# Economies of Size in Swine Production Under Different Production Methods and Phases

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# ECONOMIES OF SIZE IN SWINE PRODUCTION UNDER DIFFERENT PRODUCTION METHODS AND PHASES

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## SUMMARY

Iowa and other Corn Belt pork producers have become concerned about the potential of very large commercial or "industrialized" hog operations growing out of economies of size (or cost advantages and scale economies for larger producers). The purpose of this study was to estimate empirically the economies of size associated with specialized nonintegrated swine enterprises in central Iowa. This information can then be used to judge the competitive position of different-sized hog operations in Iowa. Costs were budgeted for 10 levels of production from 25 to 1,000 sows. The prices used for the various items were those that existed in central Iowa in 1970. Three management systems were examined: the pasture, the open front confinement, and the environmentally controlled confinement systems. Each management system consisted of four phases: gestation, farrowing, growing, and finishing.

The emphasis in this study is the extent to which average costs decline sharply as the size of the hog enterprise is increased. We are concerned with whether the average cost curve "flattens out" or approaches a minimum at a small or large volume. While different management systems are included in the analysis, the major concern of this study is with the economy of size and not with the efficiency per se of the different systems.

Costs were budgeted from research data for each phase. Total costs were divided into fixed and variable costs. Short-run average total

cost curves were developed for each system. The short-run average total cost curves in all three management systems had steeper slopes at the lower production levels than at the higher production levels. The decline in the steepness of the slope indicates that fixed costs decline relative to total costs as the level of production increases. Thus, larger operations have greater flexibility with respect to the use of fixed resources.

The long-run average total cost curve is the envelope curve of the short-run average cost curves. In the pasture system, the long-run average total cost curve declined sharply for hog operations up to 500 head annual production. For operations with annual production of 500 to 3,500 head, the decline in average cost was much smaller. For production greater than 3,500 head, average costs were relatively constant, and further reductions with volume were unimportant relative to price and other uncertainties facing swine producers. In the open front system, average costs declined sharply until annual production reached 2,000 head. From 2,000 to 9,000 head annually, average costs decline much more slowly. For levels of production in excess of 9,000 head, average costs were relatively constant. Similarly, in the environmentally controlled system, average costs declined sharply until production reached 3,000 head annually. For hog operations with 3,000 to 9,000 head annual production, a much smaller decline in average cost occurred, and for operations greater than 9,000 head, the average costs were comparatively constant. Unlike the other two systems, the environmentally controlled system showed some diseconomies of size for the 750 and the 1,000 sow

production levels because of increased manure disposal and odor control costs.

The study does not show great cost advantages in pork production for units producing more than 9,000 hogs per year for the two confinement systems or beyond 3,500 hogs for the pasture system. Indeed, it seems that most of the cost reduction per hog or hundredweight of pork produced has been attained at 5,000 to 7,000 market hogs annually under both the environmentally controlled confinement system and the open front confinement system, and at 2,000 market hogs annually for the pasture management system.

Although comparisons between systems were complicated because of differences in the number of hogs marketed, some conclusions were possible. The environmentally controlled system had the lowest gestation costs per hundredweight while the pasture system had the highest because of the longer gestation period and higher feed consumption. Farrowing costs per hundredweight were lowest in the pasture system for production levels one through seven and lowest in the environmentally controlled system for levels eight through ten. The growing costs were similar for both confinement systems at each production level. The growing costs per hundredweight in the confinement systems were lower than those in the pasture system. In the finishing phase, costs were lowest in the open front system and highest in the pasture system.

Vertical relationships were not examined in this study. Producers who produce and process their own feed may lower their feed costs as much as $15 to $20 per ton. The larger hog producers, however, have to

purchase a portion of their feed, as they are not able to produce all that they need. Alternatively, large producers may be able to differentiate their product by maintaining higher quality control measures, and be able to receive a premium for their product from packers. In addition, there is potential for vertical integration in hog production. Producers may become large enough that incorporation of a feed plant and(or) a packing plant into the hog enterprise becomes economically feasible. Consideration of the vertical production and marketing relationships, in addition to the size economies, is necessary before complete conclusions are possible with respect to the ultimate organization of the swine industry.

In this study, it was assumed that an environmentally controlled system would have a better system of surveillance of pigs during farrowing and a higher level of management than for the other two systems. The number of pigs saved and raised per sow are high under these assumptions. This level of efficiency would be difficult to attain in many hog operations. However, even this level of efficiency does not result in large cost economies for the very large units of the environmentally controlled system.

# Economies of Size in Swine Production Under Different Production Methods and Phases

## INTRODUCTION

Historically, swine production was considered a supplementary or complementary enterprise in the farm organization. Because the enterprise was complementary or supplementary, few studies have examined the cost economies of large-scale, specialized swine enterprises. In recent years, however, there has been a move towards large, specialized hog production units. In a survey of large-scale hog production units in the United States in 1974, there were 141 operations which marketed 4,000 or more hogs in any one of the years 1971 to 1973 (3). Because of developments in the past year, it is estimated that there are actually 180-200 large-scale hog operations in the United States (3). Some of these operations, however, are large feeder pig operations which raise feeder pigs for their owner-members. Of the 141 operations, only 28 percent are located in the traditional Corn Belt, with 21 percent in the Plains States and 51 percent in the South. Moreover, 85 percent of the new operations since 1965 have been outside the Corn Belt (3).

When relative costs favor labor-intensive methods of production, small farms and large farms can exist side-by-side. However, when relative costs favor capital-intensive methods, large-scale farms may have a cost advantage (2). Nationally from 1965 to 1973, the number of hog

farms declined from 1,057,570 to 752,020, a decline of 28.9 percent. In the same period the number of hogs and pigs on farms increased from 50,519,000 in 1965 to 61,022,000 in 1973 (4; 5). Thus, the number of hogs per farm increased from 48 to 81 in this eight-year period. In Iowa, the largest hog producing state, the number of hog farms declined from 104,000 to 86,000 farms in this same period, while the number of hogs and pigs on farms increased from 12,857,000 in 1965 to 14,700,000 in 1973 (4; 5). For Iowa during this period, the number of hogs per farm increased from 124 to 171. These data indicate that the size of the swine enterprise has grown rapidly both in Iowa and nationally. Whether or not this trend towards larger units will continue depends largely on the shape of the long-run average total cost curve of the farm firm specializing in swine production.

Iowa and Corn Belt farmers have become increasingly concerned with the possibility of very large-scale or "industrialized" farms specializing in swine production, just as broiler production and cattle fattening have become concentrated in mammoth units in recent years in some areas of the country. Whether this tendency will prevail in swine production depends partly on the cost advantage or scale economies associated with larger units (and also certain advantages of vertical integration not analyzed in this study).

## OBJECTIVES

The purpose of this study is to estimate empirically the economies of size associated with nonintegrated swine enterprises. The study is especially concerned with the extent of the cost economies for each enterprise type, rather than a comparison of the economies among types. The three types of hog enterprises or management systems analyzed are: single-litter pasture; multi-litter open front confinement; and multi-litter environmentally controlled confinement. The information that is obtained can be used to evaluate the competitive position of hog operations in Iowa.

Grazing characterizes the pasture system, as all animals in this management system have access to grass. Gilts, gestating in winter months in lots, can graze on any forage available. Farrowing takes place in the spring and summer with all breeding stock sold after the pigs are weaned. The weaned pigs are kept on pasture during the summer and fall until they are mature. In the fall, all the hogs are sold except for the replacement gilts, which are kept over winter and farrowed in the following spring.

The open front and environmentally controlled systems are confinement systems. All animals are confined to pens inside buildings. The open front system consists of buildings with open fronts except for the farrowing building. The farrowing building is completely enclosed and has supplemental heat for farrowing in winter. Environmentally controlled systems have the environment controlled within the range of 45 to 85 degrees.

With the controlled environment it is necessary to have all buildings enclosed and insulated. Both the open front and the environmentally controlled confinement systems have multiple farrowings.

Each of the three management systems is divided into four phases: gestation, farrowing, growing, and finishing. Gestation extends from market weight for gilts, or weaning in the case of sows, until two days before farrowing. The farrowing phase is from the end of gestation until weaning. The growing phase extends from weaning until the pigs reach 110 to 125 pounds. Finishing completes the production cycle and extends from the growing phase to a market weight of 235 pounds.

Ten levels of production from 25 to 1,000 sows are used to derive the long-run average total cost curve for each hog management system. The long-run average total cost curve shows the economies of size associated with a particular hog system. The levels of production examined are given in Table 1. The production levels are a function of the number of sows, the number of farrowings per sow per year, and the number of pigs weaned per litter. The number of sows (gilts) used is the same at each level for the three management systems. Output varies from system to system because of differences in the productivity of the farrowing phase. Production costs per hundredweight for each phase and for all four phases are estimated for each of the levels (sow numbers) indicated in Table 1.

Table 1. Number of sows and hogs for each management system by production level.

| Level | Sows | Hogs-Pasture | Hogs-Open Front | Hogs-Controlled |
|---|---|---|---|---|
| 1 | 25 | 180 | 312 | 400 |
| 2 | 50 | 360 | 656 | 801 |
| 3 | 75 | 532 | 1,032 | 1,256 |
| 4 | 125 | 885 | 1,686 | 2,440 |
| 5 | 250 | 1,770 | 3,414 | 4,943 |
| 6 | 375 | 2,655 | 5,424 | 7,704 |
| 7 | 500 | 3,540 | 7,302 | 10,272 |
| 8 | 625 | 4,432 | 9,252 | 13,097 |
| 9 | 750 | 5,318 | 11,232 | 15,601 |
| 10 | 1,000 | 7,088 | 14,886 | 20,801 |

## INPUT VARIABLES

Each system is divided into the four phases mentioned previously, and costs are computed for the 10 levels for each phase. At each level there are 14 different cost items. These items are: buildings, equipment, sows, boars, repairs, disease control, power and fuel, feed 1, feed 2, feed 3, waste disposal and odor control, labor, finance, and death loss. No consideration is given to the cost of marketing hogs. The level of technology is assumed to be that which is currently profitable to use in each case, and the techniques have been tried at least under experimental conditions. Risk and uncertainty are not treated formally in this study. These aspects are considered subjectively as they affect certain operations. Risks associated with disease and death loss were considered when disease costs were budgeted and when building systems

were adopted. Although structure and conduct are important considerations, the focus of this study is on size and related cost advantages or economic efficiency in the hog industry.

For each system, the long-run average total cost curve is given by the envelope curve of the short-run average total cost curves for each of the 10 levels. Costs for each level are the sum of the costs for each of the four phases.

A budgeting approach is used in this study to develop a series of short-run curves for each level of production.[1] Due to uneven price inflation and relative distortion in factor prices, perhaps in the short run, the budgets were developed using 1970 prices for central Iowa. Costs are analyzed at each phase to determine the minimum cost for each level. The phase costs are then added to produce a series of 10 discrete points for each system. Each point represents the minimum short-run cost for that level of production. Building and equipment costs and the fixed portion of manure disposal costs are summed to obtain the total fixed costs. The remaining costs are variable. The short-run average total cost curves are derived from these two sets of costs. The short-run average total cost curves are assumed to have positive as well as negative sloped portions, although there is little or no data available on costs associated with overcrowding of fixed facilities. Since there is generally free entry into the hog business, the diseconomies of size will limit the size of the operation.

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[1]Actually, cost functions, composed of fixed and variable components, were estimated in each case as a means of systemizing the "budgeting" efforts.

By budgeting, the management influence is eliminated (which is not the case when costs are obtained from a sample survey of farms). This study assumes that sufficient managerial skill exists to operate each system at the different levels. The budgets for each system by phase were developed from research data and farm observations. The budgeted items are divided into price variables and input variables. The price variables express the decline in input prices due to purchases of inputs in larger volumes. The input variables indicate the amount of real input needed. They also show the economies and diseconomies resulting from improved techniques, reorganization due to indivisibilities, and changes in the production process with increased size. Input variables are multiplied by their corresponding price variables to determine the cost for each of the 14 items. The total annual cost per item is divided by total annual production to determine cost per head for each item within each phase. These costs are then summed to obtain the total cost per head for each level within each phase. Finally, the total cost for each phase is summed to obtain the total cost per head. The cost per head is divided by 2.35 to obtain the total cost per hundredweight, a 235-pound marketing weight being used in each case.

Only the declining portions of the cost curves for the 10 production levels are estimated in this study. This procedure is used because we are concerned less with finding the minimum points on the cost curves, and more with determining the range over which total or phase costs of production decline rapidly. For example, if an increase in the volume

of hogs results in a decline in hog production costs by $8.00 per cwt, then this cost economy is important to farm size. However, if a further increase in the volume of production causes only a $0.26 decrease in hog production costs, then the cost reduction is probably insignificant relative to prices, disease, and other uncertainties or the cost of capital in determining size of farms and hog operations. The conventional U-shaped cost curves could have been derived by expanding hog numbers for a given set of sow facilities until diminishing returns occurred from crowding, disease, etc. However, as mentioned previously, our concern is mainly with the question: Over what range of production does the cost curve decline relatively sharply before it "flattens out" into insignificant cost reductions?

## Buildings and Equipment

Annual costs for buildings include depreciation, taxes, land, and insurance. Annual equipment costs consist of depreciation, taxes, and insurance. Because of the supplementary relationships that exist for the smaller hog enterprises, only a portion of the total annual costs for tractors, wagons, and the water system are assigned to the hog enterprises. The allocation of costs depends upon the proportion of the total annual use of the equipment that is used in the hog enterprise.

All land used in the hog enterprise is charged at an annual rate of 30 dollars per acre. Property taxes are computed by taking the assessed value times 0.27 and then multiplying by an 80 mill tax rate. The 10,000 dollar personal property exemption is used, but only a portion of the

exemption is applied to the swine enterprise until the enterprise exceeds 250 sows. No tax is paid on the breeding herd in the pasture system, since the animals are not over nine months of age on the first of January. Liability and comprehensive insurance costs are divided in proportion to the risk associated with each phase of production. Insurance for fire, wind, and theft is charged to the buildings at the rate of 44 cents per 100 dollars of value. Each phase bears the cost of this type of insurance in proportion to its use of the buildings. The portable gestation sheds in the pasture system are assumed to have a 10-year life, while the individual farrowing houses are assumed to last only seven years. For the confinement systems, depreciation is computed on the basis of a 10-year planned life for buildings and equipment. Although confinement buildings will undoubtedly last more than 10 years, changes in technology will likely make these buildings obsolete within that period.

In the open front system, the farrowing buildings are enclosed and have supplemental heat, but they are not insulated. In addition, the buildings do not have forced air ventilation systems. The controlled environment system, on the other hand, has farrowing buildings which are fully insulated, ventilated, and have electric floor heated creeps in addition to heat bulbs for the pigs. For operations with 125 sows or more, the farrowing buildings have incubators and mechanical pig nursers which reduce baby pig losses.

In the pasture system for operations larger than 50 gilts, two groups of gilts are farrowed each year. The first group farrows in April and

the second in June. The farrowing houses and equipment can be used twice each year under this method. Under this system gilts should wean an average of 7.5 pigs. In both types of confinement systems, the sows are divided into two groups for operations with 50 sows or less. For operations with 75 to 250 sows, the sows are divided into three groups for farrowing. Under these two types of groupings, the gestation buildings and equipment and the farrowing buildings and equipment are not used intensively. Operations with 375 to 500 sows are divided into six groups. By using six farrowing groups, one-sixth of the sows are in the farrowing buildings at all times, and building requirements per sow decline accordingly. For operations with 625 or more sows, the sows are separated into 9 groups. Under this arrangement, two-ninths of the sows are in the farrowing barns at one time. These latter two arrangements result in more intensive use of gestation and farrowing facilities. In the open front management system, sows are assumed to wean an average of 7.8 pigs per litter. For the environmentally controlled management system, this study assumes an average of 9.1 pigs weaned per litter for operations with 75 sows or less, and 10.7 pigs weaned per litter for operations with 125 or more sows. In both systems the sow farrows twice a year.

