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Economies of size of feed retailing operations

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Economies of size of feed

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CHAPTER I. INTRODUCTION

The feeding of livestock and poultry is of significant economic importance to Iowa and the United States. Iowa has consistently been a leading state in the production of hogs, fed cattle, soybeans, and feedgrains. If one considers the hog industry by itself, the economic importance is significant. In 1970 it was estimated that 19,000 man-years were devoted to pork production in Iowa (21). Swine producers spent 31 million dollars for veterinary and medical services; 4 million for breeding stock; 48 million for power, machinery, equipment, and fuel; 8 million for miscellaneous costs such as taxes and insurance; and 15 million dollars for marketing services in 1970. The swine producers expenditures in Iowa totaled 629 million dollars, which did not include capital outlays for buildings and land. In 1971 23,787,000 hogs weighing 5,740,052,000 pounds were slaughtered in Iowa (13). This is approximately 25 percent of the hogs slaughtered in the United States. If each pound of pork produced required 3.2 pounds of feed, then approximately 9.2 million tons of feed were consumed by the hogs slaughtered in Iowa in 1971. These statistics point out the importance of the livestock industry in Iowa. In order to feed the large numbers of livestock in Iowa, feed mills are needed to grind the farmers grain and incorporate additional ingredients to form a palatable and economical ration.

This study concerns itself with the processing, mixing, bagging, and pelleting of feed in feed mills. Costs associated with various size model feed mills determine if economies of size exist in feed mill operations. For any volume of output an optimum size feed mill will grind and mix a ton of feed for the farmer at the lowest cost per ton.

Statement of the Problem

The basic problem encountered by feed mills in Iowa is that there are too many mills with insufficient volume to utilize their facilities efficiently. In the 1971 directory of the Iowa Grain and Feed Association 972 cooperatives and private firms advertised grinding and/or mixing services to customers in Iowa. A total of 1,613 cooperatives and private firms advertised the retailing of feed in Iowa. These facts point out the competitive nature of the feed retailing industry in Iowa.

Feed mills in Iowa are often operated in conjunction with grain elevators. There were a large number of grain elevators established in close proximity to each other in earlier times when the primary means of transportation was by horse and wagon. This method of transporting grain required that the distance between the farmer and the elevator be relatively short. Many of these elevators built feed mills and warehouses to complement the grain handling activity. Today, however, grain and feed can be transported by tractor and wagon or by trucks greater distances with much less time and effort.

It might be argued by some that a large number of sellers of feed is an ideal situation since the price would be kept near the level of a perfectly competitive market. Farmers may gain some benefit from this competition, but cooperative elevators are farmer owned and thus all savings that result from large and efficient operations can be passed on to the farmer in the form of lower feed prices or patron dividends. In addition, farmers may belong to two or more cooperatives each of which may own a feed mill. Thus the farmer may actually be competing against himself. Feed mills and grain elevators located in the same rural community or only a few miles apart result in the duplication of buildings, equipment, management, and other resources. This duplication of resources has resulted in a less than efficient means of marketing feed.

Competition of this nature could be described as wasteful in a technical sense since the low volumes handled by the numerous feed mills result in higher costs causing higher feed prices. Feed prices are also high due to the nature of the product itself. Feed is a differentiated product in the farmer's mind due to advertising, various dealer services, and formula differences. The differentiation of feed as a product and the resultant higher prices has resulted in high profits for feed manufacturers and feed retailers during the past three decades. For example, Central Soya has averaged 12.7 percent return on investment over the past 35 years. Similarly, Ralston Purina averaged 12.47 percent return on equity from 1951 to 1968. Boone Valley Coop of Eagle Grove, Iowa averaged 20.58 percent return on equity from 1944 to 1968 while FS Services averaged 31.60 percent return on equity from 1955 to 1968. Although these organizations are engaged in various activities, feed manufacturing plays a major role.

