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The use and costs of capital in selected beef feedlots in four counties of northwest Iowa

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THE USE AND COSTS OF CAPITAL IN SELECTED BEEF FEEDLOTS IN FOUR COUNTIES OF NORTHWEST IOWA

by

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I. INTRODUCTION

In recent years many studies have been done in other cattle feeding states to explore the nature of the resources in these states, their costs and returns, as well as the significance of such factors as economies of scale. Notably absent, however, are any such studies of Iowa farm-feedlots in spite of the fact that Iowa is the leading cattle feeding state in the nation. Furthermore, there is frequently great concern among Iowa cattle feeders when they read accounts of the growth of the cattle feeding industry in these other states and yet receive what they feel are unsatisfactory returns from their operation. Thus this study was undertaken in the hope that it would serve in the order of a pilot or preliminary study to assess any significant trends or features of economic factors which might characterize Iowa farm feedlots.

II. THEORETICAL CONSIDERATIONS

A. The Idea of Capital

The theory of capital has a history rich with definitions and distinctions as well as replete with disagreements. Today a commonly accepted definition of capital is that it is a produced means of production, namely a productive good whose productive capacity has been either brought about or enhanced by the activity of man. This then would lead to the tri-part distinction of the factors of production into land,labor, and capital. Spitze (24), however, suggests that land also can validly be considered a produced means. It has been cleared and then perhaps shaped or leveled, irrigated or tiled, fertilized or otherwise altered. Furthermore, its value is markedly influenced by such actions of man. Thus land would be a capital asset. This is the approach followed in this study - factors of production are considered to be labor and capital. Capital then encompasses all non-labor factors necessary in the dry-lot finishing of beef cattle.

Problems frequently arise in consideration of capital because its use is, in part, a two dimensional concept; it not only involves a dollar amount, but also a time period, a duration of use. For example, in the finishing of cattle the facilities persevere through several droves, their use extends over a period of years. Likewise, the feed consumed by the beast has an element of duration: the product of the feedlot has not reached its finished stage for sometime, months or weeks, after having eaten the vitals. Yet this feed has and is contributing to the completion and quality of the slaughter animal. This is an aspect of duration, not flow. As Haavelmo says, "... capital must have the dimensions of a stock concept, something at a point in time, t, and not something per unit of time" (5, p. 43). Thus the amount of capital employed in a productive process must be stated by delineating both its monetary amount and the duration of its employment.

Closely linked with the concept of capital is that of investment. Investment is not synonomous with capital, but rather refers to increases in capital stock over time: further accumulation of productive assets or resources. It can be defined as the first derivitive of capital, or the time rate of change of capital stock. Investment, then, is of vital concern to the firm as it faces its long run planning horizon.

B. The Production Function

As a factor of production, capital is combined with labor to produce various goods, and the various types of capital can be combined in various proportions and relationships in producing these different goods. Mathematically, this can be expressed as

$$F(q_1 \ldots, q_m) = G(V_1 \ldots, V_N)$$

where

$q_1 \ldots, q_m$ = the various products,

$V_1 \ldots, V_N$ = the various inputs,

F and G define the interrelationships among products and resources during the production period.

However, a production function is specific for only one technique of production and one level of technology. It does assume technical efficiency in that the function specifies the maximum output possible with the given combination of inputs. Thus various production functions exist at each level of technology, depending upon the number of different input mixes or production techniques available to the firm.

In the case of the beef feedlot, the production function would define the efficient combination of labor and capital inputs for the production of finished beef using a specific technique. This could be expressed as

$$q = G(V_1 \ldots, V_N) \quad .$$

Further, in the short run some inputs would be fixed and some variable. Thus

$$q = G(V_1 \ldots, V_i | V_j \ldots, V_N)$$

when

$V_1 \ldots, V_i$ = the variable inputs and the bar means "given".

With abstraction the production function becomes

$$q = G(V_1 | V_2 \ldots, V_N)$$

if only one input is considered as variable. Then, by using as the function, the equation,

$$q = a + bV_1 + cV_1^2 + dV_1^3 \quad ,$$

total output can be represented geometrically as the classical total product curve of economic textbooks with its three stages of production (Figure 1). Stages I and III are termed the irrational stages because in stage I average productivity can everywhere be increased by using additional units of the variable resource, while in stage III total product can be everywhere increased by casting aside units of the variable resource. Stage II, however, remains the area of economic decision, of rational choice. It is, furthermore, this stage which is frequently represented by agricultural production functions such as the often used Cobb-Douglas. Figure 1 also illustrates areas of increasing and of decreasing returns from use of the variable resource. The area of increasing returns is that area in which total output is increasing at an increasing rate, while the area of decreasing returns is that area in which total output increases at a decreasing rate as long as marginal product is positive. A total output curve displaying decreasing returns may actually turn downward as does Figure 1 in stage III where total output is decreasing and marginal product is negative.

Two further relationships can be defined in light of the production function. Average product (AP) is simply total product divided by the quantity of input used to produce that total amount of output, while the marginal product (MP) of an input is the addition to total product attributable to the last unit of the variable resource employed. Marginal product can also be defined as the rate of change in output with respect to change in input. Thus

$$AP = \frac{TP}{V_1} = \frac{q}{V_1} = \frac{G(V_1 | V_2 \ldots, V_N)}{V_1}$$

and

$$MP = \frac{d(TP)}{dV_1} = \frac{dq}{dV_1} = \frac{d[G(V_1 | V_2 \ldots, V_N)]}{dV_1} \quad .$$

For the specific case of the production equation

$$AP = \frac{q}{V_1} = aV_1^{-1} + b + cV_1 + dV_1^2$$

and

$$MP = \frac{dq}{dV_1} = b + 2cV_1 + 3dV_1^2 \quad .$$

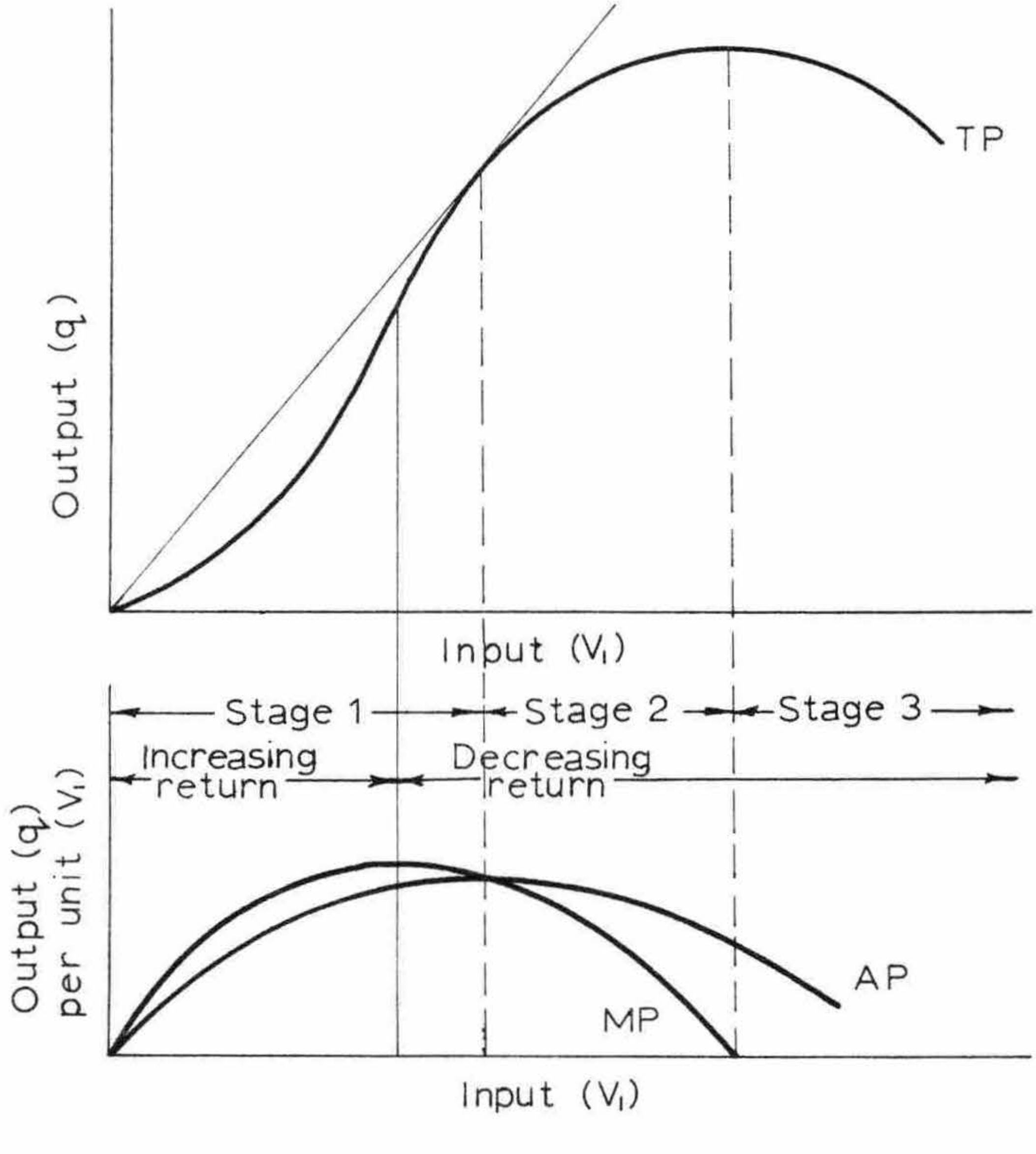

Figure 1. Total product, average product and marginal product curves for one variable resource

Again the marginal product and average product curves are illustrated in Figure 1.

C. The Cost Function

Corresponding to every production function is a cost function which is entirely and directly dependent upon that production function. The cost function then specifies the minimum total costs of producing the given outputs using a specific technique in the defined production period. This cost function can be expressed as

$$TC = \beta(q) + \alpha$$

where

TC = total costs

$\beta(q)$ = variable costs

α = fixed costs .

These are illustrated geometrically in Figure 2 where the cost curves correspond to the geometrical presentation of the simplified production function in Figure 1. There are ranges in which costs are increasing at a decreasing rate and then increasing at an increasing rate. These correspond to the areas of increasing returns and decreasing returns respectively of the production curve of Figure 1. Nevertheless, it should be noted that the shape of the short run cost curves is affected by the nature and cost of the fixed inputs as well as by the production function, since it is the production function which specifies the relationship between output and the inputs.

An example of a cost function which defines the cost curves in Figure 2 is

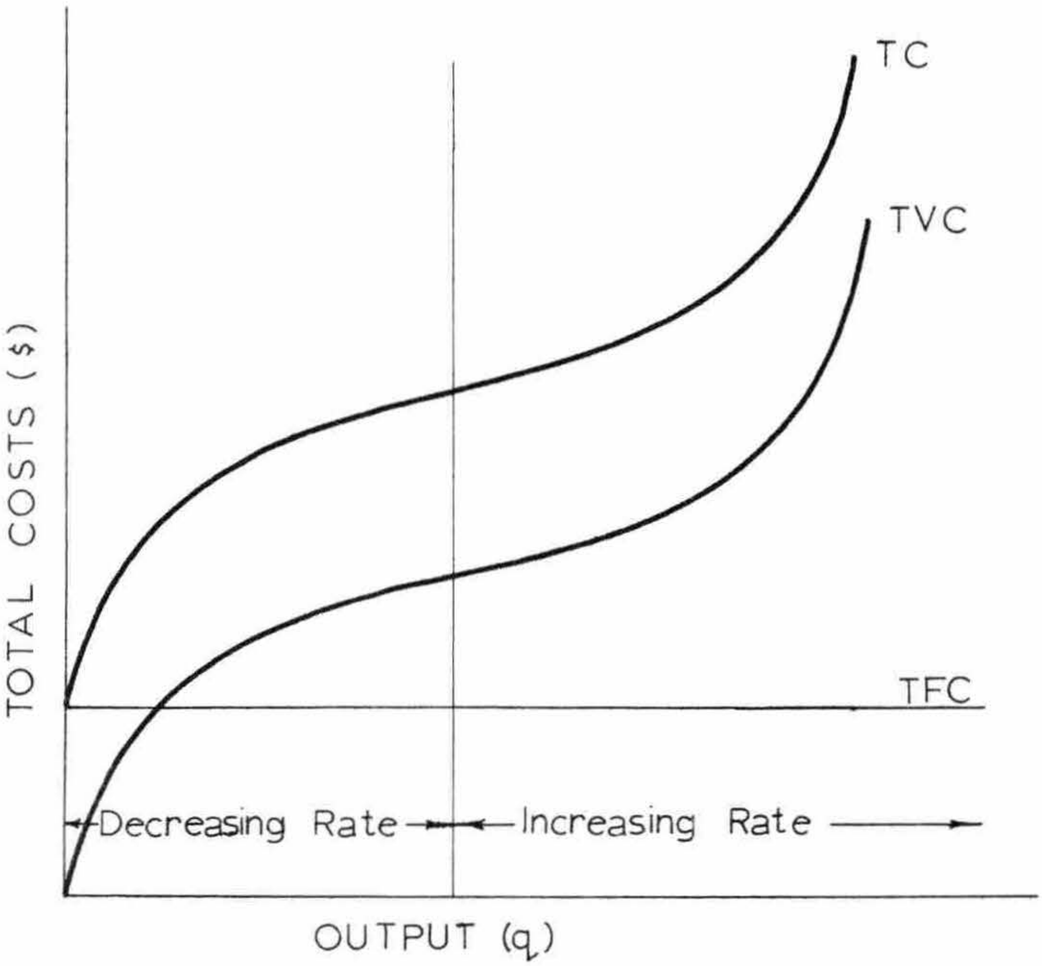

Figure 2. Total cost curves with costs increasing at a decreasing rate and then at an increasing rate

$$TC = \alpha + \beta q + \gamma q^2 + \delta q^3 \quad .$$

A cost function thus defines cost in terms of output, that is, as a function of output.

The following relationships can also be defined and derived: average total cost is total cost per unit of output; average variable cost is variable cost per unit of output; average fixed cost is fixed cost per unit of output; and marginal cost is the rate of change in total cost with respect to changes in output. Thus

$$ATC = \frac{TC}{q} = \frac{\beta(q) + \alpha}{q}$$

$$AVC = \frac{VC}{q} = \frac{\beta(q)}{q}$$

$$AFC = \frac{FC}{q} = \frac{\alpha}{q}$$

and

$$MC = \frac{d(TC)}{dq} = \frac{d[\beta(q) + \alpha]}{dq}$$

$$= \frac{d(TVC)}{dq} = \frac{d[\beta(q)]}{dq}, \quad \text{since } \alpha = \text{constant (or fixed).}$$

The cost curves for these relationships are depicted in Figure 3.

It should be noted that these are short run cost curves since there is a fixed cost, for in the long run no costs are fixed. Also, the short run cost curves are "U" shaped, a characteristic which arises because variable inputs are being combined with fixed inputs in increasing proportions. Beyond a point, average cost begins to rise because of decreasing productivity of the variable resource.