The number of pigs weaned per litter is higher for the environmentally controlled system than for the other two systems for several reasons. First, sows are assumed to receive 100 percent surveillance during farrowing which is not the case for the other two systems. Second, the environment is not controlled in the other two systems except for the

open front system where supplemental heat is provided during the farrowing phase. Without forced air ventilation and cooling in the summer, farrowing in the open front system is more difficult, resulting in higher sow losses and fewer pigs weaned. In the winter months, the lack of proper ventilàtion will result in dampness which will decrease the number of pigs weaned per litter. Third, gilts, which are used in the pasture system, farrow on average slightly smaller litters than sows. Finally, a higher level of management is assumed for the environmentally controlled system than for the other two systems. In the pasture system, the portable gestation sheds are also used to provide shelter for the growing and finishing pigs. The costs of these sheds are allocated 50 percent to the gestation phase and 25 percent each to the growing and finishing phases. The two confinement systems have separate buildings for gestation and for growing and finishing. The growing and finishing buildings accommodate six groups or lots of pigs annually in both the environmentally controlled and open front systems.

## Breeding Stock

In the pasture management system boars are purchased six weeks before the breeding season. The gilts are pen bred in the gestation houses using two boars for each 25 gilts. For pasture operations with more than 50 gilts, 2 boars will breed 50 gilts, since the gilts are bred to farrow in April and June. The boars are sold after the breeding season. The boars are not kept for more than one breeding season to avoid having to look after a separate lot of animals between breeding seasons. In the confinement systems, one boar is used for every 10 sows, as each gestation

pen contains 10 sows. Since sows are bred more often in confinement, boars can be used on more than one group of sows. The boars in confinement systems are kept for two years and then sold. The lightest load for 2 boars is 25 sows on pasture, while the heaviest is 14 boars for 1,000 sows in confinement. About 10 percent of the boars are held in reserve in the event that a boar should become sick or injured. In the pasture and open front systems, the conception rate is assumed to be 70 percent, while in the environmentally controlled system the conception rate is 80 percent. A higher rate is assumed for the latter system because of the controlled environment.

Gilts in the pasture system are selected from each year's production and are held until the breeding season. The gilts are sold after the pigs have been weaned. In confinement systems sows are not replaced annually but are kept for a maximum of six litters. Approximately 60 percent of the sows are kept for the full six litters. The other 40 percent are replaced because of disease, injury, reproductive and structural abnormalities, or undesirable traits. The 40 percent replacement rate can probably be obtained only by the better managers of hog operations. For many hog operations, however, the replacement rate for sows will be considerably higher because of the greater incidence of disease and injuries.

Although the gilts are raised on the farm, each replacement gilt is valued at 50 dollars. This value includes charges for the record keeping, the weighing, and the probing necessary to maintain a competitive breeding program. The purchase price of a boar is 150 dollars. The sale value of

first-litter gilts and boars is less than the initial value and purchase price, whereas for sows it is greater. The capital requirements for the breeding stock are included in the finance variable.

## Repairs

The repair variable is defined as the annual cost of maintenance of buildings and equipment. The cost of repairs is a function of the age, the amount of annual use, and the value of buildings and equipment. In this study, buildings and equipment are assumed to have varying life expectancies. Hence, a constant annual rate of 3.5 percent of the investment in buildings and equipment is used.

## Disease Control

The disease control variable includes those costs incurred in treating and preventing disease. These costs include the cost of pharmaceuticals, feed additives, disinfectants, and veterinarian services. Pharmaceuticals are those products which are injected into the animals or placed in the drinking water. Feed additives include products added to the feed for health purposes.

## Power and Fuel

Power and fuel costs consist of the cost of gasoline, electricity, and gas to provide energy for heating, lighting, moving feed, cooling, and ventilating for the three management systems. Usage coefficients are developed from actual farm data. Electricity requirements, however, are

developed from engineering specifications by multiplying the usage rate times the number of hours necessary to perform the operation. These figures are then multiplied by the price per KWH to obtain the electrical costs. Price discounts result in substantial savings as the usage of electricity increases.

In the pasture system the primary power needs are supplied by a tractor. Some electricity is needed to keep the water system from freezing during the winter. In the open front system, electricity is the primary source of power. Electricity is used to operate the automatic feed systems, to heat the water, and to provide heat in the farrowing house. In the environmentally controlled system, electricity is again used to operate the automatic feed systems and to provide electric heat in the farrowing and growing buildings. Gas is used to provide heat in the gestation and finishing buildings.

## Feed Variables

The feed variables are the feed in tons necessary to produce the projected pounds of pork. There is one variable for each ration fed in a particular phase. Only one ration is fed in each phase except the farrowing phase, where three rations are used. In the farrowing phase the three rations are the sow ration, the starter pig ration, and the weaning pig ration. The price variables are the costs of feed per ton. Feed costs include the cost of grinding, storage, supplement, and the value of the corn. If the feed is purchased, then there are the additional cost of transportation and the miscellaneous selling expenses and profit.

Also, there are price discounts for larger volumes of feed purchased.

The average gestation phase feed requirements for gilts in the pasture system and sows in the open front and controlled systems are 5.33, 4.46, and 4.33 pounds per head per day, respectively. Most of the higher feed intake for the pasture system is due to the fact that gestation occurs mostly during the winter months, when the animals have higher feed requirements. Boars receive the same amount of feed as gestating gilts and sows. In the farrowing phase gilts in the pasture system receive an average of 12.00 pounds per head per day, while sows in the two confinement systems are fed an average of 14.00 pounds per head per day. In the growing and finishing phases, the hogs are fed by a self feeder in the pasture system and by floor feeding in the two other systems. In all three systems, hogs in these two phases receive full feed. In the growing phase, hogs in the pasture, open front, and controlled systems are assumed to eat 3.15, 2.80, and 2.70 pounds per head per day, respectively. In the finishing phase for the three systems, hogs are fed 3.90, 3.50, and 3.40 pounds per head per day, respectively. Hogs in the pasture system are assumed to consume more feed per day, because they are combined into larger groups and placed in pens which are much larger than those in the two confinement systems. Thus, the hogs on pasture are assumed to expend more energy wandering about the larger pens.

## Waste Disposal and Odor Control

The waste disposal variable consists of all costs except labor for handling manure and controlling odor. The labor is included in the labor variable.

Costs include the construction and operation of slotted floors, pits, and lagoons. Only the difference in cost between concrete slats and concrete floor is included in the waste disposal cost. A partially slotted floor system is used in this study for both confinement systems. The partially slotted system was adopted because it was cheaper than the totally slotted floor system. Secondly, it permits the use of a floor feeding system rather than a self feeder. This system also gives the hogs a dry place to sleep, which the totally slotted floor does not provide. An aerobic lagoon is used for the 25 and 50 sow production levels in the confinement systems. Hog operations with 75 or more sows utilize an anaerobic lagoon for waste disposal. The excess wastes in the lagoons are placed on the land either by a pump system or by a manure spreader. In the pasture system, the waste disposal variable includes only the cost of removing the manure from the gestation houses.

Odor control costs are estimated only for the larger confinement operations. Odor control costs are budgeted at 50 cents per head for operations with 500 to 625 sows, 75 cents per head for operations with 750 sows, and $1.00 per head for operations with production over 20,000 head annually.

## Labor

The labor coefficient is defined as the annual labor required to produce the total number of pigs marketed at each production level. This study assumes that 25 percent of the total labor requirements is spent on maintenance of buildings and equipment. Although the confinement

systems require less maintenance of buildings and equipment than the pasture system, the total labor requirement per hog is also less for these systems.

In the gestation phase of the pasture system, the gilts are fed once every three days. However, the gilts are inspected daily. Manure is hauled once a week from each hut during the winter. The labor coefficient includes a daily inspection of the pigs in the growing and finishing phases. The labor required for delivery of the feed to the self feeders is included in the feed processing activities. The labor requirements are essentially the same for both confinement systems. In the gestation phase, daily labor is required for cleaning and inspection. In the farrowing phase, the sows are fed individually twice a day by hand. At the same time the sows and pigs can be inspected routinely for health problems and treated whenever necessary. Labor is also required daily for cleaning and surveillance during the farrowing period. Also, labor is needed for cleaning and disinfecting between farrowings, castrating boar pigs, ear notching, and moving of animals out of the farrowing buildings. In the growing and finishing phases, labor is needed for daily inspection and some cleaning, particularly in the growing pens. Manure disposal requires labor in varying amounts, depending upon the size of the spreader used and the number of animals involved.

Labor costs are computed at a rate of $3.00 per hour. This figure includes the cash wages, house, utilities, liability insurance, and social security. Each employee works 200 hours per month.

## Finance and Death Loss Variables

The finance variable is an estimate of the amount of capital needed in the swine enterprise. This estimate includes the total fixed and operating capital needed to produce a market weight animal. The value of the breeding stock is included in the finance variable.

Debt capital is charged at an interest rate of 7.5 percent for proprietorships and 7.0 percent for corporations, since corporations do not need to take out a life insurace policy on a mortgage. Up to 250 sows, the proprietorship form of ownership is assumed. With 250 or more sows, the corporate form of ownership is assumed to prevail. Equity capital is charged at an opportunity cost of 9 percent. This study assumes a 65 percent equity requirement for buildings and equipment and breeding stock, since the model includes no farm land, purchased feed, and an uncertain market. In addition, the buildings and equipment which are designed almost exclusively for hogs have a low salvage value. Hence, the average cost of capital is 8.475 and 8.30 percent for proprietorships and corporations, respectively.

Death loss is computed in terms of dollars. The dollar loss from death is the total cost incurred for the animal up to the time of death. In the gestation phase, death loss is assumed to average 0.25 percent. In the farrowing phase, death loss for sows and gilts increases to 2 percent for the pasture system but remains at 0.25 percent for the confinement systems. In the growing phase the facilities have a marked effect on death loss. The pasture system has about a 1 percent death loss.

Open front confinement growing facilities, however, are poorly designed for the small growing pig. Quick temperature changes causing flu and pneumonia will cause the death loss to average about 5 percent. Although pigs in the environmentally controlled system are not subjected to the stresses that pigs in the open front system are, death loss will still average 1.5 percent due to confinement-related problems such as increased cannibalism, tailbiting, etc. In the finishing phase, death loss for the pasture system is again assumed to be 1 percent. Death loss in the open front system declines to 2 percent in the finishing phase. The controlled environment system has the lowest death loss with an average of 0.5 percent.

## Price Levels Used

The price levels used in this study are those of 1970. We suppose for this period that the costs of feed, credit, labor, and other inputs bear "more nearly normal" relationships to each other than in 1974, when the final steps were taken on this study. Hence, the analysis shows the cost economies for hog operations of different scales and for different hog systems under the 1970 cost structure. The costs per hundredweight are presented to show the relative range of scale economies--and not the cost of pork production in a year such as 1974 when corn prices reached $3.64 per bushel in central Iowa.

This completes the discussion of the components that are included in the 14 input coefficients or variables. Some of the prices that are

assigned to some of these input variables were discussed in this section. The next section will examine the economies of size for the three management systems.

## RESULTS

The costs in this section are presented in terms of costs per hundredweight of hogs marketed. Costs per head can be computed by multiplying costs per hundredweight by 2.35. These latter costs are presented in the appendix. Comparisons between systems on a per hundredweight or per head basis is complicated by differences in productivity in the farrowing phase, and the use of gilts rather than sows in the pasture system.

### Economies of Size in the Pasture Management System

The costs per hundredweight for each phase under the pasture system are given in Table 2. These costs are summed to obtain the total cost per hundredweight for each production level. In addition, the total costs are broken down into fixed and variable costs to show the effect of increasing size on these two types of costs.

For each phase in the pasture system, costs generally decrease as the size of the enterprise increases. Decreases in costs arise from increased utilization of inputs and(or) lower input prices. In the gestation phase the costs per hundredweight decline consistently with an increase in the size of the operation. In the farrowing phase costs decrease for the first five levels of production. These decreases are due primarily

Table 2. Costs per hundredweight for pigs produced under the pasture management system.

| Production Level | Sows (Gilts) | Hogs (Mkt.) | Gestation Phase | Farrowing Phase | Growing Phase | Finishing Phase | Total | Fixed | Variable |
|---|---|---|---|---|---|---|---|---|---|
| | -numbers- | | | | -dollars- | | | | |
| 1 | 25 | 180 | 5.07 | 6.33 | 5.44 | 9.48 | 26.32 | 1.86 | 24.46 |
| 2 | 50 | 360 | 4.71 | 6.15 | 5.02 | 8.75 | 24.63 | 1.71 | 22.92 |
| 3 | 75 | 532 | 4.56 | 5.65 | 5.09 | 8.73 | 24.03 | 1.46 | 22.74 |
| 4 | 125 | 885 | 4.48 | 5.48 | 5.62 | 8.75 | 24.35 | 1.53 | 22.82 |
| 5 | 250 | 1,770 | 4.27 | 4.98 | 5.58 | 8.71 | 23.53 | 1.48 | 22.05 |
| 6 | 375 | 2,655 | 4.18 | 5.02 | 5.55 | 8.68 | 23.43 | 1.42 | 22.01 |
| 7 | 500 | 3,540 | 4.01 | 5.00 | 5.52 | 8.65 | 23.17 | 1.38 | 21.79 |
| 8 | 625 | 4,432 | 3.99 | 5.02 | 5.52 | 8.65 | 23.19 | 1.43 | 21.76 |
| 9 | 750 | 5,318 | 3.97 | 4.97 | 5.46 | 8.59 | 22.98 | 1.33 | 21.66 |
| 10 | 1,000 | 7,088 | 3.96 | 4.95 | 5.44 | 8.57 | 22.92 | 1.31 | 21.62 |

to lower feed prices and improved labor efficiency. Beyond the fifth level, however, the costs remain relatively constant. Thus, most cost economies have been achieved by the 250 sow level. In the growing phase, costs decline except at the third and fourth levels. At the third level antibiotics are fed as the general health of the hogs dictates. At the fourth and subsequent levels, antibiotics are fed as part of a disease-preventive program. Costs in the finishing phase decline slightly after the second level of production. This relatively constant cost implies that resources in the finishing phase of the pasture system are generally quite divisible, and that increased size can be achieved through duplication of facilities as well as expansion in the size of facilities.

Total fixed costs in the pasture system are the sum of building and equipment costs. Fixed costs increase at the fourth level because all equipment costs are charged against the swine enterprise (since it was assumed that at this level all equipment was used exclusively in the swine operation). Below this level of production, only a portion of the equipment cost was assigned to the hog enterprise. The other major segment of total cost is the variable costs. The variable costs decrease for the higher production levels except for the third and fourth levels where they increase slightly.

