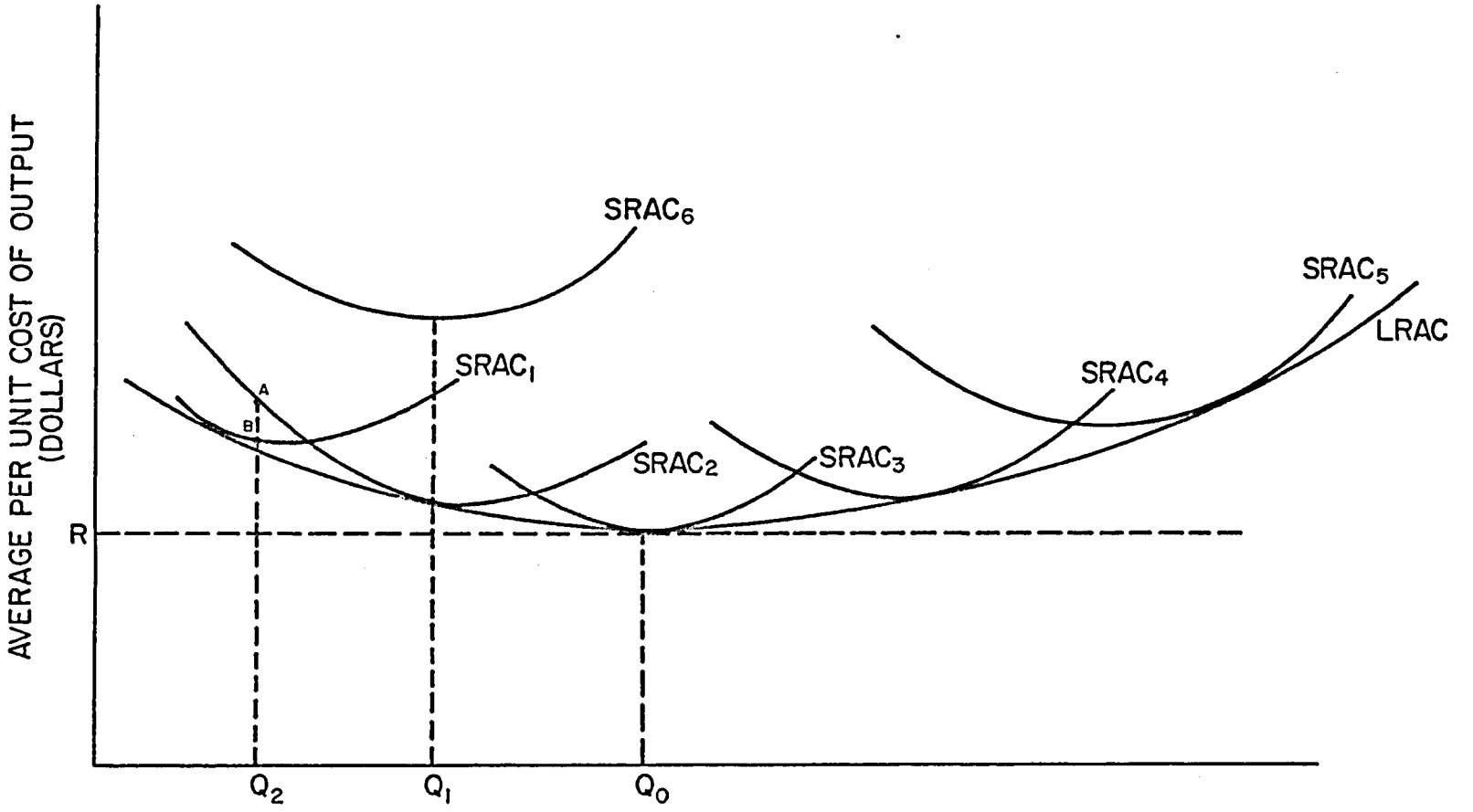

Figure 1. Hypothetical Short-Run and Long-Run Cost Curves Per Unit of Output

able to produce the same quantity of product (Q_1) at a much lower cost. At output Q_2, firm one is producing at its lowest cost, while firm two is producing at less than minimum unit cost. Firm one is, therefore, able to produce (Q_2) at a lower per unit cost of production. The vertical distance AB in Figure 1 denotes the cost advantage $SRAC_1$ has over $SRAC_2$ for output at Q_2. As firm two expands output by using additional variable resources, per unit costs decline below the lowest level of firm one. If the price fell below the lowest cost level for firm one, then in order to establish profits firm one would be required to alter its scale of plant, possibly to fit that of firm two or firm three.

The Long-Run. The long-run is defined as a period of time, great enough in length to allow a producer to alter the scale of his plant. The implication here is that all resources are available. Ferguson states: "The long-run is a planning horizon. All production, indeed all economic activity, takes place in the short-run. The 'long-run' refers to the fact that economic agents--consumers and entrepreneurs--can plan ahead and choose many aspects of the 'short-run' in which they will operate in the future."[1] Figure 1 develops the long-run cost curve per unit of output

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1. C. E. Ferguson, Microeconomic Theory, Richard D. Irwin, Inc., Homewood, Illinois, 1966, p. 176.

(LRAC). Theoretically, the LRAC curve traces out the minimum cost of production, given a particular level of technology and factor costs. Each point on the LRAC curve under these conditions represents the least-cost combination of inputs required to produce a specified output. Given the level of output, it can in principle be determined which particular combination of fixed inputs yields the lowest average cost per unit of output.

Size and Cost Economies

Size adjustments are possible through two alternatives. One is accomplished by altering the factor mix; for example, adopting technology concerning manure disposal which allows the workload to be transferred to other areas. The other involves an adjustment in scale of plant. In this instance all factors of production are increased (decreased) in equal proportion.

Cost economies (diseconomies) result from reduction (increases) in per unit costs as a result of a size adjustment. Economies or diseconomies to size may be either internal or external to the individual firm. They may also be pecuniary (monetary) or technological (physical) in nature.

Internal Economies and Diseconomies. Internal economies to size refer to per unit cost reductions realized from within the firm. Technological internal economies

result from reductions in the technical coefficients of production. A firm's savings in materials, labor, or equipment through more efficient utilization resulting from size increases would be considered internal technological economies. Economies of this nature arise when the firm's growth and expansion of output overcome the effects of the indivisibility of the factors.

Internal pecuniary market economies occur when the firm's size becomes significant enough to allow the purchase of factors in such quantities as to allow reductions in per unit cost. For example, the firm which is able to ship in feedstuffs by the truckload will be able to receive quantity discounts not available to the firm which buys feedstuffs by the ton. Internal pecuniary market economies may also result from quality advantages in selling produce.

Internal diseconomies are generally of a technological nature in agriculture. As a firm continues to expand its operations, the limitations on management, space, etc., become greater and greater. Eventually, per unit costs will begin to rise, resulting in diseconomies, and therefore a rise in the LRAC curve.

External Economies and Diseconomies. Economies accruing to a particular firm as a result of output expansion by the industry as a whole are known as external economies and may be either pecuniary or technological.

There are few examples of external economies in agriculture. Technological external economies arise where greater acreages under cultivation result in the elimination of weeds or pests allowing a greater output from given physical resources. Pecuniary external economies may result through the organization of cooperative purchasing or processing firms which result in lower factor costs or higher product prices. Arizona hog operators benefit from a pork marketing association which helps control hog flows to market resulting in better prices.

According to Viner, external diseconomies acruing to a firm are "of indisputable practical importance." emphasizing this, he says, "pecuniary diseconomies will always tend to result from the expansion of output of an industry because the increased purchases of primary factors and material which this entails must tend to raise their unit prices."[1] For example, in the hog industry in Arizona, production is greatly dependent on the quality and quantity of boars. As production in the industry increases, the quantity of boars available to individual producers may decline. If this occurs, producers will have to go out of state to purchase boars, either at an increase in cost or loss of quality. Both result in external diseconomies for the individual firm. External technological diseconomies

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1. Viner, op. cit., p. 220.

could result from increased water use of another industry causing costs of pumping by the individual firms to increase.

In examining the hog industry in Arizona, this thesis will look primarily at economies or diseconomies which result from actions taken within the firm, i.e., the relation between costs of production and size of the sow herd.

Net Economies and Diseconomies. "Net" economies are introduced at this point to suggest that economies and diseconomies may be present at the same time as output is increased. For example, it is likely that a firm is witnessing economies to size in its use of buildings, machinery, purchases of feed, etc., while at the same time experiencing diseconomies as a result of stretching management too far. The remainder of this thesis will be concerned with the effects of "net" economies or diseconomies.

Adjustments

It is assumed that the major objective of hog operators is to maximize profits. Under a purely competitive economy, equilibrium would be established at R in the long-run. Only firms producing output Q_o from the scale of plant corresponding to $SRAC_3$ could continue operations without incurring losses. Should returns rise above R,

profits could be realized by firms both larger and smaller than optimum.

Profit maximization will occur where marginal revenue (additional revenue derived from the last unit of output) equals marginal cost (additional cost of the last unit of output). In a purely competitive economy marginal revenue is identical with price, since at a given time all firms receive the same price and no one firm's expansion is great enough to influence price. Suppose price is above minimum unit cost R, with output Q_o as in Figure 1. The marginal cost of producing the last unit of output must therefore be greater than the minimum cost where marginal cost equals marginal revenue, i.e., average unit costs of production must be increasing. Assuming these conditions prevail, profit maximization will occur at some output greater than Q_o in Figure 1. Under these conditions marginal cost will equal marginal revenue at a point above minimum average cost, i.e., average unit costs are increasing.