For the simple cost function illustrated previously these relationships become:

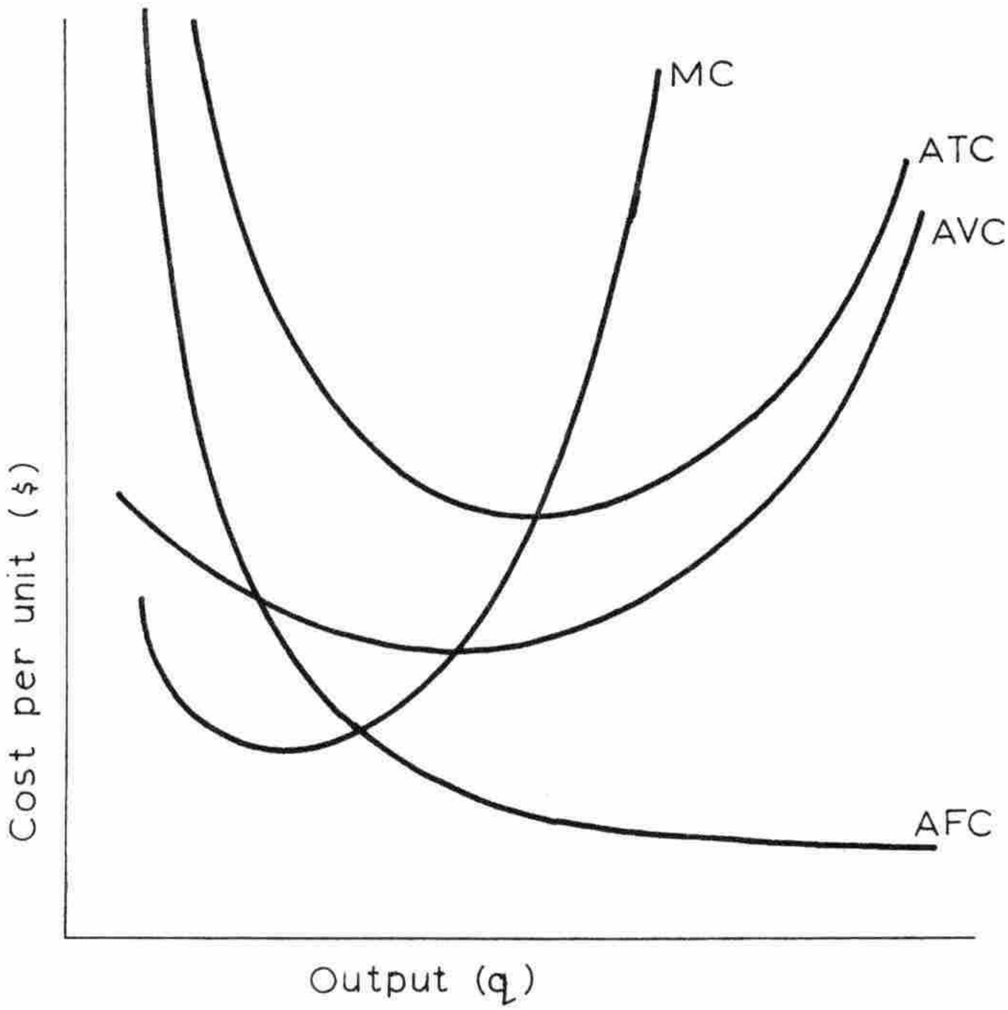

Figure 3. Average and marginal cost curves

$$ATC = \frac{TC}{q} = \alpha q^{-1} + \beta + \gamma q + \delta q^2$$

$$AVC = \frac{VC}{q} = \beta + \gamma q + \delta q^2$$

$$AFC = \frac{\alpha}{q}$$

and

$$MC = \frac{d(TC)}{dq} = \beta + 2\gamma q + 3\delta q^2 = \frac{d(VC)}{dq} \quad .$$

In the long run all factors are variable and all costs are variable. The cost function is then

$$LTC = \beta(q)$$

and

$$LAC = \frac{LTC}{q} = \frac{\beta(q)}{q}$$

$$LMC = \frac{d(LTC)}{dq} = \frac{d[\beta(q)]}{dq} \quad .$$

The long run average cost (LAC) curve differs from those of the short run, however, in that its shape is entirely dependent upon the production function. It can thus have positive, negative, or zero slope, depending upon the product-resource relationship defined or specified by the production function. The theoretical curve most frequently depicted is, nevertheless, a "U" shaped curve as shown in Figure 4, since the above are special cases of this theoretical curve. The LAC curve is often referred to as the envelope or planning curve and is drawn so it is tangent to each of the short run average total cost curves at that rate of output most efficient for a plant of that size. It assumes a known and fixed level of technology, and indicates the various production-investment opportunities available to the firm.

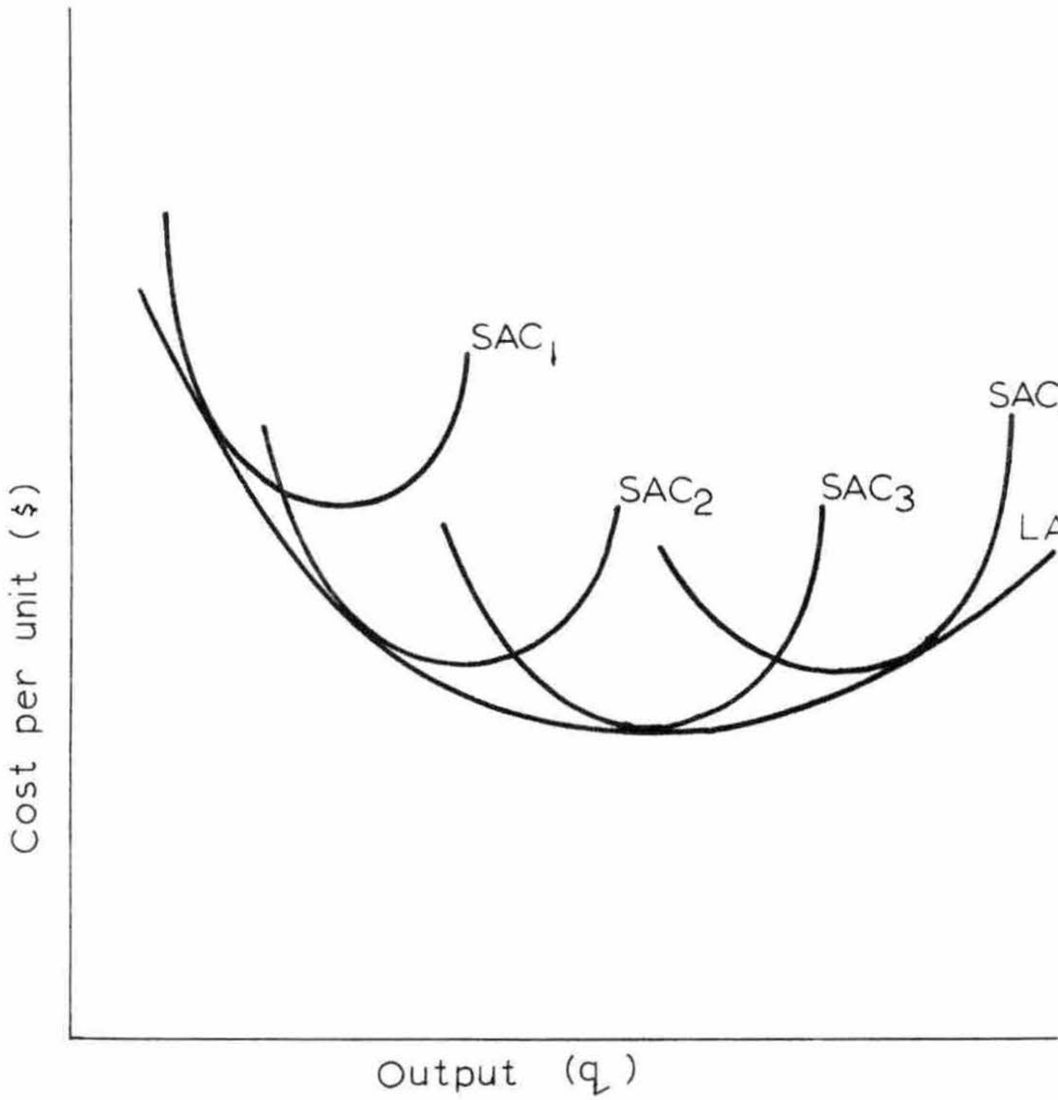

Figure 4. Long run average cost curve

The long run average cost curve is often used to indicate economies of scale available to the firm. Strictly speaking, scale refers to a proportionate increase in all inputs, and the term economies of scale refers to a more than proportionate increase in output corresponding to the proportionate increase in inputs. Economies would then result from such internal factors as increased specialization and more efficient use of discrete or heterogeneous inputs and from such external factors as more favorable purchasing and selling opportunities. In actual practice, however, researchers frequently relax the demand of proportionate increase in factors when studying scale returns. For example, all inputs except management may be increased proportionately, or there may be a shift in technology as size of the plant is increased. Justification for this lies in the fact that entrepreneurs, cattle feeders, for example, are actually interested in economies of size rather than strict scale economies.

D. Profit Maximization

The problem of profit maximization can be approached from two directions, namely from the resource or from the output side. Focusing, then, upon resource or capital use, this discussion will consider the employment of one variable resource in combination with fixed inputs, the same concept as illustrated by the product curves of Figure 1. In this case profits are maximized by equating the ratio $\frac{\text{price of capital factor}}{\text{price of output}}$ to the marginal product of the resource. Thus

$$c/p = \frac{dq}{dV_1}$$

where p = price per unit of output,

c = price per unit of resource,

dq/dV_1 = MP as defined previously.

This is illustrated graphicaly in Figure 5, where only the rational or economic area of the total product curve has been presented. The line c/p has been drawn tangent to the product curve indicating the point on the product curve where the price ratio equals marginal product, since marginal product is merely the slope of the total product curve at a given point. In the example, a profit maximizing firm would produce $\overline{q}$ using $\overline{V}_1$ of the variable resource. This further clarified by rearranging so that

$$c(dV_1) = p(dq) \quad .$$

This indicates that profits are maximized only when a change in value of the input equals the value of the change in output.

Maximum profits can also be defined in terms of marginal value productivity. If

$$dV_1 = 1 \quad ,$$

the economic indicator becomes

$$c = p(dq) \quad .$$

Thus the marginal factor cost is equated with its marginal value product to maximize profits. c is, in fact, the marginal factor cost (MFC) because the competitive firm faces a perfectly elastic factor supply curve. This is illustrated in Figure 6, where the profit maximizing firm would employ the quantity $\overline{V}_1$ of the variable resource.

On the other hand, a firm may prefer to approach the problem of profit maximization by considering revenue and output. In a perfectly

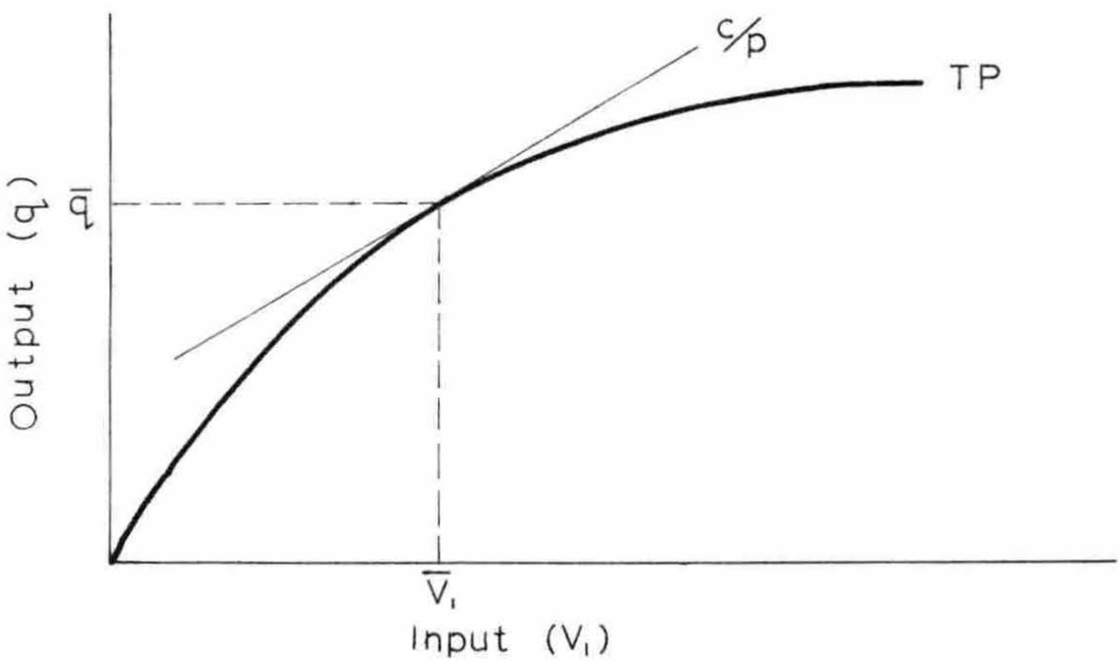

Figure 5. Profit maximization by the equation of marginal product and the factor-product price ratio

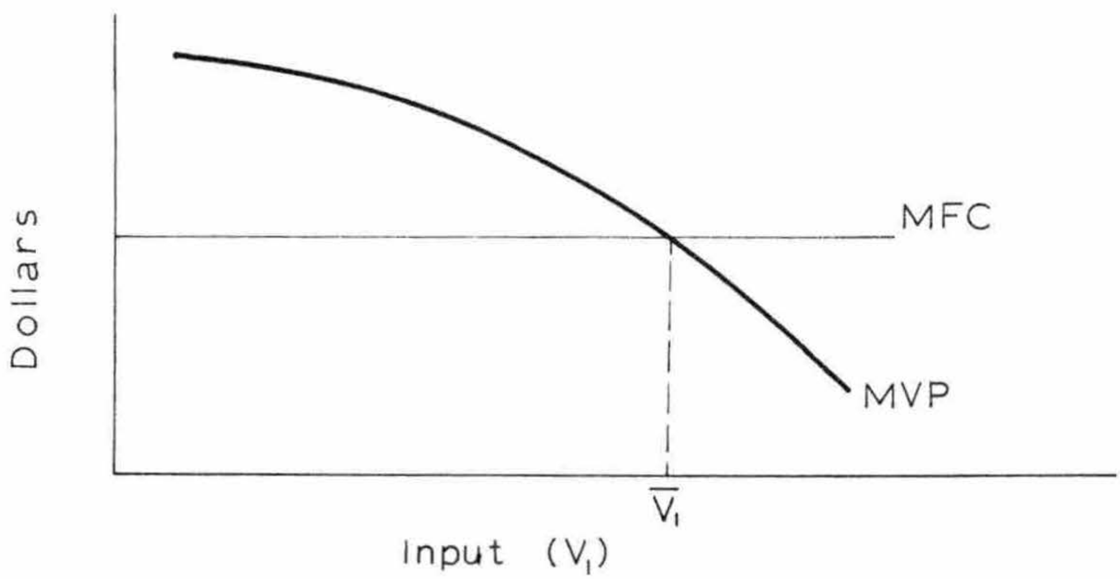

Figure 6. Profit maximization by the equation of marginal factor cost and marginal value product

competitive industry, the revenue of a firm is a direct function of output. Since it faces a perfectly elastic demand curve, the firm receives a fixed price. Thus

$$TR = pq$$

where

TR = total revenue

p = price per unit of output

q = quantity of output.

From preceding considerations

$$TC = \beta(q) + \alpha \qquad (SR)$$

or

$$TC = \beta(q) \qquad (LR) \quad .$$

Now

$$\pi = TR - TC$$

$$= pq - \beta(q) + \alpha \quad (SR)$$

or

$$\pi = pq - \beta(q) \qquad (LR) \quad .$$

Taking the first derivative and equating with zero,

$$\frac{d\pi}{dq} = p - \frac{d[\beta(q)]}{dq} = 0$$

for both the long and short run. Then

$$p = \frac{d[\beta(q)]}{dq} \quad .$$

But

$$\frac{d[\beta(q)]}{dq} = MC \ ;$$

so

$$MC = p.$$

Thus the firm maximizes profits by producing that quantity of output which equates MC with the price of the output. The second order condition for a maximum can be verified by taking the second derivative.

This approach to profit maximization is illustrated in Figure 7 for several firms having different plant sizes and cost functions where $\bar{q}_1$, $\bar{q}_2$, and $\bar{q}_3$ are the profit maximizing quantities of output for the three respective firms having SAC_1, SAC_2, and SAC_3.

E. Uncertainty and Capital Use

The preceding discussion has progressed under the assumption of perfect knowledge. In reality, however, the firm encounters problems of risk, uncertainty, and variability of expectations. These problems impinge upon the manager's economic decisions and do, in fact, affect his deployment of capital. The effect can be generated from within or without: capital may be rationed externally to the firm by the lending agency or it may be rationed internally so as to minimize or decrease vulnerability to financial loss. Figure 8 illustrates the effect of internal capital rationing wherein the entrepreneur has discounted the marginal value productivity of the capital resource according to his subjective preferences as influenced by his aversion to risk bearing and estimation of uncertainty. He thus limits his use of capital as indicated by the intersection of the marginal factor cost curve (MFC) with the original marginal value productivity curve (MVP) and with the discounted marginal value productivity curve (MVP').