Short-run total cost curves for the pasture system were derived from the total cost figures in Table 2. The 10 short-run cost curves corresponding to each of the 10 production levels are shown in Figure 1. Each production level is defined in terms of the number of sows, which range

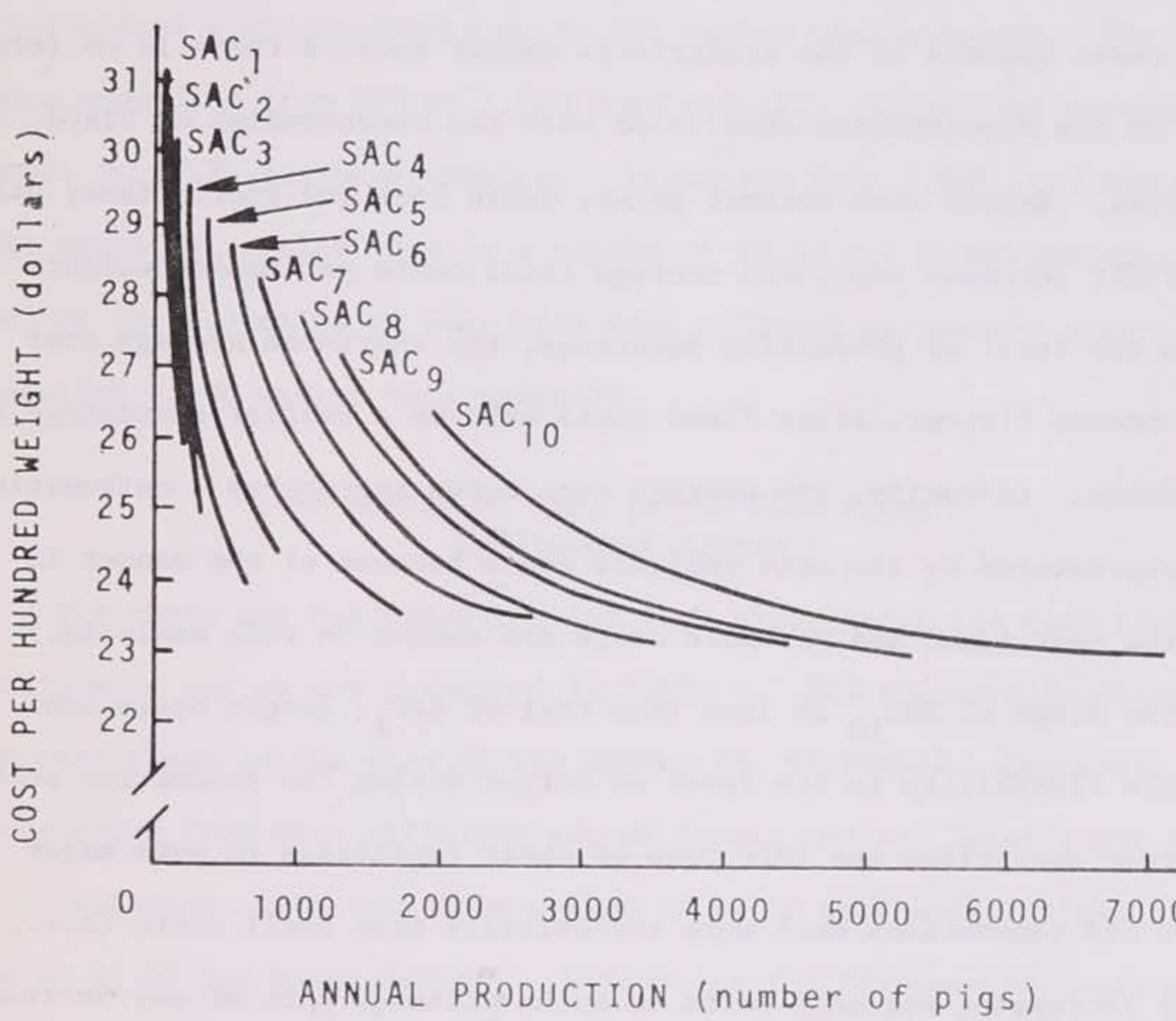


Figure 1. Short-run average total cost curves for each of the 10 production levels in the pasture management system.

from 25 to 1,000 in number. The curves were derived by holding the fixed costs constant and varying the utilization of the fixed plant up to the maximum specified for each production level. The short-run curves do not curve upwards in the traditional manner because there is no information on the diseconomies associated with the overcrowding of fixed facilities. Beyond some optimal point, death loss and inefficiency will undoubtedly increase short-run average total costs per hundredweight.

As the level of production increases, the short-run average cost curves become flatter, since fixed costs make up a smaller percentage of total costs. (Actually, the average cost curve approaches a mathematical limit represented by the unit variable costs because of the manner in which the unit fixed and variable costs are summed in this analysis.) Since the slope of $SAC_{10}$ is less than that of $SAC_1$, larger operations have more flexibility in the level of output during the production period. The larger operations can idle some of their facilities to make major repairs and renovations much more economically than small units (i.e., without increasing per unit costs so much, although part of any increased cost due to lower volume is composed of fixed costs). Losses from major clean up programs aimed at disease eradication and prevention are proportionately less for the larger producers. If an operation of size level 10 decreases output by 30 percent, total cost increases $0.56 per hundredweight, but if an operation of size level 1 decreases output by 30 percent, total cost increases $0.80 per hundredweight.

The long-run average total cost curve is the envelope of the short-run average cost curves. The curve, serving as the envelope of those in Figure 1, is presented in Figure 2.[2] Substantial economies of size are achieved with operations up to 500 market hogs annually. For operations expanding from 500 to 2,000 hogs annually, additional savings amount to $0.70 per hundredweight. Expansion from 2,000 to 7,000 market hogs annually results only in a saving of $0.50 per hundredweight. Thus, most of the economies of size have been achieved by pasture operations producing 2,000 market hogs annually.

## Economies of Size in the Open Front Confinement System

The costs per hundredweight for each phase under the open front confinement system are presented in Table 3. Costs generally decrease for each phase as the size of the enterprise increases. Decreases in costs arise from more efficient use of inputs and(or) lower input prices.

Gestation costs vary from a high of $4.10 per hundredweight to a low of $2.52 per hundredweight. Offsetting the decrease in costs of other inputs is the increase in waste disposal cost for the larger operations. In the farrowing phase, costs decline consistently from the 25 sow level to the 1,000 sow level. Farrowing costs decrease from $7.40 to $5.25, a decrease of $2.15 per hundredweight. Growing costs decline from the

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[2]As mentioned previously, we are concerned only with measuring costs as a given set of facilities is used up to reasonable capacity and not to the extent that diminishing marginal returns prevail for this set of facilities. Hence, for the short-run curves, we are measuring only the declining portion of short-run average costs. We do so mainly because we are concerned with the extent of the cost advantages which might be achieved by swine enterprises of different sizes. Accordingly, the long-run envelope or cost function reflects only the declining portions of the short-run average cost curves.

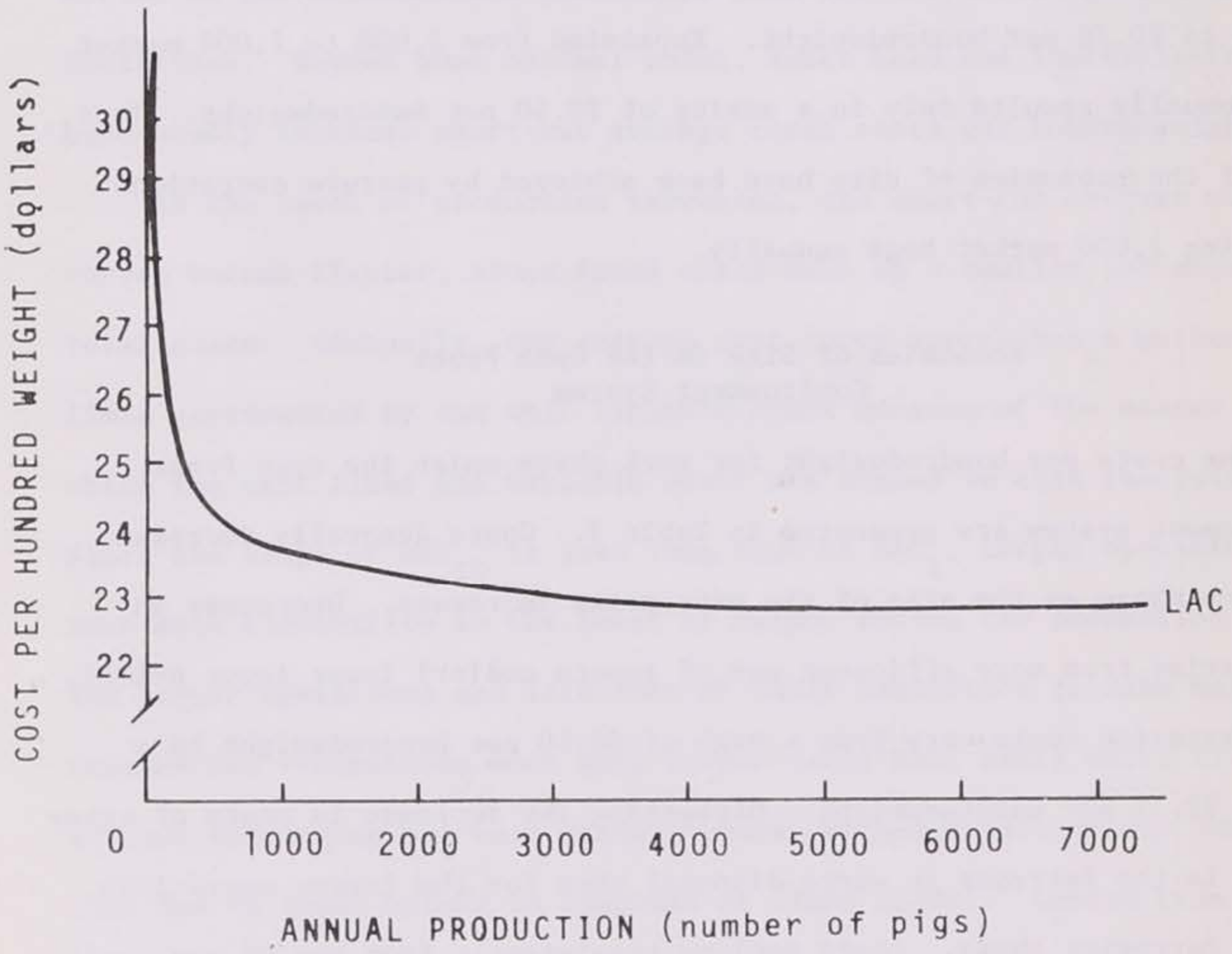


Figure 2. Long-run average total cost per hundred weight for the pasture management system.

Table 3. Costs per hundredweight for pigs produced under the open front confinement system.

| Production Level | Sows | Hogs (Mkt.) | Gestation Phase | Farrowing Phase | Growing Phase | Finishing Phase | Total | Fixed | Variable |
|---|---|---|---|---|---|---|---|---|---|
| | -numbers- | | | | -dollars- | | | | |
| 1 | 25 | 312 | 4.10 | 7.40 | 4.82 | 8.60 | 24.92 | 2.13 | 22.79 |
| 2 | 50 | 656 | 3.66 | 7.07 | 4.67 | 8.34 | 23.74 | 1.80 | 21.94 |
| 3 | 75 | 1,032 | 3.25 | 6.41 | 5.39 | 8.12 | 23.17 | 1.63 | 21.54 |
| 4 | 125 | 1,686 | 3.31 | 6.25 | 5.27 | 7.98 | 22.81 | 1.56 | 21.25 |
| 5 | 250 | 3,414 | 3.16 | 6.07 | 5.21 | 7.99 | 22.43 | 1.46 | 20.97 |
| 6 | 375 | 5,424 | 2.78 | 5.85 | 5.20 | 8.02 | 21.85 | 1.28 | 20.57 |
| 7 | 500 | 7,302 | 2.73 | 5.80 | 5.21 | 8.02 | 21.78 | 1.26 | 20.51 |
| 8 | 625 | 9,252 | 2.53 | 5.39 | 5.18 | 7.97 | 21.06 | 1.22 | 19.84 |
| 9 | 750 | 11,232 | 2.52 | 5.27 | 5.17 | 8.02 | 20.98 | 1.20 | 19.78 |
| 10 | 1,000 | 14,886 | 2.53 | 5.25 | 5.14 | 7.98 | 20.89 | 1.20 | 19.70 |

first to the second level, and then there is a sharp increase for the third level. For the remaining levels, costs per hundredweight decline. In the first two levels, sows are farrowed quarterly. Since there is no reason to move the pigs from the farrowing facilities at an early age, they are left in the farrowing barn. The pigs are moved to the finishing facilities when they weigh 45 to 60 pounds. Hence, there is no need for separate growing facilities. Building depreciation and equipment costs for the finishing facilities are divided equally between the two phases. At the third level, there are separate buildings for the growing phase. Although building costs do not increase, equipment, repairs, and labor costs do increase. Also, antibiotics are fed as part of a disease-preventive program at the third level. The decrease in costs at the higher levels is offset partly by the increased cost of waste disposal. In the finishing phase, costs do decline initially, but beyond the fourth level costs remain relatively constant. Reductions in costs are offset in the larger operations by the increasing cost of waste diposal.

The total cost per hundredweight is the sum of the cost for each phase. There is a consistent decline in total cost over all production levels analyzed.

Total cost is divided into fixed and variable costs. Total fixed costs in the open front confinement system include building and equipment costs plus the fixed portions of the waste disposal costs. These latter costs are primarily the extra cost for slotted floors and the cost of waste disposal equipment and the construction of lagoons. Fixed costs

decline for each increase in size of operation. A sharp decline occurs at the sixth level and to a lesser extent at the eighth level. At the sixth level sows are farrowed in six groups rather than three. This change in technique allows a reduction of one-sixth in the gestation housing cost per sow. A similar reduction in fixed costs occurs at the eighth level when the sows are farrowed in nine groups instead of six.

Total average short-run cost curves were developed from the total cost data in Table 3. The 10 curves corresponding to each of the 10 production levels are presented in Figure 3. The average cost curves were derived in the same manner as those for the pasture system. Because data is not available to empirically estimate the costs of overcrowding fixed facilities in the short-run, the increasing cost portions of the cost curves are not determined. The slope of the average cost curve declines as the size of the operation increases. Again, the larger operations have greater flexibility with respect to level of output. For the higher production levels, the volume of output can be reduced substantially below capacity with only a moderate increase in cost. This flexibility is important because of the lack of feasible alternative uses for open front confinement swine facilities.

The long-run average total cost curve is the envelope curve of the short-run average cost curves. The long-run average total cost curve for the open front swine system is presented in Figure 4. The curve encompasses only those levels of output with declining unit costs. Significant economies of size occur as the firm increases production up to

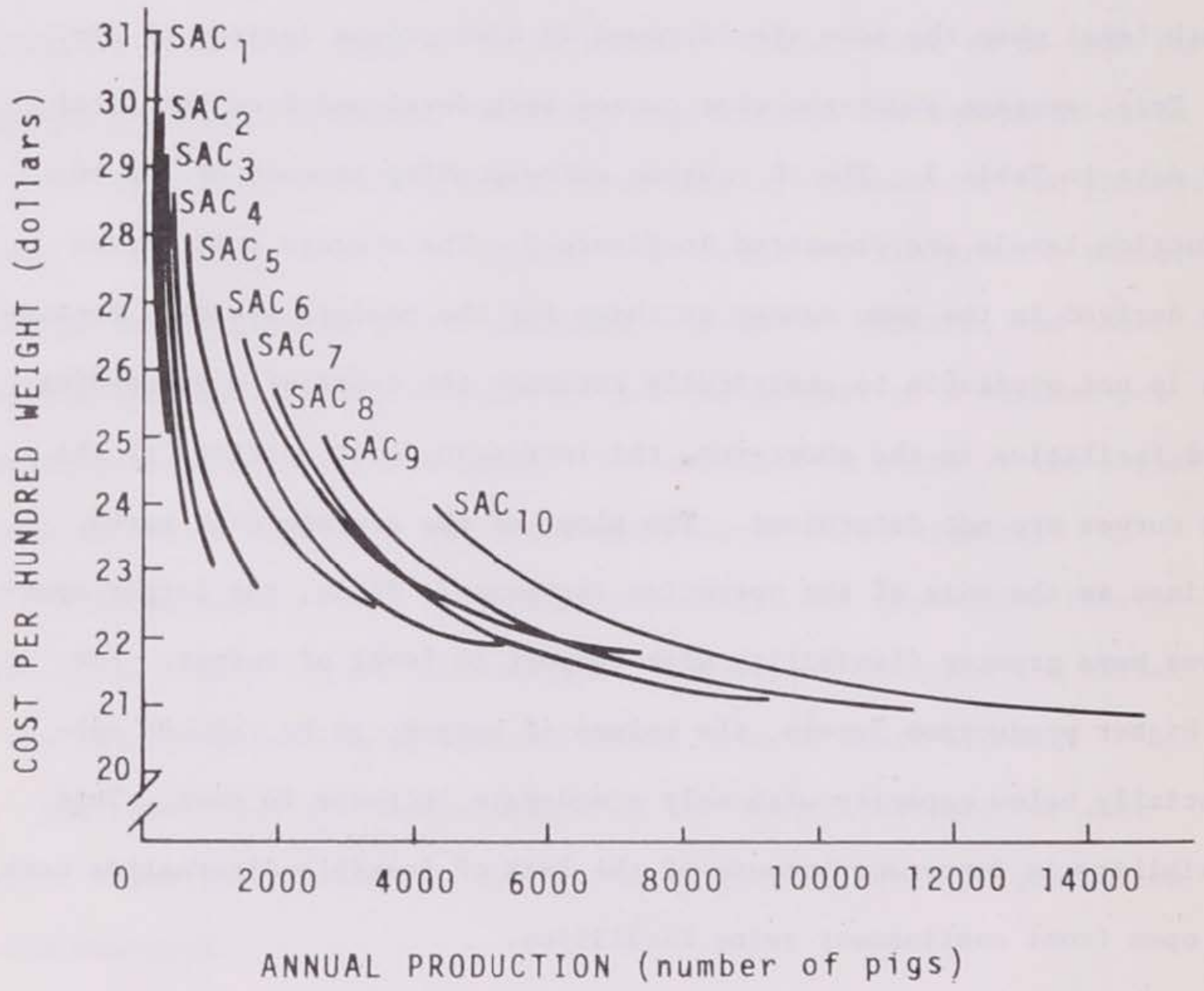


Figure 3. Short-run average total cost curves for each of the 10 production levels in the open front confinement system.

