ECONOMIES OF SCALE IN COMMERCIAL CATTLE FEEDING IN KANSAS

by

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INTRODUCTION

Finishing cattle in feedlots has made substantial growth in the United States in the last decade. On January 1, 1956, there were 5,929,000 cattle and calves on feed while at the same date in 1965, this number had increased to 9,154,000.[1] Kansas appears to be no exception to this increased national finishing trend. The number of cattle and calves on feed as of January 1, 1956, was 182,000 giving the state the twelfth highest ranking. But by January 1, 1965, Kansas had increased its ranking to eighth with 407,000 cattle and calves on feed.[2] A summary of the cattle fed in Kansas since 1956 is given in Table 1.

Kansas feedlot operators contribute a substantial proportion of the gross cash receipts of the total livestock industry—an industry which in itself plays a large part in the agricultural economy of the state. Annual cash receipts from livestock and livestock products for 1963 amounted to approximately 693 million dollars making it the largest contributor of farm income.[3] Of the total farm cash receipts from farming nearly 157 million dollars or approximately 12 percent came from the cattle feedlot industry.[4] Further, Kansas feedlots relied heavily on products produced by other Kansas industries such as mixed feeds, machinery and equipment, and various

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[1]U.S.D.A., Livestock and Meat Situation, Washington, D. C.: Economic Research Service, January 1965, p. 19.

[2]U.S.D.A., Cattle and Calves on Feed, Crop Reporting Board Statistical Bulletin No. 277 (Washington, D. C.: Agricultural Marketing Service, January 1, 1965), p. 5.

[3]Farm Facts, Annual Report of the State Board of Agriculture (Topeka: Statistical Division of Kansas State Board of Agriculture, 1964), p. 89 f.

[4]Value of cattle was derived by multiplying the average price of steers by the number of cattle fed in Kansas commercial feedlots for 1963.

TABLE 1.--Number and percent of cattle in commercial and farm-operated feedlots on January 1 by years, Kansas

Year	Commercial feedlots	Farm feedlots	Total cattle	Percent fed by commercial
		(number)		
1948	———	———	———	5
:				
:				
:				
1956	30,000	152,000	182,000	16
1957	38,000	115,000	153,000	25
1958	44,000	127,000	171,000	26
1959	49,000	166,000	215,000	23
1960	58,000	217,000	275,000	21
1961	88,000	249,000	337,000	26
1962	99,000	248,000	347,000	29
1963	150,000	242,000	392,000	38
1964	183,000	205,000	388,000	47
1965	207,000	200,000	407,000	49

Source: Kansas Agriculture Forty-third Report, 1959-1960, Kansas Board of Agriculture, Topeka, Kansas; and the Kansas Crop and Livestock Reporting Service, Kansas State Board of Agriculture, Topeka, Kansas, January 1, 1964 and 1965.

feed yard items as well as supporting a considerable payroll, thus, making the feedlot industry a large participator in the Kansas economy.

Cattle and calves are finished in two types of feedlots: (1) the farmer operated feedlot and (2) the commercial feedlot. The former is a business where the farmer normally owns all the cattle. In this type of operation, finishing cattle usually is one of several income earning enterprises of the farm business. The farmer-operated feedlot is defined in this study as an operation that feeds 1,000 head of cattle or less at any one time. The commercial feedlot is defined as a business that feeds cattle for others as well as for themselves.[5] For purposes of this study the commercial feedlot definition is restricted to those operations that provide facilities for 1,000 head of cattle or more. Most commercial feedlots are owned privately either through a partnership or a corporation.

The commercial feedlot has become well established in the West Coast and is rapidly expanding in the Great Plains area, including Kansas. On January 1, 1956, sixteen percent of the cattle and calves on feed in Kansas were in commercial yards. As of January 1, 1965, the proportion had increased to forty-nine percent (Table 1).

The distribution, both in number and percent of cattle fed, in Kansas is given in Table 2. Feedlot sizes of the 1,000-3,999 head capacity range appear to dominate the industry in number of feedlots but not with respect to the number of cattle fed. The largest grouping (14,000-25,999) comprise 36 percent of the number of cattle fed thereby making it the largest producer of finished cattle in the Kansas commercial feedlot industry.

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[5] Cf. Consumers Cooperative Association, Commercial Cattle Feedyards—Operating Policies, Facilities, and Cooperative Organization Guides (Kansas City: Economic Research Division, April 24, 1959), p. 2.

TABLE 2.--Distribution of commercial feedlots in Kansas, 1963

Size of feedlots	Number of feedlots	Percent of cattle fed
1,000-3,999	28	16
4,000-7,999	11	18
8,000-13,999	9	30
14,000-25,999	5	36

Source: Unpublished data, Agricultural Economics Department, Kansas Agricultural Experiment Station, 1963.

There are several reasons for the increase in the number of cattle on feed in Kansas in (relation to) commercial feedlots. In recent years the introduction of hybrid variety feed grains, substitution of feed grains for wheat due to restrictions on wheat acreage, and irrigation practices have resulted in a significance increase in the production of grain sorghums and roughages. This is particularly true of the western part of the state. It has been found that the greatest increase in commercial feed yards in the last decade has occurred in the western portion of the state. Whereas in 1953 approximately 43 percent of commercial feedlots were located in western Kansas, over 56 percent were located in this area in 1963.[6] Commercial feedlots tend to be located in areas in which a supply of feed is available.

The availability of feeder cattle also appears to be a factor in feedlot location. Although the number of feeder cattle that originate from the pasture land of the state are increasing, Kansas commercial feeders are

[6]John H. McCoy and Robert H. Wuhrman, Some Economic Aspects of Commercial Cattle Feeding in Kansas, Kansas Agricultural Experiment Station Bulletin 424 (Manhattan: Kansas State University of Agriculture and Applied Science, June 1960), pp. 8-9; and Unpublished data, Agricultural Economics Department, Kansas Agricultural Experiment Station, 1963.

dependent upon sources outside the state for their growing needs of feeder cattle. Unofficial estimates indicate that Texas and Oklahoma are the most important suppliers. Missouri, Colorado, and the Southeastern states are other important contributors. At the same time that Kansas imports feeder cattle, it also exports substantial numbers to other states.

Several studies have shown that decreased per unit costs can be achieved as the size of feedlots are increased, up to certain levels. For example, King, in a California study, has indicated that the average daily non-feed costs per animal decline substantially as the size of the feedlot increases from a capacity level of 3,760 head to a level of 22,560 head. Economies were indicated for increasing levels of utilization of the fixed plant until 100 percent capacity was maintained.[7] Hopkin in 1957 showed that per unit non-feed costs of commercial feedlots decline as the size of the feedlot increases from a level of 1,000 fed per year to a level of 30,000.[8] In a more recent but similar study conducted by Hopkin and Kramer, it was concluded that non-feed costs of commercial feedlots decline as numbers fed rise, at least up to 26,000 head. Costs began to rise for those lots feeding greater than 26,000 head.[9] Both of the latter studies were concerned with California conditions.

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[7] Gordon A. King, Economies of Scale in Large Commercial Feedlots, California Agricultural Experiment Station Giannina Foundation Research Report No. 251 (Berkeley: University of California Division of Agricultural Sciences, March 1962), p. 30.

[8] John A. Hopkin, Cattle Feeding in California, Bank of America, National Trust and Savings Association (San Francisco: Economics Department, February 1957).

[9] John A. Hopkin and Robert C. Kramer, Cattle Feeding in California, Bank of America, National Trust and Savings Association (San Francisco: Economic Research Department, January 1965), pp. 31-32.

Although King's study was in many respects similar to this one, differences were apparent. These will be discussed in more detail in the "cost relationship" section.

The demand for beef also plays an influential role on the trend of cattle going into commercial yards. The per capital consumption of beef for 1965 was estimated at 102.5 pounds which is a substantial increase from the 82.0 pounds in 1955.[10] Projections for the future indicate further expansions in beef consumption. Anticipated increases in population and consumer disposable income are expected to create a large increase in the future demand for beef. It has been estimated that by 1975, fifty percent more beef will be consumed in the United States than in 1959.[11] Thus, it becomes explicit that consumer demand has been the underlying reason for the expansion of the commercial feedlot. Kansas is shipping most of its beef to the Eastern and Southeastern markets but as the population trend of the United States continues to move to the West,[12] the opportunity for Kansas beef industry to ship there appears favorable.

OBJECTIVE OF THIS STUDY

The objective of this study is to determine how non-feed costs vary depending upon: (1) the size of the feedlot and (2) upon the degree of utilization of a given sized feedlot. It is designed to assist those

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[10] United States Department of Agriculture, Livestock and Meat Situation, Washington, D. C.: Economic Research Service, November 1964, p. 27 (Note: includes 48 states).

[11] John H. McCoy et al., The Competitive Position of Kansas in Marketing Beef, Kansas Agricultural Experiment Station Technical Bulletin 129 (Manhattan: Kansas State University of Agriculture and Applied Science, August 1963), p. 21.

[12] Ibid.

already in the commercial feedlot industry as well as those who are considering entering the industry. In so far as non-feed costs are a factor, those firms in the industry can obtain insight in determining whether or not it would be economically feasible to expand or contract their operation from a study of this nature. On the other hand, those who are contemplating entering the industry cannot only obtain information concerning the optimum sized plant and degree of utilization, but they can also receive an awareness of the fixed and variable capital requirements, the general type of technology employed, and some of the problems associated with the commercial feedlot industry. Such would be of practical use, for example, to a rural community which wanted to develop an industry to stimulate its area economy.

CONCEPT EMPLOYED IN THIS STUDY

In objective (1) this study is concerned with per-unit costs associated with feedlots of different size. The terms related to such are entitled economies and diseconomies of scale. Cost economies and cost diseconomies refer to phenomena which cause unit costs to decrease or increase respectively as size of the plant and output are expanded when operating under the most efficient conditions.[13]

The concept of scale itself is, however, a technical rather than an economic relationship. The basic process of any economic firm is the production of output with various inputs such as land, labor, and machinery and equipment. If these inputs are all increased by a given proportion, the output will be increased by a proportionate amount and the firm is said to

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[13] Earl O. Heady, Economics of Agricultural Production and Resource Use, Englewood Cliffs: Prentice-Hall, Inc., pp. 352-354.

possess constant returns to scale. But if the resulting increase in output is proportionately greater than the increase in inputs, then economies of scale are said to exist.[14] In the real world, however, the proportionality relations are relaxed because of the discrete nature of the inputs, the multiplicity of them, and the changes in technology related to each firm.[15]

An economies of scale curve is illustrated in Figure 1.

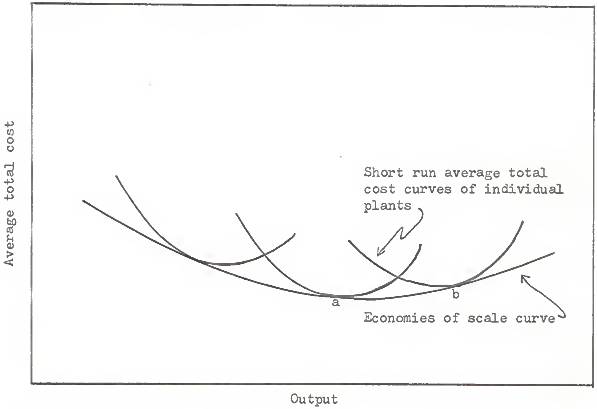

Figure 1.--Short-run average total cost curves for individual plants and long-run or economies of scale curve

[14]Ibid.

[15]Harold B. Jones, Economies of Scale in Commercial Egg Packing Plants, Marketing Economics Division, Economic Research Service, U. S. Department of Agriculture in cooperation with Georgia Agricultural Experiment Station Bulletin N. S. 120 (Athens: University of Georgia College of Agriculture, September 1964) p. 9.

The economies of scale curve, often called an envelope curve, is derived by drawing a curve tangent to a series of individual plant average total cost curves. Each individual plant is able to operate at various capacity levels and each is operating as efficiently as possible within the limits of present knowledge.[16] Theoretically, the economies of scale curve is not drawn tangent to the lowest point of each individual firm's average total cost curve except in one case, point a. Such is the minimum point on the economies of scale curve and exemplifies the least per unit cost for the plant.[17]

The average total cost curve of each individual plant is conventionally U-shaped and is made up of the average fixed costs and the average variable costs in the short-run. As output is increasing, the average fixed cost must decrease and if the law of diminishing returns is operating, average variable cost must increase. Average total cost will fall if the reduction in average fixed costs is greater than the increase in the average variable costs. Eventually the average cost curve will reach a minimum and start to rise if the increase in the average variable costs become greater than the decrease in average fixed costs.[18] These are the hypothesized conditions.

The average total cost curve is essentially the per unit cost curve of the individual firm for the short run. The short-run is "taken to be a

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[16]Heady, loc. cit., pp. 365-369.

[17]E. L. Baum, J. E. Faris, and H. G. Walkup, Economies of Scale in the Operation of Fryer Processing Plants, Washington Agricultural Experiment Station Technical Bulletin No. 7 (Pullman: The State College of Washington Institute of Agricultural Sciences, August 1952), p. 4.

[18]Jacob Viner, "Cost Curves and Supply Curves," Readings in Economic Analysis, ed. Richard V. Clemence (Cambridge: Addison-Wesley Press, Inc., Vol. No. 2, 19), p. 16.

period which is long enough to permit of any desired change of output technologically possible without altering the scale of the plant."[19] Short-run refers to a cost structure and time period[20] in which some factors are fixed in quantity and forms. For example, the cost curve for a 2,500 head capacity feedlot which includes a particular feedmill investment, a certain number of feed trucks, etc., refers to a short-run cost situation. The cost curve for a 5,000 head capacity feedlot which would include a larger feed-mill, more feed trucks, etc., would refer to another short-run cost situation and ad finitum. Scale of plant refers to the size of factors that are fixed in amount. In this study the terms scale and size are used synonymously.

The long-run is considered to be a period long enough to permit each producer to make such technological changes in the scale of plant as he desires and thus, to vary the output of the firm by varying its size.[21] The long-run curve (or the economy curve) can be looked upon as a planning curve. If a person were to start a firm such as a commercial feedlot, he could consider costs in the sense of the economy curve and proceed to build a plant with an average cost curve as a or b in Figure 1. After the plant is constructed, the economy curve becomes only of historic use.

It may be noted that the long-run curve has been drawn tangent to the individual firm cost curves in Figure 1. Such will be the case only if it is possible to have fairly continuous variations in scale. If plant sizes form a discrete series, the economy curve will consist of segments of the

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[19] Ibid., p. 17.

[20] Not necessarily a clock time consideration.

[21] Viner, loc. cit., p. 13.

plant curves and will have a scalloped structure.[22]

As Alfred Marshall stated:

> Looking more closely at the economies arising from an increase in the scale of production of any kind of goods, we found that they fall into two classes—those dependent on the general development of the industry, and those dependent on the resources of the individual houses of business engaged in it and the efficiency of their management; that is, into <u>external</u> and <u>internal</u> economies.[23]

Internal economies can then be described as those realized from scale adjustments within the individual firm; that is, they appear irrespective of the industry. Economies of scale may also be of a technological or a pecuniary nature. Internal pecuniary economies are those associated with the purchase of factors in large scale lots as in "quantity discounts." Internal technological economies occur mainly as the indivisibility of factors is overcome when output is increased.[24] An example of such would be savings in the labor, materials, or equipment requirements per unit of output that would result from improved organization of methods of production made possible by a larger scale of operation.

External economies are those realized entirely outside the individual firm. They depend on the industry as a whole and relate to the firm only as it is a part of the industry. Similar to internal, external economies may be technological or pecuniary. An illustration of a technological economy might be the improvement in production techniques for a particular plant brought about by the exchange or "cross fertilization" of ideas among

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[22] R. G. Bressler, Jr., Economies of Scale in the Operation of Country Milk Plants with Special Reference to New England, New England Research Council on Marketing and Food Supply (Boston: June 1942), p. 22.