Empirical Adaptation to the Theory

In theory, maximum plant capacity would be at the point where SRAC becomes vertical on the rising side of the "U" shaped curve. In practice, the rising side of the curve is difficult, if not impossible, to empirically document. Therefore, in this study maximum capacity is defined where

the SRAC curve is at its minimum unit cost.[1] For example, in Figure 2 capacity for SRAC is at output Q_1, $SRAC_2$ at Q_2, and $SRAC_3$ at Q_3. This is equivalent to saying that at plant capacity average variable cost and marginal cost become infinite, i.e., they become vertical at the point of minimum SRAC. Production beyond this point can then occur only with additional increments of the fixed resources. In this study, buildings, machinery and equipment, and management are assumed to compose the fixed plant. Movement from $SRAC_1$ to $SRAC_2$ can only be accomplished with additions to the plant itself.

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1. This assumption for the empirical study was based on equivalent assumptions made by others doing cost-size studies. For examples see: H. O. Carter and G. W. Dean, Cost-Size Relationships for Cash Crop Farms in Imperial Valley, California, California Agricultural Experiment Station, Giannini Foundation of Agricultural Economics, Mimeo Report No. 253, May, 1962; William E. Martin and William K. Goss, Cost-Size Relationships for Southwestern Arizona Cattle Ranches, Arizona Agricultural Experiment Station, Technical Bulletin No. 155, November, 1963.

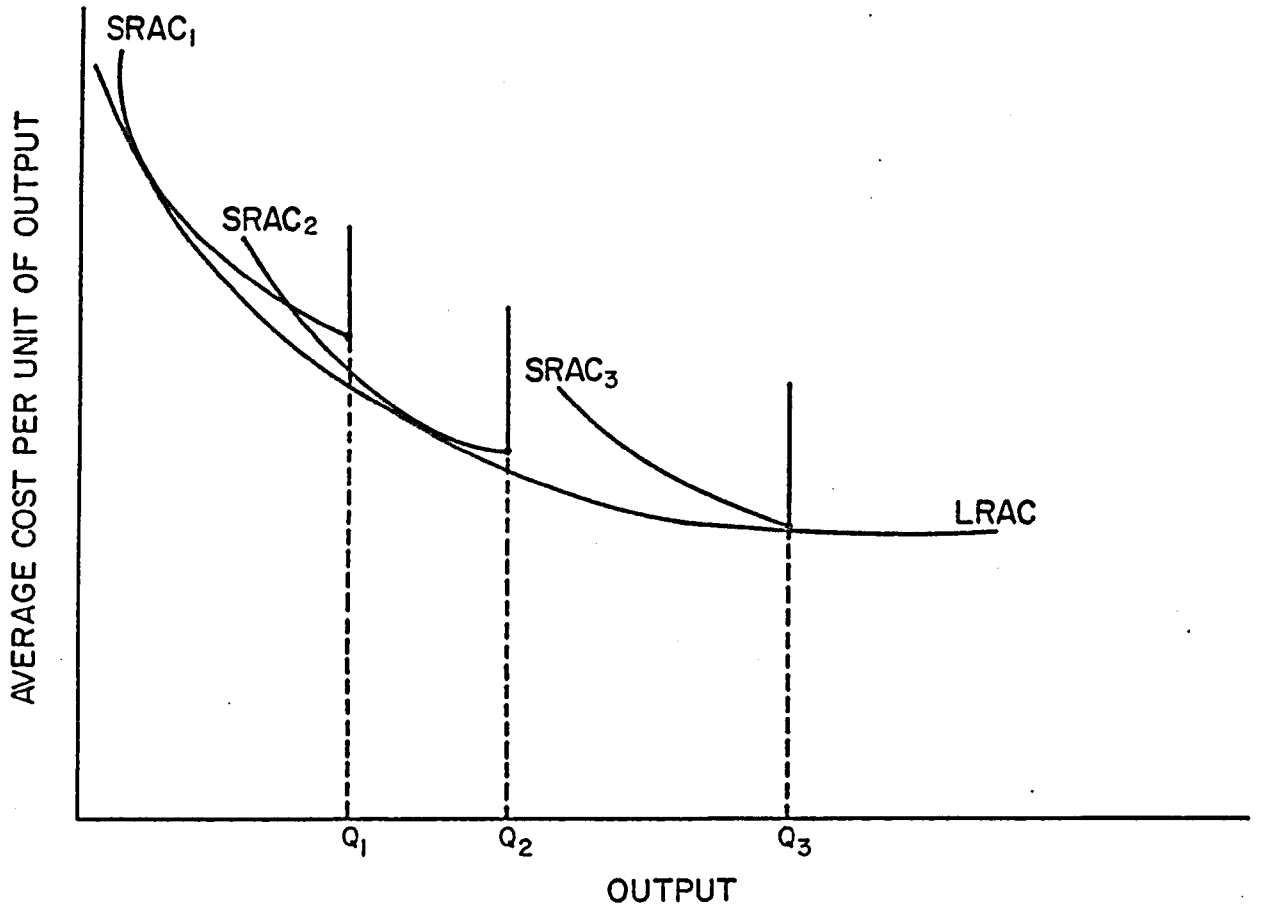

Figure 2. Hypothetical Short-Run and Long-Run Cost Curves Per Unit of Output for Different Size Plants

CHAPTER II

CHARACTERISTICS OF SAMPLED OPERATIONS

A total of 43 personal interview schedules were completed for three different types of operations. Of the 43 operations, 35 were farrow-to-finish operations, 4 farrowed pigs and sold them as feeders, and 4 bought pigs and finished them to market weight. In this study only farrow-to-finish operations were analyzed, since this is the most common system in the state. Of the 35 schedules, 33 were used in the analysis. The two not used were excluded because of inaccurate or incomplete information.

Table 2 presents the sample size groups relative to sow numbers, number of producers under each size group in the state, and the number of detailed cost interviews obtained. Characteristics of all hog operations sampled are summarized in Tables 3, 4, and 5. A general description of the various groups observed is given below, followed by some discussion on managerial differences, variations in investment costs, and other general characteristics of the hog industry in Arizona.

Group I

Operations in this group are primarily family units, ranging from 35 to 100 sows in size. Some outside labor is

Table 2. Sample Size Groups Defined Relative to Sow Numbers, Total Number of Hog Operations in Arizona, and Number of Detailed Cost Interviews[a]

Group	Number of Sows	Total Number of Hog Operations	Number of Detailed Cost Interviews
I	100 & under	65	15
II	101-200	22	10
III	201-300	7	4
IV	301-600	4	3
V	601-1,000	1	1

[a]As of July 1970.

Table 3. Physical Characteristics of Sampled Hog Operations[a]

Item & Size Groups	Unit	Mean	Range	
			Low	High
No. Sows				
Group I	head	61	35	100
Group II	head	137	110	193
Group III	head	280	220	300
Group IV	head	348	320	384
Land Required for Operation[b]				
Group I	acres	3.3	1	6
Group II	acres	4.7	2	10
Group III	acres	9.3	7	10
Group IV	acres	10	10	10
Number of Pigs Weaned per Litter				
Group I	head	7.86	6.0	9.2
Group II	head	8.3	7.0	9.5
Group III	head	8.0	6.5	9.0
Group IV	head	8.2	8.1	8.3

[a]Based on records of 32 Arizona farrow-to-finish hog operations.

[b]Cropland not included.

Table 4. Investment Characteristics and Values for Sampled Hog Operations[a]

Item & Size Group	Mean	Range	
		Low	High
	(Dollars)		
Investment, Breeding Stock			
Group I	6,499	4,000	12,000
Group II	15,535	11,750	21,550
Group III	31,188	24,750	34,000
Group IV	39,550	35,000	42,000
Investment, Buildings			
Group I	10,806	2,143	43,410
Group II	27,340	11,450	58,070
Group III	64,492	35,172	99,950
Group IV	169,227	92,750	318,000
Investment, Machinery & Equipment			
Group I	5,605	925	11,250
Group II	11,875	1,580	37,100
Group III	21,594	10,700	32,625
Group IV	6,858	0[b]	15,675

[a]Based on records of 32 Arizona farrow-to-finish hog operations.

[b]Individual firm which had no investment in machinery and equipment.

Table 5. Selected Annual Costs and Income for Sampled Hog Operations[a]

Item & Size Group	Mean	Range	
		Low	High
	(Dollars)		
Hired Labor Costs[b]			
Group I	1,096	0	3,009
Group II	6,002	0	11,563
Group III	11,285	8,572	15,369
Group IV	22,374	18,520	28,200
Feed Costs			
Group I	29,493	17,312	47,755
Group II	73,424	44,092	94,317
Group III	132,917	91,604	154,996
Group IV	181,812	161,117	216,431
Total Variable Costs[c]			
Group I	31,577	18,980	54,547
Group II	77,348	52,172	103,804
Group III	141,777	106,197	179,021
Group IV	197,591	195,340	264,283
Total Fixed Costs			
Group I	3,492	913	6,187
Group II	7,703	2,036	12,170
Group III	16,923	8,525	17,851
Group IV	32,642	11,867	44,435
Total Costs			
Group I	35,227	21,289	57,048
Group II	88,504	57,082	115,973
Group III	168,873	117,371	196,872
Group IV	244,521	207,207	308,718
Gross Income[d]			
Group I	57,572	33,829	92,718
Group II	139,490	86,174	184,217
Group III	269,664	173,198	309,548
Group IV	343,535	318,535	385,476

Table 5.--Continued

Total Cost Per Pound of Pork Produced			
Group I	.2213	.1835	.2559
Group II	.2083	.1829	.2697
Group III	.1990	.1871	.2112
Group IV	.2115	.1979	.2342
Total Feed Cost Per Pound of Pork Produced			
Group I	.144	.140	.150
Group II	.149	.140	.165
Group III	.141	.132	.149
Group IV	.148	.142	.157
Feed as a Per Cent of the Total Cost	----------(Per Cent)----------		
Group I	65.81	55.88	76.80
Group II	71.57	59.47	79.67
Group III	70.98	68.75	74.29
Group IV	69.99	67.03	71.75

[a]Based on records of 32 Arizona farrow-to-finish hog operations.