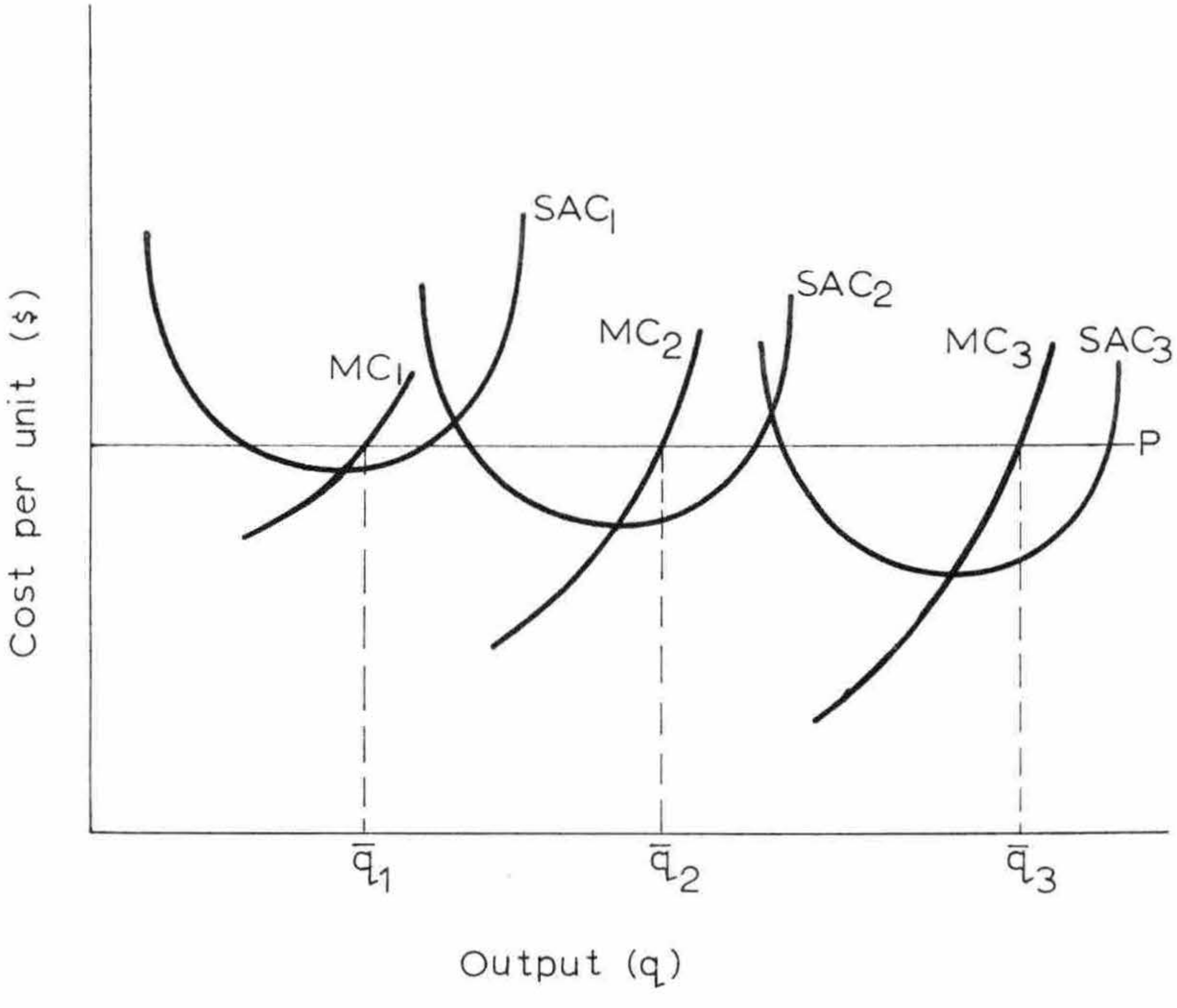

Figure 7. Short run profit maximization by three firms having differing cost functions

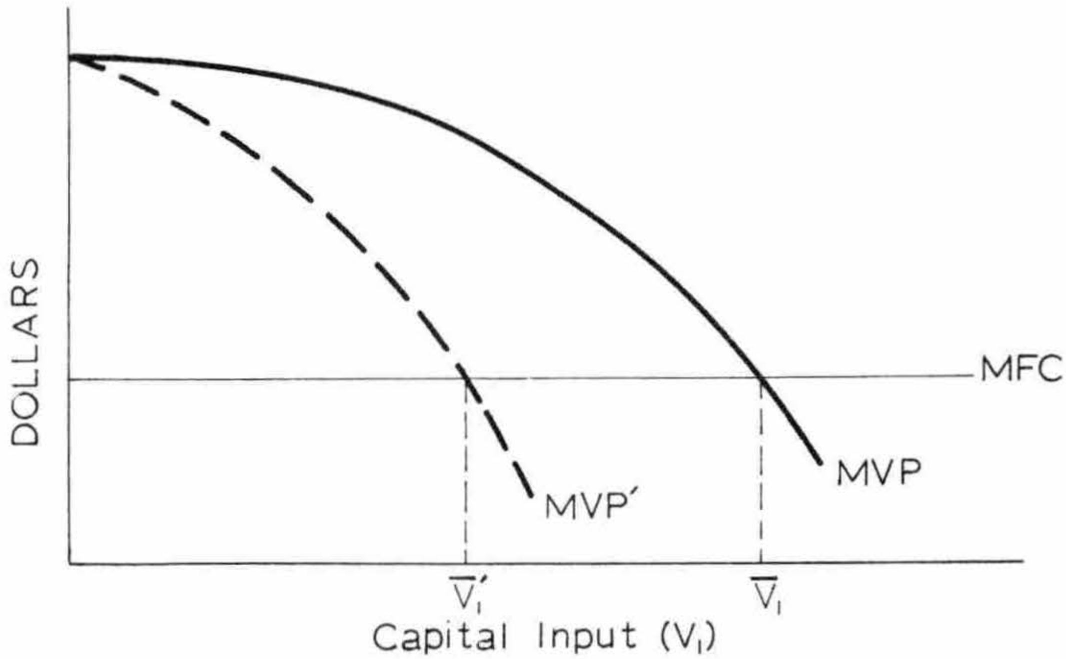

Figure 8. Internal rationing of capital because of uncertainty

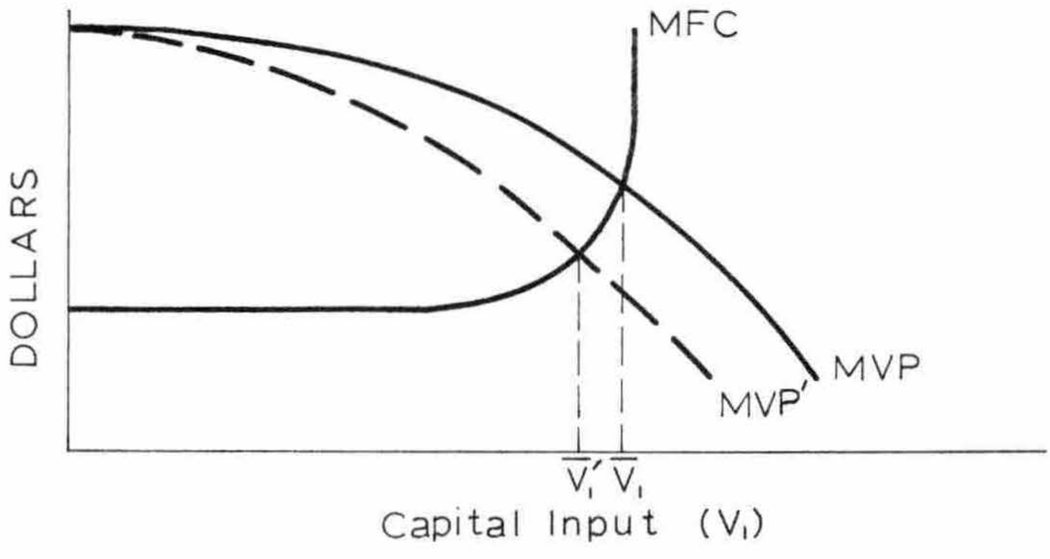

Figure 9. Combined effect of internal and external capital rationing

Figure 9 illustrates the combined effect of internal and external capital rationing. In this case the capital source has placed a maximum limit upon the supply of capital inputs and has also increased the marginal factor cost as uncertainty, or the amount of capital inputs employed, has risen.

F. A Note on the Model, the Industry and the Firm

Since the model of perfect competition has been invoked, the following assumptions are necessarily implied:

1. Homogeneous product
2. Perfect knowledge
3. Profit maximization
4. Atomistic competition
5. Free and instantaneous exit and entry of resources.

Such assumptions are obviously abstractions from the true economic situation of any industry. Yet these assumptions have been necessary in the development of economic models. Fortunately, these models approximate the real world and facilitate an analysis of an industry situation.

Nevertheless, some of the difficulties with the abstraction should be mentioned. One, that of capital rationing under uncertainty, has already been discussed. Problems of uncertainty arise in cattle feeding primarily due to market fluctuations, but there is also uncertainty involved in the gaining and finishing responses of feeder cattle. Thus the cattle feeder actually faces a distribution of production functions as well as an even wider distribution of marginal value productivity curves. Furthermore, a cattle feeder may lack complete knowledge of technological, investment, or marketing opportunities and may, for one reason or another, find it impossible or inconvenient to attain such knowledge. His decision patterns then may be based upon satisficing rather than maximizing behavior.

Although the assumption of atomistic competition appears to have considerable validity for the Iowa beef feeding industry, the marketing and bargaining skill of the individual is a crucial factor in profit determination. Thus, from the viewpoint of the firm, this assumption is problematic.

The final assumption is again unrealistic, for the resources of cattle feeders are quite specialized. However, the problem is not crucial since this is not an equilibrium analysis.

Finally there is a particular problem with the analysis of farm operations and enterprises. As Black says, "In a farm business the individual and the entrepreneur are inextricably mingled" (1, p. 475). Thus the effects of management decisions and consumer utility become confounded, and problems again arise with the profit maximization assumptions. Black (1,2) in his study of English farmers found that technical satisfaction and securing the future life of the firm were strong motives for marginal investment rather than immediate profit maximization.

In spite of such difficulties involved in the abstraction, it must be used. For without the assumptions, one can merely enumerate the characteristics of n firms. By thus eliminating some of the individual differences of the firms one can make comparisons from a certain point of view determined by the abstraction. An economic analysis can then be performed; the role of efficiency, costs, and profits in industry competition is crucial.

III. REVIEW OF LITERATURE

In recent years there have been various studies which have focused on the use of capital in beef feedlots. Such studies have been conducted both in leading cattle feeding states as well as in states where cattle feeding is a minor industry - in the latter cases primarily to explore the industry's potential. These studies have been of two basic types. The one type is primarily an empirical analysis based on a survey of actual costs and investments of existing feedlots, while the other type is generally the synthetic cost model constructed by the engineering budgeting technique, described by Bressler (3, pp. 535-536). Resource requirements for synthetic models have generally been based on surveys of existing facilities, compiled research data, extension recommendations, or estimates by agricultural engineers and/or animal scientists. Because of this difference in focus, the two types of studies will be reviewed separately with the synthetic models considered first.

Marousek and Dirks (16) studied cooperative feedlots as an alternative for farmers and ranchers of South Dakota who desired to expand their livestock enterprises but face capital constraints. A cooperative feedlot of 5000 head capacity was compared with a 200 head farm feedlot for the feeding of 650 pound yearling steers for 240 days to a final weight of 1150 pounds. Capital requirements, including land and improvements, manure and feed handling equipment, miscellaneous and working capital, were found to be $30-40 per head for the cooperative feedlot (assuming 7500 head fed per year) and $65 per head for the farm feedlot when 200 are fed annually, but $45 per head when 300 are fed annually in the same farm feedlot (200 head capacity). Annual non-feed costs (salaries, utilities, and miscellaneous) were found to be $10.42 per head for the cooperative feedlot and $16.25 and $15.25 per head for the farm feedlot when 200 and 300 head, respectively, were fed annually.

Suter and Washburn (25) in a Purdue study used the budgeting technique to develop 28 alternative systems of feeding beef cattle and then analyzed these systems for costs and returns. Equipment requirements were based primarily on a survey of 42 Indiana farm feeders who fed 79 different lots of cattle. Equipment investment required per head was found to be $53.73, $34.02, $31.89 and $34.01 when 25, 75, 125, and 250 head, respectively, were fed annually. Similarly, total per head annual equipment costs (including depreciation, interest, repairs, taxes, and insurance) were $13.24, $7.89, $7.26, and $8.74 when the same respective numbers were fed per year.

In a USDA study to find improved methods and designs for commercial cattle feedlots, Webb (26) performed time studies on 14 selected feedlots and obtained cost and labor requirements. He assumed a turnover rate of three and total per head costs of $4.60, $2.84 and $2.52 as typical for lots with capacities of 1000, 5000, and 10000 head, respectively, for the operations of receiving and loading cattle, feeding and feed preparation, inspection and care of animals, and manure disposal. Excluding land, initial investments (f.o.b. factory) for these respective lots were $17.12, $8.55 and $6.61 on a per-head-fed basis, assuming the 1000 head capacity lot used a self-mixing self-unloading truck method, the 5000 head capacity lot a mixing mill (capacity 40000 pounds per hour) and self-unloading truck method, and the 10000 head capacity lot, the latter method with a mill of 75000 pounds per hour capacity.

King (14) of California likewise developed synthetic model feedlots based on data obtained by sampling 12 large feedlots in the Imperial Valley and by consulting a feedmill construction firm. Assuming full utilization of feed mill facilities for ten hours a day, he determined total investment per head to be \$51.37, \$38.12, and \$34.13 for feedlots with a designed capacity of 3760, 11280, and 22560 head respectively. Nonfeed costs per head were likewise found to decrease with increasing size, being 7.19, 5.92, and 5.57 cents per day for the above design capacity lots. Furthermore, a short-run analysis revealed economies of use intensity: per head nonfeed costs of a feedlot operated at 80 percent of capacity were less than half those cost of a lot operated at 20 percent capacity.

Gibbons (4) studied an alternative feeding method for Iowa farms, the basket and scoop method, scoop unloaded wagon, self-unloading wagon, and a mechanized system for the feeding of good to choice steer calves for 300 days beginning November 1 at 450 pounds. Capital investment requirements (figured as 55% of the new cost of equipment) on a per head basis were \$25.53, \$17.50, \$11.75, \$10.25, and \$8.76 when 50, 100, 300, 600, and 1500 head were fed using the scoop and basket system. When these same numbers were fed on the scoop unloaded wagon system, the investment requirements were found to be about the same. The self-unloading wagon system required \$41.40, \$27.01, \$17.17, \$15.04, and \$12.86 per head, while the fully mechanized system required \$36.30, \$25.16, \$17.88, \$15.67, and

$14.05 per head investment for these respective numbers. Total non-feed costs (capital investment costs, labor costs, and operating costs combined), however, were in favor of the mechanized system at levels of about 150-200 head up to 600-800 head. Above that level, the self-unloading wagon was found to have the lowest non-feed costs. Also, at the 400 head level, costs of feeding other than feeder cattle and feed costs became sufficiently low so that a small change in either the cost of feeder cattle or feed cost could easily offset a large percentage change in non-feed costs.

Richards and Korzan (21) in a feasibility study designed to illustrate expected costs and returns for an Oregon feedlot during the 1956-1963 period estimated total equipment and facility capital requirements to be $95.28, $71.58, and $52.22 per head of capacity for 500,2000, and 5000 head capacity lots respectively. However, the authors assumed a feed processing plant and fenceline feeding for all lot sizes. Non-feed costs per head or per hundred weight gain were found to decrease with increasing capacity. Also, economies of use-intensity were found: non-feed costs decreased when the facilities were used at or near capacity as contrasted with underutilization. However, this effect, although significant for the large capacity lot, was not as great as it was for the smaller sized lots.

Williams and McDowell (28) also developed synthetic models based upon data obtained from an Oklahoma survey and previous studies, and from consultations with equipment manufacturers and dealers, feed companies, and feedlot operators. These models were designed to be "least-cost" but not necessarily "typical" in contrast with those of Richards and Korzan which were to be "reasonable" but not necessarily "optimum" in regard to costs and requirements. In the Williams and McDowell study, the generated models had capacities ranging from 300 to 1500 head. Total estimated investment per head was $74.60, $60.34, $39.37, and $28.45 for lot sizes of 300, 1000, 5000, and 15000 head respectively. Non-feed costs decreased with increased feedlot size, the greatest savings being realized up to a scale of about 2000 head. From that point, the cost reductions were relatively small. Notable cost savings were again found by increasing utilization rate to near capacity, but as would be expected, the greatest savings were found as utilization increased from 1/3 to 2/3 of capacity. Again this effect was less dramatic for the large feedlots in comparison with the smaller lots. However, it did tend to increase with increasing length of the feeding period.

In a study of Nevada warm-up cattle feedlot operations, Malone and Rogers (15) synthesized investment costs of $43.13, $31.07, $24.36, $19.61, and $16.57 per head for lots with capacities of 300, 600, 1000, 1500, and 2400 head respectively. Economies of size were found for warm-up lots in this range and were due largely to a spreading of fixed costs. The decrease in cost per head was most significant in the 300-1000 head capacity range. Short run economies of utilization were found to be similar to those in the previous studies.

McCoy and Wakefield (17) in a study based on Kansas farm feedlots likewise found decreasing per-head capacity investment as capacity increased from 40 to 925 head. Again, scale economies were found. They were greatest at a capacity of 280 head, but continued at a decreasing rate with increased capacity. A similar effect upon non-feed costs was found for the rate of utilization.

Hunter and Madden (9) in a study based on specialized Colorado feedlots in which they focused primarily on feed mill size, also found scale economies with increasing size. However, most of the savings were realized by the 1500 head capacity level; additional economies beyond that point were small.

Finally, Saunders et al. (22,23) developed synthetic models for ten alternative farm feeding systems in Georgia and budgeted the systems for capacities of 100, 500, and 1000 head. Capital requirements for dry-lot systems were found to range from $61.50 per head at 1000 head capacity to $98.78 per head for 100 head capacity depending upon the alternative system. Economies of size were found for each system - decreases in non-feed costs were associated with increases in size - with the per-head economies being greater in the 100-500 capacity range than in the 500-1000 capacity range.