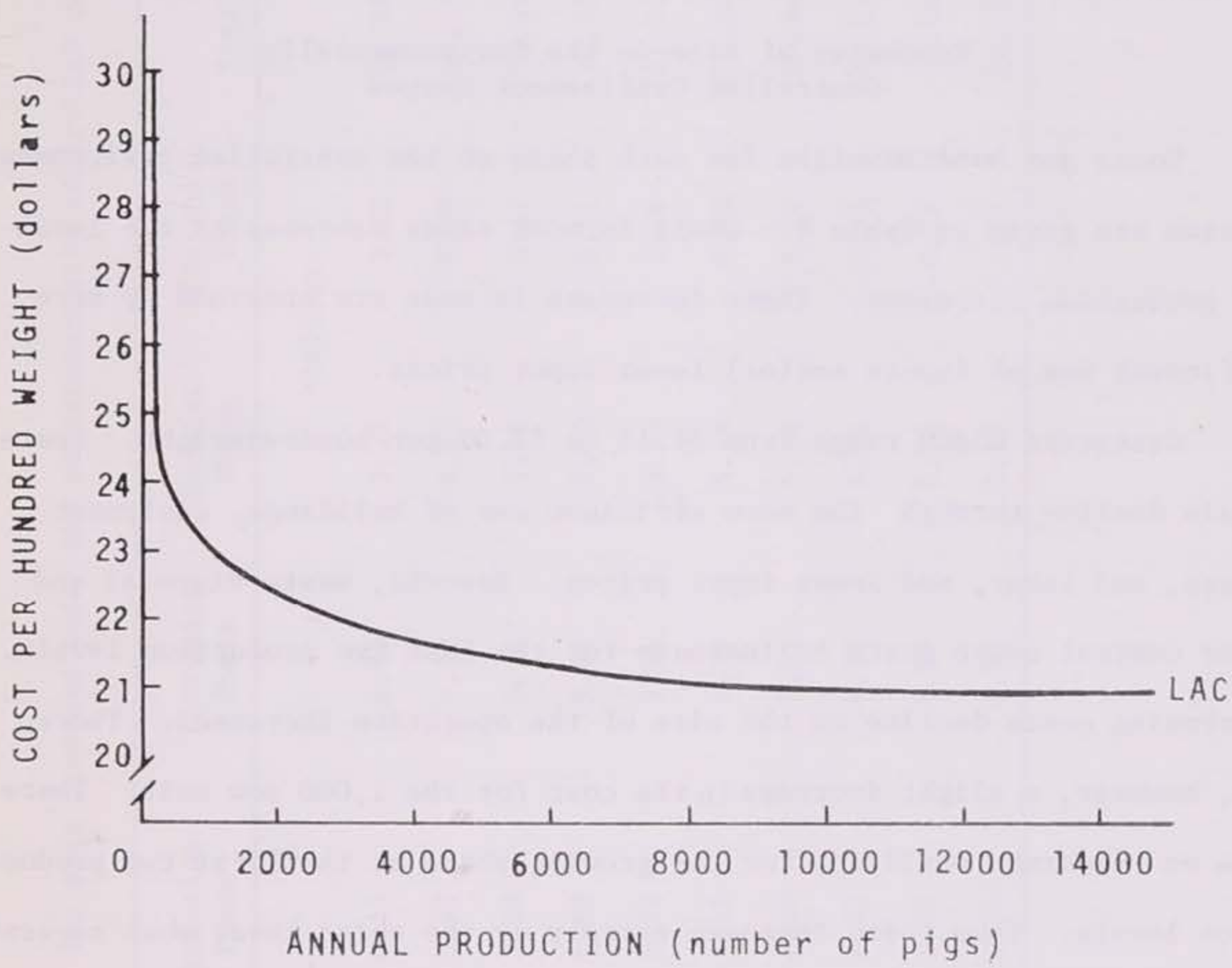


Figure 4. Long-run average total cost per hundred weight for the open front confinement system.

2,000 market hogs annually. From 2,000 to 9,000 hogs annually, costs decline much more slowly. The long-run curve is almost flat for production levels of 9,000 to 15,000 market hogs annually. For these latter output levels, duplication of units would be the more feasible method of expansion.

### Economies of Size in the Environmentally Controlled Confinement System

Costs per hundredweight for each phase of the controlled environment system are given in Table 4. Costs in most cases decrease as the level of production increases. These decreases in cost are obtained by more efficient use of inputs and(or) lower input prices.

Gestation costs range from $4.15 to $2.03 per hundredweight. Costs again decline through the more efficient use of buildings, equipment, boars, and labor, and lower input prices. However, waste disposal and odor control cause costs to increase for the last two production levels. Farrowing costs decline as the size of the operation increases. There is, however, a slight increase in the cost for the 1,000 sow unit. There are no separate buildings for the growing phase at the first two production levels. Thus costs increase sharply at the third level when separate growing facilities are included in the system. The disease-preventive program initiated at the third production level also adds to costs. At the higher levels of production, the increase in costs for waste disposal and odor control offset the reduction in costs of the other variables. The finishing costs decline over the first four levels. Beyond the fourth

Table 4. Costs per hundredweight for pigs produced under the environmentally controlled confinement system.

| Production Level | Sows | Hogs (Mkt.) | Gestation Phase | Farrowing Phase | Growing Phase | Finishing Phase | Total | Fixed | Variable |
|---|---|---|---|---|---|---|---|---|---|
| | | -numbers- | | | | -dollars- | | | |
| 1 | 25 | 400 | 4.15 | 6.88 | 5.24 | 8.62 | 24.88 | 3.03 | 21.85 |
| 2 | 50 | 801 | 3.47 | 6.59 | 4.83 | 8.22 | 23.12 | 2.34 | 20.77 |
| 3 | 75 | 1,256 | 3.09 | 5.92 | 5.33 | 8.17 | 22.50 | 2.20 | 20.30 |
| 4 | 125 | 2,440 | 2.62 | 5.72 | 5.20 | 8.11 | 21.65 | 2.08 | 19.57 |
| 5 | 250 | 4,943 | 2.52 | 5.54 | 5.15 | 8.16 | 21.37 | 2.00 | 19.37 |
| 6 | 375 | 7,704 | 2.21 | 5.38 | 5.18 | 8.20 | 20.98 | 1.84 | 19.14 |
| 7 | 500 | 10,272 | 2.20 | 5.35 | 5.18 | 8.20 | 20.94 | 1.80 | 19.13 |
| 8 | 625 | 13,097 | 2.03 | 4.93 | 5.12 | 8.12 | 20.21 | 1.78 | 18.43 |
| 9 | 750 | 15,601 | 2.08 | 4.90 | 5.14 | 8.16 | 20.28 | 1.75 | 18.53 |
| 10 | 1,000 | 20,801 | 2.10 | 4.93 | 5.17 | 8.23 | 20.43 | 1.75 | 18.67 |

production level, costs vary in both directions depending upon the impact of the waste disposal and odor control variable.

Total costs decline over the first eight levels and then increase for the last two production levels. Total costs consist of fixed and variable costs. Total fixed costs in the controlled confinement system include the building and equipment costs and the fixed portions of the waste disposal costs. Fixed costs decline until the last level where they remain constant. There is a fairly distinct decline in costs at the sixth level due to farrowing sows in six groups instead of three, which reduces the building requirements for the gestation phase. A slight reduction in fixed costs occurs at the eighth production level when sows are farrowed in nine groups instead of six.

Short-run average total cost curves were constructed using the total cost data in Table 4. The cost curve associated with each of the 10 levels of production is presented in Figure 5. As was the case for the pasture and open front systems, the average cost curves become flatter as the size of the enterprise increases. This greater operational flexibility for the larger operations is important, because these facilities have very limited alternative uses.

The long-run average total cost curve for the environmentally controlled confinement system is presented in Figure 6. Most of the economies of size are achieved by operations producing up to 9,000 market hogs annually. From a risk and uncertainty standpoint, it would be more desirable to have two independent units producing 9,000 hogs than to have one unit producing 18,000 hogs annually.

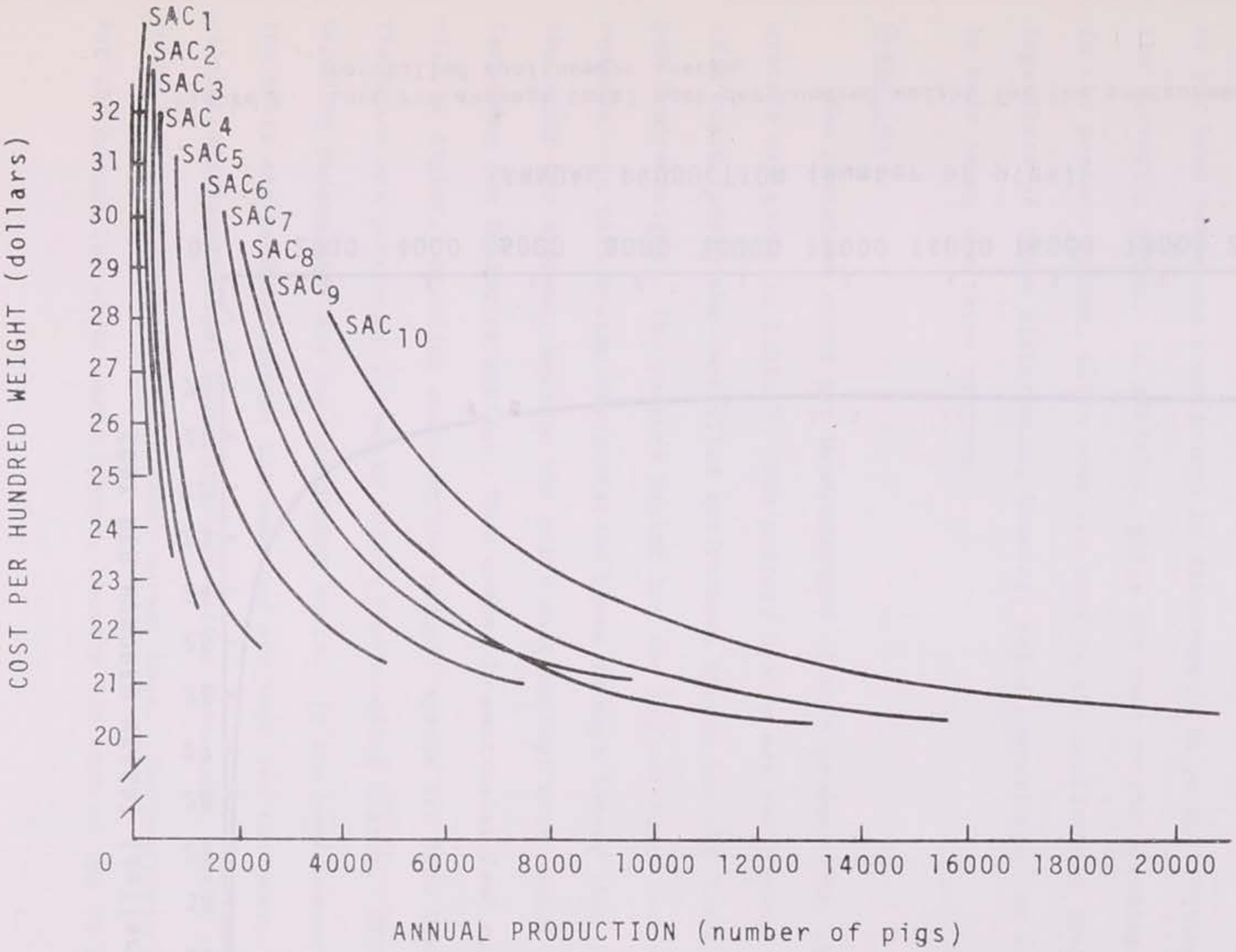


Figure 5. Short-run average total cost curves for each of the 10 production levels in the environmentally controlled confinement system.

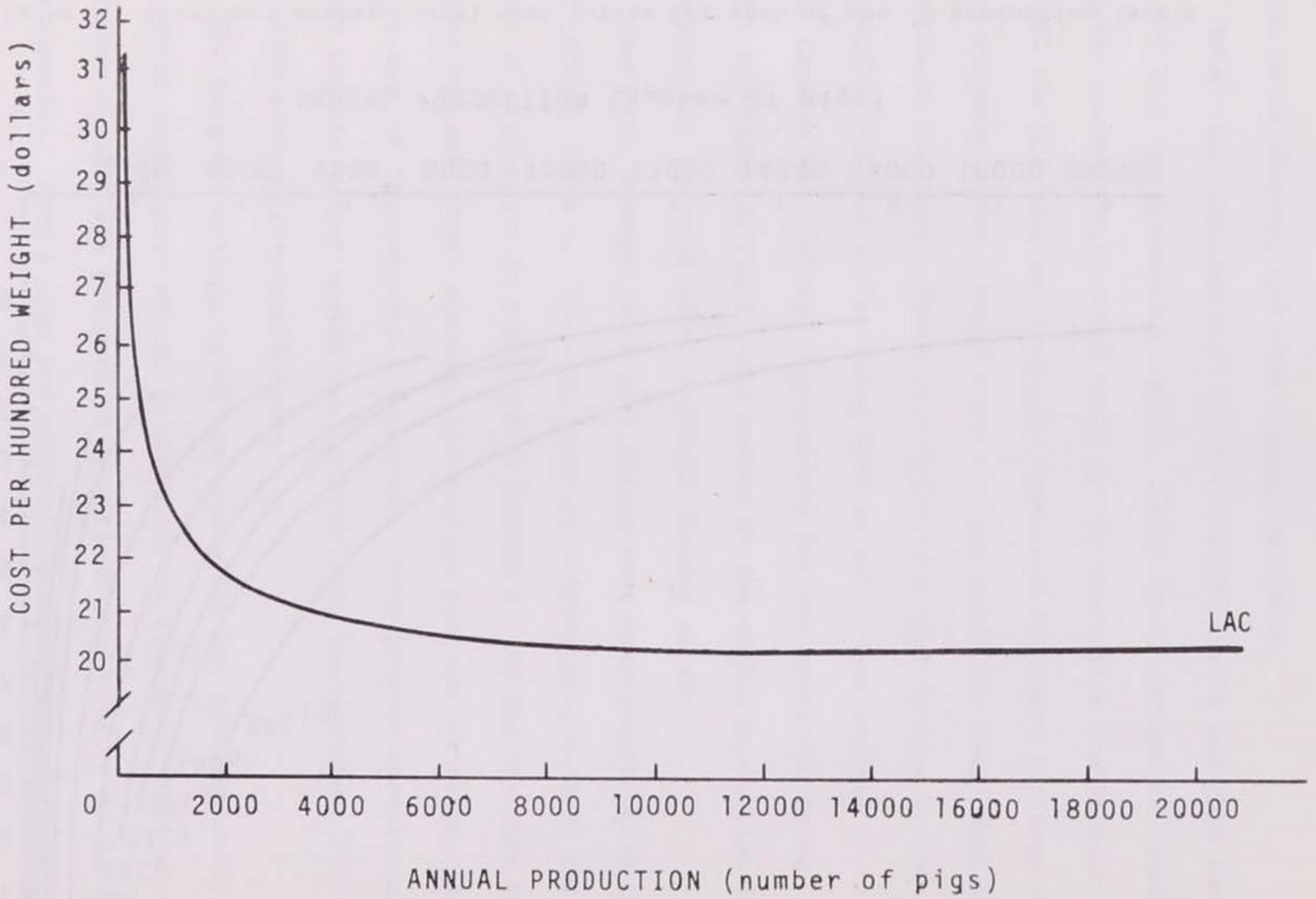


Figure 6. Long-run average total cost per hundred weight for the environmentally controlled confinement system.

## CONCLUSIONS ON PHASES

### Optimal Production System

Comparison of costs among the three systems on a per hundredweight or per head basis are complicated by differences in productivities in the farrowing phase. In addition, gilts are used as the breeding stock in the pasture system, while sows are used in the confinement systems. Regardless of these differences, however, valid comparisons can still be made among the three systems.