[b]Includes unpaid family labor (except for operator labor) as well as hired or other managerial labor.

[c]Includes feed and variable labor expenses.

[d]Based on average price during the period July 1969-July 1970.

used occasionally by the larger units. Land required for buildings and hogs amounts to approximately three acres.

The smaller operators in this group have farrowing units consisting primarily of the wooden A-frame type, housing one individual sow and her pigs. The larger units typically have a building with 10 to 20 farrowing crates. Storage capacity for grain is available. Machinery consists of a pick-up truck and trailer to haul hogs to market, a small tractor, feed grinder-mixer, some veterinary equipment, and miscellaneous small shop tools.

Group II

Hog operations in this group range from 101 to 200 sows. These operations are characterized by having one full-time man in addition to the owner-operator. Less family labor is used than in the smaller operations. Land requirements for this size operation are about five acres.

The farrowing house is constructed of cement block with individual farrowing crates. A fairly sophisticated building is used for the pig nursery. Most all other facilities for housing growing swine, sows, and boars consist of wire pens with shades for cooling. Machinery includes a tractor, portable feed grinder-mixer, pick-up truck, a 2 to 2½ ton truck for hauling hogs to market, veterinary equipment, and miscellaneous hand tools and shop equipment.

Group III

This group includes operations ranging from 201 to 300 sows. The fixed plant is similar to Group II. The major difference is that an additional man is required to handle operations of this size. Machinery and equipment requirements are similar to those in Group II. Land requirements amount to approximately nine acres.

Group IV

Group IV operations have from 301 to 600 sows. Labor needs increase at the rate of approximately one man for each 100 additional sows, such that five men are required at a 600 sow level in addition to the owner-manager. The type of building structures closely resemble those used in the smaller operations. Approximately ten acres of land are used in buildings and hog runs.

Feed milling equipment for this size group becomes more sophisticated in order to cut down handling and mixing time. Some have stationary mix-mills with augers. Operators in this group may also have their own truck to transport grains from out-of-state.

General Observations

Production of hogs in Arizona has increased rapidly in recent years. Much of this growth was the result of consistently favorable prices from 1965 until the middle of 1970. In comparison to other agricultural enterprises,

entry into and exit from the production of hogs is fairly easy, at least for smaller scale operations.

Most of the hog operations in Arizona are located in four counties, with approximately 74 per cent located in Graham, Cochise, Pinal, and Maricopa (Figure 3). Nearly 88 per cent of the operations are located in the southern (lower elevation) half of the state. This results in somewhat lower investment in buildings for housing, growing, and finishing swine.

Analysis of data collected revealed a wide variation in investment costs throughout the size ranges observed. Much of this variation may be attributed to the rate of growth of the industry at the time the information was obtained. Many producers had constructed facilities to handle expansion being planned, while others had already reached capacity for their "fixed" plant. Another reason for variations in investment costs arises from differences in producer opinions regarding plant requirements. For example, some producers feel it is important to have a sophisticated, high cost building for farrowing sows, while others feel they can do equally well with low cost individual houses.

The breeding stock and buildings are the two most important items of investment, making up approximately 70 per cent of the total (Table 6). Variations in investment in breeding stock were observed, primarily in the number of

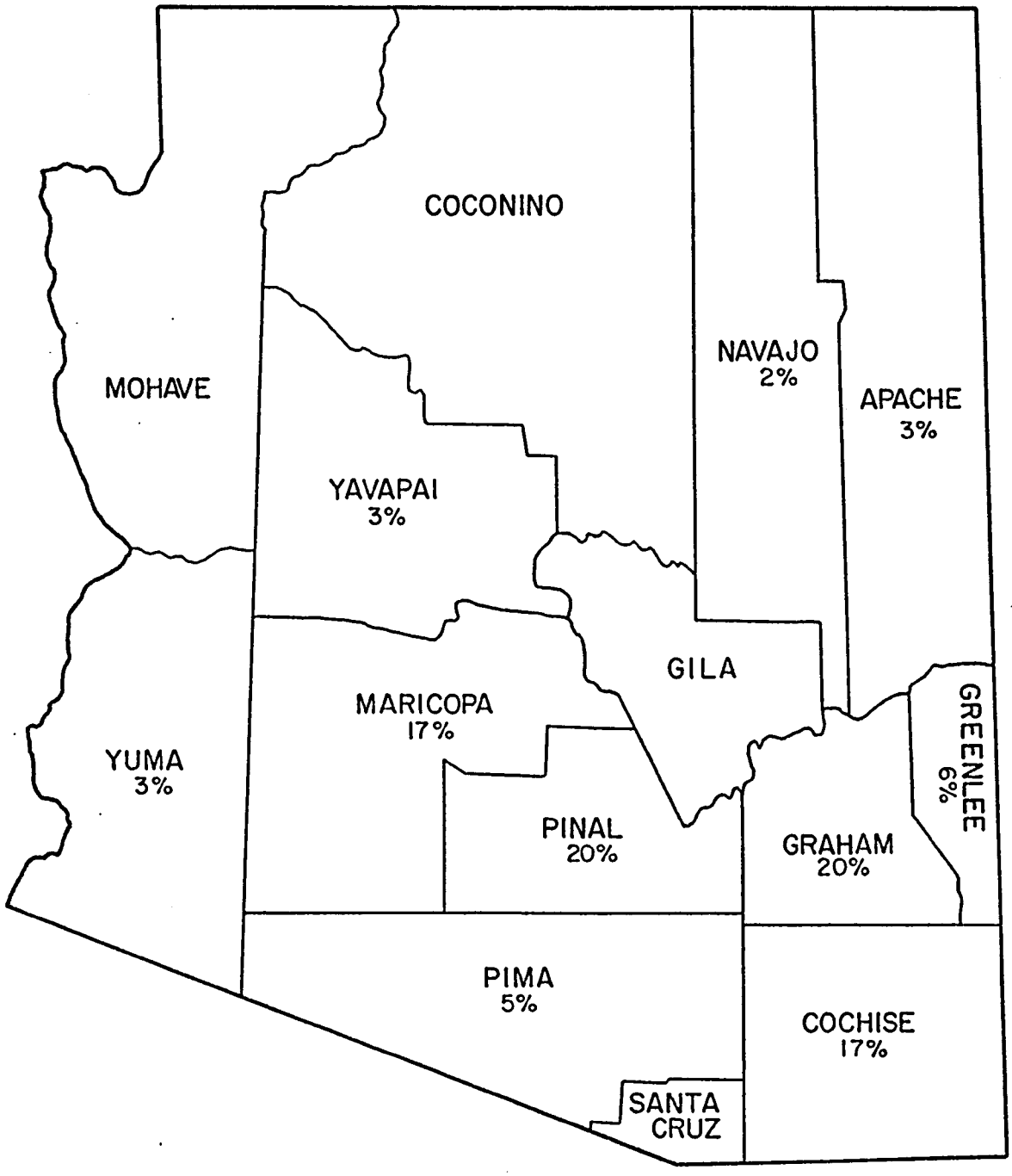

Figure 3. Location of Arizona Hog Operations by County, 1970

Table 6. Average Total Investment Per Firm by Size Group, Farrow-to-Finish Operations in Arizona, 1969-1970[a]

Item	Investment Group I (100 & under)	II (101-200)	III (201-300)	IV (301-600)
	Mean Number of Sows in Sampled Investment Group[b]			
	61	137	280	348
	(Dollars)			
Breeding Stock	6,499	15,535	31,188	39,550
Buildings	10,806	27,340	64,492	169,227
Machinery & Equipment	5,605	11,875	21,594	6,858
Land	1,550	2,820	4,650	7,000
Total Investment	24,460	57,570	121,924	222,635

[a]Based on data averages for 32 Arizona farrow-to-finish hog operations.

[b]Mean numbers in that they are averages of all firms interviewed within each size category.

boars used in the operation. Several producers maintained two to three times the number of boars required to service an operation of their size.

Land, machinery, and equipment make up the remaining 30 per cent capital investment. Many hog operations were supplemental enterprises to grain or cotton production. Where operations were mixed it was difficult to estimate the part of the investment associated with hogs. For example, many producers maintained what would be termed an excessive investment in storage facilities for grain, when only the hog operation is considered. The question arises as to whether or not any storage facilities would be maintained if the hog operation was not present. Assuming producers not raising hogs sell the grain at harvest (rather than incur handling and storage costs) all of the storage investment would be charged to hogs. Similar situations were observed with respect to other machinery investment items.

Investment items do not constitute a direct operating cost. However, charges of depreciation, interest, insurance, taxes, and repairs associated with the investment must be covered in order to maintain the business and make a normal return on money invested.

Variable costs make up the largest percentage of the total costs, with feed contributing approximately 70 per cent of all costs (Table 7). Most producers purchase feedstuff ingredients and mix them at the site of the operation

Table 7. Costs and Returns for Mean Sized Firms by Investment Group, Sampled Farrow-to-Finish Operations in Arizona, 1969-1970[a]

	(100 & under)	(101-200)	(201-300)	(301-600)
	Mean Number of Sows in Sampled Investment Group[b]			
	61	137	280	348
	(Dollars)			
Gross Income	57,572	139,490	269,664	343,553
Fixed Expenses				
Insurance	165	420	780	2,567
License, equipment	85	101	170	120
Repairs	627	1,455	3,048	5,433
Depreciation	1,760	3,667	8,814	16,436
Interest on Investment	855	2,060	4,111	8,086
Total Fixed Charges	3,492	7,703	16,923	32,642
Labor Costs[c]	1,096	6,002	11,285	22,374
Variable Expenses				
Feed	29,493	73,424	132,917	181,812
Utilities & Power	293	687	1,425	4,467
Personal Property Tax	309	553	1,069	1,686
Fuel and Lubricant	753	1,024	2,086	1,587
Veterinary Supplies	262	318	1,555	1,758
General Production	467	1,342	5,735	6,281
Total Variable Charges	31,577	77,348	141,777	197,591

Table 7.--Continued

Total Costs	36,165	91,053	169,985	252,607
Return to Management	21,407	48,437	99,679	90,946

[a]Based on records of 32 Arizona farrow-to-finish hog operations.