Among those studies which are primarily empirical analyses is that of Moran (18) which investigated Arizona non-feed costs. Based on a survey of 94 feedlots, he found that the largest feedlots tended to have less than one-third as much non-feed cost per ton as did the smallest feedlots, and that the investment cost showed more contrast between the various sizes than did other costs such as labor, nonlabor wages, death loss, or veterinary and medicine. Further analysis revealed that intensity of use was the cause of lower feed costs rather than absolute amount of investment, although the intensity of use was correlated with volume of feeding.

Weisgerber (27), in a study of 34 Montana farm feedlots, found that investment per head ranged from $65.81 to $29.11 where the number of cattle fed annually ranged from 36 to 466 head, as based on the averages of the lots when divided into five size groups. Nonfeed costs for the same size groups ranged from $18.47 to $7.79 per head while $10-$12 was "typical" for the feedlots.

Mueller (19), also in a study of Montana feedlots, found average investment per head for facilities and handling and feeding machinery and equipment to be $23.74, $36.18, $35.36, and $27.80 for lots feeding 45, 120, 240, and 450 head per year. Similarly, non feed costs were $14.46, $17.14, $17.87, and $13.21 per head for the same lots. Subsequent budgeting techniques showed, however, that in all cases non feed costs could be decreased by more intense utilization of feedlot capacity.

In a study of 77 California feedlots, Hopkin (7) found differences in daily non-feed costs to be significant when the ratio of number fed annually to yard capacity varied. Likewise, such costs were significantly different among yards of different capacities. A generated long run cost curve indicated that the California cattle feeding industry was decreasing cost industry at that time (1958) and within the size range studied.

More recently (1965) Hopkin and Kramer (8) studied 81 California feedlots and again found a fairly consistent inverse relationship between investment per head and feedlot size for feedlots up to 16000 head capacity. Beyond that point, feedlots appeared to suffer diseconomies. Investment per head for facilities and equipment (excluding land) was reported as $33.06, $28.46, $15.80, and $22.85 for feedlots with capacities of less than 4000, 4-9000, 9-16000 and over 16000 head respectively. Similarly, average daily nonfeed costs were 12.74, 8.68, 7.01, and 7.14 cents per head fed for yards feeding less than 4000, 4-10000, 10-26000, and over 26000 head. As in other studies, use intensity increased with feedlot capacity. Turnover ratios ranged from 1.08 to 1.70 as feedlot capacity progressed from less than 4000 head to over 16000 head.

IV. METHOD OF STUDY

A. Hypotheses and Objectives

Iowa has a consistent record for marketing more grain-fed cattle than any other state in the United States. Likewise, recent evidence indicates that this state will maintain its dominant position for some time in the future. The number of cattle and calves on feed in Iowa on January 1, 1967 was 14 percent greater than on January 1, 1966. Corresponding increases were 7 percent for the North Central States and 4 percent for eleven western states; however, some individual states far surpassed the percentage increase for Iowa as did Oklahoma and Texas, for example, with percentage increases of 32 and 25 respectively (29). The recent growth trend of the cattle feeding industry in Iowa as well as the magnitude of Iowa's dominance in numbers fed can be seen from Table 1 where the number of cattle and calves on feed on January first of various years is presented for Iowa, Nebraska, and Illinois, currently the three leading cattle feeding states. Yet the question of the industry's economic position often arises in view of increasing competition, particularly from some western states.

Thus the objective of this study is to assess some of the effects of farm feedlot size along with effects of type of feeding system upon feedlot investments and upon fixed or investment costs and upon operating costs of Iowa farm feedlots. An additional factor which might affect feeding investments and costs is the cattle feeder's position as owner or renter of the feeding facilities. It is thus desirable to explore the effect of this factor and its interrelationships with the size and feeding

Table 1. Cattle and calves on feed in Iowa, Nebraska and Illinois on January 1, 1960-1967[a]

Year	Iowa 1,000 head	Nebraska[b] 1,000 head	Illinois[c] 1,000 head
1960	1,510	--	--
1961	1,540	--	--
1962	1,571	--	--
1963	1,744	--	--
1964	1,796	--	--
1965	1,850	1,027	791
1966	1,776	1.227	807
1967	2,025	1,308	791

[a]Source (11, 29)

[b]The average number on feed January 1, 1960-1964 is 826,000 head for Nebraska

[c]The average number on feed January 1, 1960-1964 is 774,000 head for Illinois

system factors.

As a starting point, it is therefore hypothesized that these factors do not significantly affect the various types of investment -- building, machinery and equipment, and total investment -- on a per head basis, and further, that they do not significantly affect various fixed and operating costs either on a per head or per pound gain basis.

B. The Survey

The focus of this study is on the current Iowa farm-feedlot situation -- a cross-sectional viewpoint. Thus actual 1966 cost and investment figures were obtained by personal interviews with a number of Iowa cattle feeders.

The magnitude and extent of the industry in Iowa necessitated a limitation on this study. As a result four counties, namely, Plymouth, Cherokee, Sioux, and Woodbury, were chosen as the location for the study. As indicated in Figure 10, these counties fall either in the Northwest or West Central crop reporting districts of Iowa, the two leading districts both in the number of farms marketing grain fed cattle and in numbers of grain fed cattle marketed (Appendix A). Furthermore, these counties individually ranked high among Iowa counties in number of grain fed cattle marketed during 1966, as is shown in Table 2. When these four counties are combined to form a continuous area, the resultant is the most intensive four county cattle-feeding area of Iowa. The focal point of the survey, then, was the heart of the Iowa cattle feeding industry.

In preparing the survey, names of selected cattle feeders were obtained from the county extension directors in these four counties. The names so obtained quite likely represented cattle feeders of at least average or above average mangement ability since it was necessary that they have sufficient records to be able to provide the required cost and investment data. The names from the four counties were then pooled and grouped according to size categories of 100-199, 200-299, 300-499, 500-899, and 900-1500, based upon the number of finished cattle sold in 1966.

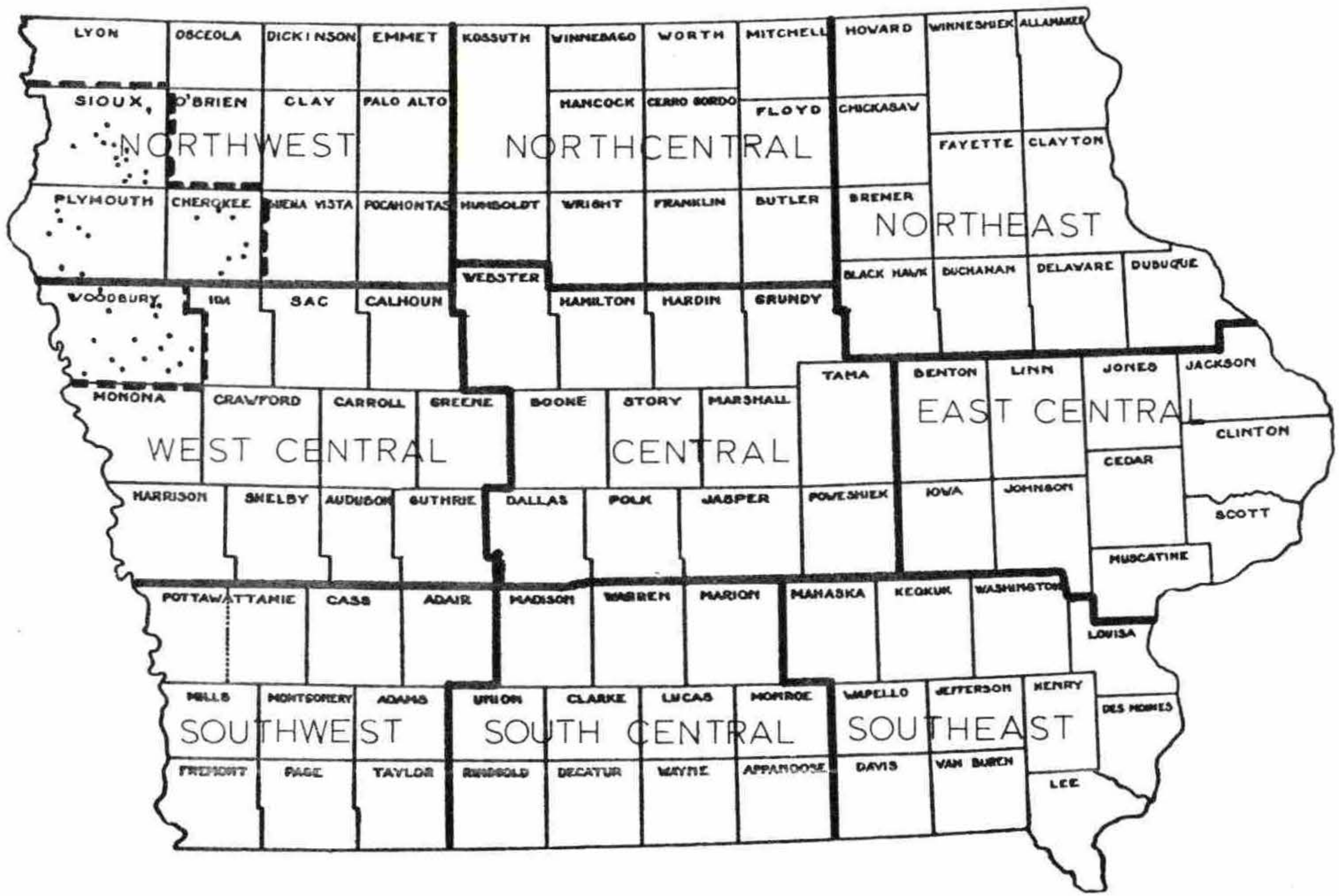

Figure 10. Iowa crop reporting districts showing distribution of sample units within the four-county sample area of Cherokee, Sioux, Plymouth, and Woodbury counties

Table 2. Number of grain fed cattle marketed by ten leading counties, Iowa, 1966[a]

County	Number of Cattle
Sioux	167,560
Pottawattamie	157,690
Plymouth	121,898
Clinton	109,255
Cherokee	108,429
Sac	98,722
Woodbury	90,234
Shelby	88,363
Carroll	87,417
Lyon	84,908

[a]Source (10)

Then names were randomly selected from among these size categories to obtain a distribution of sizes for the completed sample. The geographical distribution of the cattle feeders interviewed is illustrated in Figure 10. The total number of interviews completed was 44; of these 42 provided usable data for various parts of the study.

C. Statistical Model

The data thus obtained were analysed for the effects of size, type of ownership, and type of feeding system using the methods of analysis of variance and of analysis of covariance. The analysis of covariance was used to evaluate the effect of size upon the dependent variables, namely, the cost and investment factors. Covariance analysis was the most appropriate since size, in fact, constituted a continuous rather than a categorical effect. The data then formed a two-way cross classification for the effects of ownership and type of feeding system. Therefore, the model used can be expressed as

$$Y_{ijk} = \mu + \alpha_i + \gamma_j + (\alpha\gamma)_{ij} + \beta X_{ij\cdot k} + \varepsilon_{ijk}$$

where

μ = mean effect upon the dependent variable

α_i = effect of type of ownership

γ_j = effect of type of feeding system

$(\alpha\gamma)_{ij}$ = effect of interaction between type of ownership and type of feeding system

X_{ijk} = the covariate, size--the number of fed cattle marketed in 1966

β = regression coefficient of the covariate

ε_{ijk} = random error effect.

Additionally,

$i = 1, 2, 3$

where

1 = feedlot facilities entirely owned by the cattle feeder

2 = feedlot facilities entirely rented by the cattle feeder

3 = part of facilities owned and part rented;

and

$j = 1, 2, 3, 4$

where

1 = self unloading wagon system

2 = fully mechanized feeding system

3 = primarily self-feeder system

4 = gas-tight steel silo system;

and

$k = 1, \ldots n_{ij}$, n_{ij} corresponding to the number of observations in the ij^{th} cell of the cross-classification array.

Because n_{ij} varied among cells, the data were unbalanced. Thus the analysis of variance was calculated by least squares regression on the X matrix using the restriction

$$\alpha_3 = \gamma_4 = 0 \quad .$$

As a preliminary the additional reduction in sums of squares due to interaction was calculated by

$$R(\mu, \beta, \alpha_i, \gamma_j, (\alpha\beta)_{ij}) - R(\mu, \beta, \alpha_i, \gamma_j)$$

where R indicates the regression of the dependent variable upon those factors or independent variables contained within the associated parentheses. Then if the interaction was not significant, the reduction due to α_i and γ_j (fixed treatment effects) was found by

$$R(\mu, \beta, \alpha_i, \gamma_j) - R(\mu, \beta, \gamma_j) = R(\alpha_i)$$

and

$$R(\mu, \beta, \alpha_i, \gamma_j) - R(\mu, \beta, \alpha_i) = R(\gamma_j) \quad .$$

If the interaction was found significant, the simple effects of feeding system within ownership type were computed by

$$R(\beta,\alpha_1,\gamma_j) - R(\beta,\alpha_1) = R(\gamma_j)_{\alpha_1}$$

$$R(\beta,\alpha_2,\gamma_j) - R(\beta,\alpha_2) = R(\gamma_j)_{\alpha_2}$$

$$R(\beta,\alpha_3,\gamma_j) - R(\beta,\alpha_3) = R(\gamma_j)_{\alpha_3}$$

where

$R(\gamma_j)_{\alpha_1}$ = sum of squares reduction due to type of feeding system within owned facilities

$R(\gamma_j)_{\alpha_2}$ = reduction due to feeding system within wholly rented facilities

$R(\gamma_j)_{\alpha_3}$ = reduction due to feeding system within ownership type having partially owned and partially rented facilities.

Additionally, an orthogonal constrast was made within the first ownership class between the mean effects of the gas-tight silo system and the average mean effects of the other three types of feeding systems; however, the comparison was not adjusted for the effect of the covariate. Again the method employed was that of least-squares regression upon the X-matrix.

V. ANALYSIS AND RESULTS

A. Preliminary Test

As indicated in the previous section, the sampling units formed an unbalanced cross-classification array of the categories of the factors of type of feeding system and type of ownership. The 42 units were distributed among the various cells of the array as shown in Table 3. Unfortunately, because of the small sample size, the number of units (n_{ij}) for many cells is small; furthermore, five cells contain only one sampling unit and one cell is empty.

The results of the preliminary test for the effects of interaction[1] between type of ownership and type of feeding system are presented

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[1]In the remainder of this thesis, the terms "significant", "simple effects", "main effects", and "interaction effects" are used only in the statistical sense. Thus the term "significant" is used to indicate the results of an analysis of variance and covariance, namely, that the F-value calculated from the mean squares obtained by regression is greater than the F-value for the corresponding degrees of freedom taken from the table of points for the distribution of F. A comparison of these F-values then provides a test for the effect of a specific independent variable upon a dependent variable, in light of the hypotheses outlined on pp. 31-32. Significance, then, indicates that the effect is of such magnitude as to affect the dependent variable. The level of significance is indicated as 100 α (in percent) where α is the probability of rejecting our original hypothesis if it is true or correct. The term "main effects" is used to indicate the amount of change in the dependent variable in response to a change in the level of an independent variable (in this case, for example, as type of feeding system changed from fully mechanized to self feeder) averaged over all levels of the other factor (corresponding to the above example, the "other factor" would be ownership). Main effects can be approximated for this study by comparing means of means in the tables of means. The term "simple effects" is used to indicate the amount of change in the dependent variable in response to a change in the level of an independent variable within only one level of the other factor. An "interaction effect" is an additional response due to the combined influence of the two factors, namely, type of ownership and type of feeding system.

Table 3. Distribution of sampling units among the cells (n_{ij}) of the classification array

		Feeding system				
		Self unloading wagon	Fully mechanized	Self feeder	Gas-tight Silo	Ownership Totals
Ownership	Entirely Owned	18	6	1	5	30
	Entirely Rented	3	1	2	1	7
	Partially Owned	3	1	1	0	5
	Feeding system totals	24	8	4	6	42

in Table 4. Interaction was significant[1] for only two of the dependent variables of the study - for building investment per head and for labor costs per head. The calculated F-values for these variables were 3.95 and 5.60 respectively, whereas $F_{(.99)(5,29)} = 3.73$ for building investment per head and $F_{(.99)(5,28)} = 3.76$ for labor costs per head. The succeeding analysis of these two variables was thus an evaluation of the simple effects[1] of type of feeding system within type of ownership while the other dependent variables were analyzed for the main effects[1] of ownership type and of type of feeding system.

[1] Ibid.