Objectives of this Study

The primary objective of this study is to determine the optimum size feed mill with respect to inplant costs. The optimum size feed mill will process and mix the farmer's feed at a minimum of cost per ton. The information gained from this study should be of benefit to potential investors whether they be cooperatives or profit seeking firms when they are considering problems of expansion by merger, acquisition, or building. The results might also be helpful to management concerning various pricing problems such as custom service charges, volume discounts, and others.

CHAPTER II. REVIEW OF LITERATURE

There have been many studies made of economies of size in feed manufacturing and of feed mills. Similar studies also have been done of country grain elevators and the storing and handling of grain in Iowa (12 and 15).

In 1959 Tamashunas made an industrial engineering analysis of custom feed mill activities (19). His study was based on accounting data derived from a sample of 37 cooperative member feed mills of the Farmers Elevator Service Company of Fort Dodge, Iowa. He developed 3 model mills based on the level of operation of the feed mills. The 5 ton model varied in its level of operation from 1/4 to 9 3/4 tons per day, the 15 ton model from 10 to 19 3/4 tons per day, and the 25 ton model from 20 to 29 3/4 tons per day. The particular size model mill is not meant to imply that this is also the capacity of the model. For example, the 5 ton model may have a 20 ton per day capacity, but operates only in the 1/4 to 9 3/4 level of activity.

The 3 model custom mills ground, mixed, and bagged feed for their patrons. They also retail formula feed purchased from feed manufacturers or manufactured themselves. The 25 ton model is set up to pellet part of its output.

Tamashunas first analyzed manufacturing costs, service charges, and profit margins of the model mills. He found that larger mills came closer to breaking even on custom charges (grinding, mixing, and bulk delivery). He also found that losses incurred were largely attributable to the bulk delivery service. Tamashunas further found that larger mills had lower manufacturing costs and lower service charges. The retailing of manufactured formula feed enabled all 3 model mills to operate with an annual net financial gain.

Tamashunas also analyzed the 3 models with respect to their breakeven points. The breakeven points for the 5, 15, and 25 ton models were 3.00, 6.25, and 9.25 tons per day respectively. He found that the breakeven points declined as a percentage of the level of operation as plant sizes increased. He also found that custom charges alone would result in the feed mills operating at a loss.

Tamashunas also analyzed the capacity and utilization of facilities with respect to processing, mixing, and pelleting of feeds. Capacity of equipment was determined by applying time study techniques to the processing, mixing, and pelleting operations.

Tamashunas found that utilization of existing capacity was quite low. Part of this excess capacity could be attributable to the fact that feed mills are considered as service organizations. Some excess capacity is required for peak customer demand periods. A service firm cannot require its patrons to wait for long periods of time or they will look for a competitor that can give quicker service. Utilization of crimping equipment was 1.0, 4.9, and 6.1 percent of capacity in the 5, 15, and 25 ton model mills respectively. Similarly the utilization of the grinder was 13.7, 29.1, and 33.2 percent in the 5, 15, and 25 ton model mills respectively. The mixer was utilized 22.0, 37.0, and 20.1 percent in the 5, 15, and 25 ton model feed mills respectively. The 2 larger mills tended to utilize their equipment more fully than the 5 ton model mill.

In a 1966 analysis of the North Dakota feed manufacturing industry by Phillip Austin and David Nelson, economies of size were found to exist (1). A 30, 100, and 200 ton per day model feed plant was synthesized from a survey of firms, equipment manufacturers and building contractors. Only inplant costs were considered in this study.

These model plants were set up to process grains, mix, pellet, and bag feed. The 30, 100, and 200 ton per day models had production costs of $7.71, $4.81, and $4.07 per ton respectively at capacity. The study concluded that the 200 ton model plant was the optimal and most efficient of the 3 models developed if delivery costs were ignored.

Production costs per ton were further reduced substantially by the addition of a second eight-hour shift. The average per ton costs in the 30, 100, and 200 ton plants were reduced from $7.71, $4.81, and $4.07 to $5.82, $3.66 and $3.05 respectively, with the addition of a second eight-hour shift.