Gestation

The gestation costs per hundredweight of pork produced for the three systems are given in Table 5. The pasture system has the highest gestation costs, while the controlled environment system has the lowest costs per hundredweight. The pasture system has the highest costs for several reasons. In this system the gestation phase is much longer than it is in the other two systems, because the gilts must be kept over winter for farrowing the following spring. Thus costs, in particular feed costs, will be higher. Breeding costs in the pasture system are also higher. The boars are purchased six weeks before the breeding season. After the breeding season they are sold as market boars. In the confinement systems, the boars are used throughout the year and are kept for two years. Thirdly, gilts traditionally wean fewer pigs per litter than sows. Thus, the gestation costs are spread over fewer market hogs. The costs are lower for the controlled environment system, because for each of the 10 production

Table 5. Gestation costs per hundredweight for the pasture, open front, and controlled environment systems.

| Level | Sows | Hogs Marketed | | | Cost | | |
|---|---|---|---|---|---|---|---|
| | | Pasture | Open Front | Controlled Environment | Pasture | Open Front | Controlled Environment |
| | | -numbers- | | | -dollars- | | |
| 1 | 25 | 180 | 312 | 400 | 5.07 | 4.10 | 4.15 |
| 2 | 50 | 360 | 656 | 801 | 4.71 | 3.66 | 3.47 |
| 3 | 75 | 532 | 1,032 | 1,256 | 4.56 | 3.25 | 3.09 |
| 4 | 125 | 885 | 1,686 | 2,440 | 4.48 | 3.31 | 2.62 |
| 5 | 250 | 1,770 | 3,414 | 4,943 | 4.27 | 3.16 | 2.52 |
| 6 | 375 | 2,655 | 5,424 | 7,704 | 4.18 | 2.78 | 2.21 |
| 7 | 500 | 3,540 | 7,302 | 10,272 | 4.01 | 2.73 | 2.20 |
| 8 | 625 | 4,432 | 9,252 | 13,097 | 3.99 | 2.53 | 2.03 |
| 9 | 750 | 5,318 | 11,232 | 15,601 | 3.97 | 2.52 | 2.08 |
| 10 | 1,000 | 7,088 | 14,886 | 20,801 | 3.96 | 2.53 | 2.10 |

levels more hogs are marketed under this system than for the open front system.

Farrowing

The farrowing costs for each of the three systems are presented in Table 6. Farrowing costs are the lowest in the pasture system for levels one through seven and in the controlled environment system for levels eight through ten. Farrowing costs in the open front system are significantly higher at all levels. Long-run average total cost curves were derived for the farrowing phase of each system (Figure 7). Figure 7 shows that comparative costs favor the pasture system for hog operations up to 7,000 market hogs annually. It is apparent at the 7,000 head level in the pasture system that farrowing costs have leveled off and have become more or less constant. If the farrowing costs were to remain at this level for pasture operations larger than 1,000 sows, then the farrowing costs for the pasture and the controlled environment systems would become equal at about 15,000 market hogs annually.

The high weaning rate (10.7 pigs per litter) in the controlled environment system can probably be obtained only in those hog operations with excellent management. For many of the controlled environment hog operations, the number of pigs weaned per litter will be smaller. The lower weaning rate will increase farrowing as well as total costs per hundredweight of hogs marketed. Thus, the cost advantages of the controlled environment system relative to the other two systems will be reduced.

Table 6. Farrowing costs per hundredweight for the pasture, open front, and controlled environment systems.

| Level | Sows | Hogs Marketed | | | Cost | | |
|---|---|---|---|---|---|---|---|
| | | Pasture | Open Front | Controlled Environment | Pasture | Open Front | Controlled Environment |
| | | -numbers- | | | -dollars- | | |
| 1 | 25 | 180 | 312 | 400 | 6.33 | 7.40 | 6.88 |
| 2 | 50 | 360 | 656 | 801 | 6.15 | 7.07 | 6.59 |
| 3 | 75 | 532 | 1,032 | 1,256 | 5.65 | 6.41 | 5.92 |
| 4 | 125 | 885 | 1,686 | 2,440 | 5.48 | 6.25 | 5.72 |
| 5 | 250 | 1,770 | 3,414 | 4,943 | 4.98 | 6.07 | 5.54 |
| 6 | 375 | 2,655 | 5,424 | 7,704 | 5.02 | 5.85 | 5.38 |
| 7 | 500 | 3,540 | 7,302 | 10,272 | 5.00 | 5.80 | 5.35 |
| 8 | 625 | 4,432 | 9,252 | 13,097 | 5.02 | 5.39 | 4.93 |
| 9 | 750 | 5,318 | 11,232 | 15,601 | 4.97 | 5.27 | 4.90 |
| 10 | 1,000 | 7,088 | 14,886 | 20,801 | 4.95 | 5.25 | 4.93 |

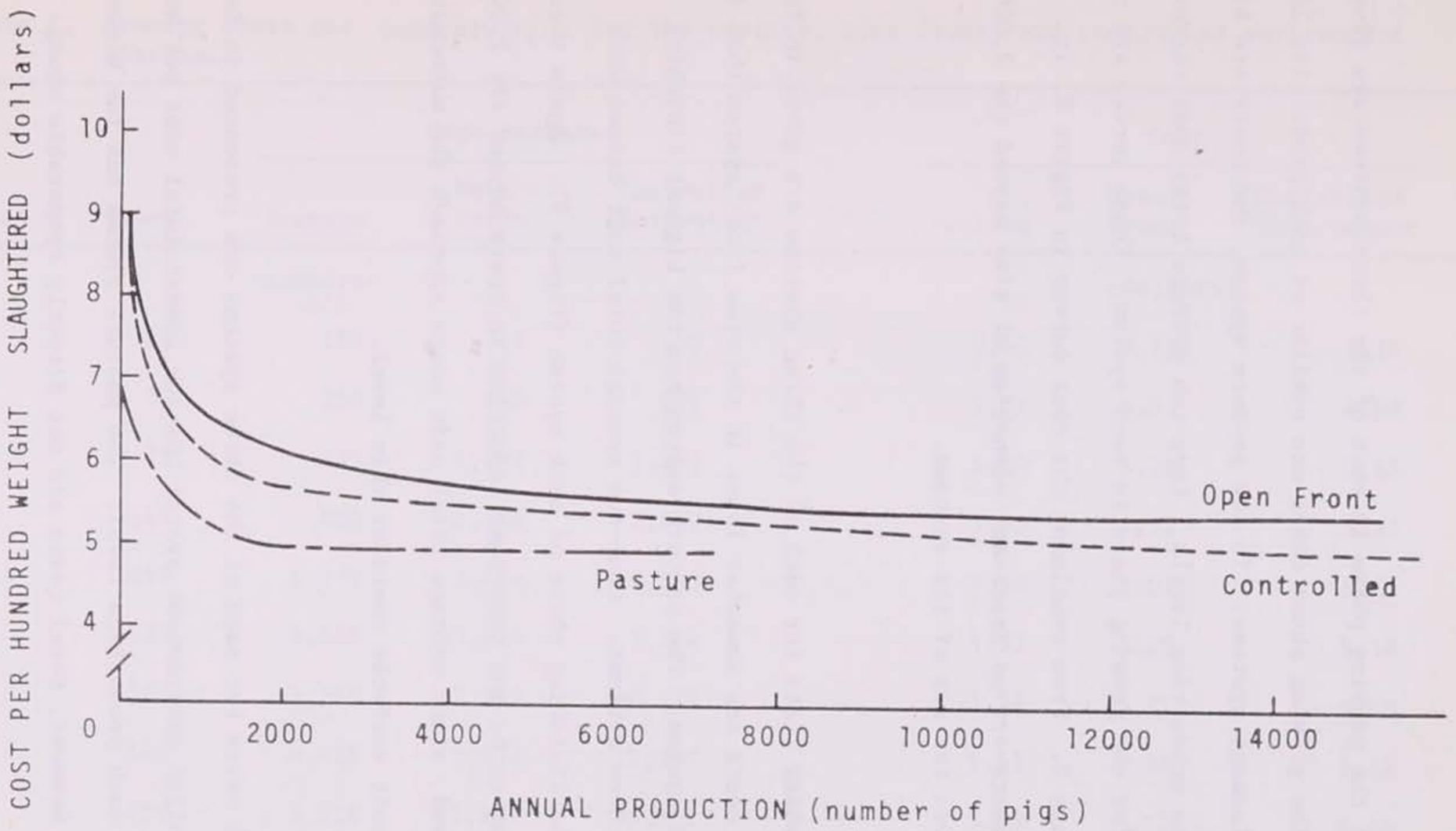


Figure 7. Long-run average total cost per hundred weight for the farrowing phase of pasture, open front, and controlled environment systems.

Growing

Costs for the growing phase in each of the three systems are given in Table 7. The growing phase costs are similar at each production level for both confinement systems. In the pasture system, the costs are higher for most of the production levels. Long-run average total cost curves were derived for the growing phase in each system. These curves are presented in Figure 8. From examining the cost curves in Figure 8, it appears that there are no important economies of size beyond the 2,000 market hog level for any of the systems.

Finishing

The finishing costs for each of the three systems are given in Table 8. Finishing costs are somewhat lower in the open front system than in the controlled system. The pasture system has the highest finishing costs of the three systems. Long-run average total cost curves were derived for the finishing phase of each system (Figure 9). Again there does not appear to be any important reduction in costs beyond the 2,000 market hog level, since average total unit costs approach the mathematical limit of per unit variable costs at this level.

Total costs

The total costs for each of the three systems are presented in Table 9. The controlled environment system has the lowest total cost per hundredweight at each production level. The pasture system has the highest total costs. However, total costs are not directly comparable among

Table 7. Growing costs per hundredweight for the pasture, open front, and controlled environment systems.

| Level | Sows | Hogs Marketed | | | Cost | | |
|---|---|---|---|---|---|---|---|
| | | Pasture | Open Front | Controlled Environment | Pasture | Open Front | Controlled Environment |
| | | -numbers- | | | -dollars- | | |
| 1 | 25 | 180 | 312 | 400 | 5.44 | 4.82 | 5.24 |
| 2 | 50 | 360 | 656 | 801 | 5.02 | 4.67 | 4.83 |
| 3 | 75 | 532 | 1,032 | 1,256 | 5.09 | 5.39 | 5.33 |
| 4 | 125 | 885 | 1,686 | 2,440 | 5.62 | 5.27 | 5.20 |
| 5 | 250 | 1,770 | 3,414 | 4,943 | 5.58 | 5.21 | 5.15 |
| 6 | 375 | 2,655 | 5,424 | 7,704 | 5.55 | 5.20 | 5.18 |
| 7 | 500 | 3,540 | 7,302 | 10,272 | 5.52 | 5.21 | 5.18 |
| 8 | 625 | 4,432 | 9,252 | 13,097 | 5.52 | 5.18 | 5.12 |
| 9 | 750 | 5,318 | 11,232 | 15,601 | 5.46 | 5.17 | 5.14 |
| 10 | 1,000 | 7,088 | 14,886 | 20,801 | 5.44 | 5.14 | 5.17 |

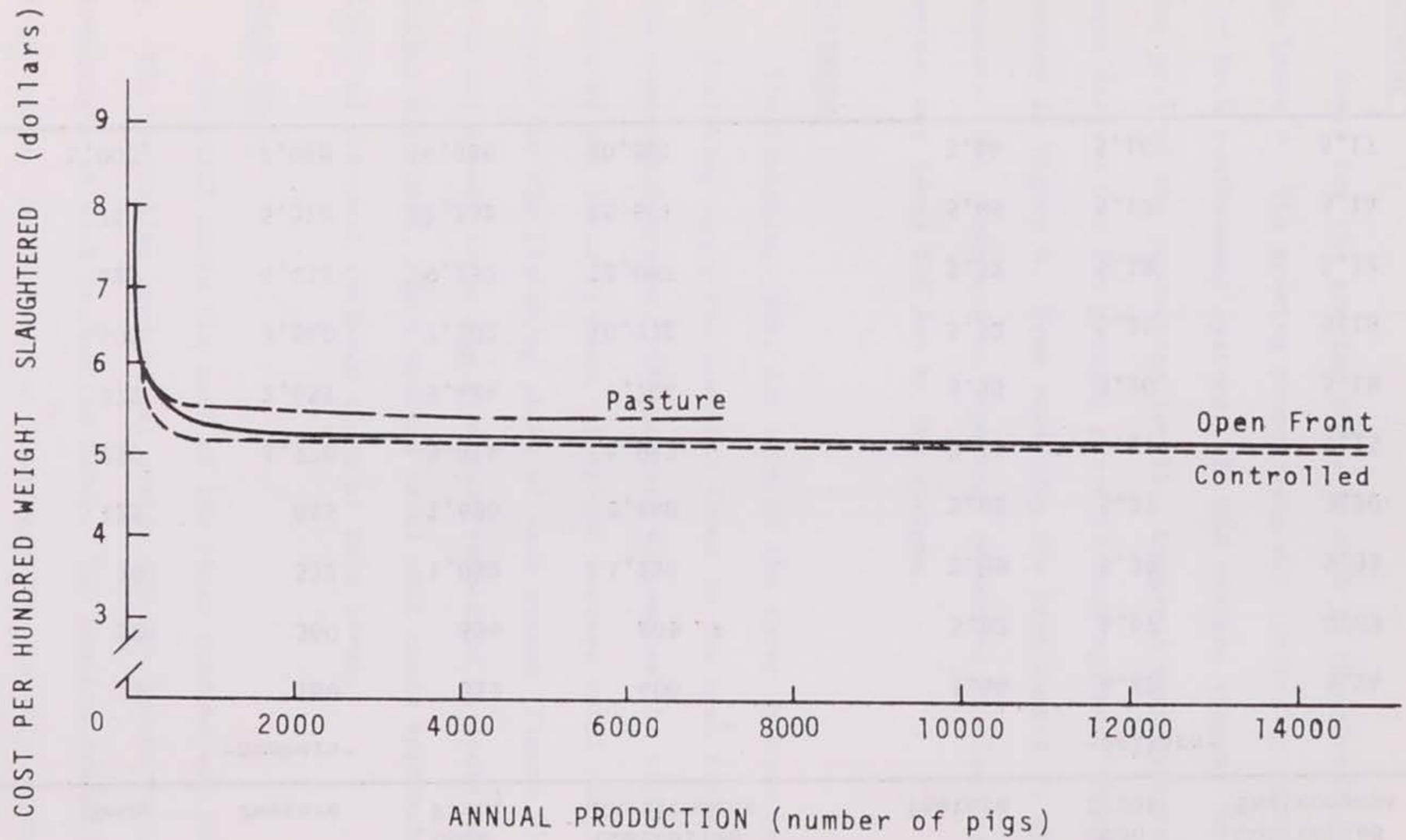


Figure 8. Long-run average total cost per hundred weight for the growing phase of pasture, open front, and controlled environment systems.

Table 8. Finishing costs per hundredweight for the pasture, open front, and controlled environment systems.

| Level | Sows | Hogs Marketed | | | Cost | | |
|---|---|---|---|---|---|---|---|
| | | Pasture | Open Front | Controlled Environment | Pasture | Open Front | Controlled Environment |
| | | -numbers- | | | -dollars- | | |
| 1 | 25 | 180 | 312 | 400 | 9.48 | 8.60 | 8.62 |
| 2 | 50 | 360 | 656 | 801 | 8.75 | 8.34 | 8.22 |
| 3 | 75 | 532 | 1,032 | 1,256 | 8.73 | 8.12 | 8.17 |
| 4 | 125 | 885 | 1,686 | 2,440 | 8.75 | 7.98 | 8.11 |
| 5 | 250 | 1,770 | 3,414 | 4,943 | 8.71 | 7.99 | 8.16 |
| 6 | 375 | 2,655 | 5,424 | 7,704 | 8.68 | 8.02 | 8.20 |
| 7 | 500 | 3,540 | 7,302 | 10,272 | 8.65 | 8.02 | 8.20 |
| 8 | 625 | 4,432 | 9,252 | 13,097 | 8.65 | 7.97 | 8.12 |
| 9 | 750 | 5,318 | 11,232 | 15,601 | 8.59 | 8.02 | 8.16 |
| 10 | 1,000 | 7,088 | 14,886 | 20,801 | 8.57 | 7.98 | 8.23 |

systems at the same level because of the vast differences in total production (with the levels of production based on sow numbers and not on the number of hogs produced). At the tenth production level, the pasture system produces 7,088 market hogs, the open front system produces 14,886 market hogs, and the controlled environment system produces 20,801 market hogs. Nevertheless, if we compare the total cost for the sixth level in the controlled environment system with the seventh level in the open front system and the tenth level in the pasture system, we see that the controlled environment has the lowest cost per hundredweight and the pasture system has the highest for production levels of approximately 7,000 market hogs annually. However, the difference in total cost per hundredweight between the two systems is less than $2.00 ($20.98 as compared to $22.92). This is not a large difference when considering the magnitude of price changes that can occur for hogs and for inputs in the hog enterprise.