[b]Mean numbers in that they are averages of all firms interviewed within each size category.

[c]Does not include a charge for management or owner labor.

(see Appendix for sample rations). Some producers, however, purchase a fully mixed ration, and thus incur higher feed costs, but lower feed handling costs. This explains in part some of the variation in machinery and equipment investment. The remainder of variable costs consists of part-time hired and family labor, utilities, veterinary supplies, fuel and lubricants, personal property taxes, and miscellaneous general production expenses.

Returns to hog operations are greatly dependent on the number of pigs weaned per sow, which in turn is dependent to a large degree on management. The number of pigs weaned per litter ranged from 6.0 to 9.5 for operations observed. The critical periods in a pig's life are the first three or four days after birth, and then on to weaning age. Producers who maintain a low weaning average cannot expect returns as great as the producer who maintains a high one.

In addition to playing an important role at post-farrowing time, management plays a crucial role in handling breeding stock prior to and during farrowing. The climate in the lower elevations makes breeding, during the summer, a more difficult job than in other areas.

It is difficult to determine the effects of heat on conception rates, and on the number and quality of pigs born per litter. The good manager is aware of these aspects of producing hogs, and the effects these losses have on returns

to the enterprise. Losses of sows to death and those which were culled because they did not conceive amounted to approximately 3 per cent of the sow herd.

Climatic conditions vary throughout Arizona. The northern part of the state with higher elevations has cooler temperatures which may provide some advantage to northern producers in the summer months in terms of conception rates, litter sizes, and feed conversion rates for fat hogs. This advantage may be offset by higher investment costs resulting from more sophisticated housing requirements for hogs during the winter months. Also, feed costs may be higher in the northern areas since little grain production occurs in this part of the state.

The dryness of climate in Arizona is conducive to the production of hogs in terms of disease control. A major problem facing producers is the lack of veterinarians trained in the problems associated with hogs. Most producers handle the jobs normally performed by veterinarians.

Nearly one-half of the operations in Arizona were started with secondary "SPF" (specific pathogen free) pigs. SPF pigs are used to control two diseases, atrophic rhinitis and virus pig pneumonia, which the pig can contact from the sow at birth. Some producers vaccinate sows for leptospirosis and erysipelas. In addition, most all producers farrowing sows in confinement inject iron into baby pigs at 2 to 3 days of age.

Marketing of slaughter hogs in Arizona is done primarily at one packing plant in Phoenix. Prices for hogs are based on Kansas City, the day prior to sale, plus a premium for a cut out on the four lean cuts of 40 per cent or better. The greater the cut out the higher the price. The market for cull sows and boars tends to be poor, with some being shipped into Mexico.

CHAPTER III

EMPIRICAL RESULTS OF THE COST ANALYSIS

The following cost analysis provides the empirical counterpart for the theoretical short-run and long-run average cost curves as discussed relative to Figures 1 and 2 of Chapter I. Separation of the empirical observations into distinct size classes was desired in order to estimate cost behavior in both the short-run and the long-run. In this study, size classification is by the number of sows in the herd.

"Optimal" fixed plants were constructed for each of the size classes based on sampled data. "Optimum" was used in the sense that the inventories were developed from the more efficient operations observed. The economic-engineering synthesis approach was used in assigning costs to the production inputs. During the period the survey was taken, many producers were in an expansionary phase of operation. This meant that most producers were experiencing some excess capacity in the utilization of their fixed resources. Budgeted resource combinations were adjusted to eliminate excess capacity.

The farrowing house was used as the base unit. Other building and equipment needs were so structured as to fit

the capacity designated by the farrowing house. Labor was assumed to be the limiting "fixed" factor in determining a short-run capacity for each synthetic resource combination. Capacities for buildings become fixed based on this assumption. If labor was capable of handling more sows, the capacity for buildings would have been so structured as to handle them. Capacities for the other fixed inputs, such as equipment and machinery were not so sharply definable.

The fixed resource combinations were assembled for five distinct size categories. No firms of the size indicated by Investment Group V were operating in Arizona at the time the survey was made. Since then, however, at least one firm has expanded to this level and several others have indicated they also were moving toward this size operation. Development of a synthetic model for 1,000 sows was made, therefore, in hopes of presenting a more accurate long-run decision making plan, even though basic input data were somewhat more limited.

The fixed costs of this analysis are insurance, license on equipment, repairs, depreciation, interest on the fixed investment, and the cost of labor, including a charge for management. Labor is considered fixed in that employees for hog operations of the sizes considered are generally hired on a monthly salary, indicating under normal operating conditions they will be held in the production process for long periods of time. Although labor is considered a fixed

input, prevailing economic conditions might occur which would indicate to a producer that he should not operate at capacity. If this occurred a producer could conceivably drop a man as the number of sows declined in order to avoid losses due to excess labor capacity. For this reason, several short-run cost curves were developed for each of the five "fixed" investment groups. In all cases the owner was assumed to be the manager. It was further assumed that as the size of operation increases the level of managerial ability required to maintain efficiency increases, and therefore must be paid a commensurate wage. This was verified by producers in the survey. Salaries for managers ranged from $850 to $1,200 per month. Full-time laborers were paid a monthly salary of $750 in all cases, except the 1,000 sow operation, where herd managment and farrowing become more and more important. Laborers in the latter case earned a monthly salary of $850. Little or no family labor was assumed.

The amount of interest charged on investment for buildings, land, breeding stock, and machinery and equipment was based on the "average" value of the item over the life of the investment. Interest on investment was charged at the rate of 8.0 per cent. This figure is representative of the rates charged as reported by hog operators purchasing investment items on credit. This estimate is thought to approximate the average rate a hog producer would have to

pay if he borrowed the money to buy the item. If the purchase was financed internally, the rate is the opportunity cost for money invested in other enterprises.

Depreciation charges were based on the amount of use and type of materials used in construction. Buildings were assumed to have a 20-year life, and pens and shades a 10-year life. Each type of machinery and equipment was depreciated separately. The estimated life of machinery and equipment ranged from 3 to 10 years. In all instances depreciation charges were determined by the straight-line method, assuming no salvage value.

Repair charges were assessed as a percentage of the investment cost. Since a 100 sow operation uses the same equipment as a 200 sow operation, repair charges for a 100 sow operation were assessed as a 5 per cent level. For all other size categories a 7.5 per cent charge on machinery and equipment was used. Repair charges on buildings were assessed at 3 per cent of the investment cost.

The remaining charges for insurance premiums and licenses on equipment were based solely on information as provided by the better producers in the survey. Producers generally carry liability, fire, and workman's compensation insurance.

Values for all items presented in Table 8 are for "average" investment. Original values are based on current costs. Values were so computed to be representative of an

Table 8. Average Investment Value[a] of Fixed Resources by Investment Group, Arizona Farrow-to-Finish Hog Operations

Type of Investment	Investment Group I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Buildings					
Labor housing			$6,000	$15,000	$27,000
Office			250	469	469
Shop			140		
Livestock facilities					
Farrowing house	$2,074	$4,017	5,854	4,935	7,403
Nursery, sow & pig	--	--	--	9,900	16,830
Nursery, pigs	1,188	2,750	3,420	6,400	10,200
Finishing facilities	3,489	6,903	9,486	20,896	35,196
Breeding pens	376	704	992	1,670	3,114
Gestating pens	947	1,851	2,580	7,110	11,018
Boar pens	125	213	276	405	603
Miscellaneous pens					
Excess finish	683	1,212	1,669	1,386	1,560
Gilt pens	179	234	317	481	779
Lagoon			500	1,250	2,000
Equipment in Buildings					
Farrowing Crates	1,107	2,214	3,362	2,952	4,551
Evaporative coolers	165	330	620	1,440	1,620
Fans	60	120	120	225	317
Automatic waterers	262	476	708	1,780	3,000

Table 8.--Continued Average Investment Value[a] of Fixed Resources by Investment Group, Arizona Farrow-to-Finish Hog Operations

Type of Investment	Investment Group I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Creep feeders				420	714
Nursery feeders	150	300	480	960	1,440
Finish feeders	2,500	4,750	6,500	13,250	21,250
Foggers	87	171	224	415	832
Grain & feed storage facilities					
Storage bins	225	375	463	625	1,150
Supplement bins	140	140	213	288	400
Stationary feed mill				3,250	3,250
Building for housing mixmill, shop, etc.				547	547
Machinery & Equipment					
Tractor	3,050	3,050	5,350	2,650	2,650
Auger Wagon				600	600
Truck		2,500	2,750	11,250	22,500
Pick-up	1,500	1,750	1,500	1,500	1,500
Stock trailer	1,250	1,250	1,250		
Feed grinder-mixer	1,250	1,250	1,250		
Scales	150	150	150	150	150
Small tools & shop equipment	250	250	250	250	250

Table 8.--Continued Average Investment Value[a] of Fixed Resources by Investment Group, Arizona Farrow-to-Finish Hog Operations

Type of Investment	Investment Group I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Cleaning equipment	250	250	250	500	500
Veterinary equipment	25	25	50	100	150
Water system	1,500	2,500	3,500	4,500	6,000
Manure spreader				325	325
Land	1,200	1,600	2,000	4,000	5,200
Sows and Boars	5,500	11,000	16,000	32,250	53,375
Total Average Investment	29,682	52,335	78,474	154,129	248,443

[a]Average investment over the life of the investment, assuming 1971 prices and a zero salvage value.

operation over the life of the investments, rather than at a particular point in time.

Total investment values for land, buildings, machinery, and equipment are presented in Table 9. Land investment is relatively small for Arizona hog operators. Requirements per 100 sows ranged from approximately 1.5 to 3.0 acres over the range of sizes examined, with the smaller operations requiring a larger amount per unit. Land values were standardized at $400 per acre for budget purposes. Variations from this level would need to be considered for each location.