The study also found actual production costs of North Dakota firms to be substantially higher than those developed in the 3 models. Possible reasons suggested for this discrepancy are: (1) firms operate at less than capacity, (2) employees have too much idle time, (3) machinery is obsolete and inefficient and (4) lack of management.

Investment costs used in the North Dakota study were 90, 206, and 314 thousand dollars in the 30, 100, and 200 ton model feed mills respectively. The cost of land is not included. Per ton investment varied from a low of $6.03 in the 200 ton model to a high of $11.49 per ton in the 30 ton model.

In 1968 the Economic Research Service of the United States Department of Agriculture made a cost study of the economies of scale in feed manufacturing (2). This analysis was made concerning operating and plant facility costs and did not include locational or distributional factors.

The engineering simulation approach was used in developing 54 model feed plants. These included 6 different size model plants of 80, 100, 150, 200, 250, and 300 tons of feed produced in an eight-hour day. Each of the 6 different size plants also had 9 variations each due to different output levels of bagged, mashed, or pelleted feed. Each of these levels were varied at the 0, 50, and 100 percent level. Plant utilization varied from 40 to 100 percent of capacity.

Investment requirements varied from $8.54 per ton for a 300 ton per day model plant with no bagging and pelleting to $19.18 per ton for an 80 ton per day plant that bags 50 percent and pellets 100 percent of its output. All the models assumed a 260 working day year.

Operating costs per ton varied from $7.13 for an 80 ton operation pelleting and bagging its entire output, to a low of $3.04 level for a 300 ton operation with no bagging or pelleting. A double-shift operation further reduced costs by spreading fixed costs over more tons of feed. Total cost per ton of feed then ranged from a low of $2.31 in a 300 ton plant to a high of $5.76 per ton in a 80 ton plant.

Dr. Ewell P. Roy of Louisiana State University also found economies to exist in a 1970 study of feed mills in Louisiana (17). Roy synthesized

3 model mills producing 20, 40, and 60 tons of feed per day. The 60 ton mill could either produce all mash or all pelleted feed. Costs per ton decreased from \$8.47, \$6.63, and \$5.80 for the 20, 40, and 60 ton mills respectively. The 60 ton mill that pelleted all of its output had operating costs of \$7.57 per ton. No delivery or transportation costs were included.

In 1970, Richard Mikes, Allen Rahn and Gene Futrell made a study of grain elevator and feed mill costs under alternative marketing densities and trade area sizes (16). This study incorporated the importance of distribution and assembly costs as well as inplant costs for the grain elevator and feed mill industry. The studies mentioned previously did not consider this important aspect in their cost analysis.

Mikes, Rahn and Futrell developed an inplant cost function by combining the observations of the North Dakota State and the Louisiana State University studies. The inplant cost function was developed by fitting a power function to the data relating average processing costs to plant volume as follows:

$$APC = A \times V^{-B}$$

where APC was the average processing costs per ton, V was the plant volume of production, and A and B were coefficients.

The data was first converted to logarithms and then the method of least squares was used to estimate the coefficients A and B with the following results:

$$\log APC = 2.13609 - 0.32634 (\log V)$$

Converted to natural numbers it reads as follows:

$$APC = 136.8 \times V^{-0.32634}$$

This equation was then used to estimate inplant processing costs per ton.

Distributional costs per ton of feed depend on the average load size and the size of the trade area. The trade area was assumed to be a square tilted 45 degrees with the feed mill located at the center. Roads are assumed to run north-south and east-west forming one mile square areas. Their study approximated the distribution cost function in Iowa as being:

$$DC_i = \$1.25 + \$0.10i$$

where i = miles feed is transported. This approximation was made under the assumption that load size was 6 to 8 tons. Fixed costs are $1.25 per ton and variable costs 10 cents per ton for each mile transported.