[23] Alfred Marshall, Principles of Economics (9th ed.; New York: The McMillan Co., 1961), p. 314.

[24] Heady, loc. cit., p. 362.

different producers resulting from an increase in the size of the industry as a whole.[25] External pecuniary economies might arise such that feedmill equipment, marketing outlets, and transportation systems are built up to such an extent that they might be offered for a lower cost when the number and size of feedlots in a particular area increase.

Some industries may have neither internal or external economies of scale. Actually some may have diseconomies of scale. Such is exemplified by obtaining a less than proportionate increase in output as inputs are increased by a given proportion.

METHOD USED IN THIS STUDY

A list prepared by Farm Management Association fieldmen of the commercial feedlots in Kansas in 1961 was studied and the feedlots were stratified into four sizes—2,500, 5,000, 12,000, and 20,000 head capacity. Stratification was based on the predominant clustering of the feedlots around a particular size range. A random sample of 13, 7, 4, and 2 feedlots, each corresponding to the stratification sizes was drawn.

Owners of the feedlots were interviewed in the summer of 1962. The distribution of the feedlots were widely scattered as is evident in Figure 2. Information from these twenty-six feedlots supplemented with that of university extension specialists, agricultural economists, equipment dealers, and feedlot managers were used to construct four model feedlots. The method employed for constructing these models and for determining the economies of scale was the so-called synthetic or budget approach.[26]

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[25]Viner, loc. cit., p. 24.

[26]For a description of this approach see: Bramm, Faris, and Walkup, loc. cit.; Bressler, loc. cit.; and Jones, loc. cit.

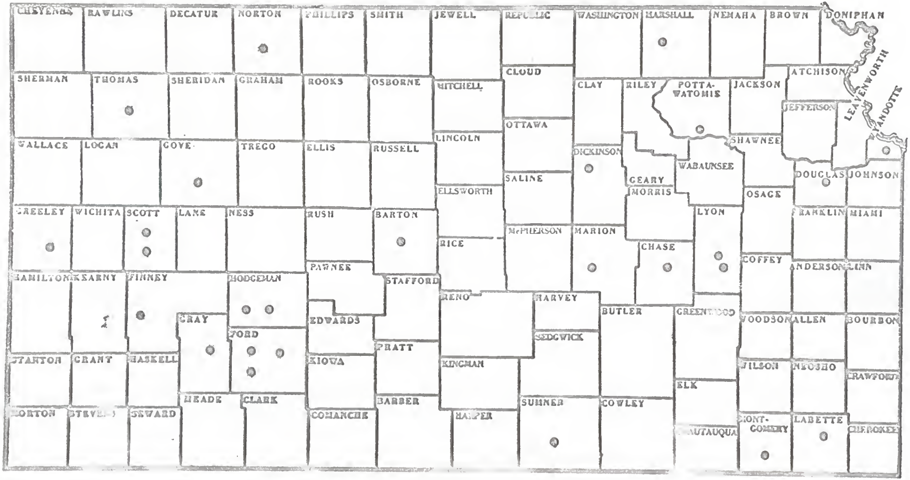

Figure 2.--Location of sample commercial feedlots, Kansas, 1961

Capacity for each model was defined as the number of cattle a feedlot will hold at any one given time as estimated by the feedlot managers. In determining capacity, the judgement of the lot manager relied largely on two factors: (1) the size of the pen space, and (2) the output of the feedmill. Most yard managers have had sufficient practical experience in determining when a feedlot was under or over-crowded and were familiar with the output of the feedmill, and since these seem to be the two limiting factors of expansion, this definition of capacity appears in close accord with reality. Five levels of capacity or degrees of plant utilization were arbitrarily chosen and considered for each model. A summary of the capacity of each model and their levels of utilization is given in Table 3.

TABLE 3.—Capacity and levels of utilization for four model commercial feedlots

Model	Capacity	Levels of utilization				
	(no. of head)	(percent)				
I	2,500	25	50	75	100	125
II	5,000	25	50	75	100	125
III	12,000	25	50	75	100	125
IV	20,000	25	50	75	100	125

An assumption with respect to time in this study was that each model was to be operated for 360 days. This allows some time for moving cattle in and out, manure removal, repairs, etc. Less than full capacity utilization is implied to mean the operation of the lot for 360 days with less than the number of cattle that would be fed at full capacity.

Each animal was assumed to be fed out to a high good or low choice grade for a duration of 140 days. This feeding period was derived by dividing the annual number of days the feedlot was in operation by the average turnover of 2.57. Turnover is the number of times cattle are brought in and removed from the feedlot annually. The average turnover for Kansas commercial feedlots as obtained from the sample feedlots was 2.57. In other words, each model was assumed to feed its full normal capacity 2.57 times per year.[27] For example, for Model I, this would result in (2,500) (2.57) = 6,425 animals fed annually.

In those commercial feedlots which feed some contract cattle, a few non-feed costs are passed back directly to the owners of the cattle. However, these costs were not distinguished in this study since essentially they are non-feed costs to the firm for the production of finished cattle no matter who is responsible for them.

CAPITAL INVESTMENTS

Short-run average total cost curves are determined by fixed and variable costs. Fixed costs do not vary with output. Variable costs include those items that vary with output such as electricity, fuel, etc. Fixed costs are to a degree associated with capital investments. Therefore, before these costs can be derived, capital investments for each model must be determined. In this section, the term costs will be construed to mean investment cost. Although cost of investment items can be determined in several ways, i.e., reproduction cost, replacement cost, etc., the criterion of original cost was implied in each case for this study. Original cost was considered as the amount paid for an investment item, including both new and second hand purchases.

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[27] Normal used in this sense and throughout the remainder of this study implies 100 percent plant utilization.

Capital investments were broken down into five major categories: (1) machinery and equipment, (2) feed yards, (3) feed storage, (4) office, shop, and scales, and (5) feedmill.

A uniform technology was selected on the basis of information obtained from the sample feedlot operators and from this, investments of capital items were developed. Difficulties encountered in obtaining certain information from sample operators, lack of uniformity in records kept by operators and a limitation in number of feedlots available in the larger size level necessitated the use of several methods and sources of information for investments and several cost calculations as will be pointed out later. Among the methods used for investment determination were: (1) use of the statistical technique of linear regression upon sample data, (2) utilization of the regression analysis in (1) in conjunction with sources of information apart from the sample population, and (3) application of information obtained completely from sources outside the sample. With respect to (1) and (2) above, investments for each individual capital item as taken from the survey questionnaires were plotted against capacity of the feedlot. A function of the form $y = a + bx$ was fitted to these data: where,

y = cost of the investment item,

a = the y intercept,

b = regression coefficient, and

x = number of cattle fed when the feedlot was operating at normal capacity.

For some investment items on those feedlots sampled, records had not been kept and the operators were unable to recall or even estimate their original cost. On other lots, records had been registered, but were not available when surveyed. There were some instances in which feedlot operators felt that they were unable to give an itemized cost breakdown and, hence, a composite figure was presented. To decipher this aggregate information was felt to be almost impossible since original cost of capital investments showed some variation depending upon whether they were purchased new or second-hand. Finally, several situations arose in which the operators either would not take the time that was required for filling-out the survey questionnaires or else they preferred that such information be kept confidential. Since a few investment items were victims of most or all of these circumstances, it was felt that the regression analysis would be of greater value if used in conjunction with information from equipment dealers, agricultural extension specialists, feedlot managers, and all other available sources for these particular items.

The cost of those capital items determined entirely by regression analysis were represented not only by a substantial number of observations in each stratified sample, relative to sample size, but also observations that were consistent with information supplied by the other sources. They, therefore, were felt to be representative for the situation.

In regard to (3) above, these items were a few that were more or less "discovered" during the survey but inadequate data were obtained on them. Since several capital investment items that were felt to be of importance fitted into this category, sources of cost information outside the sample had to be obtained. The capital items and their statistical values that were obtained from (1), (2) and (3) above are shown in Appendix Tables 1 and 2. Those items determined entirely from information apart from the sample will be acknowledged as they appear subsequently in the discussion.

Machinery and Equipment

A list of all machinery and equipment items and their costs is presented in Appendix Table 3. Pickup trucks were used on all feedlots. As the size of the lot increased, the pickup investment also increased indicating that more or greater capacity pickup trucks were used on the larger feedlots. In this study, however, it was determined that one pickup in each model, except Model IV, was adequate. In Model IV a second was added. Pickup trucks are used primarily as a means of transportation around the yards. The linear regression technique was relied upon only as a guide in determining the pickup truck investment. Agricultural extension engineers provided the basic cost information used in the study.

An important equipment item on all feedlots was the self-unloading feed truck. Nearly all yards used at least one self-unloading feed truck. Therefore, it was assumed that this type of truck would be a technology characteristic of the four models.

The number and the cost of feed trucks varied from lot to lot in the sample. The costs followed a jerky, discontinuous or lumpy pattern. That is, as the size of the feedlot increased, feed truck costs rose rapidly as a new truck or trucks were added. Further, costs vary depending on whether the trucks were purchased new or second-hand. In some feedlots, costs were reduced by mounting new feed-boxes on second-hand truck chassis.

The proportion of cattle owned by the feedlot owner has an effect on the number of feed trucks used in a commercial yard. Lot-owned cattle are usually fed fewer different rations than custom fed cattle. Feed trucks in these lots can be filled to capacity with a particular feed ration and fed to those cattle using that ration. On the other hand, contract cattle may be fed many different rations depending on the judgement of the owners.

Often batches of feed fed to a particular owner's cattle only partially fills the truck. If this is a common occurrence, which it is in many contract yards, more trucks are needed. For example, one 20,000 head feedlot owner from the survey schedules who owned all of the cattle was able to operate with a minimum of three trucks compared to the usual five or six needed for the contract feeder.

Feed truck costs were derived from the composite source of regression analysis, feedlot managers and agriculture extension engineers.

A standard truck refers to a multi-purpose type of vehicle. It is essentially a 2 to 4 ton truck, equipped with a hoist and bed. Hauling hay, silage and particularly manure is the major purpose of this truck. Regression analysis of sample data was used in deriving standard truck investment, (Equation 3, Appendix Table 2).

A grain truck was considered in all models except I. Most commercial feedlots, especially the larger ones, try to maintain one good grain-importing truck. The cost for this item was determined by the combined judgement of feedlot managers and agricultural extension engineers.

The investment of tractors varies from $5,879 for Model I to approximately $23,000 for Model IV. A tractor for ordinary use (such as operating a self-unloading wagon or pulling the hay wagon) and a tractor with a front loader was used on all lots. In Model I the front loader was simply a manure scoop mounted on the front of the tractor which was used not only for loading manure, but also for loading silage. This is not to be confused with the silage loader attached to the tractor on the other three models. The latter is a much more elaborate piece of equipment. Starting with Model II, a track-type tractor was added. A track-type tractor becomes useful not only from the standpoint of moving and loading manure, but in packing the trench silo as well. In Models III and IV, two track-type tractors were provided.

The cost of tractors was derived mainly from regression analysis upon sample data (Equation 4, Appendix Table 2). On the surface, it would appear that the figures are low compared to costs used in other studies. However, on some lots, many of the tractors were purchased second-hand and furthermore, some of the tractors used were not of the most elaborate kind. There was probably one up-to-date tractor on each feedlot that was observed from the schedules, thus indicating the importance of cutting cost by purchasing less expensive, yet adequate tractors.

A self-unloading wagon was used in Models I, II and III for the purpose of hauling silage from the trench silo to the feedmill to be incorporated with the ration. The wagon was also added as a standby in case of a feed truck breakdown. In Model IV a self-unloading feed truck was used instead of the self-unloading wagon. This change of technology was characteristic of the sample feedlots. A flat-bed wagon was set-up on Models I and II largely for general use. Many of the smaller commercial feedlots that were interviewed kept a continuous supply of hay on this piece of equipment. The hay went directly from the wagon to the hay chopper component of the feedmill. Agricultural extension engineers supplied the cost information for the self-unloading and flat-bed wagons.

Since there is a large amount of mechanical equipment on commercial feedlots, all yards have a shop with maintenance equipment. The simple regression technique, using information from the sample feedlots, was used entirely in arriving at this equipment investment (Equation 7, Appendix Table 2). The investment for infirmary equipment was derived in the same manner (Equation 6, Appendix Table 2).

An assumption made in this study was that all feed was purchased on a contract basis, usually from nearby farmers. Therefore, there was no machinery investment costs for items such as silage cutters, hay balers, rakes and mowers, and feed-grain planting and harvesting equipment. However, in those feedlots interviewed, this was not always the case. Some feedlots expanded their operation and owned land themselves or leased land which furnished at least part of the feed requirements.

<u>Feed Yards</u>

The feed yards listed in Apprndix Table 3 included the following items: land, fences, feed bunks, concrete aprons, waterers, water-distribution system, chutes, oilers, and sick animal pens and sheds. Applying the statistical technique of simple linear regressions, investment costs for each item were obtained from sample data. The statistical parameters for the feed yard items are given in Appendix Table 2.

Land was relatively more important cost item in Model I than in II, III, or IV, i.e., its cost declined relative to total cost as the size of the feedlot increased. The correlation coefficient between land investment and feedlot capacity was only .1118. Although larger feedlots use more land than smaller ones, its cost is apparently less on a per acre basis.

Many feedlots are built on slopes to facilitate drainage. In reply to a question on the survey schedules, concerning the features of an ideal feedlot, a repeated response was drainage. Feedlots are often built on slopes of hill-sides facing a southerly or easterly direction, preferably on a sandy-structured soil. Some yards have been built on obsolete air bases, thereby taking advantage of concrete runways. In such cases, an underground drainage system usually is utilized.

A variety of materials is used in constructing commercial feedlot fences. Among these are wood, pipe, wire and cable. Probably the most common is steel cables held up by steel pipes. Railroad ties with 2 x 8 inch boards were used by some lots, but cattle, especially when they become crowded, will have a tendency to push ties out of line. Further, due to time and weather, board fences will rot. Those feedlots using pipe or cable usually use either four or five rails or strands on all sides except the side in which the feed bunk is located.

All yards have feed bunks. They usually are constructed of concrete or wood. However, as was true of wooden fences, wooden feed bunks deteriorate rather rapidly. Most bunks from the survey schedules were made of concrete with concave bottoms. The concavity of the bunk enables cattle to consume all the feed which otherwise in square bunks tends to cling to the corners. Adjacent to the feed bunk, is a concrete apron which provides cattle a firm standing place for eating.

The fences, feed bunks, and concrete aprons make up a major part of feed yard investment cost in the four model commercial feedlots. They respectively amounted to approximately \$9,000, \$7,000 and \$10,000 to the total investment for Model I and nearly \$50,000, \$56,000 and \$60,000 for Model IV.

Most feedlots in Kansas obtain their water from privately owned wells. Water is pumped from the wells to a tower reservoir where it is stored until supplied to the cattle. The tower reservoir, pumping system and underground piping comprise the water-distribution system. Electric power was used exclusively by the feedlot operators interviewed. The water-distribution system was one of four investment regression items that had a negative constant value indicating a negative cost at zero capacity. This is not a logical situation. It is probable that linear extrapolation at lower levels of capacity is invalid. Additional observations would be needed at the lower levels of capacity to determine the nature of the function at these levels. A scatter diagram of observations used in this study indicated linearity within the range used in this analysis.

Automatic waterers were provided in each pen. An inlet at the bottom and a float regulates the supply of water from the reservoir. In cold weather a heater with an automatic thermostat regulates the temperature of the water.

Chute investment costs increased as the size of the feedlot increased, thus possibly indicating not only that they become more elaborate but more numerous as the size of the feedlot increases. The linear regression equation for chutes of $y = 225 + \underset{(.08579)}{.27735} X$ had a correlation coefficient (r) of .71494. The value in parenthesis indicates the standard error of the regression coefficient (Equation 14, Appendix Table 2).