Building construction cost estimates were based on 1971 prices for various types of construction materials. Costs are based on the assumption there would be no special problems in construction of buildings with respect to labor or materials. Housing for the owner-manager was not provided by the hog enterprise. Housing for all other full-time laborers was provided.

Machinery and equipment investment was based on 1971 prices as listed by several firms providing implements of the type used in hog operations.

Investment in livestock consists entirely of sows and boars. A three year productive life was assumed with salvage values of $63 each for sows and $55 each for boars. Replacements for sows were assumed to come directly from

Table 9. Total Investment[a] in Fixed Resources by Investment Group for Arizona Farrow-to-Finish Hog Operations

Type of Investment	Investment Group I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Buildings	$18,848	$35,797	$64,319	$142,724	$236,536
Equipment in Buildings	8,662	16,722	24,028	42,944	67,448
Machinery & Equipment	18,450	23,450	29,900	50,150	75,750
Land	1,200	1,600	2,000	4,000	5,200
Sows & Boars	11,000	22,000	33,000	64,500	106,750
Total Investment	58,160	99,569	153,247	304,318	491,684

[a]Total Investment indicative of actual costs for operations of the sizes shown, based on 1971 prices. No depreciation charges have been subtracted.

offspring, while boar replacements were purchased from other producers to avoid problems from inbreeding.

All costs other than "fixed" costs are termed variable, and are assumed to vary directly with the number of sows in the herd. That is (if an additional sow is of the same productive ability), the addition of one more to the herd will affect total costs, but not average variable costs. The variable costs of this study are feed, utilities and power, personal property taxes,[1] fuel and lubricant charges, veterinary supplies, and general prouction expenses. Variable costs per sow derived from survey data are shown in Table 10.

Feed for hogs consists primarily of ground milo or wheat, and soybean oil meal as a protein supplement. These ingredients make up from 70 to 90 per cent of the total ration cost, depending on the type of animal being fed. In determining feed costs it was assumed that operations in the 600 and 1,000 sow range could profitably ship in grains and soybean meal from out of state. Two cost levels were used for milo and soybean meal. For smaller operations not in a position to ship in these ingredients, milo was charged at $62 per ton, and soybean meal at $98 per ton. Milo was

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[1]It should be noted that personal property taxes have both a fixed and variable characteristic. They vary with the number of sows and boars in the breeding stock. For this reason they are included in variable rather than fixed costs.

Table 10. Total Annual Variable Costs Per Sow, by Type of Cost, for Five Farrow-to-Finish Size Groups, 1971

Item	Size of the Herd				
	100 sows	200 sows	300 sows	600 sows	1,000 sows
Feed Cost	$573.52	$573.59	$572.39	$530.74	$530.58
Utilities & Power	7.28	7.28	7.28	7.28	7.28
Personal Property Tax	17.44	14.93	15.32	15.22	14.75
Fuel & Lubricant	15.50	17.50	16.66	36.20	33.85
Veterinary Supplies	4.00	4.00	4.00	4.00	4.00
General Production	4.64	4.64	4.64	4.64	4.64
Total	$622.38	$621.94	$620.29	$598.06	$595.10

charged at $56 per ton and soybean meal at $92 per ton for the two largest operations. These figures were based on 1971 prices quoted by various feed companies in the state, and producers who were shipping in grain and soybean meal from various locations in New Mexico, Colorado, and Kansas. The feed costs presented in Table 11 consist only of the ingredients which make up the rations. All costs involved in mixing and handling were separated into the other cost categories shown.

Daily feed intakes for sows and boars were based on data from the better producers in the survey.[1] Daily consumption levels for sows, boars, and growing hogs are given below:

	Pounds
Lactating sows	10.00
Gestating sows	4.00
Boars	4.00
Pigs at 24 days	1.32
Nursery pigs	2.75
Grower	4.73
Finisher	7.71

Fuel and lubricant charges were estimated on the basis of type and size of equipment, and hourly or mileage per gallon use rates. Personal property taxes were estimated at 3 per cent of the value of investment in land, buildings,

[1]Feed requirements for growing hogs were estimated in conjunction with Dr. M. R. Selke of the Animal Science Department at The University of Arizona.

Table 11. Income Summary by Investment Group, Arizona Farrow-to-Finish Hog Operations

Item	Investment Group I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
	(Dollars/Pound of Slaughter Pork Marketed)				
Gross Income[a]	$.2091	$.2091	$.2091	$.2090	$.2091
Fixed Expenses					
Insurance	.0011	.0014	.0017	.0013	.0010
License, equipment	.0002	.0003	.0002	.0002	.0003
Repairs	.0048	.0051	.0049	.0047	.0044
Depreciation	.0105	.0105	.0102	.0088	.0089
Interest on Investment	.0056	.0049	.0050	.0050	.0048
Total Fixed Charges	$.0222	$.0222	$.0220	$.0200	$.0194
Labor Costs					
Management	$.0253	$.0126	$.0084	$.0050	$.0036
Other Labor	.0048	.0112	.0149	.0186	.0210
Total Labor	$.0301	$.0238	$.0233	$.0236	$.0246
Variable Expenses					
Feed Costs	$.1422	$.1422	$.1419	$.1316	$.1316
Utilities & Power	.0018	.0018	.0018	.0019	.0019
Personal Property Tax	.0043	.0037	.0038	.0038	.0037
Fuel & Lubricant	.0038	.0043	.0041	.0090	.0084

Table 11.--Continued

Veterinary Supplies	.0010	.0010	.0010	.0010	.0010
General Production	.0012	.0011	.0012	.0012	.0012
Total Variable Costs	$.1543	$.1542	$.1538	$.1484	$.1478
Total Costs[b]	$.2067	$.2001	$.1991	$.1920	$.1918
Net Returns	$.0024	$.0090	$.0100	$.0170	$.0173

[a]Derived by summation of sales from cull sows, cull boars, and slaughter hogs, divided only by the number of pounds of slaughter hogs marketed.

[b]Total dollar costs incurred, including sow and boar maintenance, divided by the number of pounds of slaughter hogs marketed.

equipment and machinery, and the value of hogs in the breeding stock. Utilities, veterinary supplies, and general production expenses were determined from the lower level of the cost figures obtained in the interviews. General production expenses consist of accounting, association fees, and other minor costs.

The shapes of the short-run average cost curves were determined by the spreading of fixed costs over increasing units of output. Additional sows were added to each fixed resource combination up to the "capacity" of that resource combination. The maximum number of sows that can be handled with each investment group was determined on the basis of a fixed number of full-time laborers. For example, Group IV, defined as having one manager and five full-time laborers, can handle only 600 sows at capacity. More sows could be handled by this group only if additions are made to both facilities and labor. The need for an extra man would result in an excess capacity arising from the indivisibility of labor.

The Cost Structure

Short-run average total cost curves for the five model operations and the corresponding long-run "envelope" curve are presented in Figure 4. These curves assume optimum production techniques with relatively high efficiency in resource use.

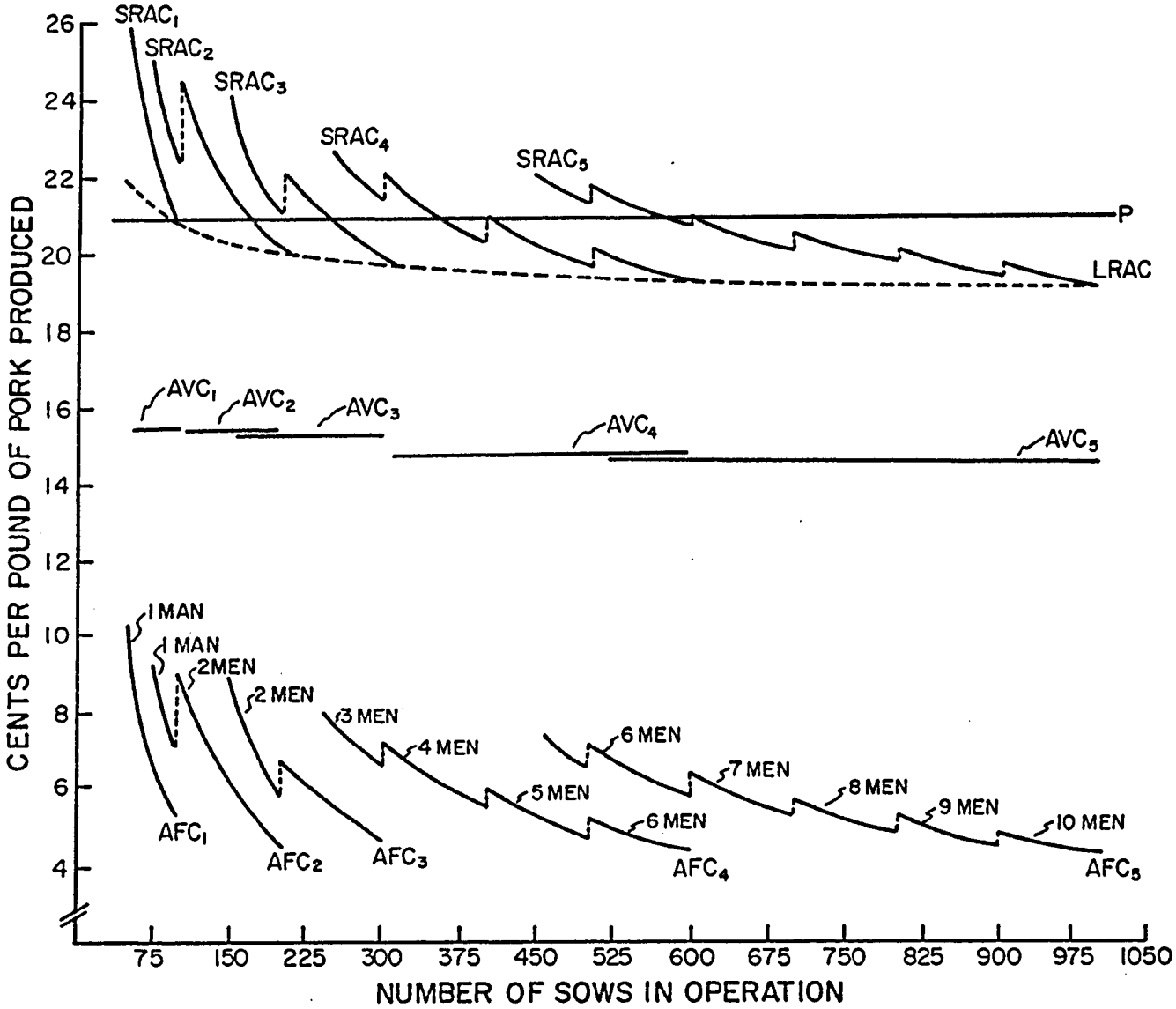

Figure 4. Costs of Production Per Pound of Slaughter Pork Marketed, Arizona Farrow-to-Finish Hog Operations, 1971