Total distributional costs will be the summation of distributing feed in each additional increment mile. Average distribution costs per ton will be equal to the total distributional costs divided by the amount of feed delivered in the trade area. Average distribution costs per ton increase at a decreasing rate as the trade area expands.

Combining inplant and distributional costs gives the total cost per ton of feed delivered. The Mikes, Rahn, and Futrell study found that combined average costs were still declining at 25 miles from the feed mill for sales densities of 20 tons and 40 tons per square mile. Similarly, combined costs also were declining 19 miles from the feed mill assuming sales densities of 60, 80, and 100 tons of feed per square mile. Diseconomies had begun to set in with this large a trade area in the grain elevator section of their study, indicating that feed mills, given the assumed densities, can economically serve a larger trade area.

CHAPTER III. THEORETICAL FRAMEWORK

This study develops internal plant costs of retailing feed in feed mills. A later study will combine distribution costs with the internal plant costs developed in this study. The combined costs can then be used to develop an optimal feed mill with respect to plant size and market area. The theoretical framework in which internal costs are developed shall be examined first.

A basic assumption in economic theory is that the objective of the individual firm is to maximize profits. Inherent in this assumption is that the entrepreneur will also minimize his costs while producing various levels of output. These costs will be jointly determined by technology, factor prices, and entrepreneurial expertise.

Economic theory in analyzing costs of production conveniently classifies inputs as either fixed or variable. A fixed input is defined as one whose quantity cannot readily be changed when market conditions indicate that an immediate change in output is desirable (9). No input is actually considered absolutely fixed for even short periods of time, but for simplicity are assumed fixed due to the prohibitive cost of making them variable. This cost would be so great as to make them irrelevant to the decision at hand. Examples of fixed inputs might be land, buildings or equipment. On the other hand, a variable input could be considered as one whose quantity can be adjusted quickly or almost instantaneously in response to desired changes in output. Raw materials and production labor are often classified as variable inputs.

Classifying inputs as variable or fixed allows the economist to divide the planning period into the short-run and the long-run. The short-run can be considered as the planning period in which one or more of the factor inputs are classified as fixed. Thus in the short-run, the entrepreneur can only adjust the level of output by varying the use of variable inputs. He cannot immediately construct a building or install equipment. However, he can adjust variable inputs such as raw materials or labor in order to expand or reduce the level of output as desired.

The long-run is considered by the economist as that period of time in which all inputs can be considered variable. In the short-run the entrepreneur could expand output by operating more hours, but in the long-run output can be increased by constructing additional productive facilities. Thus the long-run can be considered as a planning horizon (9, p. 198). Once long-run decisions have been made, however, the entrepreneur is operating in the short-run.

From the concept of fixed and variable inputs and of short and long-run planning periods, the economist can classify costs as fixed or variable. Fixed and variable inputs multiplied by their input prices will give fixed and variable costs respectively. Fixed costs are those that will exist if output is zero or if output is at capacity. On the other hand, variable costs will tend to vary proportionately with the level of output.

The typical short-run average cost curve is U-shaped, assuming a production function with a range of increasing and then decreasing returns to variable inputs. The declining portion is the result of the spreading of fixed cost (overhead) over more units of output. Eventually,