Oilers were provided for all models in this study. Some feedlot managers advocated their use while others felt that they were an added expense. A major problem with oilers is maintenance.

Most of the models interviewed provided sick animal pens and sheds. Cattle that become ill are separated and placed into a hospital pen for recovery. The investment cost of this item in the four models ranged from $430 in Model I to $1520 in Model IV.

<u>Feed Storage</u>

Total feed storage requirements are a function of number of cattle fed, quantity of feed required per animal and the proportion of total feed requirements that normally is stored. Feed rations are made up of several ingredients, e.g., grain, hay, silage, protein supplement, which have different storage characteristics. In an attempt to determine total annual feed requirements for the several ingredients, personnel of the Kansas State University Animal Husbandry Department were requested to suggest a ration. This ration may be considered an upper limit in the sense that feedlot managers would not likely feed more than the total number of pounds of dry matter to each animal daily than suggested by the ration. The ration is not necessarily recommended for the commercial feedlot industry in Kansas. Its purpose in this study is to provide an indication of feed storage requirements. The daily ration is as follows:

Nutrient	Units
chopped hay	1 pound
protein supplement (45 percent)	1 pound
silage (corn)	10 pounds
grain (1/2 corn & 1/2 grain sorghum)	23 pounds
molasses	3/8 pound
vitamin A	2500 units
Total	35 3/8 pounds

Since grain requirements are substantial, few operators keep more than a relatively small proportion of annual grain requirements on hand at any one time. A usual practice has been to maintain sufficient storage facilities to take care of several week's to a month's supply. Thus, for purposes of this study, it was assumed that each model would have storage facilities for one month's supply of grain and hay. In consultation with agricultural extension engineers, storage construction rates were determined. For Model I, three 10,000 bushel bins were budgeted at a cost of $0.25 per bushel. For Models II, III, and IV flat bulk storage was considered at a cost of

$0.30 per bushel. Grain storage capacity requirements ranged from 30,000 bushels for Model I to 238,000 bushels stored in Model IV while storage costs varied from $7,500 to $71,400 for these two models (Appendix Table 3).

Hay storage investment costs were calculated in a procedure similar to grain. Hay is usually stored in a less elaborate manner. Pole closed buildings with one open side is used in several yards. In consultation with agricultural extension engineers, a construction cost of $15 per ton was suggested. Hay storage for the 20,000 head model totaled 300 tons for a 30 day supply. As given in Appendix Table 3, hay storage investment costs varied from $560 to $4,500.

In the sample commercial feedlots, silage was stored exclusively in trench silos. Trench silo investment costs vary depending upon the capacity of the silo and the extent to which concrete is used in the construction. For purposes of this study, sufficient silage storage facilities were set up for one year's supply. Silage requirements varied from 4,500 tons for Model I to 36,000 for Model IV. Applying a cost of $0.50 per ton as suggested by Kansas State University Agricultural Extension Engineers, trench silo costs for the four models were determined. Silage storage investments ranged from $2250 for Model I to $18,000 for Model IV (Appendix Table 3).

Office, Shop, and Scales

Characteristic of most of the feedlots interviewed was an office in which the major portion of the business of the operation was conducted. Filing cabinets, adding machines, records of cattle on hand including accounts payable and accounts receivable plus other clerical data were stationed in the office. Usually a large truck scale platform was located adjacent to the office. The truck scales are used primarily for weighing purchased feed and in and out-going trailer loads of cattle.

The truck scale is different from the cattle scale. The latter is a smaller scale and usually situated near the cattle loading-unloading dock. The cattle scale is used for checking the weight of individual animals or small groups that frequently come in or out of the lot as well as for determining daily gains.

Along with the office and the two scales mentioned, a repair shop was budgeted in the four models in this study. Maintenance and repair of equipment is of vital importance in commercial feedlots.

The office, repair shop, and cattle scale investments were determined by the simple regression technique on the information obtained from the sample feedlots. Values of the statistical parameters for these items are given in Appendix Table 2. The regression analysis was used only as a guide for determining the investment of the truck scales (Appendix Tables 1 and 2). The equations of both the truck scales and the repair shop had negative constant terms and both can be explained in the same manner as was the case for the water-distribution system. The office, shop and scales made up the lowest investment cost of the five capital investment categories. Their total ranged from a low of $7,090 to a high of $40,750. The breakdown is given in Appendix Table 3.

Feedmill

The feedmill plays a prominent role in the operation of commercial feedlots. As was previously mentioned, one of the factors influencing the expansion of a particular feedlot is the capacity of its feedmill.

Most feedmill investment information as obtained from the sample feedlots consisted of one composite figure for the entire feedmill complex.

In many instances it consisted of not only the feedmill and all its supplementary components, but also the grain storage bins and the housing of the feedmill. Before the investment of the feedmill could be determined, grain storage investments as previously determined and the housing of the feedmill had to be deducted. Housing costs of the feedmills interviewed varied depending upon the type of structure and its age. Data provided by Kansas Feed Milling Extension Specialists who suggested four model feedmills for this study (which will be discussed in detail later) indicated that as an average, approximately 7 percent of the total feedmill complex investment could be allocated to housing. Applying this criterion, net feedmill investment was derived for each sample feedlot. These data were then used in conjunction with feedlot capacity in a simple linear regression analysis to determine average feedmill investment from the sample information (Equation 21, Appendix Table 2).

Although this method of computing the feedmill investment produced acceptable results with respect to the total feedmill complex, it gave no breakdown of component parts of the mill for each model. Since the feedmill is one of the major investment items in the commercial feedlot industry, information other than that provided by the sample feedlots was obtained.

The amount of feed required to feed the number of cattle in each model subject to the restrictions of the predetermined ration was calculated. With this information on hand, four feedmills with adequate capacity expressed in tons per hour were budgeted by Kansas State University Feed Milling Extension Specialists.[28] Each component of the mill was considered

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[28]The feedmills thus incorporated into the models will subsequently be referred to as "designed" feedmills to differentiate from the "sample" feedmills.

and costs were applied to each to determine total feedmill investment. The feedmills so determined had capacities of four, nine, twenty, and thirty tons per hour respectively, with each corresponding to the four model feedlots. It was assumed that each mill would be operated a ten hour day. A smaller feedmill for each model utilized on a two-shift per day basis would be a possibility. However, most feedlot operators consider it desirable to have some idle machine time to permit repairs during possible break-downs. If the feedmill is operated with little idle time, diseconomies might occur as maintenance and repair costs would rise.

A descriptive breakdown of each of the designed feedmills is given in Appendix Table 4. Kansas Feed Milling Extension personnel indicated that there is much variation in feedmill equipment costs due to different manufacturing companies, different materials used in the construction of the mill, and the type of mix that the mill is to prepare. The "designed" feedmills used in this analysis are considered average for the industry.

A comparison of the two feedmill investment costs are shown in Table 4 and Appendix Table 3. Throughout the remainder of this study, total costs and per unit costs of both derivations of the feedmill investment will be discussed and compared. The feedmill costs for the sample feedlots ranged from $44,280 to $201,950 making it the second largest investment category of total capital investments. In Models I, II, and III the investment of the "designed" feedmill was in each case higher than the "sample" survey feedmills but lower in Model IV. In Models I and II it was the most expensive capital investment in that feedlot.

Total capital investments for the four model feedlots are summarized in Table 4. Two investment figures appear, one relating to the "survey"

TABLE 4.--Capital investments for four model commercial feedlots, Kansas, 1961

Item	Model							
	I		II		III		IV	
	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill
	(dollars)							
Machinery and equipment	22,530	22,530	45,430	45,430	62,070	62,070	88,220	88,220
Feed yards	48,340	48,340	74,600	74,600	148,200	148,200	232,260	232,260
Feed storage	10,310	10,310	23,625	23,625	56,400	56,400	93,900	93,900
Office, shop, and scales	7,090	7,090	13,290	13,290	30,650	30,650	40,750	40,750
Feedmill	44,280	54,550	65,440	100,110	129,160	148,010	201,950	175,150
Total	132,550	142,820	222,385	257,055	426,480	445,330	657,080	630,280
Investment per head capacity	53.02	57.13	44.48	51.41	35.54	37.11	32.85	31.51
Investment per head fed[a]	20.63	22.23	17.31	20.00	13.83	14.44	12.78	12.26

[a]Assumed feedlot is operated at normal capacity.

feedmill and the other to the "designed" feedmill. In both cases, the feed yards and the feedmill contribute the major portion of the cost. In the two derivations investment per head figured on a capacity basis varies but little. With respect to the survey "sample" feedmill, it varies from $53 for Model I to $33 for Model IV, while the investment per head with the "designed" feedmill, ranges from $57 to $32 for the same models. This compares closely to a similar commercial feedlot study.[29] Because of the turnover phenomenon, capital investment per head annually would be lower for all models of the two investment derivations than for investment per head capacity. With the "designed" feedmill, the investment per head fed annually at 100 percent utilization was $22, $20, $14, and $12 for the four respective models starting with the smallest.

FIXED COSTS

Fixed costs are associated with short-run conditions. They are unaffected by volume changes within a given plant. As output is increased the fixed costs are spread out over more and more units of output, thus, causing fixed cost per unit to decrease. They are, in general, associated with the capital investments just described and in this study are depreciations, maintenance and repairs, interest on investment, taxes, insurance, wages of management and office expense.

Management was considered a fixed cost in the sense that it was commonly employed on a salary basis. The manager in many commercial feedlots studied was hired on the basis of an expert laborer whose salary was

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[29] King, loc. cit. In this study, investment per head capacity ranged from $51 for a 3,760 head model to $34 for a 22,500 head model.

competitive with his equivalents in other feedlots. In those corporate yards in which several owners acted as managers, a predetermined salary was a common procedure. Earnings of the firm after all expenses were accounted for, were then either earmarked into the business or paid out in the form of dividends. Consequently, since management owned the major share of the stock in these feedlots, they were essentially the beneficiaries of their exceptional management through indirect means other than salary. The amount designated as fixed cost in this study did not include dividends.

Depreciation

Depreciation is the reduction in value resulting from wear and tear through use, action of the elements, inadequacy, accident, or obsolescence.[30] As a plant operates over a period of years, it is necessary for the return to it to be sufficient for management to replace equipment and buildings as they wear out.[31] The rates used for calculating depreciation costs in this study utilize the straight-line method which assumes that the investments depreciate the same amount each year.

The major problem in determining depreciation costs was in obtaining adequate information with respect to the life expectancy of each investment item. Some investment items depreciate in a shorter period than others, thereby requiring a higher depreciation rate. Through consultation with Kansas State University Farm Management Specialists, the expected years of life of each investment was determined. They were grouped into those lasting ten years and those with a twenty-year life. Depreciation rates of

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[30]Harold S. Sloan and Arnold J. Zurcher, Dictionary of Economics, New York: Everyday Handbook, Barne and Noble, Inc., 1961, p. 96.

[31]Bressler, loc. cit., p. 49.

ten percent and five percent were applied to the two categories respectively.

Depreciation costs are given in Table 5. There are two sets of costs in the table due to the two methods of determining the feedmill investment. Two rates were used, one for the feedmill equipment and one for the building of the mill. Kansas Feed Milling Extension personnel recommended that the feedmill equipment be depreciated at a higher rate than the building. Rates of 10 percent and 5 percent of investment cost were applied as recommended.

The annual depreciation costs for the four model plants vary from slightly over $10,000 for Model I to nearly $45,000 for Model IV for the "designed" feedmill. The range is greater for the "sample" feedmill investment as it extends from over $9,000 to nearly $47,000. Costs per head per day in this latter investment cost decreases from $.01033 for Model I to $.00652 for Model IV when operating at a capacity of 100 percent.

Maintenance and Repairs

Maintenance and repair costs for investment items other than machinery and equipment and the feedmill equipment were considered to be a function of time rather than use. Actually maintenance, repairs and depreciation are closely related. If capital investment items are well cared for and kept in good shape, their length of productiveness will be enhanced. Hence, the depreciation rates used would be lower than if the items were tended with less care but this may necessitate higher maintenance and repair expenditures. In conjunction with the straight line method of determining depreciation costs, normal maintenance and repairs were assumed. A rate similar to that used in other related studies of two percent annually was applied to the

TABLE 5.--Depreciation costs for four model commercial feedlots, Kansas, 1961

Item	Model							
	I		II		III		IV	
	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill
	(dollars)							
Machinery and equipment	2,140	2,140	4,409	4,409	6,025	6,025	8,574	8,574
Feed yards	1,945	1,945	3,279	3,279	7,015	7,015	11,280	11,280
Feed storage	628	628	1,406	1,406	3,360	3,360	5,595	5,595
Office, shop, and scales	355	355	666	666	1,533	1,533	2,038	2,038
Feedmill	4,228	5,245	6,315	9,676	12,464	14,326	19,488	17,020
Total depreciation	9,296	10,313	16,075	19,436	30,397	32,259	46,975	44,507
Cost per head per day[a]	0.01033	0.01146	0.00893	0.01080	0.00704	0.07470	0.00652	0.00618

[a]Assumed feedlot is operated at normal capacity.

original investment cost for those items under consideration.[32] Maintenance and repair costs for machinery and equipment and the feedmill equipment were considered as variable costs and will be covered in a later section. As the degree of utilization of a given size feedlot is increased, machinery, equipment and feedmill equipment will be used more intensively, relative to other capital investment items, thereby causing their maintenance and repair expenditure to be more of a function of output rather than time.

Maintenance and repairs expressed in costs per head per day decreased as size of the feedlot increased for both sample and "designed" feedmill investments. They were lower for Models I, II, and III and higher for Model IV with the "sample" feedmill than those characterized by the "designed mill." Maintenance and repairs for the "sample" feedmill capital investment ranged from $.00124 to $.00100 per head per day as the size of the feedlot increased from 2500 to 20,000 head while operating at 100 percent capacity. Table 6 summarizes the maintenance and repair expenditures for the four models.

Interest

Interest is a cost whether capital is borrowed or not. If it is borrowed, interest is the payment to the lender. If capital invested in a commercial feedlot is not borrowed, an opportunity cost is involved which would be the return on this capital if it were invested in another enterprise of approximately equal risk. For the calculation of interest on fixed

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[32]Harry G. Gilliam, L. A. Ihnen, and W. D. Toussaint, An Economic Analysis of Selected Systems for Feeding Beef Cattle in North Carolina, A. E. Information Series No. 112 (Raleigh: North Carolina State of the University of North Carolina, April 1964) and King, loc. cit.

TABLE 6.—Maintenance and repair costs for four model commercial feedlot, Kansas, 1961

Item	Model							
	I		II		III		IV	
	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill
	(dollars)							
Feed yards	689	689	1,197	1,197	2,613	2,613	4,236	4,236
Feed storage	206	206	473	473	1,128	1,128	1,878	1,878
Office, shop, and scales	143	143	266	266	613	613	815	815
Feedmill building	80	84	92	134	181	190	283	200
Total maintenance and repairs	1,118	1,122	2,028	2,070	4,535	4,544	7,212	7,129
Cost per head per day[a]	0.00124	0.00125	0.00113	0.00115	0.00105	0.00105	0.00100	0.00099

[a]Assumed feedlot is operated at normal capacity.

investment in this study, a rate of five percent was used.[33] This seems to be in agreement with that used in comparable cost studies.[34]

The interest rate was applied to one-half the initial investment of all capital items except land, in which case it was applied to the full investment cost.[35] This is based on the assumption that the capital investment of a feedlot becomes less as the feedlot ages because part of the investment has been written off as depreciation. This means that over the life of these items, the investment has varied from full value to zero.[36] In cents per head per day interest costs on capital investment using the "sample" feedmill investment were .41, .33, .26, and .24 for Models I-IV respectively operating at full normal capacity (Table 7).