The cost curves depicted cover all costs incurred in the production of pork, including a charge for management. The business enterprise is assumed to be the residual claimant against income, with net returns being the difference between the average total cost of producing a pound of pork and the average price received. The price line P, shown in Figure 4, was derived from the summation of sales of cull sows, cull boars, and slaughter hogs, divided by the number of pounds of slaughter pork sold. An estimated life of three years was assumed for sows and boars, thus one-third of the breeding stock was sold each year. Slaughter hog sales were derived in the following manner:

> Number sold = 18.7 pigs weaned per sow per year - 2 per cent death loss from weaning to market - number of gilts held as replacements for cull sows

A price on market hogs of $20.75 per cwt (hundredweight) was based on July 1971 prices at Kansas City of $19.00 per cwt., plus $1.75 per cwt. premium for a cut-out percentage of 43 per cent on the four lean cuts.

For each of the five size groups, the short-run average "total cost" (SRAC) curve is obtained by summing vertically the average fixed cost curve (AFC) and the average variable cost curve (AVC). (See Appendix for basic data used in developing the budgets.) Average variable costs per pound of slaughter pork marketed are constant

within each size group but become progressively lower for each group as size increases.

The largest decline in variable costs occurs at the 600 sow level. The reason for this is that feed makes up the greater part of total variable costs, and is the most critical item considered (see Table 11). At the 600 sow and above level, operators benefit from lower feed input costs resulting from their ability to profitably ship in grains from out of state. Figure 4 indicates that reductions in average variable costs will occur for numbers below 600 sows as a result of the purchase of a large truck. It is not likely to be a feasible investment however, at levels as low as 300 sows because of the excess capacity of the truck and other fixed investment items. Purchase of such a truck probably becomes feasible at some point before the 600 sow level is reached.

A long-run average cost curve is drawn as an "envelope" to the short-run average cost curves (Figure 4).[1] The "envelope" (LRAC) curve shows the least cost of producing a pound of pork for the entire group of sizes observed.

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[1]Conceptually, an infinite number of short-run cost curves relating to successively larger fixed resource combinations are required to draw the "envelope" curve. The LRAC curve of Figure 4 is therefore only an empirical approximation to the "envelope" curve. See: Edward C. Chamberlain, "Proportionality, Divisibility, and Economies Scale," Quarterly Journal of Economics, February, 1948, pp. 234-35.

Production costs per pound of slaughter pork marketed decline from 20.67 cents to 20.01 cents as the operation moves from a 100 sow to 200 sow operation. Most of this saving is directly related to machinery and equipment use. Equipment and machinery requirements for the 100 sow operation are nearly identical to those for a 200 sow operation.

A shift from 200 to 300 sows results in a modest saving of .10 cents per pound. Beyond this a .71 cent reduction in production cost is possible by expansion to a 600 sow operation. Although much of the latter reduction results from lower feed costs, it is also observed that management costs have been spread over a greater number of animals.

The preceding analysis suggests that hog operators may reduce costs as they increase herd size up to 600 sows. Once a herd size of 600 is reached, additional unit cost benefits apparently are not available with increased size. If good management practices are maintained, unit costs should not rise as herd size is increased; therefore the larger the operation the greater the total return to the business enterprise. This assumes, however, that the firm size does not adversely affect price levels for products sold. Also, greater total returns in this instance are not the result of a greater percentage return on the investment.

CHAPTER IV

SUMMARY, CONCLUSIONS, AND APPRAISAL

This study has examined the costs of producing pork in Arizona to determine whether economies can be obtained by increasing herd size. Knowledge of the extent to which economies to size exist, if they do exist, would provide a basis for decision-making relative to expansion of the sow herd.

Data on investments, production costs, and management practices were obtained by interviews with a sample of 33 farrow to finish hog operators, supplemented by data from various machinery and equipment dealers and persons in the Agricultural Engineering and Animal Science Departments of The University of Arizona.

Analysis of the data was divided into two areas. Initially, data on costs were analyzed to determine the general characteristics of the industry. This analysis was followed by development of synthetic models used to evaluate cost-size relationships. The economic engineering synthesis approach was used in developing these models, employing input structures representative of the more efficient operations in the survey. Short-run average total cost curves were presented for five distinct size classes

(100-1,000 sows). The respective long-run "envelope" curve was then approximated.

The general characteristics of the hog industry in Arizona based on survey data may be characterized briefly as follows:

1. Analysis of the data collected showed wide variations in investment costs throughout the size ranges observed. Variations in building investment resulted primarily from the many operations which had expanded facilities and not yet reached capacity. Differences in investment costs from operation to operation were also observed for the breeding stock and machinery and equipment. The differences in breeding stock were generally a function of producers maintaining too many boars.
2. Variable costs of production make up the largest percentage of total costs. Of the variable costs, feed is by far the most significant, contributing approximately 70 per cent of the total. The figure is higher for operations purchasing fully mixed rations than those buying feedstuff ingredients and mixing them at the site of the operation.
3. The role of management prior to, during, and immediately following farrowing is of crucial importance. Most of the producers in Arizona are located in the southern half of the state where the summer

heat affects conception rates, as well as the number and quality of pigs born per litter. In addition, sows easily become overheated and excited during farrowing. Many sows are lost during farrowing because of this.

Assuming no problems during farrowing, management is especially strained after farrowing. Keeping pigs alive is of utmost importance in terms of dollar returns to the enterprise. The range of pigs weaned per litter for the operations observed was from 6.0 to 9.5 pigs. Although variable costs (feed) make up the greatest percentage of total costs, it is the spreading of fixed costs over greater number which reduces the per unit costs of production.

4. Disease problems seem to be of lesser importance for Arizona producers than for those in midwestern states. The dryness of climate in addition to the distance between operations lowers the possibility of transferring diseases from operation to operation. A major problem facing producers is the lack of available veterinarians, trained in the problems associated with hog diseases.
5. Marketing alternatives for producers are mostly nonexistent with most of the slaughter hogs marketed to one plant in Phoenix. Arizona producers, due to their relative closeness to deficit producing areas,

receive a price advantage over midwestern producers. Markets for cull sows and boars tend to be poor, with some being shipped into Mexico.

Results of the Empirical Analysis

The results and conclusions of the empirical analysis may be summarized as follows:

1. Given present technology, above average management, and high production levels, average total costs of producing a pound of pork decline throughout the range of the operations studied. Decreasing costs per unit produced occur as the fixed costs are spread over increasing units of output.

Although no evidence of net diseconomies with increasing size was found in this study, certain indicators of possible diseconomies do appear between the 600 and 1,000 sow levels. This is a result of certain indivisibilities in investment requirements. At the 600 sow level, the use of a $20,000+ semi-trailer truck is at capacity. Size increases above this would require the use of two such trucks, with an additional laborer required to drive the truck. At the 1,000 sow level, average total costs of production are almost identical with those at the 600 sow level with the near capacity use of two trucks. It appears then that there may be a discontinuity in economies to size between these levels.

2. There are cost advantages related to size, especially in moving from a 100 to 200 sow operation and again in moving from 300 sows to 600 sows. Per unit cost reductions of 0.66 cents per pound of slaughter pork marketed are noted in moving from the 100 to 200 sow levels, while an additional 0.71 cents per pound marketed occur in moving from 300 to 600 sows. Beyond the 600 sow level no further economies appear to occur.
3. The analysis presented showed positive net returns to the operation when all income sources (cull sows, cull boars, and slaughter hogs) were considered. When cull sows and cull boars were not included as a source of income, net returns were negative at the 100 sow level, and dropped by one-third in the larger operations and as much as two-thirds at the 300 sow level. When all income sources were considered, per unit returns to the hog operations (which is the residual after all production costs have been paid) ranged from 0.24 cents per pound of slaughter pork marketed for the 100 sow operation to 1.73 cents per pound of slaughter pork marketed for the 1,000 sow operation.
4. In general, the trend toward larger hog operations will likely continue in Arizona. When per unit costs decrease as size increases the incentive exists for

producers, especially those with above average management, to increase the size of operation. Upward pressure on the size of hog operations is likely to occur as many producers seek to improve their income position through lower unit costs and the larger gross income associated with increasing size. Primary factors limiting this expansion will be the willingness of operators to assume increased risk and uncertainty, and their willingness to assume the increased burdens which expansion places on management.

Appraisal

The cost-size relationships presented in this study may be of benefit to hog operators, bankers, businessmen, and others associated with the hog industry in Arizona. However, limitations do exist and should be recognized.

Budgets developed in this study were assumed to be those attained by the most efficient operators. Predictions can therefore be made for the hog industry in general, but not for specific operations.