Table 4. F-values calculated for effect of interaction between ownership and type of feeding system during preliminary analyses of variance

Dependent variable	F-value[a]
Building investment per head	3.95**
Machinery and equipment investment per head	0.20
Total investment per head (excluding land)	2.25
Total investment per head (including land)	2.10
Total fixed and investment costs per head	1.06
Labor costs per head	5.60**
Labor plus fixed and investment costs per head	1.71
Veterinary and medical per head	0.32
Total non-feed costs per head	1.89
Feed costs per pound gain	0.97
Non-feed costs per pound gain	0.57
Total costs per pound gain	1.77
Net profits per pound gain	0.61
Turnover ratio	1.17

[a]In this and all successive tables displaying F-values.

*Indicates significance at $\alpha = 0.05$.

**Indicates significance at $\alpha = 0.01$, namely, that the calculated F-values so displayed exceeds the F-value for the corresponding degrees of freedom from a table of points for the distribution of F while α is the probability of rejecting the original hypothesis (pp. 31-32) if they are true.

B. Investment[1]

Four aspects of investment, namely, building investment per head, machinery and equipment investment per head, total investment per head (including land), and total investment per head (excluding land) were further analyzed as indicated previously.

1. Building investment per head

A table of means for each cross-classification of building investment per head is presented in Table 5, and the corresponding analysis of variance is presented in Table 6.

As would be expected, the ownership effects were found to be significantly different for building investment per head ($\alpha = 0.01$). Since the ownership-feeding system interaction was found significant in the preliminary test, only the simple effects of feeding system within ownership type are here examined.

Table 6 shows that only for wholly owned facilities are the simple effects of feeding system significant ($\alpha = 0.01$). As can be seen from Table 5, building investment per head is considerably higher for the gas-tight silo system as compared to the other three types of feeding systems when facilities in the first ownership category are considered. The simple effects of feeding system within the second ownership category are not significant; no differences would be expected when facilities are entirely rented. The empty cell for the partially-owned facilities - gas-tight silo system classification prevents a true test within the third ownership category, particularly if a pattern similar to that of the first category would be expected.

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[1]Investment in this study is based upon actual 1966 values, that is, on 1966 book value, as indicated in Section IV, B. The Survey.

Table 5. Table of means for building investment per head[a]

		Feeding system				Ownership	
		Self-Unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means[b]
Ownership	Entirely Owned	\$14.26 (17)	\$19.47 (6)	\$26.28 (1)	\$66.66 (5)	\$24.78 (29)	\$31.67
	Entirely Rented	9.03 (3)	6.30 (1)	1.90 (2)	0 (1)	5.31 (7)	4.31
	Partially Owned	4.86 (3)	14.99 (1)	3.61 (1)	-	6.64 (5)	12.89
Feeding system	Mean	12.35 (23)	17.26 (8)	8.42 (4)	55.56 (6)	19.25 (41)	
	Mean of Means[b]	9.38	13.59	10.60	31.59		

[a]The numbers in parentheses indicate the number of sample units which have formed the tabulated means immediately above these respective numbers in parentheses. In other words, they are the n_{ij}.

[b]Because of the disproportionate n_{ij} of the array, the analysis is not orthogonal. Thus in the following analysis of variance tables the sum of squares for ownership adjusted represents the additional sum of squares due to fitting ownership effects after fitting all other effects. The problem is to obtain a mean which reflects the true ownership effects given the unbalanced nature of the sample. For example,

$$E(y_{.1}) = 23\mu + 17\alpha_1 + 3\alpha_2 + 3\alpha_3 + 23\gamma_1$$

where

$E(y_{.1})$ = expected value of the sum of observations for the first type of feeding system -- the self-unloading wagon method, and the other items are as defined in IV, C. Statistical Model.

But

$$17\alpha_1 + 3\alpha_2 + 3\alpha_3 \neq 0$$

(Footnote continued on next page)

Table 6. Analysis of variance of building investment per head

Source of variation	Degrees of freedom	Mean[a] Square	F-value
Ownership	2	1219.7466	8.10**
Feeding system within owned	3	3628.8536	24.11**
Feeding system within rented	3	18.2123	0.12
Feeding system within partially owned	2	77.6201	0.52
Covariate-size	1	993.6050	6.60*
Error	29	150.5364	
Total	40		

[a]Because the analysis is not orthogonal, the sums of squares for main effects, interactions, and covariate, upon which these mean squares are based, are adjusted in this and all successive analysis of variance tables. That is to say that the sum of squares represents the additional sum of squares due to fitting the item after fitting the other main effects and interaction effects.

**Indicates significance at $\alpha = 0.01$.

*Indicates significance at $\alpha = 0.05$.

Footnote continued from previous page

whereas in the balanced case the situation would be such that

$$n\alpha_1 + n\alpha_2 + n\alpha_3 = 0.$$

However, the mean of means does include

$$\alpha_1 + \alpha_2 + \alpha_3 = 0.$$

The mean of means is thus included as a marginal in this and the following tables of means.

A problem also arises with the empty cell, because the mean of means including this cell contains only α_1 and α_2. An estimate of $\mu + \alpha_3 + \beta_4$ - an estimate of the value for the empty cell - was obtained by the missing plot formula for a two-way table in order to calculate the mean of means which includes the empty cell.

This has been discussed in terms of ownership effect; however, the principle applied for feeding system effects as well. Furthermore, this method is not pretended to be an exact procedure; however, it should yield marginal means which reflect the significance levels achieved the treatment effects in the analysis of variance tables.

The effect of size was also found significant ($\alpha = 0.05$); building investment per head tended to decrease with increasing size as indicated by the $\hat{\beta}$ value of -0.01555 (Table 34), since the sign of $\hat{\beta}$ indicates the direction of the relationship where $\hat{\beta}$ is the overall regression coefficient obtained when the dependent variable, in this case, building investment per head, was regressed upon size as a covariate.

2. Machinery and equipment investment per head[1]

The means for machinery and equipment investment per head for the various ownership-feeding system combinations are presented in Table 7. The variation among the marginal means ranges from \$6.75 to \$11.67 for types of feeding system and from \$9.30 to \$10.74 for ownership types, while the same respective means of means range only from \$6.88 to \$10.81 and from \$8.08 to \$10.04. As hypothesized none of the main effects are significant for either type of ownership or type of feeding system as is shown by the analysis of variance in Table 8. Thus machinery and equipment investment per head would not be expected to vary greatly among types of feeding systems or type of ownership.

3. Total investment per head (excluding land)

There is considerable variation among the means for total investment per head as is illustrated in Table 9 where means for the classification groups range from \$8.26 to \$78.40. The main effects are significant for both types of feeding system ($\alpha = 0.01$) and type of ownership ($\alpha = 0.05$); thus type of ownership and type of feeding system do affect total investment per head (excluding land). That type of ownership would affect total

[1]Machinery and equipment investment does not include the investment in manure disposal equipment; however, it does include all other investments in machinery and equipment for the cattle feeding operation.

Table 7. Table of means for machinery and equipment investment per head

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	$11.15 (17)	$9.17 (6)	$8.08 (1)	$11.74 (5)	$10.74 (29)	$10.04
	Entirely Rented	9.17 (3)	13.55 (1)	6.36 (2)	11.34 (1)	9.30 (7)	10.10
	Partially Owned	12.11 (3)	4.50 (1)	6.21 (1)	--	9.41 (5)	8.08
Feeding system	Mean	11.02 (23)	9.14 (8)	6.75 (4)	11.67 (6)	10.33 (41)	
	Mean of Means	10.81	9.07	6.88	10.86		

Table 8. Analysis of variance of machinery and equipment investment per head

Source of variation	Degrees of freedom	Mean square[a]	F-value
Ownership	2	13.139	0.21
Feeding system	3	39.662	0.65
Covariate-size	1	157.325	2.26
Error	35	61.386	
Total	41		

[a]As indicated previously, the sums of squares for main effects, interaction and the covariate are adjusted. However, the sums of squares for the orthogonal breakdown of feeding system within ownership one - facilities entirely owned - is not adjusted. It is an orthogonal breakdown within ownership type one and thus does not involve the cross-classification of other ownership types. This applies for the sums of squares for all orthogonal comparisons in successive tables as well.

Table 9. Table of means for total investment per head (excluding land)

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	\$25.41 (17)	\$28.64 (6)	\$34.36 (1)	\$78.40 (5)	\$35.52 (29)	\$41.70
	Entirely Rented	18.21 (3)	19.85 (1)	8.26 (2)	11.34 (1)	13.84 (7)	19.96
	Partially Owned	16.97 (3)	19.48 (1)	9.82 (1)	--	16.04 (5)	21.52
Feeding system	Mean	23.13 (23)	26.40 (8)	15.18 (4)	67.22 (6)	29.44 (41)	
	Mean of Means	20.20	22.66	17.48	43.18		

investment would be expected since investment as considered in this study implies ownership. The orthogonal[1] breakdown of feeding system effects within the wholly owned feedlot category shows that total investment per head for gas-tight silo systems was significantly greater than the average total investment per head of the other three feeding systems studies, as can be seen by observing Tables 9 and 10. Finally, the $\hat{\beta}$ value of -0.02234 was significant at $\alpha = 0.05$ (Table 34) indicating that total investment per head tended to decrease as size increased.

[1]In this thesis orthogonal is used in the statistical sense to indicate independence of the tests for the various effects and of comparisons of factor effects. Thus orthogonality implies that the results of any two tests or comparisons are uncorrelated. An orthogonal breakdown or contrast, then, is a splitting up of the sums of squares due to the factor effects to assess significant differences among levels of the factor -- but the process is independent of any other tests and contrasts.

Table 10. Analysis of variance for total investment per head (excluding land)

Source of variation	Degrees of freedom	Mean Square	F-value
Ownership	2	1592.4359	4.91*
Feeding system	3	3363.9356	10.37**
Gas-tight silo vs. others	1	11211.2738	34.56**
Covariate-size	1	1844.1640	6.73*
Error	34	324.3478	
Total	40		

4. Total investment per head (including land)

Since only the land having an opportunity cost -- that land having an alternative economic use in the total farm operation -- is considered in this study, the results of an analysis including such land in total investment per head are not greatly different from those of the preceding discussion. This follows because most of the land currently used for cattle feeding has few alternative uses -- it has either a steep slope or is often situated between older farm buildings which prevent cropping of the land. In the study the amount of land whose value added to investment was generally only several acres. The same effects are found to be significant as found for total investment per head (excluding land) while the mean total investment per head for owned facilities has increased by $5.40.

Table 11. Table of means for total investment per head (including land)[a]

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	$30.79 (17)	$33.72 (6)	$45.38 (1)	$83.12 (5)	$40.92 (29)	$48.25
	Entirely Rented	18.31 (3)	19.85 (1)	8.26 (2)	11.34 (1)	13.84 (7)	19.96
	Partially Owned	16.97 (3)	19.48 (1)	11.33 (1)	--	16.34 (5)	21.22
Feeding system	Mean	27.11 (23)	30.21 (8)	18.31 (4)	71.58 (6)	33.30 (41)	
	Mean of Means	22.02	24.35	21.66	43.86		

[a]Includes investment per head for buildings, machinery and equipment, and for land having an opportunity cost. Some feedlots are located on land that has no alternative use at present; thus the land for these feeding facilities is not included here.

Table 12. Analysis of variance for total investment per head (including investment in land)

Source of variation	Degrees of Freedom	Mean Square	F-value
Ownership	2	2353.3162	6.44 **
Feeding system	3	3241.3670	8.87 **
Gas-tight silo vs. others	1	10881.7953	29.78 **
Covariate-size	1	2039.0180	6.48 *
Error	34	365.3498	
Total	40		

C. Costs

Both fixed and variable costs are considered. Some of the variable costs were adaptable to analysis on a per-head basis, while others only to analyses on a per-pound basis. This is due to the fact that some of the individuals interviewed kept their records using an inventory method and not a per-lot or on a drove basis. Thus some costs, for example, feed costs, can be analyzed only on a per-pound-gain basis.

1. Total fixed and investment costs per head

The means for the total fixed and investment costs of the various classification groups are presented in Table 13.

The analysis of variance (Table 14) shows that type of ownership does not have a significant effect upon total fixed and investment costs per head whereas the effect of type of feeding system is quite significant. Thus such costs will vary with type of feeding system, but not with type of ownership. The marginal means of means (Table 13) indicate that the significant difference lies between the costs of the gas-tight silo system and costs of the other three feeding systems. This is, in fact, borne out by the orthogonal contrast within wholly owned facilities where the cost of \$11.12 per head differs significantly from the average of \$5.44, \$6.34, and \$5.00 for the feeder wagon, fully mechanized, and self feeder systems respectively. Also the $\hat{\beta}$ value of -0.004607 was found to be significant, indicating some decrease in the per head costs with an increase in size.

2. Labor costs per head

As was indicated in Table 4, the effect of ownership-feeding system interaction was found to be significant for labor costs per head. Further

Table 13. Table of means for total fixed and investment costs per head[a]

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	$5.44 (16)	$6.34 (6)	$5.00 (1)	$11.12 (5)	$6.63 (28)	$6.98
	Entirely Rented	4.38 (3)	4.42 (1)	2.36 (2)	17.37 (1)	5.66 (7)	7.13
	Partially Owned	3.12 (3)	3.04 (1)	2.20 (1)	--	2.92 (5)	5.18
Feeding system	Mean	4.98 (22)	5.69 (8)	2.98 (4)	12.16 (6)	5.60 (40)	
	Mean of Means	4.31	4.60	3.19	13.61		

[a]Includes taxes on total investment (including land), depreciation, insurance, annual interest charge of 5.5% or real estate and 6.5% on machinery and equipment, and the rental cost for non-owned feedlot facilities.

Table 14. Analysis of variance for total fixed and investment costs per head

Source of variation	Degrees of Freedom	Mean Square	F-value
Ownership	2	16.9827	2.16
Feeding system	3	101.4163	12.89**
Gas-tight silo vs. others	1	125.2157	15.91**
Covariate-size	1	58.3798	7.49*
Error	33	7.8682	
Total	39		

analysis revealed that the simple effects of feeding system were significant only within the category of partially owned facilities. In this ownership classification there are two cells each having only one sample unit as well as the empty cell. Furthermore, the cattle feeder falling into cell 3,3 estimated the opportunity cost of his labor at $4.00 per hour, more than twice as much as the other estimates. This, then, accounts for the finding of significant interaction. A reasonable interpretation of the analysis is to accept the original hypothesis, namely, that there are no significant effects upon labor costs per head arising from ownership type, feeding system, or size, or their interaction.

3. Labor plus fixed and investment costs per head

When labor costs per head are combined with fixed and investment costs per head, the result obtained is similar to that for fixed and investment costs alone. The effects of feeding system differ significantly ($\alpha = 0.01$), and the costs of the gas-tight silo system are significantly different ($\alpha = 0.05$) from those of the other types of feeding system as shown by the orthogonal contrast. As with fixed and investment costs per head, type of feeding system is important here in its effect upon the combined costs. Higher labor plus fixed and investment costs would be expected with the gas-tight silo system. Again, the value of $\hat{\beta}$ (-0.007406) is also significant ($\alpha = 0.1$) indicating that the labor plus fixed and investment costs per head decrease as size increases.

4. Veterinary and medical costs per head

As shown in Table 19, the mean veterinary and medical costs per head are fairly uniform for the various classifications. No effects of

Table 15. Table of means for labor costs per head[a]

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	$4.16 (17)	$3.76 (6)	$3.57 (1)	$3.93 (5)	$4.02 (29)	$3.86
	Entirely Rented	3.48 (3)	6.88 (1)	4.71 (2)	3.76 (1)	4.36 (7)	4.71
	Partially Owned	2.35 (3)	12.48 (1)	17.59 (1)	--	7.42 (5)	10.66
Feeding system	Mean	3.84 (23)	5.24 (8)	7.64 (4)	3.90 (6)	4.49 (41)	
	Mean of Means	3.33	7.71	8.62	5.97		

[a]Based upon the cattle feeder's estimate of the opportunity cost of his labor.

Table 16. Analysis of variance for labor costs per head

Source of variation	Degrees of Freedom	Mean Square	F-value
Ownership	2	20.0500	3.72*
Feeding system within owned	3	1.5041	0.28
Feeding system within rental	3	5.5704	1.03
Feeding system within partially owned	2	120.0278	22.27**
Covariate-size	1	21.6369	4.02
Error	28	5.3888	
Total	39		

Table 17. Table of means for labor plus fixed and investment costs per head

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	$9.44 (16)	$10.10 (6)	$8.57 (1)	$15.06 (5)	$10.55 (28)	$10.79
	Entirely Rented	7.87 (3)	11.30 (1)	7.06 (2)	21.13 (1)	10.22 (7)	11.84
	Partially Owned	5.46 (3)	15.52 (1)	19.79 (1)	--	10.34 (5)	15.84
Feeding system	Mean	8.68 (22)	10.93 (8)	10.62 (4)	16.07 (6)	10.43 (40)	
	Mean of Means	7.59	12.31	11.81	19.60		

Table 18. Analysis of variance for labor plus fixed and investment costs per head

Source of variation	Degrees of Freedom	Mean Square	F-value
Ownership	2	14.7545	0.70
Feeding system	3	128.1924	6.11**
Gas-tight silo vs. others	1	124.1836	5.92*
Covariate-size	1	150.8729	7.97**
Error	33	20.9753	
Total	39		

ownership, feeding system, or size were found to be significant (Table 20); thus veterinary and medical costs are independent of type of ownership, type of feeding system, and feedlot size.