Taxes

Property taxes include personal property and real estate taxes. Included in the former was all machinery and equipment items and the feedmill equipment investment. Cattle were considered as a variable cost item and taxes for them will be discussed later. Real estate included the feedmill building, feed yards, feed storage facilities, office, shop, and scales.

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[33]Rate was recommended by Kansas State University Farm Management Specialists.

[34]John H. McCoy, "Grain Storage Policy with Particular Reference to Cost of Storing Wheat in Kansas," (unpublished Ph.D. dissertation, University of Wisconsin, 1955); Bressler, loc. cit.; and Henry D. Wakefield, "Economies of Scale in Farmer Operated Cattle Feedlots, Kansas," (unpublished Master's dissertation, Kansas State University, 1964).

[35]Related studies in which this approach has been used are: Bressler, loc. cit., pp. 51-52; Jones, loc. cit., p. 38; Consumers Cooperative Association, loc. cit., p. 28; Wakefield, loc. cit., p. 48.

[36]More precisely, investment in most items would vary from full value to some salvage value but that was not considered in this analysis.

TABLE 7.—Interest costs for four model commercial feedlots, Kansas, 1961

Item	Model							
	I		II		III		IV	
	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill
	(dollars)							
Original cost of investment	132,550	142,820	222,385	257,055	426,480	445,330	657,080	630,280
Present value of investment[a]	73,235	78,370	118,618	135,953	221,980	231,405	338,780	325,380
Interest on investment	3,662	3,919	5,931	6,798	11,099	11,570	16,939	16,269
Cost per head per day[b]	0.00407	0.00435	0.00330	0.00378	0.00257	0.00268	0.00235	0.00226

[a]Present value equals one-half original investment of all items except land. Total original investment of land was used.

[b]Assumed feedlot is operated at normal capacity.

Personal and real property taxes were determined by applying an average mill levy to estimated assessed valuation. The average levy of Kansas rural areas for 1961 as determined by the Property Valuation Department, State of Kansas, was 50 mills per dollar assessed valuation (one mill equals one-tenth of one cent). Rural real estate in Kansas for the year 1961 was assessed at 22 percent of its current valuation.[37] Personnel of Kansas State University Department of Economics recommended assessment of personal property at 33 percent of current valuation for the same time period. Similar to the derivation of interest, the current value of real and personal property is one-half of the initial investment of all items except land. Such provides an average value of property over time.

Total annual tax costs and per head per day tax costs for all models of both feedmill investment derivation are shown in Table 8. Total annual tax costs ranged from a low of $978 for Model I to a high of $4,485 for Model IV. The costs expressed in cents per head per day were the lowest for Models I, II and III of the "sample" feedmill capital investment; but, Model IV in this category was higher than Model IV of the investment derivation designated as the "designed" feedmill.

Insurance

Information concerning insurance costs was obtained from independent insurance agencies. There is no set amount of coverage for the perils insured against nor premium rates for commercial feedlots. In practice, each feedlot is analyzed separately and policies are written individually according to the location, value distribution, age and type of construction

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[37]Kansas, Property Valuation Department, Report of Real Estate Assessment Ratio Study State of Kansas, (Topeka, 1961), p. 2.

TABLE 8.—Real and personal property tax costs for four model commercial feedlots, Kansas, 1961

Item	Model							
	I		II		III		IV	
	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill
	(dollars)							
Assessed value of real property[a]	9,203	9,225	14,404	14,637	23,795	28,845	44,168	43,713
Assessed value of personal property[b]	10,364	12,025	17,538	22,909	30,061	33,096	45,546	41,806
Total assessed value	19,567	21,250	31,942	37,546	58,856	61,941	89.714	85,519
Annual property tax[c]	978	1,062	1,597	1,878	2,943	3,097	4,485	4,276
Property tax in cost per head per day[d]	0.00109	0.00118	0.00089	0.00104	0.00068	0.00072	0.00062	0.00039

[a]Based on 22 percent of present value.

[b]Based on 33 percent of present value.

[c]Based on 50 mills for each dollar of assessed value.

[d]Assumed feedlot is operated at normal capacity.

of physical property and number of employees involved (payroll of employees affects liability rate). Therefore, it is difficult to specify general premium rates that would apply to a particular feedlot. However, the insurance agency was able to supply general rates as a guide applicable to the industry.

The insurance information supplied was based on the assumption that coverage would be on the basis of 80 percent of "actual cash value" of the property. The perils considered to be covered were fire, lightning, and extended coverage. Extended coverage included windstorms, hail, explosion, riot, riot attending a strike, civil commotion, aircraft, vehicles and smoke.

The description of the type of property insured and rates are as follows:

(1) physical property which includes all buildings and most feed yard items except fences and chutes; net premium $1.471 per $100 insured,

(2) all feed and personal property normally stored in buildings and bins excluding mobile agricultural equipment and licensed vehicles; net premium $1.414 per $100 insured;

(3) fences and chutes that are entirely incombustible; net premium $0.236 per $100 insured;

(4) mobile agricultural equipment not licensed for road use, such as tractors, wagons, etc.; net premium $0.70 per $100 insured;

(5) licensed vehicles including feedtrucks, pickup trucks, etc., net premium for only liability $16.40 per vehicle.

Fixed insurance costs excluded cattle insurance and legal liability. Cattle insurance varies with the number of cattle on hand and legal

TABLE 9.--Insurance costs for four model commercial feedlots, Kansas, 1961

Item[a]	Model							
	I		II		III		IV	
	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill
	(dollars)							
Insured value of physical property[b]	8,520	8,600	16,042	16,890	36,449	36,632	58,803	57,148
Insured value of contents[c]	43,878	47,906	78,753	91,773	176,248	183,604	284,862	275,796
Insured value of fences and chutes	4,040	4,040	6,636	6,636	13,908	13,908	22,192	22,192
Insured value of mobile agricultural equipment[d]	3,232	3,232	6,760	6,760	7,080	7,080	10,352	10,352
Insured value of licensed vehicle[e]	4,952	4,952	10,420	10,420	16,289	16,289	22,945	22,945
Total insured value	64,622	68,730	118,611	132,479	249,974	257,513	399,154	388,433
Insurance costs of personal property	125	127	236	248	536	539	865	841
Insurance costs of contents	620	677	1,114	1,298	2,492	2,596	4,028	3,900
Insurance costs of fences and chutes	10	10	16	16	33	33	52	52
Insurance costs of mobile agricultural equipment	23	23	47	47	50	50	73	73
Insurance costs of licensed vehicles	49	49	98	98	148	148	213	213
Total insurance costs	827	886	1,511	1,707	3,259	3,366	5,231	5,079
Insurance costs per head per day[f]	0.00092	0.00098	0.00084	0.00095	0.00075	0.00078	0.00073	0.00071

[a]All items insured at 80 percent of actual cash value.

[b]Includes all buildings and all feed yard items except land, concrete feed bunks and aprons.

[c]Includes one month's supply of grain and hay; infirmary, shop tool and feedmill equipment; and scales.

[d]Includes tractors, self-unloading wagon, flat-bed wagon, and silage loader.

[e]Includes pickup, standard feed and grain trucks.

[f]Assumed feedlot is operated at normal capacity.

liability (both contractors and workmen's compensation) vary with the number of employees. Both will be considered under variable costs. Insurance costs are summarized in Table 9. They range from a low of $827 to a high of $5,231. The per unit costs in cents per head per day decline as the size of each model is expanded. They are also shown in Table 8.

Management and Office

Wages of management and office expenses were combined as one cost mainly because it was difficult to get a distinct differentiation of the two from records of operators interviewed. In the smaller commercial feedlots many of the duties of the manager include clerical duties. As the size of the lot increases, office work becomes more time-consuming and additional office help is required. Office help in commercial feedlots is often employed on a monthly basis rather than annually.

Management and office expenses were computed by regression analysis as previously discussed. Data were obtained from the sample feedlots. The correlation coefficient, i.e., r, for this relationship was .81346 (Equation 22, Appendix Table 2).

The expenses for management and office are summarized in Table 10. They contributed the greatest proportion of the total fixed cost items for this study.

TABLE 10.--Management and office costs for four model commercial feedlots

Item	Model			
	I	II	III	IV
	(dollars)			
Annual management and office costs	7,674	13,151	28,488	46,015
Management and office costs per head per day	.00853	.00731	.00659	.00639

VARIABLE COSTS

Variable costs of commercial feedlots are costs which vary with output. No variable costs would be incurred at zero output, but these costs arise as soon as there is any output. Few, if any, of the cost elements involved in commercial feedlots vary in an exactly proportionate manner.[38] For example, the cost of electricity for a 20,000 head feedlot is not likely to be four times greater than the cost for a 5,000 head feedlot. Lumpiness of inputs also has an effect on the perfect variability of output.[39] Although hired labor theoretically can be divided into one-half or three-fourth man-units depending upon hourly employment, the one man increment is the usual practice.

Total variable costs may increase at an increasing, decreasing or constant rate as output increases. The per unit costs associated with these three types of variable costs would thereby imply increasing, decreasing, and constant costs respectively, as output increases. All three types of relationships were experienced in this study for various items of expense.

The variable costs encountered in this study were: veterinary, insecticides, dues (fees and subscriptions), trucking (other than cattle), maintenance and repairs of machinery and equipment and feedmill, electricity, fuel, taxes on cattle, interest on cattle, insurance on cattle, liability insurance on the feedlot, death loss, and hired labor. Antibiotics and feed additives were not included in this study as they were considered to be feed elements and this analysis is confined to non-feed costs.

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[38] Baum, Faris, and Walkup, loc. cit., p. 19.

[39] Bressler, loc. cit., p. 24.

Miscellaneous expenses such as telephone and bedding were of relatively minor importance on the sample feedlots and were excluded from this study. Buying, selling, and trucking cattle are nonfeed costs to the commercial feedlot. However, they are considered as questionable nonfeed costs by some since they are "off" feedlot expenses rather than the conventional costs usually associated with commercial feedlot firms and, therefore, will be analyzed separately in a later section.

Variable costs were determined for the five degrees of utilization discussed earlier (i.e., 25, 50, 75, 100 and 125 percent respectively) for each variable cost item. Veterinary, insecticides, dues, trucking (other than cattle), maintenance and repairs of machinery and equipment and feed-mill equipment, electricity, and fuel costs were obtained from the survey data of sample feedlots. For each of these items, records were obtained for the year 1961. The amount of such expense could be obtained directly from entries in the operators' records.

These costs were adjusted where necessary, to make them equivalent to full normal capacity utilization (i.e., 100 percent capacity). The feedlot operator was then asked to estimate the degree to which each cost item would vary from the amount of full capacity utilization if he operated at 25 percent, 50 percent, 75 percent, and 125 percent of capacity. This particular information was recorded on a percentage basis. For example, assume a situation where it had been established that at full normal capacity (i.e., 100 percent) utilization, electricity expense was $2,000. The operator was then asked to estimate the fraction (or percentage when this facilitated the response) that electricity expense would be if he operated at one-fourth of capacity, one-half of capacity, etc. These estimates were based, where possible, on records of previous cattle feeding operations where varying degrees of capacity utilization were experienced by the feedlot manager.

The survey information on these variable cost items were summarized by simple regression techniques to obtain average relationships between (A) the dollar amount of an expense where operating at normal capacity and size of lot, and (B) degree of utilization and cost for a particular item.

Before any attempts were made to fit functions to the survey data, scatter diagrams were studied to determine the nature of the relationships (i.e., linear or curvilinear). The observations indicated linearity in each case but with varying slopes.

Two equations were formulated for each of the 7 above mentioned variable cost items. One equation was utilized for estimating the dollar cost of that item for each of the four models when operating at full normal capacity. The second equation was utilized to estimate the proportion by which each item varied from the full capacity cost when a given size model was operating at various degrees of utilization. The coefficients of determination (R^2) for the second set of equations were better than for the first set. Values for R^2 in the first varied from 34 percent for maintenance and repairs of machinery and equipment and feedmill to 54 percent for veterinary expenses. The range in the second set was from approximately 30 percent for dues (fees and subscriptions) to 93 percent for trucking (other than cattle). Derived values for these equations and details are given in Appendix Table 5. The equations are referred to as A and B respectively.

Information concerning taxes on cattle, interest on cattle, insurance on cattle, and liability on the feedlot was obtained from tax specialists, lending institutions, and insurance agencies. Death loss was estimated by feedlot managers to average about one percent of the total number of cattle handled. Labor requirements were obtained from the survey schedules. The average amount of time allocated to each job within the feedlot was determined. Total labor costs were determined by applying rates appropriate to Kansas conditions.

Veterinary Expense

Veterinary costs were one of the two variable cost items that showed slightly increasing per unit costs. The costs expressed in cents per head per day at 100 percent capacity were 23.8, 27.2, 29.1, and 29.7 respectively for the four models. One possible interpretation of these results is that as feedlot size increases, not only are more veterinarians needed, but also ones that are more qualified. Annual veterinary costs are shown in Table 11.

TABLE 11.--Annual veterinary costs for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(dollars)			
125	2,586	5,895	15,161	25,751
100	2,144	4,888	12,571	21,352
75	1,705	3,886	9,994	16,975
50	1,263	2,879	7,404	12,576
25	823	1,877	4,827	8,199

Insecticide Expense

Insecticide costs were one of the smaller variable costs in terms of dollar amounts in all feedlots. As shown in Table 12 insecticide costs ranged from $710 in Model I to $4,651 in Model IV while operating at 100 percent capacity.

TABLE 12.—Annual insecticide costs for four model commercial feedlots

Percent of capacity utilization	Model I	Model II	Model III	Model IV
(percent)	(dollars)			
125	868	1,556	3,482	5,684
100	710	1,273	2,849	4,651
75	552	990	2,217	3,619
50	395	708	1,584	2,586
25	236	424	949	1,549

Dues, Fees, and Subscriptions Expense

Dues, fees, and subscriptions was the smallest variable cost item for all models. Every feedlot indicated some costs for this item. Table 13 gives the dues, fees, and subscription costs for all models at all degrees of utilization.

TABLE 13.—Annual dues, fees, and subscription costs for four model commercial feedlots

Percent of capacity utilization	Model I	Model II	Model III	Model IV
(percent)	(dollars)			
125	186	337	761	1,247
100	185	335	756	1,238
75	184	333	751	1,229
50	182	330	745	1,221
25	181	328	741	1,213

Trucking (other than cattle) Expense

Trucking (other than cattle) does not include the trucking cost of cattle, but rather encompasses primarily feed transporting costs. Trucking cattle cost is primarily a function of feedlot location with respect to buying-selling markets and will be analyzed separately. In this study diseconomies of scale were indicated with the expense considered in this section. The per unit costs starting with Model I were .393, .441, .469, and .477 cents per head per day at normal capacity. A possible explanation for this phenomenon is that in order to meet increasing total feed requirements as size increases, it may be necessary to haul greater distances with resultant increases in cost. Other trucking costs are presented in Table 14.

TABLE 14.—Trucking (other than cattle) costs for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(dollars)			
125	4,355	9,771	24,936	42,268
100	3,535	7,931	20,240	34,308
75	2,718	6,099	15,565	26,383
50	1,902	4,267	10,889	18,458
25	1,085	2,435	6,214	10,533

Equipment—Maintenance and Repair Expense

Maintenance and repair costs for machinery and equipment and the feedmill are more of a function of use rather than time. If the feedmill is operated at near normal capacity, maintenance and repair costs will be greater than if it were operated at less than normal capacity. Maintenance and repair costs as derived from the survey schedules with the aid of the two equations earlier discussed are given in Table 15.

As a percentage of machinery, equipment and feedmill investment, maintenance and repair costs not only increased with the degree of utilization, but also with the size of the feedlot. This is evident in Table 16.