More accurate estimates of input relationships would improve the accuracy of the predictions. For example, information on rates of use and depreciation as applied to hog operations in Arizona was nearly non-existent. Judgment decisions, therefore, were required in terms of depreciation

and repair charges used. In addition it was difficult to ascertain whether or not actual managerial differences were existent as sizes of operations increase, since there are all levels of efficiency noted in all size categories. Determination of internal economies or diseconomies was dependent on judgment decisions which were made.

In this study, management was not assumed to be the residual claimant against all incomes. Quantification of the managerial cost was difficult to determine, especially for the larger operations. At the time of the survey, no firms in the 1,000 sow area (Group V) were in operation. Since then at least one firm has expanded to 1,000 sows and several others have indicated they are moving in that direction.

Finally, a given level of technology was assumed throughout the analysis. Major changes in technology could change the shapes or the levels of long-run cost curves.

APPENDIX

BASIC DATA USED IN DEVELOPMENT OF BUDGETS

Table 12. Fixed Resources by Investment Group, Arizona Farrow-to-Finish Hog Operations, 1971

Item	Investment Group				
	I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Buildings					
Labor housing			2, mobile homes 12' x 50'	5, mobile homes 12' x 50'	9, mobile homes 12' x 50'
Office			1, old mobile home 8' x 30'	1, 15' x 25' cement block	1, 15' x 25' cement block
Shop			Frame building, metal siding and roof, 10' x 16'		
Livestock Buildings					
Farrowing House	1, cement block, metal roof, partial aluminum slatted floor, 1659 sq. ft.	2, cement block, metal roof, partial aluminum slatted floor, 3213 sq. ft.	2, cement block, metal roof, partial aluminum slatted floor, 4683 sq. ft.	2, cement block, metal roof, partial aluminum slatted floor, 3948 sq. ft.	3, cement block, metal roof, partial aluminum slatted floor, 5922 sq. ft.
Nursery, Sows & Pigs				4, cement block, metal roof, partial aluminum slatted floor, 7920 sq. ft.	6, cement block, metal roof, partial aluminum slatted floor, 13,464 sq. ft.
Nursery, pigs only	1, cement block, metal roof, partial aluminum slatted floor, 950 sq. ft.	1, cement block, metal roof, partial aluminum slatted floor, 1800 sq. ft.	2, cement block, metal roof, partial aluminum slatted floor, 2736 sq. ft.	4, cement block, metal roof, partial aluminum slatted floor, 2736 sq. ft.	6, cement block, metal roof, partial aluminum slatted floor, 8160 sq. ft.
Finishing facilities	3 pens, metal hog-wire fence, shade metal const. over cement floor 10' cement slab, each pen 98' x 60'	6 pens, metal hog-wire fence, shade metal const. over cement floor 10' cement slab, each pen 98' x 60'	6 pens, metal hog-wire fence, shade metal const. over cement floor 10' cement slab, each pen 140' x 60'	18 pens, metal hog-wire fence, shade metal const. over cement floor 10' cement slab, each pen 114' x 60'	27 pens, metal hog-wire fence, shade metal const. over cement floor 10' cement slab, each pen 130' x 60'
Breeding pens	1 pen, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, 64' x 20'	2 pens, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, each pen 64' x 20'	2 pens, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, each pen 92' x 20'	4 pens, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, each pen 80' x 20'	6 pens, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, each pen 90' x 20'
Gestating pens	3 pens, metal hog-wire fence, shade metal const. over cement floor, 8' cement slab, each pen 58' x 20'	6 pens, metal hog-wire fence, shade metal const. over cement floor, 8' cement slab, each pen 58' x 20'	6 pens, metal hog-wire fence, shade metal const. over cement floor, 8' cement slab, each pen 84' x 20'	18 pens, metal hog-wire fence, shade metal const. over cement floor, 8' cement slab, each pen 78' x 20'	28 pens, metal hog-wire fence, shade metal const. over cement floor, 8' cement slab, each pen 78' x 20'

Table 12.--Continued Fixed Resources by Investment Group, Arizona Farrow-to-Finish Hog Operations, 1971

Item	Investment Group				
	I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Boar pens	2 pens, metal hog-wire fence, shade metal const. over cement floor, 4' cement slab, each pen 19' x 6'	4 pens, metal hog-wire fence, shade metal const. over cement floor, 4' cement slab, each pen 19' x 6'	4 pens, metal hog-wire fence, shade metal const. over cement floor, 4' cement slab each pen 19' x 9'	6 pens, metal hog-wire fence, shade metal const. over cement floor, 4' cement slab, each pen 19' x 9'	9 pens, metal hog-wire fence, shade metal const. over cement floor, 4' cement slab, each pen 19' x 9'
Miscellaneous Pens					
Excess finish	1 pen, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, 60' x 54'	1 pen, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, 98' x 60'	1 pen, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, 140' x 60'	1 pen, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, 114' x 60'	2 pens, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, each pen 130' x 60'
Gilt pen	1 pen, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, 28' x 20'	1 pen, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, 40' x 20'	1 pen, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, 58' x 20'	1 pen, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, 74' x 30'	1 pen, metal hog-wire fence, shade metal const. over cement floor, 10' cement slab, 114' x 30'
Lagoon			Yes	Yes	Yes
Equipment in Buildings					
Farrowing Crates	27, includes feeder, waterer, creep feeder	54, includes feeder, waterer, creep feeder	82, includes feeder, waterer, creep feeder	72, includes feeder, waterer, creep feeder	111, includes feeder, waterer, creep feeder
Evaporative cooler	1, 23,000 BTU	2, 23,000 BTU	4, 20,000 BTU	8, 26,000 BTU	9, 26,000 BTU
Fans	2, large fan on thermostat	4, 2 large fans on thermostat	4, 2 large fans on thermostat	10, 2 large fans on thermostat	12, 3 large fans on thermostat
Automatic waterers	70, cup type	127, cup type	189, cup type	475, cup type	800, cup type
Creep feeders				120	204
Nursery feeders	10.	20	32	64	96
Finish feeders	20, 45 bushel	38, 45 bushel	52, 45 bushel	106, 45 bushel	162, 45 bushel
Foggers	102 nozzles, 1282' plastic hose	178 nozzles, 2500' plastic hose	217 nozzles, 2750' plastic hose	262 nozzles, 4400' plastic hose	529 nozzles, 6770' plastic hose

Table 12.--Continued Fixed Resources by Investment Group, Arizona Farrow-to-Finish Hog Operations, 1971

Item	Investment Group				
	I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Grain & Feed Storage Facilities					
Storage bins	15 ton metal bin	28 ton metal bin	40 ton metal bin	75 ton metal bin	75 ton metal bin 50 ton metal bin
Supplement bins	4 ton round metal bulk bin	8 ton round metal bulk bin	12 ton round metal bulk bin	20 ton round metal bulk bin	35 ton round metal bulk bin
Stationary feed mill				Grinder, mixer, motors, augers, etc.	Grinder, mixer, motors, augers, etc.
Building for housing, mixmill, shop				Frame const., metal siding, 25' x 25'	Frame const., metal siding, 25' x 25'
Machinery & Equipment					
Tractors	1, 50 HP	1, 50 HP	1, 90 HP	1, 40 HP	1, 40 HP
Auger Wagon				1, 2½ ton	1, 2½ ton
Truck		1, 2 ton	1, 2½ ton	1, semi-trailer	2, semi-trailer
Pick-up	1, ½ ton	1, 3/4 ton	1, ½ ton	1, ½ ton	1, ½ ton
Feed grinder-mixer	1, portable, 2 ton	1, portable, 2 ton	1, portable, 2 ton	Stationary	Stationary
Scales	1 pair, portable	1 pair, portable	1 pair, portable	1 pair, portable	1 pair, portable
Small tools & shop equip.	Welder, general misc. tools	Welder, general misc. tools	Welder, general misc. tools	Welder, general misc. tools	Welder, general misc. tools
Cleaning equipment	High pressure	High pressure	High pressure	2, High pressure	2, High pressure
Veterinary equipment	Misc. syringes, needles, etc.	Misc. syringes, needles, etc.	Misc. syringes, needles, etc.	Misc. syringes, needles, etc.	Misc. syringes, needles, etc.
Water system	Pump, water lines, etc.	Pump, water lines, etc.	Pump, water lines etc.	Pump, water lines, etc.	Pump, water lines, etc.
Manure spreader				1,000 gal. liquid manure tank	1,000 gal. liquid manure tank
Land	3 acres	4 acres	5 acres	10 acres	13 acres

Table 13. Labor Use and Cost by Investment Groups for Arizona Farrow-to-Finish Hog Operations

Investment Group	Job Performed	Monthly Charge	Annual Cost
100 sow operation			
Owner operator	Handles all aspects of the operation	$850	$10,200
Part-time		160	1,920
200 sow operation			
Manager	Handles breeding, operation of the farrowing house, and the nursery	850	10,200
Full-time man	Handles mixing of feeds, operation of finishing units and hauling pigs to market	750	9,000
300 sow operation			
Manager	Handles all administrative matters, works some in farrowing house	850	10,200
Full-time Man #1	Handles breeding, operation of farrowing house and nursery operation	750	9,000
Full-time Man #2	Handles mixing of feeds, the finishing operation and hauling hogs to market	750	9,000
600 sow operation			
Manager	Handles all administrative matters, oversees all aspects of the operation	1,000	12,000
Full-time Man #1	Manages the breeding herd	750	9,000

Table 13.--Continued

Full-time Man #2	Full-time farrowing house	750	9,000
Full-time Man #3	Full-time nursery's	750	9,000
Full-time Man #4	Handles mixing of feeds & finishing operation	750	9,000
Full-time Man #5	Truck driver, hauling in grain, hauling hogs to market	750	9,000
1,000 sow operation Manager	Handles all administrative matters, oversees all aspects of the operation	1,200	14,400
Full-time Man #1	Handles breeding herd	850	10,200
Full-time Men #2 & #3	Manage operation of farrowing house	850/man	20,400
Full-time Men #4 & #5	Manage operation of nurseries	750/man	18,000
Full-time Man #6	Manage operation of finishing units	750	9,000
Full-time Man #7	Handles all mixing of feeds	750	9,000
Full-time Men #8 & #9	Truck drivers, bringing in grain, hauling hogs to market	750/man	18 000