The long-run average total cost curves for the three systems are presented in Figure 10. For the pasture system, the long-run average total cost curve declines up to an annual production of 3,500 market hogs. Beyond this level of production, costs remain relatively constant. In the open front system, costs decline until annual production reaches 9,000 market hogs. For production levels greater than 9,000 hogs, costs remain comparatively constant. Similarly, in the controlled environment system, total costs decrease until production reaches approximately 9,000 market hogs annually. Unlike the other two systems, the controlled

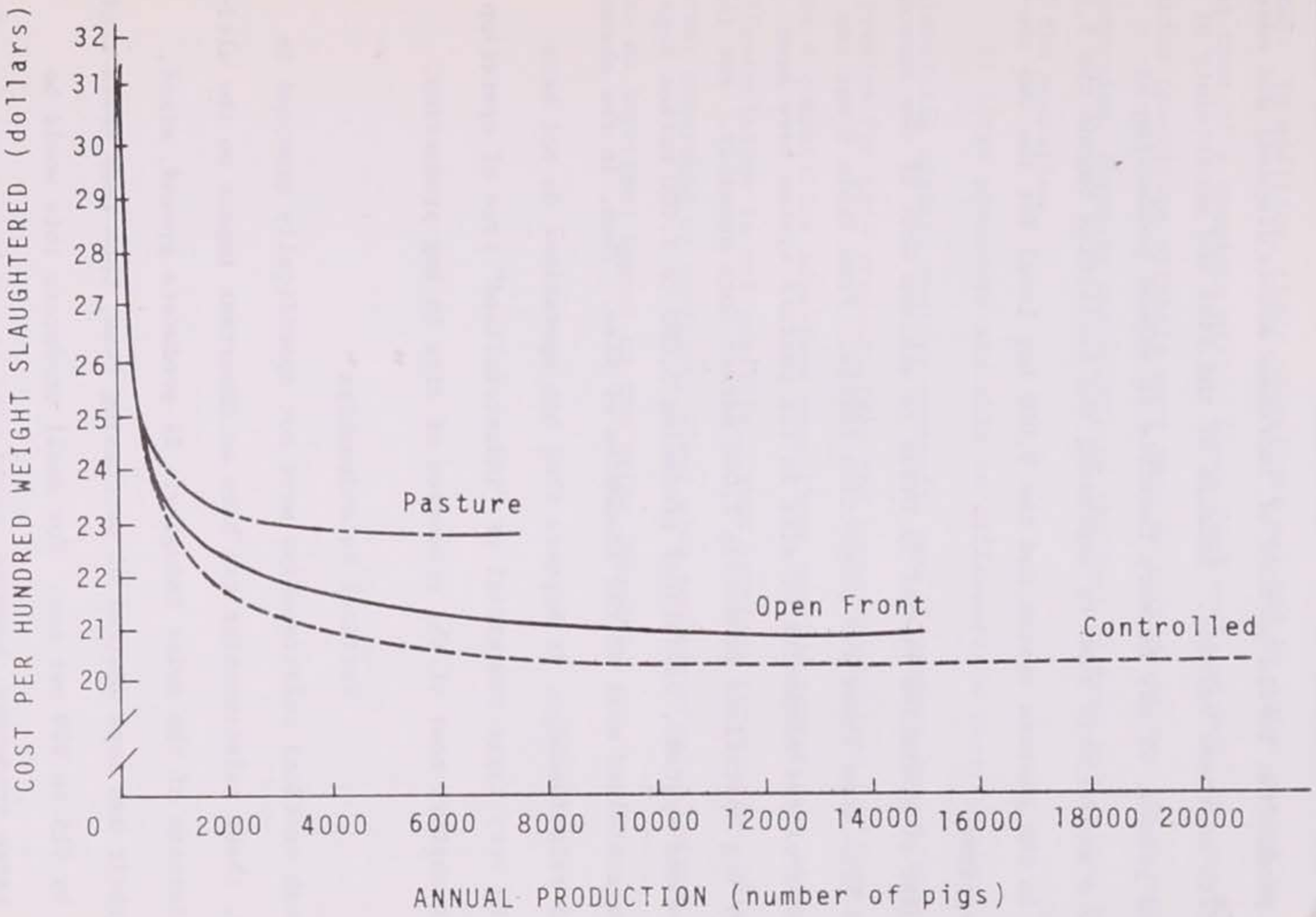


Figure 10. Long-run average total cost per hundred weight for all phases of the pasture, open front, and controlled environment systems.

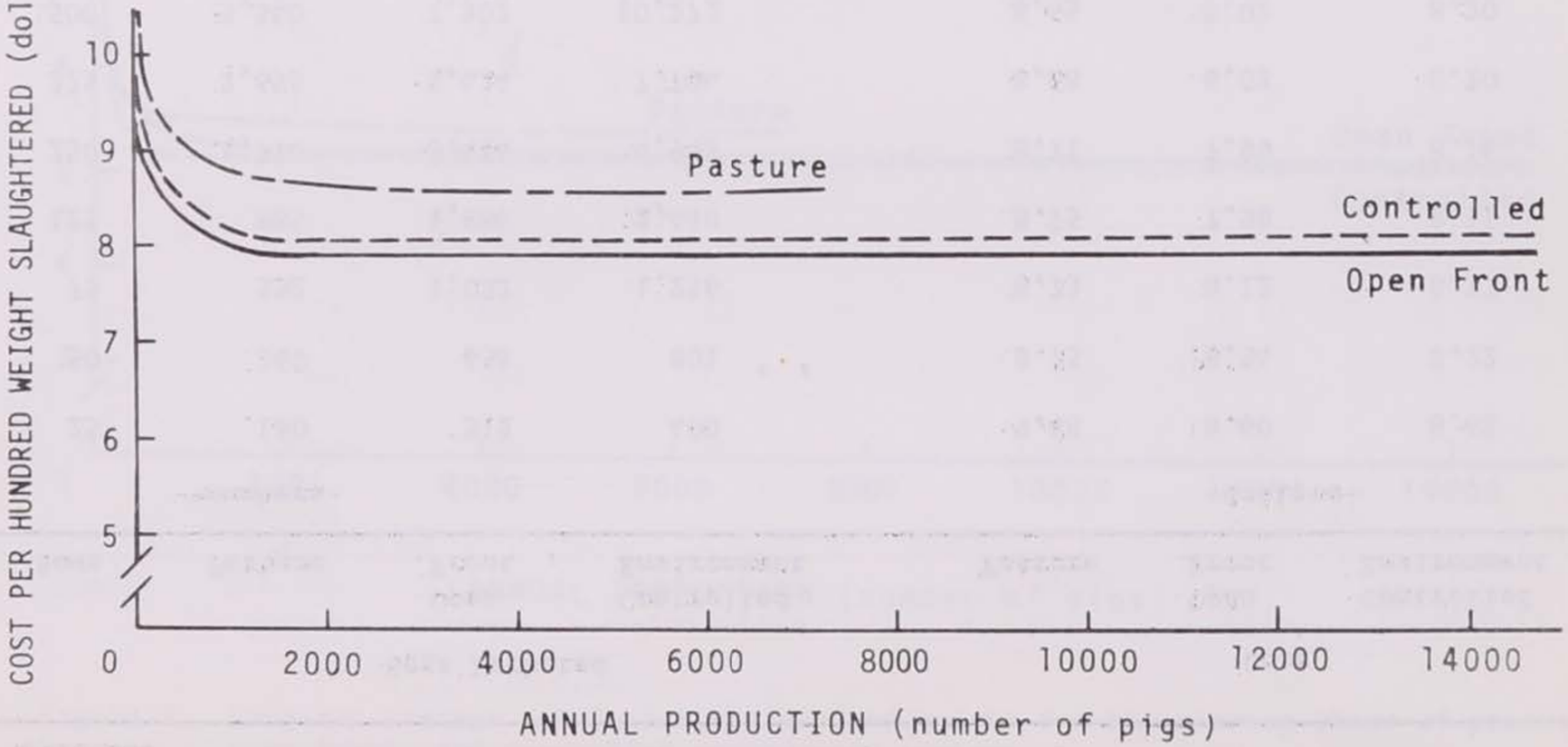


Figure 9. Long-run average total cost per hundred weight for the finishing phase of pasture, open front, and controlled environment systems.

Table 9. Total costs per hundredweight for the pasture, open front, and controlled environment systems.

| Level | Sows | Hogs Marketed | | | Cost | | |
|---|---|---|---|---|---|---|---|
| | | Pasture | Open Front | Controlled Environment | Pasture | Open Front | Controlled Environment |
| | | -numbers- | | | -dollars- | | |
| 1 | 25 | 180 | 312 | 400 | 26.32 | 24.92 | 24.88 |
| 2 | 50 | 360 | 656 | 801 | 24.63 | 23.74 | 23.12 |
| 3 | 75 | 532 | 1,032 | 1,256 | 24.03 | 23.17 | 22.50 |
| 4 | 125 | 885 | 1,686 | 2,440 | 24.35 | 22.81 | 21.65 |
| 5 | 250 | 1,770 | 3,414 | 4,943 | 23.53 | 22.43 | 21.37 |
| 6 | 375 | 2,655 | 5,424 | 7,704 | 23.43 | 21.85 | 20.98 |
| 7 | 500 | 3,540 | 7,302 | 10,272 | 23.17 | 21.78 | 20.94 |
| 8 | 625 | 4,432 | 9,252 | 13,097 | 23.19 | 21.06 | 20.21 |
| 9 | 750 | 5,318 | 11,232 | 15,601 | 22.98 | 20.98 | 20.28 |
| 10 | 1,000 | 7,088 | 14,886 | 20,801 | 22.92 | 20.89 | 20.43 |

systems at the same level because of the vast differences in total production (with the levels of production based on sow numbers and not on the number of hogs produced). At the tenth production level, the pasture system produces 7,088 market hogs, the open front system produces 14,886 market hogs, and the controlled environment system produces 20,801 market hogs. Nevertheless, if we compare the total cost for the sixth level in the controlled environment system with the seventh level in the open front system and the tenth level in the pasture system, we see that the controlled environment has the lowest cost per hundredweight and the pasture system has the highest for production levels of approximately 7,000 market hogs annually. However, the difference in total cost per hundredweight between the two systems is less than $2.00 ($20.98 as compared to $22.92). This is not a large difference when considering the magnitude of price changes that can occur for hogs and for inputs in the hog enterprise.

The long-run average total cost curves for the three systems are presented in Figure 10. For the pasture system, the long-run average total cost curve declines up to an annual production of 3,500 market hogs. Beyond this level of production, costs remain relatively constant. In the open front system, costs decline until annual production reaches 9,000 market hogs. For production levels greater than 9,000 hogs, costs remain comparatively constant. Similarly, in the controlled environment system, total costs decrease until production reaches approximately 9,000 market hogs annually. Unlike the other two systems, the controlled

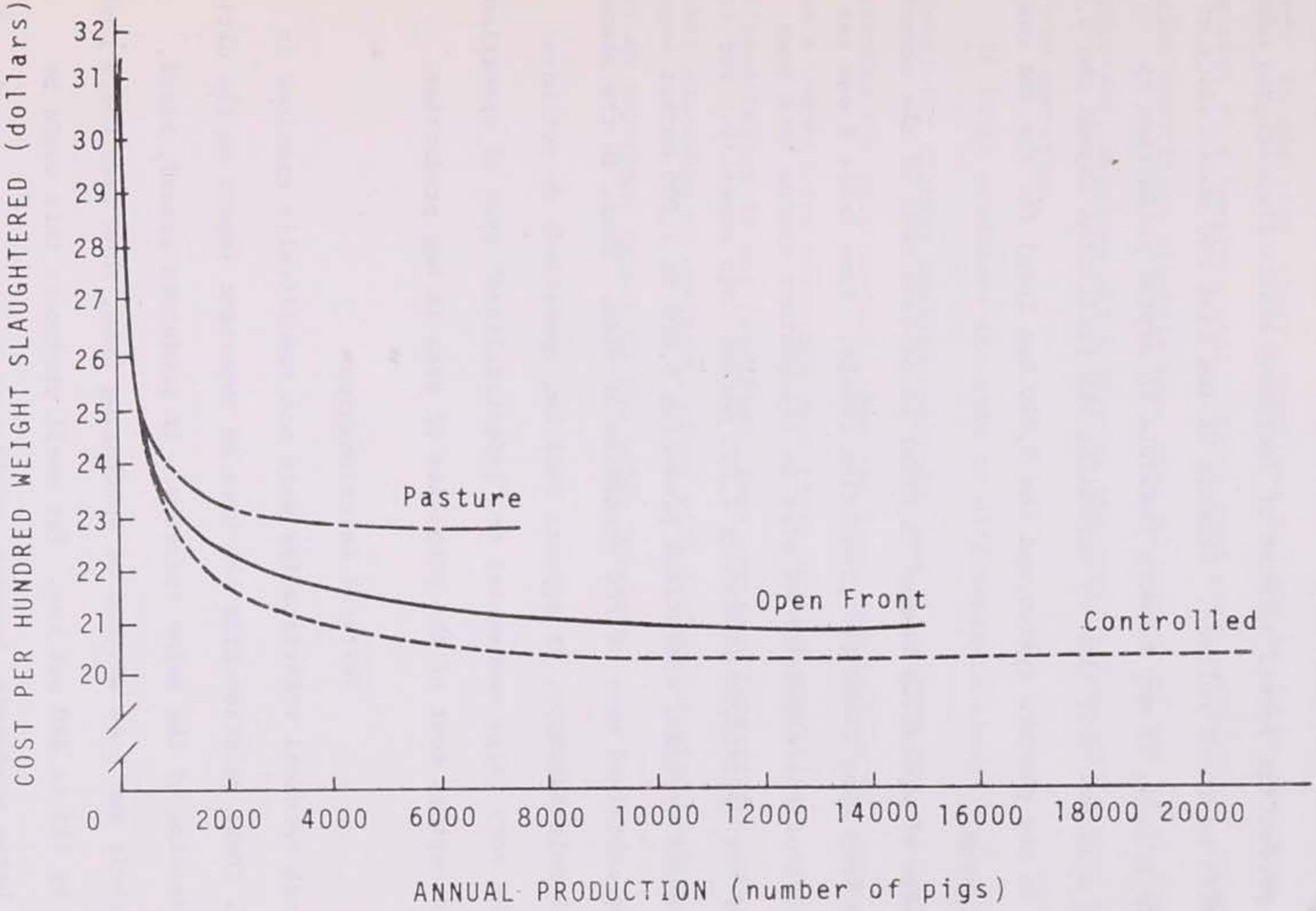


Figure 10. Long-run average total cost per hundred weight for all phases of the pasture, open front, and controlled environment systems.

environment system exhibits some diseconomies of size for the 750 and the 1,000 sow production levels because of increased manure disposal and odor control costs at these volumes. Because of the risk and uncertainty of disease and prices, it may be more feasible to expand production by setting up a second unit than by expanding the facilities beyond the 3,500 hog level in the pasture system, and the 9,000 hog level for the two confinement systems.

The size of operation needed in order to achieve most of the economies of size is less than these two production levels. From Table 9 one can see that most of the economies of size in the pasture system have been obtained by hog operations producing 2,000 market hogs annually. For the two confinement systems, operations producing 5,000 to 7,000 market hogs annually haveobtained most of the economies of size. Thus, in the absence of vertical relationships, it appears that hog operations do not have to be of the very large commercial or "industrialized" type of operation in order to capture most of the economies of size in hog production.

## Vertical Relationships

Although vertical relationships were not specifically examined in this study, these relationships can have an important impact on the ultimate organization of the swine industry. If producers ground, mixed, and stored their own feed instead of purchasing feed, then feed costs could be lowered by $15 to $20 per ton. For small producers this would be possible. Large producers, however, would need to purchase a portion of

their feed, since they probably would not be able to raise all their own feed. In addition, their operations may not be large enough to justify the cost of a complete mill. Since feed costs without the cost of medication constitute slightly more than 60 percent of the total cost of production, anything which affects the cost of feed will alter the size of the operation.