TABLE 15.--Annual equipment-maintenance and repair costs for four model feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(dollars)			
125	3,239	6,014	13,788	22,672
100	3,041	5,647	12,946	21,288
75	2,843	5,280	12,105	19,904
50	2,643	4,907	11,250	18,499
25	2,445	4,540	10,409	17,116

TABLE 16.--Maintenance and repair costs as a percent of machinery, equipment and feedmill investment for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(percent)			
125	4.8	5.4	7.2	7.8
100	4.5	5.1	6.8	7.3
75	4.3	4.8	6.3	6.9
50	4.0	4.4	5.9	6.4
25	3.7	4.1	5.4	5.9

Electricity Expense

Electricity plays an important role in the operation of a commercial feedlot. Its major use lies in the functioning of the feedmill and in the utilization of the water distribution system. Among variable costs it ranks about ninth in annual dollar expenditures, i.e., not the most important. Annual electricity costs varied from $1,682 for Model I to $10,554 for Model IV under normal capacity operation conditions. Expressed in cents per head per day, electricity costs varied from .187 to .147 for the same models operating under the same capacity levels. Electricity costs are given in Table 17.

TABLE 17.--Annual electricity costs for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(dollars)			
125	1,912	3,353	7,388	12,000
100	1,682	2,949	6,498	10,554
75	1,453	2,548	5,614	9,119
50	1,223	2,144	4,724	7,673
25	994	1,743	3,840	6,237

Fuel Expense

Although higher than electricity, fuel costs were still not a major variable cost item. Gasoline, oil, and diesel fuel are used primarily by the feed trucks, standard trucks, and tractors. Fuel costs are summarized in Table 18. Fuel costs in cents per head per day for the four models operating at full normal capacity amounted to .330, .277, .246, and .237 respectively.

TABLE 18.--Annual fuel costs for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(dollars)			
125	3,482	5,840	12,446	19,993
100	2,968	4,979	10,610	17,044
75	2,452	4,113	8,764	14,078
50	1,938	3,251	6,928	11,130
25	1,625	2,390	5,093	8,181

Taxes on Cattle Expense

Cattle are considered as personal property. The same rates that were used in obtaining fixed tax costs were applicable in obtaining tax costs for cattle. The cattle were assumed to be assessed at one-third of current value and a tax levy of 50 mills per dollar assessed valuation was utilized. Feeder cattle were assumed to be between one and two years of age and were valued at $150 per animal.

Essentially there are two alternatives in which cattle can be reported for taxation in Kansas. One is the number of cattle in the feedlot as of January 1. The other is the average monthly inventory of cattle for the tax year. Since it was assumed that each model feedlot would be operated at a consistent level of capacity for the entire year, there was no preference of alternative. The average number of cattle in the feedlot for the year would always equal the number of cattle in the feedlot at one time.

Taxes on cattle was an important variable cost item. Total annual tax costs are given in Table 19. On a per unit basis (e.g., per head) taxes on cattle do not vary with scale of operation, nor with degree of utilization of a given size feedlot.

TABLE 19.--Annual tax costs for cattle for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(dollars)			
125	7,813	15,625	37,500	62,500
100	6,250	12,500	30,000	50,000
75	4,688	9,375	22,500	37,500
50	3,125	6,250	15,000	25,000
25	1,563	3,125	7,500	12,500

These annual tax costs were calculated by the following equation:

$y = a\ b\ c\ d$

where, y = annual tax cost

a = current value of cattle ($150)

b = number of cattle fed (varies with scale and degree of utilization)

c = assessed value of cattle (.33) and

d = tax levy per dollar assessed valuation (50 mills).

<u>Insurance on Cattle Expense</u>

Cattle are usually insured under a policy calling for the values of the number of cattle on hand each month. Since the owners of the cattle are responsible for cattle insurance, this enables each to pay only for the actual exposure on hand. For purposes of this study, it was assumed that the feedlot would be filled at a consistent capacity level for the entire year regardless of who owned the cattle. Therefore, the monthly charge was multiplied by 12 to obtain an annual charge. Information provided by independent insurance agencies, referred to in a previous section indicated that the monthly rate was subject to variation, depending upon particular feedlots under consideration. If the feedlot was relatively free from a flood area, major highway, etc., it was in contention for a good merit rating and the higher the rating the lower would be the insurance rate. A rate of $.07 per month per $100 insured was used for purposes of this study. The perils considered to be covered were: (1) death or destruction resulting from fire and lightning, windstorm, cyclone, tornado, hail, earthquake, flood, etc., and (2) theft. Each animal was considered to be insured for $150.

Per unit insurance costs (in cents per head per day) were constant at .35 for all models operating at all capacities. Annual insurance costs on cattle are given in Table 20. They were derived from the following equation:

$$y = \frac{a}{d} bc$$

where, y = total annual insurance cost,

a = insured value of animals ($150)

b = insurance rate for 12 months ($.07 x 12 = $.84) per $100 insured valuation

c = number of cattle fed (varies with scale and degree of utilization)

and

d = $100

TABLE 20.—Annual insurance costs on cattle for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(dollars)			
125	3,938	7,875	18,900	31,500
100	3,150	6,300	15,120	25,200
75	2,363	4,725	11,340	18,900
50	1,575	3,150	7,560	12,600
25	788	1,575	3,780	6,300

Interest on Cattle Expense

Interest on cattle investment made up the largest variable cost item in this study comprising approximately 32 percent of total variable costs when the feedlot was operated at 100 percent capacity. Expressed on a per unit basis, interest exemplifies a constant cost. Interest costs were calculated by applying a rate of 6 percent to an estimated value of $150 for each animal. The annual interest costs as shown in Table 21 were determined by the equation

$$y = a\ b\ c$$

where, y = total annual interest cost

a = estimated value of each animal ($150)

b = number of cattle fed (varies with scale and degree of utilization)

and,

c = interest rate (6 percent).

TABLE 21.--Annual interest on cattle costs for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(dollars)			
125	23,125	56,250	135,000	225,000
100	22,500	45,000	108,000	180,000
75	16,875	33,750	81,000	135,000
50	11,250	22,500	54,000	90,000
25	5,625	11,250	27,000	45,000

Feedlot Liability Insurance Expense

Most commercial feedlot insurance policies include what is referred to as legal liability and workmen's compensation coverage. Both were considered as variable costs since the rates were charged for each $100 of payroll. They were combined in this analysis to comprise the total feedlot liability insurance cost.

Legal liability is made up of two major divisions, bodily injury and property damage. Indicated below is the coverage included and the applicable rate:

(1) bodily injury includes $50,000 for each person plus $10,000 for each accident;

(2) property damage includes $25,000 for each accident;

(3) rate was .395 for each $100 payroll.

Workmen's compensation covers the statutory limits set by the State Compensation Bureau. The rate is $1.40 for each $100 of payroll.

Annual feedlot liability insurance extended from $228 for Model I operating at 25 percent capacity to $1,741 for Model IV while functioning at 125 percent capacity (Table 22).

TABLE 22.--Annual legal liability insurance costs for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(dollars)			
125	290	546	1,230	1,741
100	274	517	1,163	1,648
75	259	487	1,097	1,554
50	244	459	1,032	1,462
25	228	429	965	1,368

Death Loss Expense

Death loss was estimated at one percent of the number of cattle fed. This corresponds to the average level obtained from the sample feedlots. The value of each animal was assumed to be $150.

Several assumptions in this study with respect to time periods were: (1) each feedlot was to be operated 360 days annually, and (2) each animal was to be fed for a period of 140 days. This was based on an average turnover of 2.57 for commercial feedlots as obtained from the sample feedlots. These assumptions are relevant in the determination of costs associated with death loss. Annual death loss costs can be explained by the equation y = a b c d

where, y = total annual death loss cost,

a = number of cattle fed at a given time (varies with scale and degree of utilization),

b = turnover (2.57),

c = value of each animal ($150), and

d = percent of cattle subject to death loss (one percent).

Annual death loss costs which are shown in Table 23 were the third most expensive variable cost item. They were $9,638, $19,275, $46,260, and $77,100 for the four models starting with the smallest when operating at 100 percent capacity. A constant daily death loss cost per head of $.01071 was obtained for each model at each capacity level.

TABLE 23.--Annual death loss costs for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(dollars)			
125	12,048	24,094	57,825	96,375
100	9,638	19,275	46,260	77,100
75	7,229	14,456	34,695	57,825
50	4,819	9,638	23,130	38,550
25	2,410	4,819	11,565	19,275

Hired Labor Expense

Hired labor costs comprised the second largest variable cost item when the feedlot was operating at full normal capacity as it was responsible for 20 percent of the total variable cost. These costs were developed by applying hourly wage rates to estimated man-hour requirements for the jobs: (1) feeding, (2) feed processing, (3) watering, (4) observing, (5) treating sick animals, (6) manure and grain hauling, (7) repair, maintenance, and service, and (8) working cattle. The number of man-hours allocated to each is given in Table 24. These hours are averages of all feedlots as obtained from the survey schedules and must be considered as approximations since no detailed time and motion study was conducted. Further, it is difficult for feedlot managers to draw arbitrary lines between various jobs as there is much overlapping.

TABLE 24.--Estimated man-hours of labor for four model commercial feedlots

Item	Model			
	I	II	III	IV
	(hours)			
Feeding	6.93	14.00	27.03	44.30
Feed processing	5.01	11.17	17.03	32.38
Watering	.99	1.67	7.28	7.48
Observing	3.80	4.67	13.63	20.18
Treating sick animals	.66	4.50	6.39	9.84
Manure and grain hauling	4.13	7.33	21.08	27.62
Repair, maintenance and service	5.71	6.50	32.13	35.26
Working cattle	4.01	5.17	14.69	21.96
Total	31.24	55.01	139.31	199.20

The total number of hours for each model divided by the number of hours in each working day (10 hours per day) provided information as to the total number of laborers per model. For example, Model I would require 3.124 laborers or 3, since man is considered as a discrete input. Similarly 6, 14, and 20 laborers would be required for Models II, III, and IV.

Applying hourly rates of $1.75 for feedmill foremen and $1.25 for all other employees, labor costs at full normal capacity for all models were determined. Each model was assumed to have one feedmill foreman who was in charge of the operation of the feedmill. Costs at levels other than 100 percent or normal capacity were determined by the regression equation discussed earlier. (Equation B, Appendix Table 5) Annual labor costs are shown in Table 25. Labor costs per head per day were $0.01700, $0.01600, $0.01500, and $0.01275 for Models I-IV respectively.

TABLE 25.--Annual total hired labor costs for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(dollars)			
125	16,172	30,442	68,494	97,033
100	15,300	28,800	64,800	91,800
75	14,428	27,158	61,106	86,567
50	13,571	25,546	57,478	81,427
25	12,699	23,904	53,784	76,194

AVERAGE COST RELATIONSHIPS

Total costs are the sum of fixed and variable costs. Total costs are presented in Appendix Table 6 for all models at all levels of plant utilization for both sources of feedmill costs. Since a better understanding of the cost structure of commercial feedlots can be obtained from per unit costs, a common divisor had to be incorporated. In the cattle feeding industry there are numerous indexes e.g., costs per day, costs per head, costs per head per day, costs per pound gain, etc. In this study only the unit costs of per head per day and per pound gain were analyzed since they appeared to be the ones in which the industry is most concerned.

In determining costs per head per day, total annual costs were divided by the annual number of animal days. Animal days can be computed several ways: (1) it is the product of the number of cattle on feed on any given day and the number of days the yard is operated annually, providing a constant number of head are on feed at all times. As an illustration, for Model I the animal days at normal capacity would be 2,500 head x 360 days = 900,000. (2) The alternative method takes into consideration, at least more explicitly, the feedlot turnover. It is the product of the number of cattle on feed on a given day, turnover, and number of days each animal is fed. For Model I again, total animal days at normal capacity would be 2,500 head x 2.57 x 140 days = 900,000.

The common divisor when considering cost per pound gain was the number of pounds of gain. Information obtained from the sample feed yards indicated an average of 2.72 pounds per head per day and the feeding period most commonly reported was approximately 140 days. Utilizing this information a total gain of 381 pounds per animal for the feeding period in each model was determined. The products of this figure and the number of cattle fed annually is the total number of pounds gain produced annually.

Average Total Costs Per Head Per Day

Degree of Feedlot Utilization

Average total non-feed costs per head per day for each of the four models of both feedmill investment derivations are summarized in Table 26 and illustrated in Figure 3. Table 27 gives the number of cattle fed annually for the four models at all levels of utilization assuming a turnover of 2.57. The degrees of utilization were used to locate five points on the short-run cost curve of each feedlot. These five points were connected with a continuous curve indicating approximate intermediate points.

TABLE 26.--Summary of non-feed costs in cents per head per day for four model feedlots

Percent of capacity utilization	Model I	Model II	Model III	Model IV
(percent)		Sample feedmill (cents)		
125	9.7	9.2	8.9	8.7
100	10.6	10.0	9.6	9.2
75	12.1	11.4	10.7	10.3
50	15.0	14.0	13.1	12.5
25	24.0	22.0	20.1	18.9
		Designed feedmill (cents)		
125	9.8	9.5	8.9	8.5
100	10.7	10.3	9.6	9.2
75	12.3	11.7	10.8	10.2
50	15.4	14.6	13.2	12.4
25	24.7	23.1	20.4	18.7

TABLE 27.--Total number of cattle fed annually four model commercial feedlots

Percent of capacity utilization	Model I	Model II	Model III	Model IV
(percent)		(number)		
125	8,031	16,063	38,550	64,250
100	6,425	12,850	30,840	51,400
75	4,819	9,638	23,130	38,550
50	3,213	6,425	15,420	25,700
25	1,606	3,213	7,710	12,850

It is apparent that degree of utilization has a pronounced influence on unit costs. Costs declined substantially as feedlot utilization was expanded from 25 percent capacity to 125 percent capacity for all models.

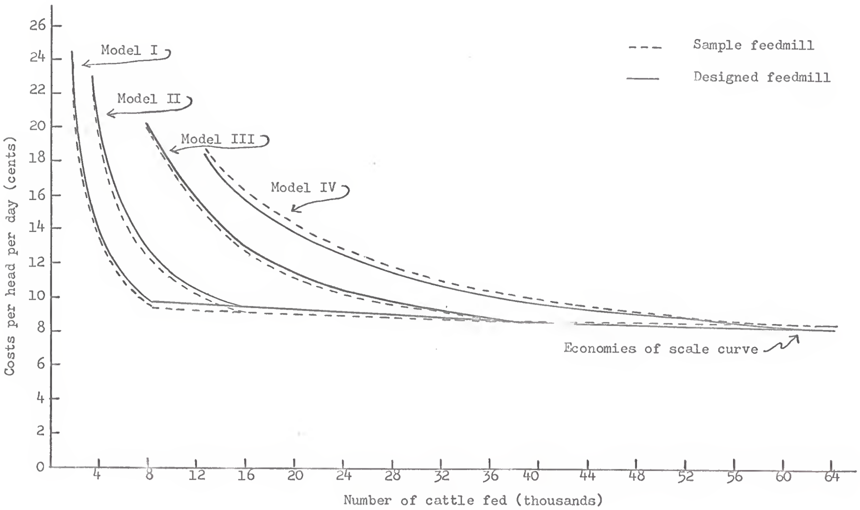

Figure 3.--Short-run average total cost curves for four model commercial feedlots with economies of scale curve, Kansas, 1961

In Model I, costs decreased from 24.0 cents per head per day at 25 percent capacity utilization to 9.7 cents at 125 percent utilization for the "sample" feedmill investment situation. The cost decline for this same model with the "designed" feedmill ranged from 24.7 to 9.8 cents per head per day.

The most substantial cost decline for each model occurred when plant utilization was increased from 25 percent to 50 percent of capacity. Costs continued to decline for each model up to 125 percent of capacity, but the rate of decline tapered off as degree of utilization increased.