5. Total nonfeed costs per head

Mean total nonfeed costs per head are presented in Table 21 for the various classifications. Only the effects of type of feeding system are found to be significant ($\alpha = 0.05$). Thus nonfeed costs per head are related to type of feeding system, but not feedlot size or type of ownership. The marginal means of means indicate that the gas-tight silo system has a significantly higher cost, but the breakdown within ownership group one did not verify this for wholly-owned facilities alone. Thus the one observation for rented gas-tight silo systems contributed to the significant difference between total nonfeed costs per head for the types of feeding systems more than did the wholly owned gas-tight silo systems.

6. Total nonfeed costs per pound gain

The analysis of total nonfeed costs per pound gain gives results similar to those of the preceding section. However, in this case, not only are the over-all effects of feeding system upon costs significant but the orthogonal contrast within the first ownership category is significant as well. This indicates, then, that not only are total nonfeed costs related to type of feeding system, but that the gas-tight silo system does have significantly higher costs when analyzed on a per-pound-gain basis, while type of ownership and size do have a marked effect upon these costs.

One reason for the difference in significance for the orthogonal

Table 19. Table of means for veterinary and medical costs per head (dollars)

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	$1.08 (16)	$1.10 (6)	$1.59 (1)	$0.84 (5)	$1.06 (28)	$1.15
	Entirely Rented	0.66 (3)	0.63 (1)	1.02 (2)	1.00 (1)	0.80 (7)	0.83
	Partially Owned	1.55 (3)	1.14 (1)	1.20 (1)	--	1.40 (5)	1.27
Feeding system	Mean	1.08 (22)	1.05 (8)	1.20 (4)	0.87 (6)	1.06 (40)	
	Mean of Means	1.10	0.96	1.27	1.01		

Table 20. Analysis of variance for veterinary and medical per head

Source of variation	Degrees of Freedom	Mean Square	F-value
Ownership	2	0.5457	1.51
Feeding system	3	0.0838	0.23
Covariate-size	1	0.0822	0.20
Error	33	0.3618	
Total	39		

Table 21. Table of means for total non-feed costs per head[a]

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	$25.60 (16)	$26.48 (6)	$27.32 (1)	$32.60 (5)	$27.10 (28)	$28.00
	Entirely Rented	21.78 (3)	20.93 (1)	23.21 (2)	48.91 (1)	25.94 (7)	28.71
	Partially Owned	20.25 (3)	30.91 (1)	42.00 (1)	--	26.73 (5)	35.18
Feeding system	Mean	24.35 (22)	26.34 (8)	28.91 (4)	35.32 (6)	26.85 (40)	
	Mean of Means	22.54	26.11	30.84	43.02		

[a]Total nonfeed costs include costs of labor, fuel and utilities, repairs and maintenance, veterinary and medical, depreciation, taxes, insurance, rent, and miscellaneous items as well as an interest charge on real estate, machinery and equipment, and on operating capital. (Interest on operating capital was calculated on 6.5% per year times one-half the operating capital for the period of use.)

Table 22. Analysis of variance for total non-feed costs per head

Source of variation	Degrees of Freedom	Mean Square	F-value
Ownership	2	34.8261	0.59
Feeding system	3	256.0445	4.37*
Gas-tight vs. others	1	185.7566	3.17
Covariate-size	1	108.3608	2.10
Error	33	58.5957	
Total	39		

breakdowns in this and the preceding section is that there is not necessarily a one-to-one correspondence between weight gained and number of head marketed for the various classifications. This relationship varies with the type of cattle fed and the length of the feeding period. The difference is apparent if one compares, for example, a lot of steer calves fed 300 days from an initial weight of 450 pounds to a market weight of 1100 pounds with a lot of two-year-old steers fed 120 days from 825 to 1100 pounds. The cattle feeder finishing two-year olds would have to feed 2.36 times more cattle than the feeder of calves to produce the same amount of beef in terms of pounds. Thus if different types of cattle were fed in the various classifications, the relative values for the non-feed costs would differ considerably when the two different denominators -- per-head basis and per-pound-gain basis -- are used to evaluate costs and investments. In effect, the use of pounds of gain as the denominator provides the more meaningful analysis since the cattle feeder is producing pounds of beef and not just numbers. The use of costs and profits per pound of gain enables an economic comparison among or between systems feeding different types of cattle for different lengths of time.

7. Feed costs per pound gain

As shown in Table 25, the marginal means for feed costs do not vary greatly among types of feeding system or types of ownership. Analysis of variance (Table 26) revealed no significant effects upon feed costs by ownership class, type of feeding system, or size. Thus there are no characteristic differences in feed costs per pound gain among types of feeding systems nor ownership classes, nor for size variations.

Table 23. Table of means for total non-feed costs per pound of gain (cents)[a]

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	4.21¢ (15)	4.73¢ (5)	4.36¢ (1)	6.23¢ (5)	4.71¢ (26)	4.88¢
	Entirely Rented	4.61 (3)	2.94 (1)	4.05 (2)	8.60 (1)	4.78 (7)	5.05
	Partially Owned	4.28 (3)	4.22 (1)	5.70 (1)	--	4.55 (5)	5.54
Feeding system	Mean	4.28 (21)	4.40 (7)	4.54 (4)	6.63 (6)	4.70 (38)	
	Mean of Means	4.37	3.96	4.70	7.60		

[a]Total nonfeed costs here include the same items as do the total costs of Table 21.

Table 24. Analysis of variance for total non-feed costs per pound of gain

Source of variation	Degrees of Freedom	Mean Square	F-value
Ownership	2	0.1401	0.05
Feeding system	3	11.0132	4.07*
Gas-tight vs. others	1	14.4080	5.32*
Covariate-size	1	5.8970	2.03
Error	31	2.7081	
Total	37		

Table 25. Table of means for feed costs per pound gain (cents)[a]

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	18.00¢ (16)	18.27¢ (5)	19.64¢ (1)	20.77¢ (5)	16.62¢ (27)	19.17¢
	Entirely Rented	19.38 (3)	15.06 (1)	16.95 (2)	25.40 (1)	18.93 (7)	19.20
	Partially Owned	16.39 (3)	12.78 (1)	18.30 (1)	--	16.05 (5)	17.13
Feeding system	Mean	17.97 (22)	17.03 (7)	17.96 (4)	21.54 (6)	18.83 (38)	
	Mean of Means	17.92	15.37	18.30	22.41		

[a]Feed costs include the cost of purchased feed and the opportunity cost of feeding home raised feed. A large percentage of those interviewed fed a high-roughage ration; thus concrete, pit, or bunker silos were usually involved in the self-unloading wagon and fully mechanized feeding systems. Also, the estimates of feed fed, particularly silage, are generally on the basis of amount harvested so that feed costs do, in fact, include the cost of spoilage for silage as well as actual silage fed. Finally, a charge was placed on pastured stalk ground only when there were actual rental costs. Yet the feeders interviewed, almost without exception, did pasture corn stalks with feeder cattle.

Table 26. Analysis of variance for feed costs per pound of gain

Source of variation	Degrees of Freedom	Mean Square	F-value
Ownership	2	8.3055	0.80
Feeding system	3	24.0199	2.31
Covariate-size	1	3.3093	0.32
Error	31	10.3826	
Total	37		

8. Total costs per pound gain

No significant differences were found for the effects of ownership type upon total costs per pound gain. Thus the fact that facilities are either owned, rented, or only owned in part does not affect total costs per pound gain. However, the effects of type of feeding system were significant. Examination of marginal means leads to a conclusion that the gas-tight silo system has total costs per pound gain which are higher than those of the other three systems. Within the first ownership class the orthogonal breakdown shows the same effect: the gas-tight silo system has a mean for total costs per pound gain of 27.0¢ which differs significantly from the average of the other three types of systems which had costs of 21.80, 23.0, and 24.0 cents per pound gain.

D. Net Profit per Pound Gain

The analysis of variance shows no significant effects of any factors upon net profit per pound gain. Thus neither type of feeding system, type of ownership, nor size exert an important influence upon net profits. The table of means reveals that the mean net profit for the various classifications ranges from -9.0¢ to +7.0¢ per pound gain while the mean for the total sample is 0.8¢ per pound gain.

E. Turnover Ratio

The table of means (Table 31) indicates that the cattle feeders in the sample had an average turnover ratio of approximately one. No significant differences were found for turnover ratio among types of feeding system; however, the effects of ownership type were significant. Thus

Table 27. Table of means for total costs per pound gain (cents)[a]

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely owned	21.80¢ (15)	23.00¢ (5)	24.00¢ (1)	27.00¢ (5)	23.12¢ (26)	23.95¢
	Entirely Rented	24.00 (3)	18.00 (1)	21.00 (2)	34.00 (1)	23.71 (7)	24.25
	Partially Owned	20.67 (3)	17.00 (1)	24.00 (1)	--	20.60 (5)	22.70
Feeding system	Mean	21.95 (21)	21.42 (7)	22.50 (4)	28.17 (6)	22.89 (38)	
	Mean of Means	22.16	19.33	23.00	30.37		

[a]Total costs as tabulated here include the total nonfeed costs defined in the footnote of Table 21 as well as the feed costs discussed in the footnote of Table 25.

Table 28. Analysis of variance for total costs per pound of gain

Source of variation	Degrees of Freedom	Mean Square	F-value
Ownership	2	7.4249	0.60
Feeding system	3	66.9726	5.43**
Gas-tight vs. others	1	94.7095	7.68**
Covariate-size	1	18.0415	1.64
Error	31	12.3295	
Total	37		

Table 29. Table of means for net profit per pound gain (cents)[a]

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	0.6¢ (15)	-0.8¢ (5)	-2.0¢ (1)	-3.0¢ (5)	-0.4¢ (26)	-1.3¢
	Entirely Rented	7.0 (3)	-5.0 (1)	2.0 (2)	-9.0 (1)	3.0 (7)	-1.25
	Partially Owned	5.0 (3)	+6.0 (1)	-2.0 (1)	--	4.0 (5)	-1.3
Feeding system	Mean	2.2 (21)	1.0 (7)	0 (4)	-4.0 (6)	0.8 (38)	
	Mean of Means	4.2	.07	0.7	-5.3		

[a]Net profit as tabulated here represents pure economic profits minus a return to management. That is to say that all opportunity costs have been accounted for except that of management. Net profit has been derived by subtracting from sale value the purchase costs as well as production and marketing costs, and by then adding to the remainder the net value of manure produced and the value of benefit derived by hogs following cattle. Net value of manure was determined by subtracting the costs of disposal from the total value of manure obtained.

Table 30. Analysis of variance for net profit per pound gain

Source of variation	Degrees of Freedom	Mean Square	F-value
Ownership	2	0.0085	2.74
Feeding system	3	0.0069	2.22
Covariate-size	1	0.0041	1.24
Error	31	0.0031	
Total	37		

turnover ratio is not characteristically different among the types of feeding system whereas it is for the different types of ownership. The marginal means show that the cattle feeders operating with entirely rented facilities have a higher turnover ratio than the feeders of the other ownership groups. The $\hat{\beta}$ value (0.0006757) for size as a covariate was also significant ($\alpha = 0.01$), indicating that turnover ratio increases along with feedlot size.

F. Effect of Size

The feedlots in the sample had sizes ranging from 118 to 1500 head, based upon the number of cattle marketed in 1966. Table 33 gives the mean sizes for the cells in the cross-classification array. As can be seen, the overall mean for size was 519.8 head. Feedlots involving only wholly-owned facilities had a larger mean size than did the other two ownership classifications. Likewise, the gas-tight silo systems had the larger mean size when compared to the means of the other types of feeding systems.

When the effect of size was determined by regression of the dependent variable upon size as a covariate, only the items listed in Table 34 had $\hat{\beta}$ values - the overall regression coefficients - which were significant. the sign of β indicates the direction of the relationship between the covariate and the dependent variable. Thus building investment, total investment, total fixed and investment costs, and labor plus the total fixed and investment costs -- all on a per-head basis -- were found to decrease as size of the feedlot increased. Turnover ratio, on the other hand, increased slightly as size increased.

These relationships for various cross classifications are depicted

Table 31. Table of means for turnover ratio[a]

		Feeding system				Ownership	
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Mean	Mean of Means
Ownership	Entirely Owned	0.95 (18)	0.90 (6)	0.76 (1)	1.03 (5)	0.95 (30)	0.91
	Entirely Rented	1.62 (3)	0.99 (1)	0.86 (2)	0.58 (1)	1.16 (7)	1.01
	Partially Owned	1.11 (3)	0.77 (1)	0.85 (1)	--	0.99 (5)	.86
Feeding system	Mean	1.06 (24)	0.90 (8)	0.83 (4)	0.96 (6)	0.99 (42)	
	Mean of Means	1.23	0.87	0.82	0.77		

[a]Turnover ratio is defined here as the number of cattle marketed during 1966 divided by the 1966 feedlot capacity.

Table 32. Analysis of variance for turnover ratio

Source of variation	Degrees of Freedom	Mean Square	F-value
Ownership	2	.5514	4.33*
Feeding system	3	.1609	1.26
Covariate-size	1	1.7277	13.57**
Error	35	.1273	
Total	41		

Table 33. Table of means for size (based upon number of head marketed in 1966)

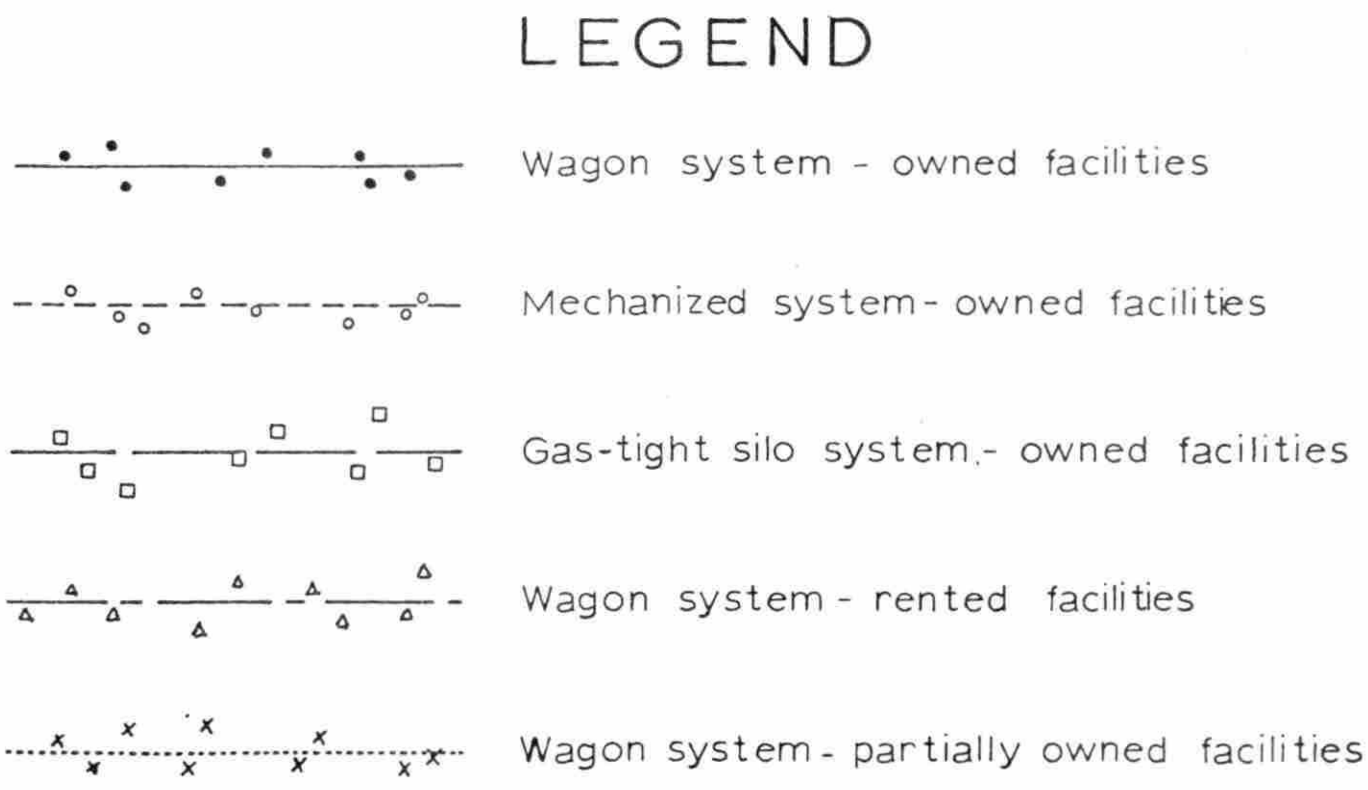
		Feeding system				
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Ownership means
Ownership	Entirely Owned	573.8 (18)	417.3 (6)	908.0 (1)	827.0 (5)	595.9 (30)
	Entirely Rented	411.0 (3)	238.0 (1)	170.0 (2)	351.0 (1)	308.8 (7)
	Partially Owned	439.3 (3)	307.0 (1)	166.0 (1)	--	358.2 (5)
	Feeding System Means	536.7 (24)	381.1 (8)	353.5 (4)	747.7 (6)	519.8 (42)

Table 34. Significant values of $\hat{\beta}$ obtained by regression of the dependent variable upon size as a covariate

Dependent variable	$\hat{\beta}$
Building investment per head	-0.01555*
Total investment per head (excluding land)	-0.02234*
Total investment per head (including land)	-0.02348*
Total fixed and investment costs per head	-0.004607*
Labor plus total fixed and investment costs per head	-0.007406 **
Turnover ratio	0.0006757**

graphically for total investment per head (land excluded), total fixed and investment costs per head, and for turnover ratio in Figures 11-13 respectively. Although quite undramatic to be sure, these graphs do afford a

Figure 11. Total investment per head (excluding land) for various types and sizes of Iowa farm feedlots, 1966.