If large producers are able to differentiate their product by maintaining tighter quality controls, and if packers are willing to pay a premium for this product, then the large specialized hog farm will have a competitive advantage over those smaller operations, where product differentiation is not possible. Thus vertical integration, through either ownership or contract, along with economy-of-size factors, could have an important impact on the swine industry.

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# Appendix

Table A1. Cost of inputs 1 through 7 per head marketed for pasture gestation (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 0.33 | 0.21 | 0.92 | 1.27 | 0.10 | 0.19 | 0.27 |
| 2 | 0.33 | 0.14 | 0.92 | 1.27 | 0.08 | 0.19 | 0.22 |
| 3 | 0.32 | 0.13 | 0.93 | 1.29 | 0.08 | 0.19 | 0.20 |
| 4 | 0.32 | 0.18 | 0.93 | 1.29 | 0.10 | 0.19 | 0.23 |
| 5 | 0.31 | 0.18 | 0.93 | 1.36 | 0.10 | 0.18 | 0.13 |
| 6 | 0.31 | 0.15 | 0.93 | 1.33 | 0.09 | 0.17 | 0.12 |
| 7 | 0.31 | 0.13 | 0.93 | 1.36 | 0.09 | 0.16 | 0.11 |
| 8 | 0.31 | 0.15 | 0.93 | 1.34 | 0.08 | 0.15 | 0.10 |
| 9 | 0.31 | 0.13 | 0.93 | 1.35 | 0.07 | 0.15 | 0.10 |
| 10 | 0.31 | 0.12 | 0.93 | 1.35 | 0.07 | 0.15 | 0.10 |

Table A2. Cost of inputs 8 through 14 per head marketed for pasture gestation (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 5.68 | 0.0 | 0.0 | 0.33 | 1.67 | 0.91 | 0.03 |
| 2 | 5.48 | 0.0 | 0.0 | 0.17 | 1.42 | 0.83 | 0.03 |
| 3 | 5.42 | 0.0 | 0.0 | 0.11 | 1.20 | 0.82 | 0.03 |
| 4 | 5.44 | 0.0 | 0.0 | 0.07 | 0.88 | 0.85 | 0.03 |
| 5 | 5.10 | 0.0 | 0.0 | 0.03 | 0.88 | 0.80 | 0.02 |
| 6 | 4.99 | 0.0 | 0.0 | 0.04 | 0.88 | 0.77 | 0.02 |
| 7 | 4.66 | 0.0 | 0.0 | 0.03 | 0.88 | 0.75 | 0.02 |
| 8 | 4.61 | 0.0 | 0.0 | 0.03 | 0.88 | 0.76 | 0.02 |
| 9 | 4.60 | 0.0 | 0.0 | 0.02 | 0.88 | 0.74 | 0.02 |
| 10 | 4.60 | 0.0 | 0.0 | 0.03 | 0.88 | 0.73 | 0.02 |

Table A3. Cost of inputs 1 through 7 per head marketed for pasture farrowing (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 1.17 | 0.42 | 0.0 | 0.0 | 0.33 | 0.85 | 0.06 |
| 2 | 1.17 | 0.37 | 0.0 | 0.0 | 0.32 | 0.85 | 0.04 |
| 3 | 0.69 | 0.35 | 0.0 | 0.0 | 0.22 | 0.85 | 0.04 |
| 4 | 0.71 | 0.39 | 0.0 | 0.0 | 0.23 | 0.85 | 0.03 |
| 5 | 0.67 | 0.38 | 0.0 | 0.0 | 0.23 | 0.74 | 0.03 |
| 6 | 0.67 | 0.34 | 0.0 | 0.0 | 0.22 | 0.82 | 0.03 |
| 7 | 0.67 | 0.33 | 0.0 | 0.0 | 0.20 | 0.82 | 0.03 |
| 8 | 0.67 | 0.35 | 0.0 | 0.0 | 0.21 | 0.82 | 0.03 |
| 9 | 0.68 | 0.30 | 0.0 | 0.0 | 0.18 | 0.81 | 0.03 |
| 10 | 0.68 | 0.28 | 0.0 | 0.0 | 0.17 | 0.81 | 0.02 |

Table A4. Cost of inputs 8 through 14 per head marketed for pasture farrowing (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 3.89 | 1.08 | 2.08 | 0.0 | 3.63 | 1.06 | 0.29 |
| 2 | 3.89 | 1.08 | 2.08 | 0.0 | 3.08 | 1.28 | 0.28 |
| 3 | 3.89 | 1.08 | 2.08 | 0.0 | 2.78 | 1.02 | 0.26 |
| 4 | 3.46 | 1.09 | 2.08 | 0.0 | 2.77 | 1.03 | 0.25 |
| 5 | 3.46 | 1.08 | 1.82 | 0.0 | 2.77 | 0.93 | 0.22 |
| 6 | 3.02 | 0.94 | 1.82 | 0.0 | 2.77 | 0.92 | 0.23 |
| 7 | 3.02 | 0.94 | 1.82 | 0.0 | 2.77 | 0.91 | 0.23 |
| 8 | 3.02 | 0.94 | 1.82 | 0.0 | 2.77 | 0.93 | 0.23 |
| 9 | 3.02 | 0.95 | 1.82 | 0.0 | 2.77 | 0.89 | 0.23 |
| 10 | 3.02 | 0.95 | 1.82 | 0.0 | 2.77 | 0.87 | 0.23 |

Table A5. Cost of inputs 1 through 7 per head marketed for pasture growing (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 0.53 | 0.59 | 0.0 | 0.0 | 0.25 | 0.06 | 0.08 |
| 2 | 0.53 | 0.47 | 0.0 | 0.0 | 0.21 | 0.06 | 0.05 |
| 3 | 0.52 | 0.45 | 0.0 | 0.0 | 0.21 | 0.26 | 0.04 |
| 4 | 0.51 | 0.49 | 0.0 | 0.0 | 0.22 | 1.38 | 0.04 |
| 5 | 0.50 | 0.47 | 0.0 | 0.0 | 0.21 | 1.37 | 0.03 |
| 6 | 0.49 | 0.44 | 0.0 | 0.0 | 0.21 | 1.37 | 0.03 |
| 7 | 0.49 | 0.41 | 0.0 | 0.0 | 0.18 | 1.36 | 0.03 |
| 8 | 0.50 | 0.44 | 0.0 | 0.0 | 0.15 | 1.36 | 0.03 |
| 9 | 0.47 | 0.38 | 0.0 | 0.0 | 0.17 | 1.36 | 0.03 |
| 10 | 0.47 | 0.37 | 0.0 | 0.0 | 0.16 | 1.35 | 0.02 |

Table A6. Cost of inputs 8 through 14 per head marketed for pasture growing (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 9.00 | 0.0 | 0.0 | 0.0 | 1.07 | 1.08 | 0.13 |
| 2 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.95 | 0.12 |
| 3 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.95 | 0.12 |
| 4 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 1.02 | 0.13 |
| 5 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.98 | 0.13 |
| 6 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.95 | 0.13 |
| 7 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.93 | 0.13 |
| 8 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.95 | 0.13 |
| 9 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.88 | 0.13 |
| 10 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.87 | 0.13 |

Table A7. Cost of inputs 1 through 7 per head marketed for pasture finishing (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 0.53 | 0.59 | 0.0 | 0.0 | 0.25 | 0.06 | 0.08 |
| 2 | 0.53 | 0.47 | 0.0 | 0.0 | 0.21 | 0.06 | 0.05 |
| 3 | 0.52 | 0.45 | 0.0 | 0.0 | 0.21 | 0.06 | 0.04 |
| 4 | 0.51 | 0.49 | 0.0 | 0.0 | 0.22 | 0.05 | 0.04 |
| 5 | 0.50 | 0.47 | 0.0 | 0.0 | 0.21 | 0.04 | 0.03 |
| 6 | 0.49 | 0.44 | 0.0 | 0.0 | 0.21 | 0.03 | 0.03 |
| 7 | 0.50 | 0.41 | 0.0 | 0.0 | 0.18 | 0.03 | 0.03 |
| 8 | 0.50 | 0.44 | 0.0 | 0.0 | 0.15 | 0.02 | 0.03 |
| 9 | 0.47 | 0.38 | 0.0 | 0.0 | 0.17 | 0.02 | 0.03 |
| 10 | 0.47 | 0.37 | 0.0 | 0.0 | 0.16 | 0.01 | 0.02 |

Table A8. Cost of inputs 8 through 14 per head marketed for pasture finishing (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 7.49 | 10.53 | 0.0 | 0.0 | 1.07 | 1.46 | 0.22 |
| 2 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.30 | 0.20 |
| 3 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.29 | 0.20 |
| 4 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.32 | 0.20 |
| 5 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.27 | 0.20 |
| 6 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.24 | 0.20 |
| 7 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.22 | 0.20 |
| 8 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.24 | 0.20 |
| 9 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.17 | 0.20 |
| 10 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.16 | 0.20 |

Table A5. Cost of inputs 1 through 7 per head marketed for pasture growing (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 0.53 | 0.59 | 0.0 | 0.0 | 0.25 | 0.06 | 0.08 |
| 2 | 0.53 | 0.47 | 0.0 | 0.0 | 0.21 | 0.06 | 0.05 |
| 3 | 0.52 | 0.45 | 0.0 | 0.0 | 0.21 | 0.26 | 0.04 |
| 4 | 0.51 | 0.49 | 0.0 | 0.0 | 0.22 | 1.38 | 0.04 |
| 5 | 0.50 | 0.47 | 0.0 | 0.0 | 0.21 | 1.37 | 0.03 |
| 6 | 0.49 | 0.44 | 0.0 | 0.0 | 0.21 | 1.37 | 0.03 |
| 7 | 0.49 | 0.41 | 0.0 | 0.0 | 0.18 | 1.36 | 0.03 |
| 8 | 0.50 | 0.44 | 0.0 | 0.0 | 0.15 | 1.36 | 0.03 |
| 9 | 0.47 | 0.38 | 0.0 | 0.0 | 0.17 | 1.36 | 0.03 |
| 10 | 0.47 | 0.37 | 0.0 | 0.0 | 0.16 | 1.35 | 0.02 |

Table A6. Cost of inputs 8 through 14 per head marketed for pasture growing (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 9.00 | 0.0 | 0.0 | 0.0 | 1.07 | 1.08 | 0.13 |
| 2 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.95 | 0.12 |
| 3 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.95 | 0.12 |
| 4 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 1.02 | 0.13 |
| 5 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.98 | 0.13 |
| 6 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.95 | 0.13 |
| 7 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.93 | 0.13 |
| 8 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.95 | 0.13 |
| 9 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.88 | 0.13 |
| 10 | 8.35 | 0.0 | 0.0 | 0.0 | 1.07 | 0.87 | 0.13 |

Table A7. Cost of inputs 1 through 7 per head marketed for pasture finishing (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 0.53 | 0.59 | 0.0 | 0.0 | 0.25 | 0.06 | 0.08 |
| 2 | 0.53 | 0.47 | 0.0 | 0.0 | 0.21 | 0.06 | 0.05 |
| 3 | 0.52 | 0.45 | 0.0 | 0.0 | 0.21 | 0.06 | 0.04 |
| 4 | 0.51 | 0.49 | 0.0 | 0.0 | 0.22 | 0.05 | 0.04 |
| 5 | 0.50 | 0.47 | 0.0 | 0.0 | 0.21 | 0.04 | 0.03 |
| 6 | 0.49 | 0.44 | 0.0 | 0.0 | 0.21 | 0.03 | 0.03 |
| 7 | 0.50 | 0.41 | 0.0 | 0.0 | 0.18 | 0.03 | 0.03 |
| 8 | 0.50 | 0.44 | 0.0 | 0.0 | 0.15 | 0.02 | 0.03 |
| 9 | 0.47 | 0.38 | 0.0 | 0.0 | 0.17 | 0.02 | 0.03 |
| 10 | 0.47 | 0.37 | 0.0 | 0.0 | 0.16 | 0.01 | 0.02 |

Table A8. Cost of inputs 8 through 14 per head marketed for pasture finishing (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 7.49 | 10.53 | 0.0 | 0.0 | 1.07 | 1.46 | 0.22 |
| 2 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.30 | 0.20 |
| 3 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.29 | 0.20 |
| 4 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.32 | 0.20 |
| 5 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.27 | 0.20 |
| 6 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.24 | 0.20 |
| 7 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.22 | 0.20 |
| 8 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.24 | 0.20 |
| 9 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.17 | 0.20 |
| 10 | 6.95 | 9.73 | 0.0 | 0.0 | 1.07 | 1.16 | 0.20 |

Table A9. Cost of inputs 1 through 7 per head marketed for open front gestation (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 0.47 | 0.79 | -0.03 | 0.45 | 0.36 | 0.22 | 0.20 |
| 2 | 0.39 | 0.73 | -0.02 | 0.28 | 0.32 | 0.19 | 0.16 |
| 3 | 0.30 | 0.60 | -0.02 | 0.18 | 0.25 | 0.17 | 0.13 |
| 4 | 0.31 | 0.64 | -0.02 | 0.19 | 0.24 | 0.16 | 0.14 |
| 5 | 0.31 | 0.61 | -0.02 | 0.15 | 0.23 | 0.14 | 0.13 |
| 6 | 0.23 | 0.43 | -0.02 | 0.09 | 0.15 | 0.12 | 0.09 |
| 7 | 0.22 | 0.42 | -0.02 | 0.08 | 0.15 | 0.11 | 0.09 |
| 8 | 0.20 | 0.38 | -0.02 | 0.06 | 0.14 | 0.10 | 0.08 |
| 9 | 0.20 | 0.38 | -0.02 | 0.05 | 0.13 | 0.10 | 0.08 |
| 10 | 0.20 | 0.38 | -0.02 | 0.06 | 0.14 | 0.09 | 0.08 |

Table A10. Cost of inputs 8 through 14 per head marketed for open front gestation (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 4.68 | 0.0 | 0.0 | 0.12 | 0.87 | 1.48 | 0.02 |
| 2 | 4.29 | 0.0 | 0.0 | 0.10 | 0.80 | 1.34 | 0.02 |
| 3 | 3.99 | 0.0 | 0.0 | 0.13 | 0.75 | 1.14 | 0.02 |
| 4 | 4.08 | 0.0 | 0.0 | 0.11 | 0.75 | 1.14 | 0.02 |
| 5 | 3.78 | 0.0 | 0.0 | 0.14 | 0.82 | 1.12 | 0.02 |
| 6 | 3.49 | 0.0 | 0.0 | 0.24 | 0.77 | 0.92 | 0.02 |
| 7 | 3.46 | 0.0 | 0.0 | 0.23 | 0.76 | 0.91 | 0.02 |
| 8 | 3.15 | 0.0 | 0.0 | 0.22 | 0.75 | 0.86 | 0.01 |
| 9 | 3.11 | 0.0 | 0.0 | 0.28 | 0.74 | 0.85 | 0.01 |
| 10 | 3.13 | 0.0 | 0.0 | 0.28 | 0.75 | 0.85 | 0.01 |

Table A11. Cost of inputs 1 through 7 per head marketed for open front farrowing (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 1.13 | 0.95 | 0.0 | 0.0 | 0.59 | 1.46 | 0.58 |
| 2 | 0.94 | 0.84 | 0.0 | 0.0 | 0.51 | 1.39 | 0.49 |
| 3 | 0.60 | 0.54 | 0.0 | 0.0 | 0.32 | 1.36 | 0.31 |
| 4 | 0.54 | 0.52 | 0.0 | 0.0 | 0.27 | 1.34 | 0.30 |
| 5 | 0.53 | 0.42 | 0.0 | 0.0 | 0.26 | 1.19 | 0.29 |
| 6 | 0.53 | 0.41 | 0.0 | 0.0 | 0.23 | 1.18 | 0.28 |
| 7 | 0.54 | 0.39 | 0.0 | 0.0 | 0.23 | 1.17 | 0.27 |
| 8 | 0.52 | 0.39 | 0.0 | 0.0 | 0.23 | 1.16 | 0.28 |
| 9 | 0.50 | 0.38 | 0.0 | 0.0 | 0.22 | 1.16 | 0.27 |
| 10 | 0.52 | 0.39 | 0.0 | 0.0 | 0.22 | 1.15 | 0.27 |