Each short-run average total cost curve exhibits a declining trend throughout its entire length. The usual theoretical presentation of short run average total cost curves depict them as U-shaped. In this study it was expected that unit cost would tend to rise beyond 100 percent utilization of a given size feedlot but such was not the case. There are several possible explanations for this apparent departure from expected cost behavior. It is possible that feedlot managers misinterpreted the concept of capacity as explained by interviewers. Another possibility is that feedlot operators attempt to attain a degree of flexibility by providing some extra capacity in what they consider to be normal capacity.

Scale of Operation

Economies of scale were determined by constructing a curve tangent to the individual short-run cost curves. In this study the economies of scale curve was tangent at the low point of each short-run curve. Again, this does not conform to the usual illustration of the relationship between the two types of curves (pointed out in an earlier section) but the sample phenomenon has been observed in other empirical analysis.[40]

These data indicate that some economies may be obtained in the commercial feedlot industry as size of feedlots increase, at least within the range covered in this study. Per unit costs, expressed as cents per head per day, declined from 10.7 for Model I to 9.2 for Model IV when operating at normal capacity (100 percent) for the "designed" feedmill investments. This indicates a unit cost savings between the largest and smallest feedlot amounting to 1.5 cents per head per day. Results were essentially the same where "sample" feedmill data were used (top part of Table 26). While some economies of scale are indicated, it is apparent that the degree of utilization of a given size lot may have considerably greater effect on unit costs than size of operation.

In a previously mentioned California commercial feedlot study, economies of scale appeared more pronounced between the largest and smallest plants when operating at 100 percent capacity than they were in this study.[41] In that study, the non-feed cost for the smallest lot (3,760 head) was 7.19 cents per head per day while the largest (22,560 head) dipped to 5.57 cents. Although it is difficult to pinpoint the exact reason for the substantial cost differences between the largest and smallest feedlots in the two studies (i.e., whether it was due largely to the increasing per unit costs of some of the variable cost items in this study or for some other

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[40] Baum, Faris and Walkup, loc. cit.; E. L. Baum, R. D. Riley, and E. E. Weeks, Economies of Scale in the Operation of Can and Tank Milk Receiving Rooms, with Special Reference to Western Washington, Washington Agricultural Experiment Station Technical Bulletin 12 (Pullman: The State College of Washington of Agricultural Sciences, May 1954); Bressler, loc. cit.; King, loc. cit.; and Wakefield, loc. cit.

[41] King, loc. cit., p. 301

reason), the absolute difference with respect to each plant between the two studies can be partially explained. The California study did not take into consideration the cost of interest on cattle which in this Kansas study was the largest single cost item. Insecticides, dues, and trucking (other than cattle) costs used in this study were not included in the California study. Further, King used a higher rate of feedlot turnover which spreads fixed costs to a greater extent.

Average Total Cost Per Pound Gain

Degree of Feedlot Utilization

The derived costs per pound gain are presented in Appendix Table 6 and summarized in Table 28. The short-run average cost curves that correspond to each of the four models are illustrated in Figure 4. The influence of degree of utilization is apparent from the tables and illustration. As was true of costs per head per day, the greatest economies in costs per pound gain occurred with the degree of plant utilization. Those feedlots that can operate at or near capacity levels have apparent cost economies. Although cost economies resulted as plant utilization was increased for all models, the greatest occurred as the firm expanded its operation beyond 25 percent of capacity. At 25 percent utilization costs per pound gain for Models I and II were approximately 2.5 times average total cost at 125 percent utilization and for Models III and IV average total costs were nearly 2.2 times greater than those at 125 percent plant capacity.

The average total cost curves for the four models are of the same general shape as those determined on a cost per head per day basis. The reasons for such are expalined in the same manner as was the situation when costs per head per day were analyzed.

TABLE 28.—Summary of non-feed costs in cents per pound gain for four model commercial feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	Sample feedmill (cents)			
125	3.6	3.4	3.3	3.2
100	3.8	3.7	3.5	3.4
75	4.4	4.2	3.9	3.8
50	5.5	5.2	4.8	4.6
25	8.8	8.1	7.4	7.0
	Designed feedmill (cents)			
125	3.6	3.5	3.3	3.1
100	3.9	3.8	3.5	3.4
75	4.5	4.3	4.0	3.8
50	5.7	5.4	4.9	4.5
25	9.1	8.5	7.5	6.9

Scale of Operation

The analysis summarized in Table 28 and shown graphically in Figure 4 shows that economies of scale are present. The economies of scale between Model I and Model IV are more pronounced in those models employing the "designed" feedmill when 125 percent utilization is taken as a point of reference. At 100 percent they appear about equal with those of the "sample" feedmill. At normal (i.e., 100 percent) capacity non-feed costs for the "designed" feedmill models declined from 3.9 cents per pound gain for a 2,500 head feedlot to 3.4 cents for a 20,000 head operation—a decline of one-half cent.

The rate of cost decline as size of feedlot increases appears to be relatively uniform throughout the range encompassed in this study. While the rate of decline might be arbitrarily classified as relatively small, in view of possible variations in actual lot to lot operations, there is no

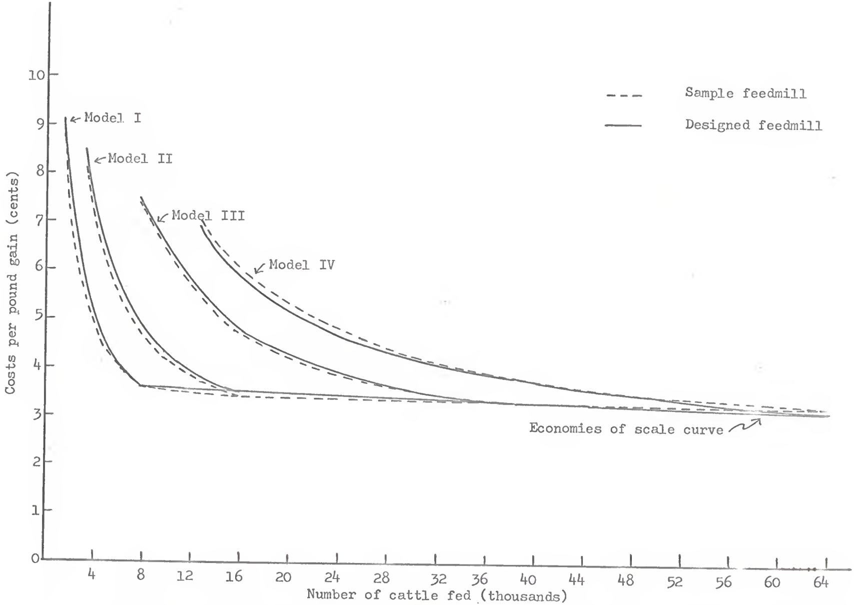

Figure 4.--Short run average total cost curves for four model commercial feedlots with economies of scale curve, Kansas, 1961

clear indication that costs are tending to level off. Presumably some further economies could be gained by sizes larger than envisioned in this study but this analysis is not designed to make such projections.

BUYING, SELLING, AND TRUCKING CATTLE COSTS

This section presents a description of those non-feed cost items that are usually considered to be apart from the actual feedlot entity. They, are, nevertheless, non-feed costs in addition to those presented in previous sections. These costs are shown in Appendix Table 7 for all levels of utilization. Similar to the other non-feed costs, the unit costs of cents per head per day and cents per pound gain were determined.

Buying and selling costs were supplied by those feedlots sampled. Regressions of an identical nature as those used in determining some of the other variable costs were utilized. Their statistical values are given in Appendix Table 5. Total annual buying cattle costs increased with output at an increasing rate thereby producing increasing per unit costs. Buying costs include such items as travel expenses involved in soliciting cattle, commission charges, and all other expenses incurred in obtaining cattle. Feedlot operators try to obtain as many cattle as possible in the near locality other things being equal, in order to minimize buying expenses. But as more cattle are demanded and because of either limited cattle supplies in a particular locality or limited contacts of feedlot operators, order buyers who are familiar with cattle markets in other areas are employed. This appears to be a reason for increasing unit buying costs.

Selling costs of those feedlots interviewed showed that as feedlot capacity increased total annual selling costs declined. As feedlot size reached a particular level, selling expenses became non-existent.[42] It is reasonable to believe that the larger commercial feedlots do not incur explicit selling costs. Several of the larger feedlot operators indicated that they avoid charges associated with selling cattle by shipping direct to packers.

Trucking costs are largely influenced by the distance that feedlots are located from feeder and finished cattle markets. Since there was much variation in the trucking costs of those feedlots sampled these costs were, therefore, budgeted in a different manner than those of buying and selling. A trucking distance of 100 miles was considered to be a reasonable average distance from feedlot to feeder and finished cattle markets. Many cattle are shipped large distances while on the other hand, many are purchased at local sales. Trucking costs were computed by using an original feeder weight of 700 pounds, a finished weight of 1,081 pounds and applying a shipping rate of 25 cents per hundred weight.

Buying, selling, and trucking cattle costs are summarized in Tables 29 and 30. Both unit costs of per head per day and per pound gain increased slightly with feedlot size at all capacity levels. Since per unit trucking costs were constant and per unit selling costs decreased with increases in feedlot size, the obvious reason for increasing unit costs of the three items aggregated was due to pronounced increasing average costs incurred in buying cattle. The total cost of buying, selling, and trucking cattle was in the neighborhood of 3 to 4 cents per head per day and approximately 1.5 cents in terms of cost per pound gain.

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[42] The regression equation used to derive selling costs would have produced negative results if extrapolated to a point beyond observed values but this was considered illogical.

TABLE 29.--Buying, selling and trucking cattle costs per head per day for four model feedlots

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(cents)			
125	3.7	4.0	4.2	4.3
100	3.8	4.1	4.3	4.3
75	3.8	4.1	4.3	4.4
50	3.9	4.3	4.5	4.6
25	4.1	4.6	4.9	5.0

TABLE 30.--Buying, selling, and trucking cattle costs per pound gain

Percent of capacity utilization	Model			
	I	II	III	IV
(percent)	(cents)			
125	1.4	1.5	1.6	1.6
100	1.4	1.5	1.6	1.6
75	1.4	1.5	1.6	1.6
50	1.4	1.6	1.6	1.7
25	1.5	1.7	1.8	1.8

SUMMARY

Substantial changes are taking place with respect to the cattle feedlot industry in Kansas. Although commercial feedlots were responsible for only 16 percent of the finished cattle in the state a decade ago, they presently account for approximately 49 percent. Kansas feedlots have become increasingly concerned with the two objectives of this study: (1) plant size and (2) degree of plant utilization associated with minimum costs.

Four model feedlots with sizes of 2,500, 5,000, 12,000 and 20,000 head, respectively, were budgeted for this study. A stratified sample of

26 commercial feedlots ranging in size from 1,000 to 25,000 head supplied information supplemented with that of university specialists, equipment dealers and lending and insurance agencies for determining the per unit costs of the four above models. Costs included capital investments (which took into consideration both a "designed" and "sample" feedmill so as to present a more detailed breakdown), conventional fixed costs of depreciation, interest, etc., and numerous variable costs such as veterinary, electricity, etc. Fixed and variable costs were totaled and converted into the per unit costs of cents per head per day and per pound gain for five capacity utilization levels. These levels were arbitrarily chosen as being 25, 50, 75, 100 and 125 percent. In reliance with information as obtained from the survey, it was assumed that the feeding period would be 140 days, turnover 2.57 and the gain per head would be 381 pounds.

The costs of buying, selling and trucking cattle were analyzed separately to show a more direct comparison between "on and off" feedlot costs.

On the basis of this study, it was found that degree of plant utilization is of primary importance in the commercial feedlot industry. With respect to both feedmill investments, the bulk of cost economies for both costs per head per day and per pound gain occurred when plant utilization was 75 percent of capacity. The most noticeable cost decline resulted when the firm pushed utilization past 25 percent of capacity.

In contradiction to economic theory, unit costs failed to increase after normal capacity had been reached. This may have been due to a misinterpretation of the term capacity on the part of feedlot operators or to the excess capacity that feedlot operators provide in their lots above actual normal capacity.

Economies of scale existed at normal and 125 percent capacity for both "sample" and "designed" feedmill derivations, although the economies were more pronounced in the latter case. For example, daily non-feed costs per head at 125 percent capacity utilization varied from 9.7 to 8.7 cents for the "sample" feedmill and 9.8 to 8.5 cents for the "designed" one, thus, indicating that larger feedlots are slightly more efficient than the smaller ones in Kansas. This is also true of other areas. For example, in California the larger lots "are so efficient that operators who own lots of 4,000 to 5,000 head capacity are closing them down and moving their cattle to larger lots."[43] The economies of scale, although small, did not tend to taper off, thus, perhaps indicating that further economies could be gained by sizes larger than analyzed in this study. However, this study cannot predict that a structural change in the commercial feedlot industry similar to that of California will occur in Kansas.

A similar pattern of cost behavior resulted when costs were determined on a per pound gain basis. At normal capacity, costs ranged from 3.9 to 3.4 cents for both feedmill investments.

Buying, selling and trucking cattle costs increased slightly with the size of feedlots for both average total cost derivations. Economies of these costs resulted only with increased degrees of plant utilization.

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[43] H. Louis Moore, "Big Changes in the Beef Industry," Farm Economics, The Pennsylvania State University and U. S. Department of Agriculture Cooperating (University Park: Cooperative Extension in Agriculture and Home Economics, June 1, 1965).

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APPENDIX

APPENDIX TABLE 1.--Sources of information and method used in determining the investment in specified items

Item	Sample survey data			Consultation with extension service personnel	Consultation with private industry representatives
	Regression analysis		Utilized subjectively with other information		
	Used exclusively	Used as a guide with other information			
Pickup truck		*	*	*	
Feed truck		*	*	*	*
Standard truck	*			*	
Grain truck				*	*
Tractor		*	*	*	
Self-unloading wagon			*	*	*
Silage loader		*	*	*	
Flat-bed wagon			*	*	
Infirmary equipment	*				
Shop tool equipment	*				
Land	*				
Fences	*				
Feedbunks	*				
Concrete aprons	*				
Waterers	*				
Water distribution system	*				
Chutes	*				
Oilers	*				
Sick animal pens & sheds	*				
Grain bin				*	
Hay shed			*	*	
Trench silo			*	*	
Office	*				
Cattle scale	*				
Truck scale		*	*	*	
Repair shop	*				
Feedmill	*		*	*	*

APPENDIX TABLE 2.--Statistical values for the simple linear regression equation considered in determining investments and management and office costs[a]

Item	Constant term "a"	Regression coefficient "b"	Standard error of regression coefficient	Correlation coefficient "r"
(1) Pickup truck	2,614	.04428	.21392	.10294
(2) Feed truck	3,188	1.17350	.40731	.71360
(3) Standard truck	2,512	.66746	.35248	.53377
(4) Tractor	2,820	1.22335	.40061	.66127
(5) Silage loader	616	.26120	.09905	.79675
(6) Infirmary equipment	220	.03646	.02000	.49768
(7) Shop tool equipment	1,432	1.30040	.19542	.21655
(8) Land	12,980	.37517	.89096	.11183
(9) Fences	3,383	2.31990	.39884	.88876
(10) Feedbunks	-67	2.81810	.49465	.88482
(11) Concrete aprons	3,198	2.84707	1.12931	.58844
(12) Waterers	1,806	.11617	.11786	.31218
(13) Water distribution system	-837	1.55283	.21907	.91325
(14) Chutes	225	.27735	.08579	.71494
(15) Oilers	1,074	.14589	.37970	.15496
(16) Sick animal pens & sheds	272	.06243	.02429	.83001
(17) Office	730	.21912	.23690	.41976
(18) Cattle scale	1,568	.30348	.22738	.37332
(19) Truck scale	-419	1.18507	.32384	.85331
(20) Repair shop	-992	.77241	.38013	.76103
(21) Feedmill	2,013	12.66093	6.05423	.57186
(22) Management and office	2,196	2.19095	.49537	.81346

[a]Equation is of the form $y = a + bx$ where,
y = dollar cost of the particular item,
a = a constant term,
b = regression coefficient and
x = number of head of cattle in each model when operated at normal capacity (i.e., 2,500, 5,000, 12,000 and 20,000).