Table 14. Total Investment Value of Fixed Resources by Investment Group, Arizona Farrow-to-Finish Hog Operations[a]

Type of Investment	Investment Group I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Buildings					
Labor housing			12,000	30,000	54,000
Office			500	938	938
Shop			280		
Livestock facilities					
Farrowing house	4,148	8,033	11,708	9,870	14,805
Nursery, sow & pig				19,800	33,660
Nursery, pigs	2,375	4,500	6,840	12,800	20,400
Finishing facilities	6,978	13,806	18,972	41,792	70,392
Breeding pens	752	1,408	1,984	3,340	6,228
Gestation pens	1,893	3,702	5,160	14,220	22,036
Boar pens	249	426	552	810	1,206
Miscellaneous pens					
Excess finish	1,366	2,424	3,337	2,772	3,120
Gilt pens	357	468	634	962	1,557
Lagoon			1,000	2,500	4,000
Equipment in buildings					
Farrowing crates	2,214	4,428	6,724	5,904	9,102
Evaporative coolers	330	660	1,240	2,880	3,240
Fans	120	240	240	510	634
Automatic waterers	524	952	1,416	3,560	6,000

Table 14.--Continued Total Investment Value of Fixed Resources by Investment Group, Arizona Farrow-to-Finish Hog Operations[a]

Type of Investment	Investment Group I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Creep feeders				840	1,428
Nursery feeders	300	600	960	1,920	2,880
Finish feeders	5,000	9,500	13,000	26,500	42,500
Foggers	174	342	448	830	1,664
Grain & feed storage facilities					
Storage bins	450	750	926	1,250	2,300
Supplement bins	280	280	426	576	800
Stationary feed mill				6,500	6,500
Building for housing mixmill, shop, etc.				1,094	1,094
Machinery & equipment					
Tractors	6,100	6,100	10,500	5,300	5,300
Auger wagon				1,200	1,200
Truck		5,000	5,500	22,500	45,000
Pick-up	3,000	3,500	3,000	3,000	3,000
Stock trailer	2,500				
Feed grinder-mixer	2,500	2,500	2,500		
Scales	300	300	300	300	300
Small tools & shop equipment	500	500	500	500	500

Table 14.--Continued Total Investment Value of Fixed Resources by Investment Group, Arizona Farrow-to-Finish Hog Operations[a]

Type of Investment	Investment Group I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Cleaning equipment	500	500	500	1,000	1,000
Veterinary equipment	50	50	100	200	300
Water system	3,000	5,000	7,000	9,000	12,000
Manure spreader				650	650
Land	1,200	1,600	2,000	4,000	5,200
Sows & boars	11,000	22,000	33,000	64,500	106,750
Total investment	58,160	99,569	153,247	304,318	491,684

[a]Investment values are based on 1971 prices as supplied by producers, machinery and equipment dealers, and Agricultural Engineers at The University of Arizona.

Table 15. Average Investment[a] in Fixed Resources Per Sow, by Investment Group, Arizona Farrow-to-Finish Hog Operations

Item	Investment Group I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Buildings					
Labor housing			$20.00	$25.00	$27.00
Office			.83	.78	.47
Shop			.47		
Livestock facilities					
Farrowing house	$20.74	$20.09	19.51	8.23	7.40
Nursery, sow & pig				16.50	16.83
Nursery, pigs	11.88	13.75	11.40	10.67	10.20
Finishing facilities	34.89	34.52	31.62	34.83	35.20
Breeding pens	3.76	3.52	3.31	2.78	3.11
Gestation pens	9.47	9.26	8.60	11.85	11.02
Boar pens	1.25	1.07	.92	.68	.60
Miscellaneous pens					
Excess finish	6.83	6.06	5.56	2.31	1.56
Gilt pens	1.79	1.17	1.06	.80	.78
Lagoon			1.67	2.08	1.73
Equipment in buildings					
Farrowing crates	11.07	11.07	11.21	4.92	4.55
Evaporative cooler	1.65	1.15	2.07	2.40	1.62
Fans	.60	.60	.40	.43	.42
Automatic waterers	2.62	2.38	2.36	2.97	3.00

Table 15.--Continued Average Investment[a] in Fixed Resources Per Sow, by Investment Group, Arizona Farrow-to-Finish Hog Operations

Item	Investment Group I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
Creep feeders				.70	.71
Nursery feeders	1.50	1.50	1.60	1.60	1.44
Finish feeders	25.00	23.75	21.67	22.08	21.25
Foggers	.89	.86	.75	.69	.83
Grain & feed storage facilities					
Storage bins	2.25	1.88	1.54	1.04	1.15
Supplement bins	1.40	.70	.71	.48	.40
Stationary feed mill				5.42	3.25
Building for housing mix-mill, shop, etc.				.91	.55
Machinery & equipment					
Tractors	30.50	15.25	17.50	4.41	2.65
Auger wagon				1.00	.60
Truck		12.50	9.17	18.75	22.50
Pick-up	15.00	8.75	5.00	2.50	1.50
Stock trailer	12.50				
Feed grinder-mixer	12.50	6.25	4.17		
Scales	1.50	.75	.50	.25	.15
Small tools & shop equipment	2.50	1.25	.83	.42	.25

Table 15.--Continued Average Investment[a] in Fixed Resources Per Sow, by Investment Group, Arizona Farrow-to-Finish Hog Operations

Item	Investment Group				
	I	II	III	IV	V
	(100 sows)	(200 sows)	(300 sows)	(600 sows)	(1,000 sows)
Cleaning equipment	2.50	1.25	.83	.83	.50
Veterinary equipment	.25	.13	.17	.17	.15
Water system	15.00	12.50	11.67	7.50	6.00
Manure spreader				.54	.33
Land	12.00	8.00	6.67	6.67	5.20
Sows & boars	55.00	55.00	55.00	53.75	53.38
Total Average Investment per Sow	$296.84	$254.96	$254.17	$256.94	$248.28

[a]Average investment over the life of the investment, assuming 1971 prices and zero salvage value.

Table 16. Income Summary by Investment Group, Arizona Farrow-to-Finish Hog Operations

Item	Investment Group I (100 sows)	II (200 sows)	III (300 sows)	IV (600 sows)	V (1,000 sows)
	(Gross Dollars)				
Income					
Cull sows	$2,079	$4,221	$6,237	$11,844	$20,979
Cull boars	55	165	220	330	495
Slaughter hogs	82,170	164,249	246,464	493,385	821,380
Gross Income[a]	$84,304	$168,635	$252,921	$505,559	$842,854
Fixed Expenses					
Insurance	$450	$1,100	$2,000	$3,200	$4,000
License, equipment	100	250	250	600	1,400
Repairs	1,921	4,086	5,975	11,264	17,836
Depreciation	4,227	8,446	12,394	21,389	35,956
Interest on Investment	2,278	3,919	6,050	12,013	19,459
Total fixed charges	$8,976	$17,801	$26,669	$48,466	$78,651
Labor Costs					
Management	$10,200	$10,200	$10,200	$12,000	$14,400
Other Labor	1,920	9,000	18,000	45,000	84,600
Total Labor	$12,120	$19,200	$28,200	$57,000	$99,000

Table 16.--Continued

Variable Expenses					
Feed cost[b]	$57,352	$114,717	$171,719	$318,445	$530,584
Utilities & power	728	1,456	2,184	4,500	7,500
Personal property tax	1,744	2,987	4,597	9,129	14,751
Fuel & lubricant	1,550	3,500	5,000	21,720	33,850
Veterinary supplies	400	800	1,200	2,400	4,000
General production	464	913	1,392	2,786	4,640
Total Variable Costs	$62,238	$124,373	$186,092	$358,980	$595,325
Total Costs	$83,334	$161,374	$240,961	$464,446	$772,976
Net Returns	$907	$7,261	$11,960	$41,113	$69,878

[a]Based on July 1971 prices at Kansas City, plus premium for a cut-out of 43 per cent on the four lean cuts.

[b]Result from prices during July 1971 of $62 and $56 per ton for milo, and $98 and $92 per ton for soybean meal.

Table 17. Comparison of Two Major Cost Items in the Production of Hogs as a Per Cent of Total Cost for Sizes of Operations Considered

Size Group	Number of Sows	Per Cent of Total Cost		
		Feed	Labor	Total
I	100	68.3	14.5	82.8
II	200	71.1	11.9	83.0
III	300	71.3	11.7	83.0
IV	600	68.5	12.3	80.8
V	1,000	68.5	12.8	81.3

Table 18. Typical Rations Used in Production of Hogs

Ration	Ingredients	No. of Pounds in a Ton of Feed
Sow & Boar	Milo	1575
	SBM	300
	Meat & Bone Scrap	50
	Salt	10
	Dical	15
	Vit. Premix	5
	Antibiotics	5
	Limestone	10
	Mineral	1
Baby Pig Ration	Milo	700
	Oatmeal	504
	SBM	446
	Dried Skim Milk	296
	Salt	10
	Dical	13
	Limestone	20
	Vit. Premix	5
	Mineral	6
Starter	Milo	955
	Milk	100
	Whey	300
	Meat Scrap	50
	SBM	450
	Dical	15
	Limestone	10
	Salt	10
	Fish Meal	100
	Antibiotics	5
	Vit. Premix	5
Grower	Milo	1500
	SBM	455
	Dical	15
	Limestone	10
	Salt	10
	Antibiotics	5
	Vit. Premix	5

Table 18.--Continued

Finisher	Milo	1600
	SBM	325
	Dical	15
	Limestone	10
	Salt	10
	Vit. Premix	5
	Antibiotics	5
	Mineral	1

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