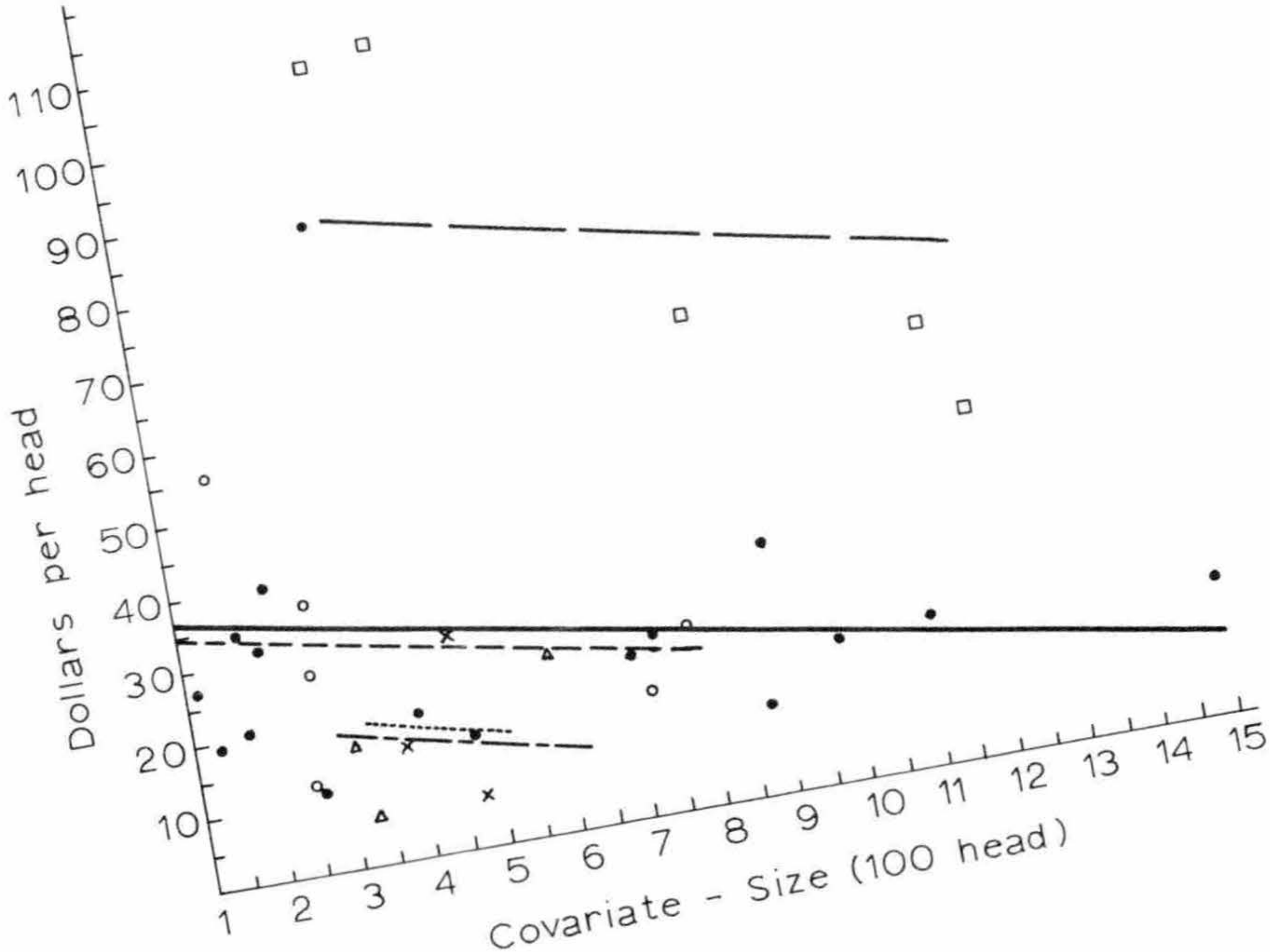
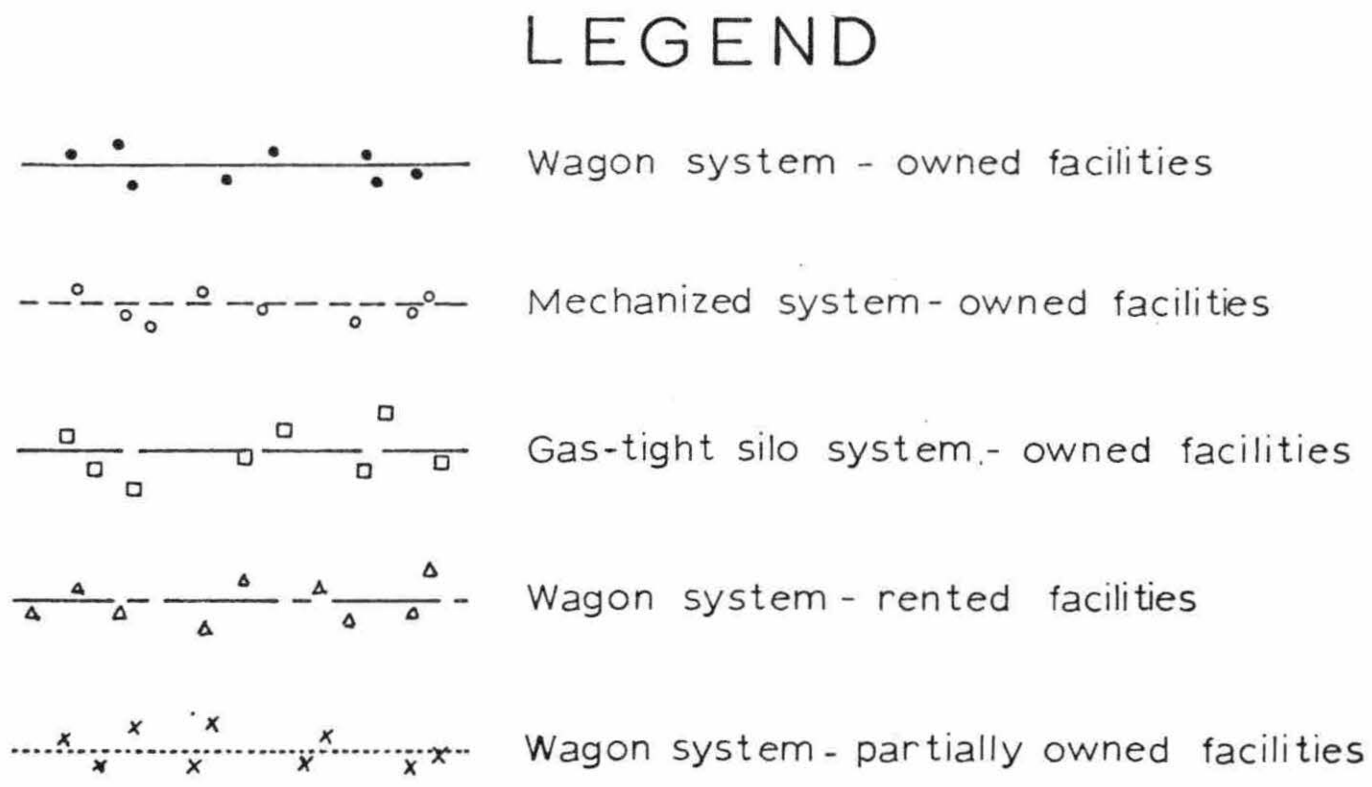

Dollars per head
110
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Covariate - Size (100 head)

Figure 12. Total fixed and investment costs per head for various types and sizes of Iowa farm feedlots, 1966



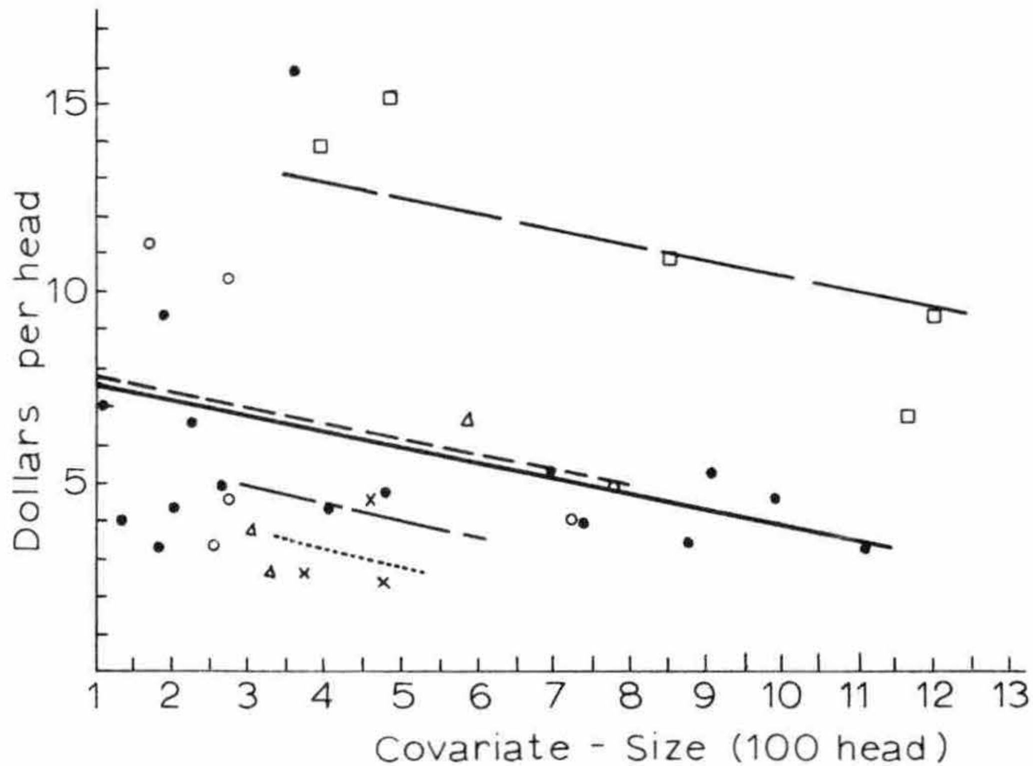
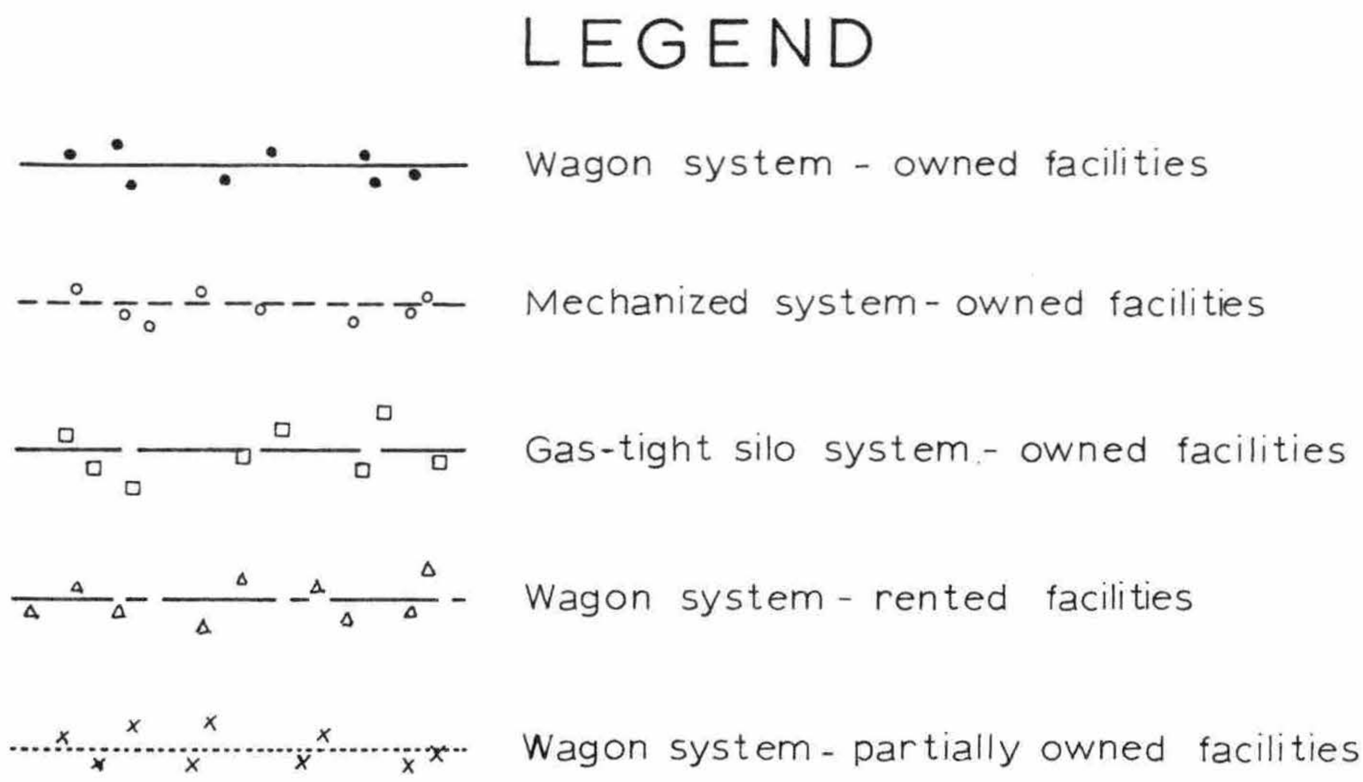
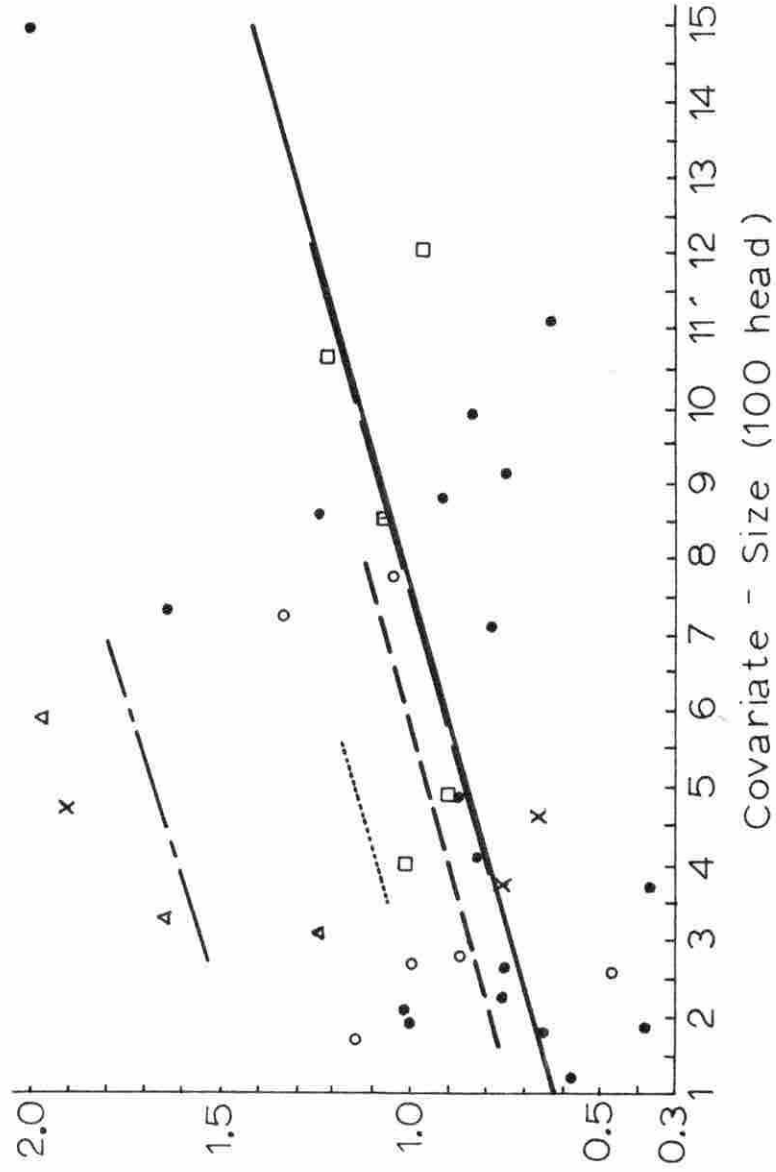

Dollars per head
15
10
5
1
2
3
4
5
6
7
8
9
10
11
12
13
Covariate - Size (100 head)

Figure 13. Turnover ratio for various types and sizes of Iowa farm feedlots, 1966




Turnover ratio
2.0
1.5
1.0
0.5
0.3
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Covariate - Size (100 head)

realistic presentation of the covariate effect. The $\hat{\beta}$ determines the slope of the curve, while the means determine the intercept. (Equations for these curves are given in Appendix B.) Although the covariate was found significant in the analysis of variance, the degree or closeness of fit of the plotted data with regression line is small as is here shown; the points are indeed widely scattered. Thus effect of size upon the variables studied is small within the range of farm feedlot sizes surveyed.