APPENDIX TABLE 3.--Investment costs for four model feedlots, Kansas 1961

Item	Model I Number capacity	Model I Cost	Model II Number capacity	Model II Cost	Model III Number capacity	Model III Cost	Model IV Number capacity	Model IV Cost
Mach. & equip.:								
Pickup truck	1, 1/2T	$ 2,200	1, 1/2T	$ 2,200	1, 1/2T	$ 2,200	2, 1/2T	$ 3,500
Feed truck	1, 3T	6,000	2, 3T	10,000	4, 3T	20,000	6, 3T	30,000
Standard truck	1, 2-4T	4,180	2, 2-4T	5,850	3, 2-4T	10,520	4, 2-4T	15,860
Grain truck	------	---	1, 4-6T	8,000	1, 4-6T	8,000	1, 4-6T	8,000
Tractor	2	5,880	2	5,880	2	5,880	2	5,880
Tract-type tractor	------	---	1	7,500	1	8,500	2	17,000
Self-unloading wagon	1, 3-5T	1,400	1, 3-5T	1,400	1, 3-5T	1,400	------	---
Silage loader	------	---	1	1,920	1	1,920	1	3,000
Front loader	1	600	------	---	------	---	------	---
Flat-bed wagon	1	200	1	200	------	---	------	---
Infirmary equipment	------	310	------	400	------	660	------	950
Shop tool equipment	------	1,760	------	2,080	------	2,990	------	4,030
Total mach. & equip.	------	22,530	------	45,430	------	62,070	------	88,220
Feed yards:								
Land	------	13,920	------	14,850	------	17,480	------	20,480
Fences	------	9,180	------	14,980	------	31,220	------	49,780
Feed bunks	------	6,980	------	14,030	------	33,750	------	56,300
Concrete aprons	------	10,320	------	17,430	------	37,360	------	60,140
Waterers	------	2,100	------	2,390	------	3,200	------	4,130
Water-distribution system	------	3,050	------	6,930	------	17,800	------	30,220
Chutes	------	920	------	1,610	------	3,550	------	5,700
Oilers	------	1,440	------	1,800	------	2,820	------	3,990
Sick animal pens and sheds	------	430	------	580	------	1,020	------	1,520
Total feed yards	------	48,340	------	74,600	------	148,200	------	232,260

APPENDIX TABLE 3.--Continued

Item	Model I Number capacity	Model I Cost	Model II Number capacity	Model II Cost	Model III Number capacity	Model III Cost	Model IV Number capacity	Model IV Cost
Feed storage:								
Grain bin	30,000B	$ 7,500	60,000B	$ 18,000	143,000B	$ 42,900	238,000B	$ 71,400
Hay shed	37, 5T	560	75T	1,125	180T	2,700	300T	4,500
Trench silo	4,500T	2,250	9,000T	4,500	21,600T	10,800	36,000T	18,000
Total feed storage	------	10,310	------	23,625	------	56,400	------	93,900
Office, shop & scales:								
Office	------	1,280	------	1,830	------	3,360	------	5,110
Cattle scale	1	2,330	1	3,080	1	5,210	1	7,640
Truck scale	1	2,540	1	5,510	1	13,800	1	16,000
Repair shop	------	940	------	2,870	------	8,280	------	12,000
Total office, shop, and scales	------	7,090	------	13,290	------	30,650	------	40,750
Feedmill:								
Sample feedmill	1	44,280	1	65,440	1	129,160	1	201,950
Total[a]	------	132,550	------	222,385	------	426,480	1	657,080
Designed feedmill	1, 4TPH	54,550	1, 9TPH	100,110	1, 20TPH	148,010	1, 30TPH	175,150
Total[b]	------	142,820	------	257,055	------	445,330	------	630,280

[a]Total with "sample" feedmill.

[b]Total with "designed" feedmill.

APPENDIX TABLE 4.--Investment in "designed" feedmills

Item	Model I i.e., 4 tons 1 hr.		Model II i.e., 9 tons 1 hr.		Model III i.e., 20 tons 1 hr.		Model IV i.e., 30 tons 1 hr.	
	Description	Cost	Description	Cost	Description	Cost	Description	Cost
Receiving:								
Grain hopper	200 ft.^{3}	$ 200	300 ft.^{3}	$ 300	300 ft.^{3}	$ 300	300 ft.^{3}	$ 300
Silage hopper	Concrete	150	300 ft.^{3} "stainless"	500	300 ft.^{3} "stainless"	500	300 ft.^{3} "stainless"	500
Conveyor from silage to mixer tank or surge bin	10" portable drag to mixer tank	800	10"x30'screw to surge bin "stainless"	650	10"x30'screw to surge bin "stainless"	650	10"x30'screw to surge bin "stainless"	650
Conveyor from grain hopper to elevator leg	10"x15' drag	650	10"x20' drag	700	10"x20' drag	800	12"x20' drag	800
Bucket elevators:	1 800BPH[a] 60'long	1,600	1 2500BPH 60'long	2,000	1 2500BPH 70'long	2,200	1 300BPH 75'long	2,300
			1 800BPH 60'long	1,600	1 1500BPH 70'long	1,800	1 2000BPH 75'long	1,900
Turnheads	1 4-5 way	900	3 4-5 way	1,300	2 6-way 1 4-way	1,500	3 6-way 8" opening	1,800
Rollermill	1 12x18" 2.5TPH[b]	2,200	1 16x30" 150BPH 5TPH	3,300	2 16x30" 340BPH 10TPH	6,500	2 16x36" 500BPH 15TPH	8,000
Roller blower and collector	----	1,000	----	1,400	----	2,000	----	2,500
Steamer	----	550	----	600	----	1,000	----	1,000
Boiler	----	2,500	----	3,000	----	4,500	----	5,000

APPENDIX TABLE 4.--Continued

Item	Model I i.e., 4 tons 1 hr.		Model II i.e., 9 tons 1 hr.		Model III i.e., 20 tons 1 hr.		Model IV i.e., 30 tons 1 hr.	
	Description	Cost	Description	Cost	Description	Cost	Description	Cost
Hay grinding equip. Bale breaker, hay grinder and hay conveyor	----	$ 5,200	----	$ 7,200	----	$10,500	----	$12,000
Ingredient bins: Grain & supplement	10 2@3-5T[c] 6@8-10T 2@15T	6,500	15 3@3-5T 10@8-10T 2@15T	9,500	15 2@3-5T 11@8-10 2@20T	13,000	15 2@3-5T 11@10T 2@20T	13,600
Screw conveyor to mixer truck from 8 bins	2-10'convey. 5-15'convey. 1-8' convey.	1,000						
Screw conveyor to hopper scale from 10 bins			2-15'convey. 5-10'convey. 3-8'(with live bottom for hay) conveyors	1,000	2-20'convey. 5-15'convey. 3-10'(with live bottom for hay) conveyors	3,500	2-20'convey. 5-15'convey. 3-10'(with live bottom for hay) conveyors	3,500
Scale hopper			1 T. cap.	1,600	2T. cap.	2,500	2T. cap.	2,500
Control panel	----	1,200	----	2,500	----	3,500	----	3,500
Elevator leg with screw conveyors to truck	25', 2 bins @25 ft.^{3} used for premixes or concentrates	1,550						
Mixer-horizontal drop bottom			1 T.	2,900	2 T.	4,500	2 T.	4,500

APPENDIX TABLE 4.--Continued

Item	Model I i.e., 4 tons 1 hr.		Model II i.e., 9 tons 1 hr.		Model III i.e., 20 tons 1 hr.		Model IV i.e., 30 tons 1 hr.	
	Description	Cost	Description	Cost	Description	Cost	Description	Cost
Surge bin with drag conveyor	----	--	----	$ 1,900	----	$ 2,100	----	$ 2,100
Premixing-scales, mixer, elevator leg	----	--	----	2,500	----	3,000	----	3,000
Molasses mixer	----	--	9 TPH	1,200	20 TPH	1,500	30 TPH	1,800
Molasses tank & heaters	----	--	10,000 gal.	3,800	20,000 gal.	5,400	30,000 gal.	8,000
Inclined screw to loadout bins	----	--	12"x35'	950	12"x40'	1,000	12"x40'	1,000
Loadout bins	----	--	2@5 T. cap.	--	4@5 T. cap.	--	6@5 T. cap.	--
	----	--	500 ft.^{3}	1,150	1000 ft.^{3}	2,300	1500 ft.^{3}	3,000
Conveyors from grain storage	12"x40'	550	13"x50'	600	12"x50'	600	12"x60'	800
Motors & drives	175HP	5,300	220HP	8,800	320HP	12,000	400HP	14,000
Spouting & adapters	----	2,200	----	3,100	----	4,000	----	4,500
Construction: Mill right & equip. installation (approximately 30% of all equip. costs)	----	6,000	----	11,800	----	16,900	----	19,200
Electrical	----	4,900	----	7,000	----	10,000	----	13,000

APPENDIX TABLE 4.--Continued

Item	Model I i.e., 4 tons 1 hr.		Model II i.e., 9 tons 1 hr.		Model III i.e., 20 tons 1 hr.		Model IV i.e., 30 tons 1 hr.	
	Description	Cost	Description	Cost	Description	Cost	Description	Cost
Bin erection (approximately 30% of all storage costs)including hay building	----	$ 4,200	----	$ 8,560	----	$17,460	----	$26,400
Driveway and grading	----	1,200	----	2,000	----	3,000	----	4,000
Mill building(steel construction)	----	4,200	----	6,700	----	9,500	----	10,000
Total	----	$54,550	----	$100,110	----	$148,010	----	$175,150

[a] Bushel per hour

[b] Ton per hour

[c] Ton

APPENDIX TABLE 5.--Statistical values for the simple linear regression equations used in determining variable costs

Item	Constant term "a"	Regression coefficient "b"	Standard error of regression coefficient	Correlation coefficient "r"
Veterinary (A)[a]	-599.7	1.09757	.21289	.73343
Veterinary (B)[b]	18.4	.85017	.04796	.85260
Insecticide (A)	146.5	.22524	.05857	.63387
Insecticide (B)	10.9	.87317	.03421	.92027
Dues (fees & subscriptions) (A)	34.3	.06017	.02236	.50503
Dues (fees & subscriptions) (B)	97.3	.02696	.01449	.17212
Trucking (other than cattle) (A)	-861.5	1.75849	.68056	.72573
Trucking (other than cattle) (B)	7.6	.92444	.01483	.96181
Equip.--maint. & repairs (A)	433.9	1.04270	.31629	.58397
Equip.--maint. & repairs (B)	73.6	.25965	.03550	.56707
Electricity (A)	414.5	.50697	.12538	.64462
Electricity (B)	45.1	.54233	.03478	.82069
Fuel (A)	957.5	.80434	.18924	.66330
Fuel (B)	30.5	.69067	.03578	.87166
Hired labor (B)	76.6	.22509	.03286	.55048
Buying cattle (A)	-7,627.5	4.54980	.79541	.87517
Buying cattle (B)	18.1	.81846	.04733	.90876
Selling cattle (A)	2,025.8	.18846	.40567	-.15303
Selling cattle (B)	27.3	.72727	.02898	.80000

[a]Equation (A) in each case is of the form $y = a + bx$ where,
- y = dollar cost of each item with the feedlot operating at normal (100 percent) capacity,
- a = a constant term,
- b = regression coefficient, and
- x = the number of head of cattle in each model operated at normal capacity (i.e., 2,500, 5,000, 12,000 and 20,000 head).

[b]Equation (B) in each case is of the form $y = a + bx$ where,
- y = the percentage by which the item varies from normal capacity (dollar amount) when the lot is operated at various levels of capacity,
- a = a constant term,
- b = regression coefficient
- x = an index of degree of utilization of a given size lot (i.e., 25, 50, 75, 100 and 125 percent).

APPENDIX TABLE 6.--Non-feed costs for four model commercial feedlots operating at 25 percent capacity

Item	Model							
	I		II		III		IV	
	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill
	(dollars)							
Fixed costs:								
Depreciation	9,296	10,313	16,076	19,436	30,397	32,259	46,975	44,507
Maintenance & repairs	1,118	1,122	2,028	2,070	4,535	4,544	7,212	7,129
Taxes	978	1,062	1,597	1,878	2,943	3,097	4,485	4,276
Interest	3,662	3,919	5,931	6,798	11,099	11,570	16,939	16,269
Insurance	827	886	1,511	1,707	3,259	3,366	5,231	5,079
Management&office	7,674	7,674	13,151	13,151	28,488	28,488	46,015	46,015
Total fixed costs	23,555	24,976	40,293	45,040	80,721	83,324	126,857	123,275
Variable costs:								
Veterinary	823	823	1,877	1,877	4,827	4,827	8,199	8,199
Insecticides	236	236	424	424	949	949	1,549	1,549
Dues, fees & subscrip.	181	181	328	328	741	741	1,213	1,213
Trucking(other than cattle)	1,085	1,085	2,435	2,435	6,214	6,214	10,533	10,533
Equip-maint.&repairs	2,445	2,445	4,540	4,540	10,409	10,409	17,116	17,116
Electricity	994	994	1,743	1,743	3,840	3,840	6,237	6,237
Fuel	1,425	1,425	2,390	2,390	5,093	5,093	8,181	8,181
Taxes on cattle	1,563	1,563	3,125	3,125	7,500	7,500	12,500	12,500
Interest on cattle	5,625	5,625	11,250	11,250	27,000	27,000	45,000	45,000
Insurance on cattle	788	788	1,575	1,575	3,780	3,780	6,300	6,300
Insurance on feedlot	228	228	429	429	965	965	1,368	1,368
Death loss	2,410	2,410	4,819	4,819	11,565	11,565	19,275	19,275
Hired labor	12,699	12,699	23,904	23,904	53,784	53,784	76,194	76,194
Total var'ble costs	30,502	30,502	58,839	58,839	136,667	136,667	213,665	213,665
Total fixed&var'bl cost	54,057	55,478	99,132	103,879	217,388	219,991	340,522	336,940
Av. Total cost per day	150.16	154.11	275.37	288.55	603.86	611.09	945.89	935.94
Av. Total cost/head per day	0.24025	0.24657	0.22029	0.23084	0.20129	0.20370	0.18918	0.18719
Av. Total cost/pound gain	0.08834	0.09067	0.08098	0.08486	0.07400	0.07489	0.06955	0.06882

APPENDIX TABLE 6.--Non-feed costs for four model commercial feedlots operating at 50 percent capacity