Table A12. Cost of inputs 8 through 14 per head marketed for open front farrowing (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 4.36 | 1.08 | 2.08 | 0.14 | 2.98 | 1.99 | 0.04 |
| 2 | 4.36 | 1.08 | 2.08 | 0.12 | 2.98 | 1.78 | 0.04 |
| 3 | 4.35 | 1.08 | 2.08 | 0.10 | 2.96 | 1.31 | 0.04 |
| 4 | 4.36 | 1.08 | 2.08 | 0.09 | 2.85 | 1.22 | 0.04 |
| 5 | 4.36 | 1.09 | 2.08 | 0.10 | 2.77 | 1.14 | 0.04 |
| 6 | 3.88 | 1.09 | 2.08 | 0.16 | 2.76 | 1.11 | 0.03 |
| 7 | 3.88 | 1.08 | 2.08 | 0.15 | 2.68 | 1.11 | 0.03 |
| 8 | 3.40 | 0.94 | 1.82 | 0.15 | 2.68 | 1.06 | 0.03 |
| 9 | 3.39 | 0.94 | 1.82 | 0.18 | 2.47 | 1.03 | 0.03 |
| 10 | 3.39 | 0.94 | 1.82 | 0.18 | 2.38 | 1.04 | 0.03 |

Table A13. Cost of inputs 1 through 7 per head marketed for open front growing (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 0.28 | 0.32 | 0.0 | 0.0 | 0.17 | 0.23 | 0.10 |
| 2 | 0.23 | 0.25 | 0.0 | 0.0 | 0.14 | 0.22 | 0.07 |
| 3 | 0.23 | 0.42 | 0.0 | 0.0 | 0.17 | 1.52 | 0.09 |
| 4 | 0.19 | 0.40 | 0.0 | 0.0 | 0.14 | 1.49 | 0.08 |
| 5 | 0.19 | 0.34 | 0.0 | 0.0 | 0.13 | 1.43 | 0.07 |
| 6 | 0.19 | 0.29 | 0.0 | 0.0 | 0.11 | 1.41 | 0.06 |
| 7 | 0.19 | 0.31 | 0.0 | 0.0 | 0.11 | 1.41 | 0.07 |
| 8 | 0.19 | 0.31 | 0.0 | 0.0 | 0.11 | 1.39 | 0.07 |
| 9 | 0.19 | 0.30 | 0.0 | 0.0 | 0.11 | 1.38 | 0.06 |
| 10 | 0.19 | 0.28 | 0.0 | 0.0 | 0.10 | 1.37 | 0.06 |

Table A14. Cost of inputs 8 through 14 per head marketed for open front growing (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 8.40 | 0.0 | 0.0 | 0.08 | 0.49 | 0.82 | 0.54 |
| 2 | 8.40 | 0.0 | 0.0 | 0.07 | 0.42 | 0.72 | 0.52 |
| 3 | 7.88 | 0.0 | 0.0 | 0.09 | 0.81 | 0.86 | 0.60 |
| 4 | 7.88 | 0.0 | 0.0 | 0.07 | 0.77 | 0.79 | 0.59 |
| 5 | 7.88 | 0.0 | 0.0 | 0.10 | 0.78 | 0.76 | 0.58 |
| 6 | 7.88 | 0.0 | 0.0 | 0.18 | 0.79 | 0.73 | 0.58 |
| 7 | 7.88 | 0.0 | 0.0 | 0.18 | 0.80 | 0.74 | 0.58 |
| 8 | 7.80 | 0.0 | 0.0 | 0.18 | 0.81 | 0.74 | 0.58 |
| 9 | 7.80 | 0.0 | 0.0 | 0.22 | 0.78 | 0.73 | 0.58 |
| 10 | 7.80 | 0.0 | 0.0 | 0.22 | 0.77 | 0.72 | 0.57 |

Table A15. Cost of inputs 1 through 7 per head marketed for open front finishing (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 0.28 | 0.32 | 0.0 | 0.0 | 0.17 | 0.27 | 0.11 |
| 2 | 0.23 | 0.25 | 0.0 | 0.0 | 0.14 | 0.20 | 0.07 |
| 3 | 0.30 | 0.32 | 0.0 | 0.0 | 0.17 | 0.17 | 0.09 |
| 4 | 0.32 | 0.32 | 0.0 | 0.0 | 0.16 | 0.65 | 0.08 |
| 5 | 0.31 | 0.24 | 0.0 | 0.0 | 0.14 | 0.62 | 0.07 |
| 6 | 0.32 | 0.20 | 0.0 | 0.0 | 0.12 | 0.60 | 0.06 |
| 7 | 0.32 | 0.21 | 0.0 | 0.0 | 0.12 | 0.60 | 0.06 |
| 8 | 0.31 | 0.21 | 0.0 | 0.0 | 0.12 | 0.59 | 0.07 |
| 9 | 0.31 | 0.21 | 0.0 | 0.0 | 0.12 | 0.58 | 0.06 |
| 10 | 0.31 | 0.20 | 0.0 | 0.0 | 0.12 | 0.57 | 0.06 |

Table A16. Cost of inputs 8 through 14 per head marketed for open front finishing (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 6.72 | 9.53 | 0.0 | 0.12 | 0.60 | 1.58 | 0.40 |
| 2 | 6.72 | 9.53 | 0.0 | 0.09 | 0.54 | 1.39 | 0.38 |
| 3 | 6.30 | 9.53 | 0.0 | 0.18 | 0.50 | 1.14 | 0.37 |
| 4 | 6.30 | 8.89 | 0.0 | 0.13 | 0.43 | 1.10 | 0.37 |
| 5 | 6.30 | 8.89 | 0.0 | 0.20 | 0.58 | 1.05 | 0.37 |
| 6 | 6.30 | 8.89 | 0.0 | 0.39 | 0.56 | 1.04 | 0.37 |
| 7 | 6.30 | 8.89 | 0.0 | 0.38 | 0.57 | 1.05 | 0.37 |
| 8 | 6.24 | 8.80 | 0.0 | 0.38 | 0.60 | 1.04 | 0.37 |
| 9 | 6.27 | 8.80 | 0.0 | 0.49 | 0.60 | 1.05 | 0.37 |
| 10 | 6.24 | 8.80 | 0.0 | 0.48 | 0.58 | 1.03 | 0.37 |

Table A17. Cost of inputs 1 through 7 per head marketed for controlled environment gestation (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 1.01 | 1.12 | -0.02 | 0.35 | 0.61 | 0.14 | 0.22 |
| 2 | 0.70 | 0.82 | -0.02 | 0.23 | 0.43 | 0.13 | 0.16 |
| 3 | 0.56 | 0.72 | -0.02 | 0.15 | 0.36 | 0.12 | 0.14 |
| 4 | 0.48 | 0.62 | -0.02 | 0.11 | 0.28 | 0.10 | 0.12 |
| 5 | 0.47 | 0.60 | -0.02 | 0.10 | 0.27 | 0.09 | 0.12 |
| 6 | 0.36 | 0.44 | -0.02 | 0.05 | 0.18 | 0.08 | 0.09 |
| 7 | 0.35 | 0.43 | -0.02 | 0.05 | 0.18 | 0.08 | 0.08 |
| 8 | 0.33 | 0.39 | -0.02 | 0.04 | 0.17 | 0.07 | 0.08 |
| 9 | 0.33 | 0.41 | -0.02 | 0.03 | 0.17 | 0.07 | 0.08 |
| 10 | 0.33 | 0.40 | -0.02 | 0.03 | 0.17 | 0.06 | 0.08 |

Tables A18. Cost of inputs 8 through 14 per head marketed for controlled environment gestation (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 3.54 | 0.0 | 0.0 | 0.12 | 0.68 | 1.96 | 0.02 |
| 2 | 3.41 | 0.0 | 0.0 | 0.08 | 0.66 | 1.52 | 0.02 |
| 3 | 3.18 | 0.0 | 0.0 | 0.11 | 0.62 | 1.32 | 0.02 |
| 4 | 2.74 | 0.0 | 0.0 | 0.08 | 0.52 | 1.10 | 0.02 |
| 5 | 2.53 | 0.0 | 0.0 | 0.11 | 0.56 | 1.07 | 0.01 |
| 6 | 2.38 | 0.0 | 0.0 | 0.17 | 0.54 | 0.89 | 0.01 |
| 7 | 2.38 | 0.0 | 0.0 | 0.20 | 0.54 | 0.87 | 0.01 |
| 8 | 2.16 | 0.0 | 0.0 | 0.20 | 0.53 | 0.82 | 0.01 |
| 9 | 2.17 | 0.0 | 0.0 | 0.26 | 0.53 | 0.83 | 0.01 |
| 10 | 2.17 | 0.0 | 0.0 | 0.33 | 0.53 | 0.83 | 0.01 |

Table A19. Cost of inputs 1 through 7 per head marketed for controlled environment farrowing (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 1.08 | 0.97 | 0.0 | 0.0 | 0.59 | 1.25 | 0.70 |
| 2 | 0.87 | 0.90 | 0.0 | 0.0 | 0.52 | 1.20 | 0.63 |
| 3 | 0.56 | 0.58 | 0.0 | 0.0 | 0.33 | 1.18 | 0.41 |
| 4 | 0.61 | 0.84 | 0.0 | 0.0 | 0.35 | 1.04 | 0.38 |
| 5 | 0.56 | 0.75 | 0.0 | 0.0 | 0.32 | 0.93 | 0.37 |
| 6 | 0.57 | 0.72 | 0.0 | 0.0 | 0.29 | 0.93 | 0.38 |
| 7 | 0.56 | 0.71 | 0.0 | 0.0 | 0.28 | 0.93 | 0.37 |
| 8 | 0.57 | 0.72 | 0.0 | 0.0 | 0.28 | 0.92 | 0.37 |
| 9 | 0.55 | 0.70 | 0.0 | 0.0 | 0.28 | 0.92 | 0.36 |
| 10 | 0.56 | 0.71 | 0.0 | 0.0 | 0.28 | 0.91 | 0.37 |

Table A20. Cost of inputs 8 through 14 per head marketed for controlled environment farrowing (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 3.74 | 1.08 | 2.08 | 0.11 | 2.56 | 1.96 | 0.04 |
| 2 | 3.74 | 1.09 | 2.08 | 0.10 | 2.55 | 1.76 | 0.04 |
| 3 | 3.74 | 1.08 | 2.08 | 0.09 | 2.54 | 1.28 | 0.03 |
| 4 | 3.18 | 1.08 | 2.08 | 0.06 | 2.47 | 1.34 | 0.03 |
| 5 | 3.18 | 1.08 | 2.08 | 0.08 | 2.39 | 1.25 | 0.03 |
| 6 | 2.83 | 1.08 | 2.08 | 0.12 | 2.39 | 1.23 | 0.03 |
| 7 | 2.83 | 1.08 | 2.08 | 0.13 | 2.20 | 1.36 | 0.03 |
| 8 | 2.47 | 0.94 | 1.82 | 0.13 | 2.14 | 1.18 | 0.03 |
| 9 | 2.47 | 0.94 | 1.82 | 0.16 | 2.11 | 1.16 | 0.03 |
| 10 | 2.47 | 0.94 | 1.82 | 0.20 | 2.11 | 1.17 | 0.03 |

Table A21. Cost of inputs 1 through 7 per head marketed for controlled environment growing (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 0.61 | 0.65 | 0.0 | 0.0 | 0.35 | 0.18 | 0.26 |
| 2 | 0.48 | 0.46 | 0.0 | 0.0 | 0.20 | 0.18 | 0.20 |
| 3 | 0.43 | 0.55 | 0.0 | 0.0 | 0.26 | 1.43 | 0.18 |
| 4 | 0.38 | 0.51 | 0.0 | 0.0 | 0.22 | 1.40 | 0.17 |
| 5 | 0.38 | 0.44 | 0.0 | 0.0 | 0.20 | 1.35 | 0.16 |
| 6 | 0.38 | 0.43 | 0.0 | 0.0 | 0.18 | 1.35 | 0.17 |
| 7 | 0.39 | 0.42 | 0.0 | 0.0 | 0.18 | 1.35 | 0.17 |
| 8 | 0.38 | 0.42 | 0.0 | 0.0 | 0.18 | 1.33 | 0.16 |
| 9 | 0.38 | 0.41 | 0.0 | 0.0 | 0.18 | 1.32 | 0.16 |
| 10 | 0.38 | 0.41 | 0.0 | 0.0 | 0.18 | 1.32 | 0.16 |

Table A22. Cost of inputs 8 through 14 per head marketed for controlled environment growing (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 8.10 | 0.0 | 0.0 | 0.08 | 0.68 | 1.24 | 0.15 |
| 2 | 8.10 | 0.0 | 0.0 | 0.07 | 0.49 | 1.01 | 0.15 |
| 3 | 7.59 | 0.0 | 0.0 | 0.08 | 0.73 | 1.07 | 0.18 |
| 4 | 7.59 | 0.0 | 0.0 | 0.07 | 0.72 | 0.98 | 0.18 |
| 5 | 7.59 | 0.0 | 0.0 | 0.09 | 0.76 | 0.94 | 0.18 |
| 6 | 7.59 | 0.0 | 0.0 | 0.15 | 0.79 | 0.95 | 0.18 |
| 7 | 7.59 | 0.0 | 0.0 | 0.17 | 0.80 | 0.94 | 0.18 |
| 8 | 7.51 | 0.0 | 0.0 | 0.17 | 0.78 | 0.93 | 0.18 |
| 9 | 7.52 | 0.0 | 0.0 | 0.21 | 0.79 | 0.93 | 0.18 |
| 10 | 7.52 | 0.0 | 0.0 | 0.26 | 0.78 | 0.94 | 0.18 |

Table A23. Cost of inputs 1 through 7 per head marketed for controlled environment finishing (dollars).

| Level | Building | Equipment | Sows | Boars | Repairs | Disease | Power |
|---|---|---|---|---|---|---|---|
| 1 | 0.62 | 0.65 | 0.0 | 0.0 | 0.35 | 0.20 | 0.26 |
| 2 | 0.48 | 0.46 | 0.0 | 0.0 | 0.26 | 0.15 | 0.21 |
| 3 | 0.74 | 0.59 | 0.0 | 0.0 | 0.37 | 0.13 | 0.27 |
| 4 | 0.63 | 0.48 | 0.0 | 0.0 | 0.29 | 0.60 | 0.24 |
| 5 | 0.66 | 0.46 | 0.0 | 0.0 | 0.29 | 0.57 | 0.24 |
| 6 | 0.63 | 0.46 | 0.0 | 0.0 | 0.26 | 0.57 | 0.24 |
| 7 | 0.64 | 0.43 | 0.0 | 0.0 | 0.25 | 0.57 | 0.23 |
| 8 | 0.63 | 0.44 | 0.0 | 0.0 | 0.25 | 0.56 | 0.24 |
| 9 | 0.63 | 0.42 | 0.0 | 0.0 | 0.25 | 0.55 | 0.23 |
| 10 | 0.64 | 0.44 | 0.0 | 0.0 | 0.25 | 0.55 | 0.23 |

Table A24. Cost of inputs 8 through 14 per head marketed for controlled environmental finishing. (dollars).

| Level | Feed 1 | Feed 2 | Feed 3 | Waste | Labor | Finance | Death Loss |
|---|---|---|---|---|---|---|---|
| 1 | 6.53 | 9.18 | 0.0 | 0.11 | 0.64 | 1.61 | 0.11 |
| 2 | 6.53 | 9.18 | 0.0 | 0.09 | 0.48 | 1.37 | 0.10 |
| 3 | 6.12 | 8.57 | 0.0 | 0.17 | 0.57 | 1.59 | 0.10 |
| 4 | 6.12 | 8.57 | 0.0 | 0.13 | 0.47 | 1.44 | 0.09 |
| 5 | 6.12 | 8.57 | 0.0 | 0.17 | 0.56 | 1.43 | 0.10 |
| 6 | 6.12 | 8.57 | 0.0 | 0.31 | 0.58 | 1.43 | 0.10 |
| 7 | 6.12 | 8.57 | 0.0 | 0.36 | 0.58 | 1.42 | 0.10 |
| 8 | 6.06 | 8.48 | 0.0 | 0.36 | 0.57 | 1.41 | 0.10 |
| 9 | 6.06 | 8.48 | 0.0 | 0.47 | 0.58 | 1.41 | 0.10 |
| 10 | 6.06 | 8.48 | 0.0 | 0.58 | 0.59 | 1.43 | 0.10 |

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