Figures 11-13, however, point out some characteristics mentioned earlier. The curve for the gas-tight silo systems is considerably higher than the other curves, reflecting the greater investment per head found in the discussion of the table of means and the analysis of variance. Also, the total per-head investment curves for the wholly-owned self-unloading wagon systems and the wholly-owned fully mechanized systems lie near to each other, reflecting the similarity of per head investment for these two classifications. This very same relationship is likewise indicated for self-unloading wagon systems utilizing entirely rented facilities and for self-unloading wagon systems utilizing partially owned facilities.

In Figure 12 the total fixed and investment cost curve for the gas-tight silo systems employing wholly owned facilities again lies considerably higher than the other curves. In this case it reflects higher the total fixed and investment costs per head of this system which were found to be significant in the discussion relating to the table of means and analysis of variance. The relationships among the other four curves are the same as for the total per-head investment curves except that the curves for the self-unloading wagon system using entirely owned facilities does not lie so near to the curve for the self-unloading wagon system involving partially rented facilities as was the case for the curves depicting total per head investment. But this merely reflects the greater difference between the means for these classifications as shown in the table of means.

In Figure 13, the same relationship between the table of means and the curves for turnover ratio is particularly clear for the self-unloading wagon system using entirely rented facilities. This classification has by far the largest mean value (Table 31), and the turnover ratio curve lies much higher than do the other curves.

G. Descriptive and Miscellaneous Findings

In Table 35 the means of investment and cost variables along with the means for size and the remaining variables have been brought together as an overall summary and for greater ease of comparison. It can be seen for example, that the percentage variation among ownership types is not as great for total fixed and investment costs per head as it is for building investment per head.

For the cattle feeders surveyed in this study, cattle sales constituted the major portion of their total farm sales. This indicates, on the average for these feeders, a tendency to specialize in the finishing of beef cattle. The mean value for total cattle sales as a percentage of total farm sales are notably higher for owned facilities involving self-feeder and gas-tight silo systems and for the partially owned facilities involving the self-unloading wagon system when compared to the same mean for the other classifications.

The cattle feeders surveyed also rented on the average about 40% of their farm land (Table 37). The mean value for all wholly owned

Table 35. Tabulated summary of means compiled from tables of means for far feedlot survey data[a]

Investment Per Head

Ownership	Feeding System	Building	Machinery and Equipment	Total (excluding land)	Total (including land)
Entirely owned	Self-unloading wagon	$14.26	$11.15	$25.41	$30.79
	Fully mechanized	19.47	9.17	28.64	33.72
	Self-feeder	26.28	8.08	34.36	45.38
	Gas-tight silo	66.66	11.74	78.40	83.12
Entirely rented	Self-unloading wagon	9.03	9.17	18.21	18.21
	Fully mechanized	6.30	13.55	19.85	19.85
	Self-feeder	1.90	6.36	8.26	8.26
	Gas-tight silo	0	11.34	11.34	11.34
Partially owned	Self-unloading wagon	4.86	12.11	16.97	16.97
	Fully mechanized	14.99	4.50	19.48	19.48
	Self-feeder	3.61	6.21	9.82	11.33
	Gas-tight silo	-----	-----	-----	-----
Overall mean		$19.25	$10.33	$29.44	$33.30

[a]The means here presented will not necessarily be additive across columns because of different n_{ij} for various dependent variables. For example, machinery and equipment investment plus building investment may not equal total investment for all classification groups. Nor will the mean of the tabulated means equal the over all mean because of the disproportionate n_{ij}.

Table 35. (Continued)

Costs Per Head

Ownership	Feeding System	Total Fixed and Investment	Labor	Labor Plus Fixed and Investment	Veterinary and Medical	Total Non-Feed
Entirely owned	Self-unloading wagon	$ 5.44	$ 4.16	$ 9.44	$ 1.08	$25.60
	Fully mechanized	6.34	3.76	10.10	1.10	26.48
	Self-feeder	5.00	3.57	8.57	1.59	27.32
	Gas-tight silo	11.12	3.93	15.06	0.84	32.60
Entirely rented	Self-unloading wagon	4.38	3.48	7.87	0.66	21.78
	Fully mechanized	4.42	6.88	11.30	0.63	20.93
	Self-feeder	2.36	4.71	7.06	1.02	23.21
	Gas-tight silo	17.87	3.76	21.13	1.00	48.91
Partially owned	Self-unloading	3.12	2.35	5.46	1.55	20.25
	Fully mechanized	3.04	12.48	15.52	1.14	30.91
	Self-feeder	2.20	17.58	19.79	1.20	42.00
	Gas-tight silo	-----	-----	-----	----	-----
Overall mean		$ 5.60	$ 4.49	$10.43	$ 1.06	$26.85

Table 35. (Continued)

Ownership	Feeding System	Costs Per Pound Gain: Total Non-Feed	Feed Costs	Total Costs	Net Profits Per Pound Gain	Turnover Ratio	Size	Number of Cattle Feeders[b]
Entirely owned	Self-unloading wagon	4.21¢	18.00¢	21.80¢	0.6¢	0.95	573.8	18
	Fully mechanized	4.73	18.27	23.00	-0.8	0.90	413.3	6
	Self-feeder	4.36	19.64	24.00	-2.0	0.70	908.0	1
	Gas-tight silo	6.23	20.77	27.00	-3.0	1.03	827.0	5
Entirely rented	Self-unloading wagon	4.61	19.38	24.00	7.0	1.62	411.0	3
	Fully mechanized	2.94	15.06	18.00	-5.0	0.98	238.0	1
	Self-feeder	4.05	16.95	21.00	2.0	0.86	170.0	2
	Gas-tight silo	8.60	25.40	34.00	-9.0	0.58	351.0	1
Partially owned	Self-unloading wagon	4.28	16.39	20.67	5.0	1.11	439.3	3
	Fully mechanized	4.22	12.78	17.00	6.0	0.77	307.0	1
	Self-feeder	5.70	18.30	24.00	-2.0	0.85	166.0	1
	Gas-tight silo	----	-----	-----	----	----	-----	0
Overall mean		4.70¢	18.83¢	22.89¢	0.8¢	0.99	519.8	
Total								42

[b]Indicates the number of cattle feeding operations which fell into this cross-classification, but not necessarily the number of observations for the dependent variables.

Table 36. Table of means for cattle sales as a percentage of total farm sales

		Feeding system				
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Ownership means
Ownership	Entirely Owned	74.9 (16)	77.2 (5)	93.0 (1)	89.4 (5)	78.7 (27)
	Entirely Rented	83.0 (3)	50.0 (1)	81.0 (2)	80.0 (1)	77.3 (7)
	Partially Owned	89.0 (2)	66.0 (1)	82.0 (1)	--	81.5 (4)
	Feeding system means	77.4 (21)	71.7 (7)	84.2 (4)	87.8 (6)	78.7 (38)

Table 37. Table of means for owned land as a percentage of total land operated

		Feeding system				
		Self-unloading wagon	Fully mechanized	Self Feeder	Gas-tight Silo	Ownership means
Ownership	Entirely Owned	74.4 (18)	64.3 (6)	100.0 (1)	66.4 (5)	71.9 (30)
	Entirely Rented	9.0 (3)	70.0 (1)	0 (2)	0.0 (1)	13.8 (7)
	Partially Owned	31.7 (3)	44.0 (1)	38.0 (1)	--	35.4 (5)
	Feeding system means	60.8 (24)	62.5 (8)	34.5 (4)	55.3 (6)	57.9 (42)

classifications except owned-self-feeder showed that cattle feeders using wholly-owned facilities for feeding cattle rented about 25-35% of their farmland. The percentage of land owned decreases correspondingly, as would be expected, for the other two ownership groups, namely, for those employing entirely rented facilities and those employing partially owned facilities.

In making the survey, an effort was made to determine the value of manure, which value was used in calculating net profits. It is interesting to note that in the areas of these counties where land is more rolling, a greater value was generally attributed to manure by the farmers. Thus manure was less highly valued by the cattle feeders in the more level Galva-Primghar-Sac Soil Association than in the Monona-Ida-Hamburg Association. The farmers with more sloping land gave greater emphasis to the value of the humus in the manure, maintaining that its soil structuring and holding characteristics contributed significantly to soil productivity. In these cases less emphasis, often little or none, was placed upon the nutrient value of the manure.

VI. SUMMARY AND CONCLUSIONS

Per-head investments and costs from a sample of 42 northwestern Iowa cattle feeders were analyzed using the methods of analysis of variance and analysis of covariance to determine how these investments and costs are affected by feedlot size, type of feeding system, and type of ownership. The cattle feeders sampled are likely to have represented those of above-average ability, not only because of the method used to obtain the sample, but also because of internal evidence in the analysis. Differences among the groups were small when they were analyzed for feed costs per pound gain or for veterinary and medical costs per head; the sample means for these factors are 18.83¢ and $1.06 respectively. Both figures are indications of competent management. Thus the results of this study would be representative of well-managed farm feedlots in northwestern Iowa which fit the ownership and feeding system classifications of the study.

In light of the above analysis ownership does play a major role in determining the amount of building and of total investment per head, but does not greatly affect the amount of machinery and equipment investment per head. This would be expected since a certain amount of machinery and equipment is needed to perform the routine feedlot operations, irrespective of ownership of the land and buildings. On the other hand, ownership plays no role in determining either fixed and investment costs or variable costs. Of course, investment costs alone would be higher for an owner, but since investment costs and rent are both fixed costs, they are categorically the same. On this basis, then, if a cattle feeder, under conditions similar to those of the sample feeders, were faced with the decision of buying or renting feeding facilities, he should base his solution upon the availability of capital or credit and upon the impact that either investing or renting would have upon his supply of operating funds rather than on cost alone.

The results of this study do show, however, that the type of feeding system does have a marked effect upon total investment per head as well as upon total fixed and investment costs per head and upon non-feed costs per pound gain. The gas-tight silo system has higher per head building and total investment requirements than do either the self-unloading wagon, fully mechanized, or self-feeder types of feeding systems. This difference is also reflected in higher per head fixed and investment costs as well. Furthermore, this same difference between the gas-tight silo system and the other three types of feeding systems also appears when costs are analyzed on a per-pound-gain basis. Likewise, nonfeed costs per pound gain are higher for the gas-tight silo than for the other three types of feeding systems; this difference is in turn reflected in total costs per pound of gain. But there are no apparent differences among feeding system types for feed costs per pound gain, veterinary and medical costs per head, or labor costs per head.

Net profits per pound gain are not shown to be affected by any of the factors studied. It should be pointed out that this is a volatile characteristic affected not only by efficiency, but also by uncertainty and by the marketing ability of the cattle feeder. Saunders, et al. (23, pp. 43-46) explicitly point out the effects upon profits of price variations for feeder and slaughter animals. Not only is the price margin important, but an unfavorable change in sale price has a greater effect upon profits than does an unfavorable change in purchase price because of the additional weight of the slaughter animal. In this study, however, the survey sample as a group had an average 0.8 cents per pound to allocate between management return and pure profit -- all opportunity costs having been covered.

The effect of size in this study is not conclusive. There are indications that economies can be found for building and for total investment per head as well as for the total fixed and investment costs per head as the size of the farm feedlot increases. However, since size here is based upon the number of head marketed in 1966, a thorough analysis of the type of cattle fed and length of the feeding period would be necessary so that the number of head fed could be standardized to account for differences in type of cattle and feeding period length. One alternative would be to use "per head of capacity" as the denominator -- that is to say, investments and costs could be figured on a per-head-of-capacity basis. The problem here, however, is that the term capacity has considerable ambiguity when applied to Iowa farm feedlots. Within the size range covered by this study, capacity can often be increased by adding more feedbunks, expanding a trench silo, or fencing off another acre of land. This is particularly true for the self-feeder and self-unloading wagon types of feeding systems, although it is less so for the fully mechanized and gas-tight silo methods. Capacity, then, is less meaningful when applied to Iowa farm feedlots than to large commercial feedlots.

A more meaningful approach for determining the effect of size can be found, namely, the per-pound-gain basis. This, in fact, corresponds to the method of valuing finished beef, since the feeder's product is marketed as pounds of slaughter beef and not number of head of slaughter animals. When this approach is used size has no effect upon feed costs, non-feed costs, or total costs per pound gain. Thus this study indicates no economics of size when costs are evaluated on the same basis as that used to value the product, at least for a size range of from 100 to 1500 head of cattle marketed annually.

Turnover ratio was also analyzed and was found to increase along with increasing size. Likewise, it was higher for cattle feeders employing entirely rented facilities. However, turnover ratio is not a meaningful term when applied to Iowa farm feedlots. Not only does it misplace the emphasis for making cost comparisons between various cattle feeders, it does not reflect feedlot production realistically because of the differences already mentioned in regard to length of feeding period and type of cattle fed.

In effect, then, for feedlots of above-average management in the area and size range studied, types of feeding system and ownership classification do have some effect upon feedlot investment per head, while only type of feeding system has a marked influence upon costs per pound gain or per pound produced. Size, in terms of numbers marketed, has no significant effect upon these per pound costs.

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IX. APPENDIX A

Table 38. Farms marketing grain fed cattle and number of grain fed cattle marketed by crop reporting districts, Iowa, 1963 and 1965[a]

District	Number of farms		Number of cattle	
	1963	1965	1963	1965
Northwest	9,595	8,800	740,538	785,339
North Central	5,987	5,450	310,458	308,101
Northeast	2,759	2,705	141,856	154,852
West Central	9,027	8,363	629,648	676,109
Central	7,493	7,156	428,951	478,063
East Central	6,789	6,456	447,027	457,946
Southwest	5,164	4,940	373,518	399,415
South Central	1,782	1,936	70,956	90,199
Southeast	3,195	3,185	147,008	170,612
State	51,788	48,991	3,289,960	3,520,636

[a]Source(12,13).

X. APPENDIX B

The regression equations for the curves of Figures 11-13 were derived from the general equation

$$\hat{y} = \bar{y} - \hat{\beta}\ (x - \bar{x})$$

by inserting the values of $\bar{y}$, $\hat{\beta}$, and $\bar{x}$ into the equation.

The following equations result for total investment per head (excluding land):

Owned -- self-loading wagon:	$\hat{y} = 38.23 - 0.02234\ x$
Owned -- fully mechanized:	$\hat{y} = 37.96 - 0.02234\ x$
Owned -- gas-tight silo:	$\hat{y} = 96.88 - 0.02234\ x$
Rented -- self-unloading wagon:	$\hat{y} = 27.39 - 0.02234\ x$
Partially owned -- self-unloading wagon:	$\hat{y} = 26.78 - 0.02234\ x$

For total fixed and investment costs per head, the following equations are obtained:

Owned -- self-unloading wagon:	$\hat{y} = 8.08 - 0.004607\ x$
Owned -- fully mechanized:	$\hat{y} = 8.26 - 0.004607\ x$
Owned -- gas-tight silo:	$\hat{y} = 14.93 - 0.004607\ x$
Rented -- self-unloading wagon:	$\hat{y} = 6.27 - 0.004607\ x$
Partially owned -- self-unloading wagon:	$\hat{y} = 5.14 - 0.004607\ x$

And for turnover ratio, the following equations are obtained:

Owned -- self-unloading wagon:	$\hat{y} = 0.5623 + 0.0006757\ x$
Owned -- fully mechanized:	$\hat{y} = 0.6180 + 0.0006757\ x$
Owned -- gas-tight silo:	$\hat{y} = 0.4712 + 0.0006757\ x$
Rented -- self-unloading wagon:	$\hat{y} = 1.3423 + 0.0006757\ x$
Partially owned -- self-unloading wagon:	$\hat{y} = 0.8132 + 0.0006757\ x$