Item	Model I: With "sample" feedmill	Model I: With "designed" feedmill	Model II: With "sample" feedmill	Model II: With "designed" feedmill	Model III: With "sample" feedmill	Model III: With "designed" feedmill	Model IV: With "sample" feedmill	Model IV: With "designed" feedmill
	(dollars)							
Fixed costs:								
Depreciation	9,296	10,313	16,075	19,436	30,397	32,259	46,975	44,507
Maintenance & repairs	1,118	1,122	2,028	2,070	4,535	4,544	7,212	7,129
Taxes	978	1,062	1,597	1,878	2.943	3,097	4,485	4,276
Interest	3,662	3,919	5,931	6,798	11,099	11,570	16,939	16,269
Insurance	827	886	1,511	1,707	3,259	3,366	5,231	5,079
Management & office	7,674	7,674	13,151	13,151	28,488	28,488	46,015	46,015
Total fixed costs	23,555	24,976	40,293	45,040	80,721	83,324	126,857	123,275
Variable costs:								
Veterinary	1,263	1,263	2,879	2,879	7,404	7,404	12,576	12,576
Insecticides	395	395	708	708	1,584	1,584	2,586	2,586
Dues, fees & subscriptions	182	182	330	330	745	745	1,221	1,221
Trucking(other than cattle)	1,902	1,902	4,267	4,267	10,889	10,889	18,458	18,458
Equip.--maint. & repairs	2,643	2,643	4,907	4,907	11,250	11,250	18,499	18,499
Electricity	1,223	1,223	2,144	2,144	4,724	4,724	7,673	7,673
Fuel	1,938	1,938	3,251	3,251	6.928	6.928	11,130	11,130
Taxes on cattle	3,125	3,125	6,250	6,250	15,000	15,000	25,000	25,000
Interest on cattle	11,250	11,250	22,500	22,500	54,000	54,000	90,000	90,000
Insurance on cattle	1,575	1,575	3,150	3,150	7,560	7,560	12,600	12,600
Insurance on feedlot	244	244	459	459	1,032	1,032	1,462	1,462
Death loss	4,819	4,819	9,638	9,638	23,130	23,130	38,550	38,550
Hired labor	13,571	13,571	25,546	25,546	57,478	57,478	81,426	81,427
Total variable costs	44,130	44,130	86,029	86,029	201,724	201,724	321,182	321,182
Total fixed & var'ble costs	67,685	69,106	126,322	131,069	282,445	285,048	448,039	444,457
Av. total costs per day	188.01	191.96	350.89	364.08	784.57	791.80	1244.55	1234.60
Av. total costs per head per day	0.15041	0.15357	0.14036	0.14563	0.13076	0.13197	0.12446	0.12346
Av. total costs per pound gain	0.05529	0.05645	0.05160	0.05354	0.04808	0.04852	0.04576	0.04539

APPENDIX TABLE 6.--Non-feed costs for four model commercial feedlots operating at 75 percent capacity

Item	Model I: With "sample" feedmill	Model I: With "designed" feedmill	Model II: With "sample" feedmill	Model II: With "designed" feedmill	Model III: With "sample" feedmill	Model III: With "designed" feedmill	Model IV: With "sample" feedmill	Model IV: With "designed" feedmill
	(dollars)							
Fixed costs:								
Depreciation	9,296	10,313	16,075	19,436	30,397	32,259	46,975	44,507
Maintenance & repairs	1,118	1,122	2,028	2,070	4,535	4,544	7,212	7,129
Taxes	978	1,062	1,597	1,878	2,943	3,097	4,485	4,276
Interest	3,662	3,919	5,931	6,798	11,099	11,570	16,939	16,269
Insurance	827	886	1,511	1,707	3,259	3,366	5,231	5,079
Management & office	7,674	7,674	13,151	13,151	28,488	28,488	46,015	46,015
Total fixed costs	23,555	24,976	40,293	45,040	80,721	83,324	126,857	123,275
Variable costs:								
Veterinary	1,705	1,705	3,886	3,886	9.994	9,994	16,975	16,975
Insecticides	552	552	990	990	2,217	2,217	3,619	3,619
Dues, fees & subscriptions	184	184	333	333	751	751	1,229	1,229
Trucking(other than cattle)	2,718	2,718	6.099	6,099	15,565	15,565	26,383	26,383
Equip.--maint. & repairs	2,843	2,843	5,280	5,280	12,105	12,105	19,904	19,904
Electricity	1,453	1,453	2,548	2,548	5,614	5,614	9,119	9,119
Fuel	2,452	2,452	4,113	4,113	8,764	8,764	14,078	14,078
Taxes on cattle	4,688	4,688	9,375	9,375	22,500	22,500	37,500	37,500
Interest on cattle	16,875	16,875	33,750	33,750	81,000	81,000	135,000	135,000
Insurance on cattle	2,363	2,363	4,725	4,725	11,340	11,340	18,900	18,900
Insurance on feedlot	259	259	487	487	1,097	1,097	1,554	1,554
Death loss	7,229	7,229	14,456	14,456	34,695	34,695	57,825	57,825
Hired labor	14,428	14,428	27,158	27,158	61,106	61,106	86,567	86,567
Total variable costs	57,749	57,749	113,200	113,200	266,748	266,748	428,653	428,653
Total fixed & var'ble costs	81,304	82,725	153,493	158,240	347,469	350,072	555,510	551,928
Av. total costs per day	225.84	229.79	426.37	439.56	965.19	972.42	1543.08	1533.13
Av. total costs per head per day	0.12045	0.12256	0.11370	0.11721	0.10724	0.10805	0.10287	0.10221
Av. total costs per pound gain	0.044[illegible]3	0.04506	0.04180	0.04309	0.03943	0.03972	0.03782	0.03758

APPENDIX TABLE 6.--Non-feed costs for four model commercial feedlots operating at 100 percent capacity

Item	Model							
	I		II		III		IV	
	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill	With "sample" feedmill	With "designed" feedmill
	(dollars)							
Fixed costs:								
Depreciation	9,296	10,313	16,075	19,436	30,397	32,259	46,975	44,507
Maintenance & repairs	1,118	1,122	2,028	2,070	4,535	4,544	7,212	7,129
Taxes	978	1,062	1,597	1,878	2,943	3,097	4,485	4,276
Interest	3,662	3,919	5,931	6,798	11,099	11,570	16,939	16,269
Insurance	827	886	1,511	1,707	3,259	3,366	5,231	5,079
Management & office	7,674	7,674	13,151	13,151	28,488	28,488	46,015	46,015
Total fixed costs	23,555	24,976	40,293	45,040	80,721	83,324	126,857	123,275
Variable costs:								
Veterinary	2,144	2,144	4,888	4,888	12,571	12,571	21,352	21,352
Insecticides	710	710	1,273	1,273	2,849	2,849	4,651	4,651
Dues, fees & subscriptions	185	185	335	335	756	756	1,238	1,238
Trucking(other than cattle)	3,535	3,535	7,931	7,931	20,240	20,240	34,308	34,308
Equip.--maint. & repairs	3,041	3,041	5,647	5,647	12,946	12,946	21,288	21,288
Electricity	1,682	1,682	2,949	2,949	6,498	6,498	19,554	10,554
Fuel	2,968	2,968	4,979	4,979	10,610	10,610	17,044	17,044
Taxes on cattle	6,250	6,250	12,500	12,500	30,000	30,000	50,000	50,000
Interest on cattle	22,500	22,500	45,000	45,000	108,000	108,000	180,000	180,000
Insurance on cattle	3,150	3,150	6,300	6,300	15,120	15,120	25,200	25,200
Insurance on feedlot	274	274	517	517	1,163	1,163	1,648	1,648
Death loss	9,638	9,638	19,275	19,275	46,260	46,260	77,100	77,100
Hired labor	15,300	15,300	28,800	28,800	64,800	64,800	91,800	91,800
Total variable costs	71,377	71,377	140,394	140,394	331,813	331,813	536,183	536,183
Total fixed & var'ble costs	94,932	96,353	180,687	185,434	412,534	415,137	663,040	659,458
Av. total costs per day	263.70	267.65	501.91	515.09	1145.93	1153.16	1841.78	1831.83
Av. total costs per head per day	0.10548	0.10706	0.10038	0.10302	0.09549	0.09610	0.09209	0.09159
Av. total costs per pound gain	0.0[illegible]878	0.03936	0.03691	0.03788	0.03511	0.03533	0.03386	0.03367

APPENDIX TABLE 6.--Non-feed costs for four model commercial feedlots operating at 125 percent capacity

Item	Model I: With "sample" feedmill	Model I: With "designed" feedmill	Model II: With "sample" feedmill	Model II: With "designed" feedmill	Model III: With "sample" feedmill	Model III: With "designed" feedmill	Model IV: With "sample" feedmill	Model IV: With "designed" feedmill
	(dollars)							
Fixed costs:								
Depreciation	9,296	10,313	16,075	19,436	30,397	32,259	46,975	44,507
Maintenance & repairs	1,118	1,122	2,028	2,070	4,535	4,544	7,212	7,129
Taxes	978	1,062	1,597	1,878	2,943	3,097	4,485	4,276
Interest	3,662	3,919	5,931	6,798	11,099	11,570	16,939	16,269
Insurance	827	886	1,511	1,707	3,259	3,366	5,231	5,079
Management & office	7,674	7,674	13,151	13,151	28,488	28,488	46,015	46,015
Total fixed costs	23,555	24,976	40,293	45,040	80,721	83,324	126,857	123,275
Variable costs:								
Veterinary	2,586	2,586	5,895	5,895	15,161	15,161	25,751	25,751
Insecticides	868	868	1,556	1,556	3,482	3,482	5,684	5,684
Dues, fees & subscriptions	186	186	337	337	761	761	1,247	1,247
Trucking(other than cattle)	4,355	4,355	9.771	9,771	24,936	24,936	42,268	42,268
Equip.--maint. & repairs	3,239	3,239	6,014	6,014	13,788	13,788	22,672	22,672
Electricity	1,912	1,912	3,353	3,353	7,388	7,388	12,000	12,000
Fuel	3,482	3,482	5,840	5,840	12,446	12,446	19,993	19,993
Taxes on cattle	7,813	7,813	15,625	15,625	37,500	37,500	62,500	62,500
Interest on cattle	28,125	28,125	56,250	56,250	135,000	135,000	225,000	225,000
Insurance on cattle	3,938	3,938	7,875	7,875	18.900	18,900	31,500	31,500
Insurance on feedlot	290	290	546	546	1,230	1,230	1,741	1,741
Death loss	12,048	12,048	24,094	24,094	57,825	57,825	96,375	96,375
Hired labor	16,172	16,172	30,442	30,442	68,494	68,494	97,033	97,033
Total variable costs	85,014	85,014	167,598	167,598	396,911	396,911	643,764	643,764
Total fixed & var'ble costs	108,569	109,990	207,891	212,638	477,632	480,235	770,621	767,039
Av. total costs per day	301.58	305.53	577.48	590.66	1326.76	1333.99	2140.61	2130.66
Av. total costs per head per day	0.09651	0.09777	0.09240	0.09451	0.09945	0.08893	0.08562	0.08523
Av. total costs per pound gain	0.03548	0.03595	0.03398	0.03474	0.03252	0.03270	0.03148	0.03133

APPENDIX TABLE 7.--Buying, selling and trucking cattle costs for four model feedlots operating at 25 percent capacity

Item	Model			
	I	II	III	IV
	(dollars)			
Buying cattle	1,446	5,837	18,130	32,180
Selling cattle	706	492	0	0
Trucking cattle	7,148	14,296	34,310	57,183
Total	9,300	20,625	52,440	89,363
Av. total cost per day	25.83	57.29	145.67	248.23
Av. total cost per head per day	0.04133	0.04583	0.04856	0.04965
Av. total cost per pound gain	0.01520	0.01685	0.01785	0.01825

APPENDIX TABLE 7.--Buying, selling and trucking cattle costs for four model feedlots operating at 50 percent capacity

Item	Model			
	I	II	III	IV
	(dollars)			
Buying cattle	2,214	8,937	27,759	49,271
Selling cattle	989	689	0	0
Trucking cattle	14,296	28,592	68,619	114,365
Total	17,499	38,218	96,378	163,636
Av. total cost per day	48.61	106.16	267.72	454.54
Av. total cost per head per day	.03889	.04246	.04462	.04545
Av. total cost per pound gain	.01429	.01561	.01640	.01671

APPENDIX TABLE 7.--Buying, selling and trucking cattle costs for four model feedlots operating at 75 percent capacity

Item	Model			
	I	II	III	IV
	(dollars)			
Buying cattle	2,983	12,037	37,388	66,362
Selling cattle	1,272	886	0	0
Trucking cattle	21,443	42,887	102,929	171,548
Total	25,698	55,810	140,317	237,910
Av. total cost per day	71.38	155.03	389.77	660.86
Av. total cost per head per day	.03807	.04134	.04331	.04406
Av. total cost per pound gain	.01400	.01520	.01592	.01620

APPENDIX TABLE 7.--Buying, selling and trucking cattle costs for four model feedlots operating at 100 percent capacity

Item	Model I	Model II	Model III	Model IV
	(dollars)			
Buying cattle	3,747	15,122	46,970	83,369
Selling cattle	1,555	1,083	0	0
Trucking cattle	28,591	57,183	137,238	228,730
Total	33,893	73,388	184,208	312,099
Av. total cost per day	94.15	203.86	511.69	866.94
Av. total cost per head per day	.03766	.04077	.04264	.04335
Av. total cost per pound gain	.01385	.01499	.01568	.01594

APPENDIX TABLE 7.--Buying, selling and trucking cattle costs for four model feedlots operating at 125 percent of capacity

Item	Model I	Model II	Model III	Model IV
	(dollars)			
Buying cattle	4,515	18,222	56,599	100,460
Selling cattle	1,836	1,280	0	0
Trucking cattle	35,739	71,479	171,548	285,913
Total	42,090	90,981	228,147	386.373
Av. total cost per day	116.92	252.73	633.74	1,073.26
Av. total cost per head per day	.03741	.04044	.04225	.04293
Av. total cost per pound gain	.01376	.01487	.01553	.01578

ECONOMIES OF SCALE IN COMMERCIAL CATTLE FEEDING IN KANSAS

by

CALVIN C. HAUSMAN

B. S., Kansas State University, 1963

AN ABSTRACT OF A MASTER'S THESIS

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The question of reduced costs associated with size of feedlots is of major concern in the long run as it may implicate a structural change of the commercial feedlot industry in Kansas as well as affect the state's competitive position in relation to other states. This study was designed to determine what effect (1) size and (2) degree of plant utilization has upon non-feed costs of commercial feedlots in Kansas.

Four model commercial feedlots of sizes 2,500, 5,000, 12,000 and 20,000 head capacity were budgeted for this study. A stratified sample of 26 commercial feedlots ranging in size from 1,000 to 25,000 head capacity supplied information supplemented with that of university specialists, equipment dealers, feedlot managers, lending and insurance agencies for determining capital investments and fixed and variable costs for the four above models. Capital investments included, among other things, a "designed" and "sample" feedmill so as to present a more comprehensive breakdown of the mill components. Fixed and variable costs were totaled and converted into the per unit costs of per head per day and per pound gain for five capacity utilization levels. These levels were arbitrarily chosen as being 25, 50, 75, 100 and 125 percent of capacity. In accordance with information obtained from the sample, it was assumed that the feeding period would be 140 days, turnover would be 2.57 and gain per head would average 381 pounds.

From this study it was found that degree of plant utilization is of primary importance in the Kansas commercial cattle feedlot industry. The bulk of the cost decline occurred by the time 75 percent of plant utilization had been obtained. The most substantial cost decline for each model occurred when plant utilization was increased from 25 to 50 percent of capacity.

In contradiction to the usual theoretical presentation, unit costs failed to increase beyond 100 percent utilization. This was believed to be due to either a misinterpretation of capacity on the part of the feedlot operators or to the possibility that these operators attempt to obtain a degree of flexibility by providing some excess capacity in what they consider to be normal capacity.

There are indications that some economies of scale may be obtained in the commercial feedlot industry within the 2,500-20,000 head range covered in this analysis. For example, costs varied from 10.7 for Model I to 9.2 cents per head per day for Model IV for the "designed" feedmill when operating at normal capacity. While the range was small, there was no clear indication that costs were tending to level with variations in feedlot size. It is reasonable to assume that further economies could be gained by sizes larger than considered in this study, but this empirical analysis could not verify this assumption for Kansas feedlots.

A cost pattern of a similar nature occurred when average total costs were determined on a cost per pound gain basis. At normal capacity, costs ranged from 3.9 for Model I to 3.4 cents per pound gain for Model IV for both "designed" and "sample" feedmill investments.

Buying, selling and trucking cattle costs were analyzed separately to show a more direct comparison between "on and off" feedlot costs. When aggregated these costs increased slightly with the size of feedlot for both unit cost derivations. Economies of buying, selling and trucking cattle costs occurred only with increased degree of plant utilization.