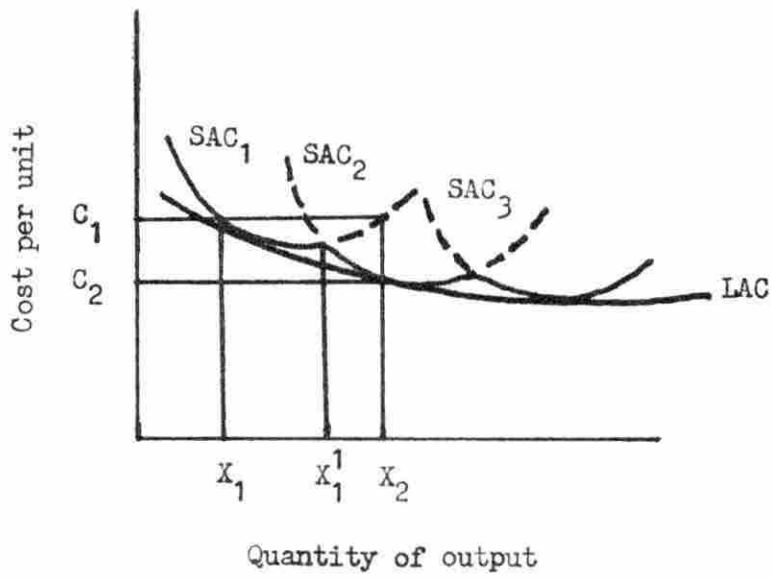

Figure 1. Long-run average cost curve

however, average variable cost increases at a faster rate than average fixed cost declines, causing the short-run average cost curve to rise.

Figure 1 illustrates alternative plant sizes and their associated short-run average cost curves. A feed mill capable of producing 100 tons per day might be represented by (SAC_1), while (SAC_2) and (SAC_3) represent mills producing 200 and 300 tons of feed per day respectively. The most efficient method of producing X_1 tons of feed is in plant 1, until we desire X_1^{1} tons of feed produced per day. At output levels greater than X_1^{1}, a larger plant will have a lower per unit cost than plant 1. For example, to produce X_2 tons of feed will only cost C_2 per ton in plant 2 as compared to C_1 per ton in plant 1.

The average cost of producing a ton of feed in various size feed mills will form a long-run average cost curve. The long-run average cost curve is an envelope of various short-run average cost curves as illustrated by the heavy dark line in figure 1. The long-run average cost curve is a planning device for building the optimal size plant to produce a level of output at the least possible cost per unit.

The shape of the long-run average cost curve is U-shaped as was the short-run average cost curve. The reason for the U-shape of the long-run average cost curve is due to increasing and decreasing returns to size.

Economies of size are said to exist when the long-run average cost curve slopes downward. Two reasons are given to explain this concept (9, p. 21). The first is due to the specialization and division of labor. This occurs in large plants where each worker becomes very proficient in a few tasks. On the other hand, smaller plants require each worker to do many different jobs in the production process. Fewer jobs per employee in a larger plant also reduces the time spent changing jobs and equipment.

Technological factors are also an explanation for economies of size. Larger plants can better harmonize the rates of output of different machines and equipment. Another technological factor is due to the fact that average investment per unit of output is lower with larger facilities. A final technological element which causes economies of scale to exist is the use of substantially better quality equipment in larger plants (9). The expansion of scale also often permits the use of automated equipment which tend to reduce the per unit cost.

Economic theory refers to the rising part of the long-run average cost curve as diseconomies of scale. Loss of coordination and control of various plant activities by management result as the scale of the plant expands. Inefficiency and rising per unit cost set in when paperwork and red tape become excessive (9, p. 212).

Empirical evidence has suggested that diseconomies of scale do not actually exist. Cost studies have suggested an L-shaped long-run average cost curve exists in reality unless assembly or distributional costs are included in the analysis.

Under the theory of perfect competition, the optimal size plant will be the one where long-run average costs are minimized. At this point, quantity X_3 in figure 1, per unit costs of production will be minimized with respect to internal plant costs.

In analyzing plants in the real world, some modifications and elaborations of conventional economic theory are in order. The nature of plant operations and the modifications needed are discussed by French, Sammet, and Bressler (11). The time dimension for output variation, plant segmentation, discontinuous variation in rates of output, and plant stages need to be stressed in their relation to economic theory.

The time and rate dimensions are important in varying output and in determining total cost functions. When output is varied by holding the rate of output fixed and varying the hours that the plant operates, marginal cost will tend to be constant and the total cost function linear. However, if the time dimension is held constant and the rate of output varied, the total cost function will be the conventional curvilinear shape.

Some statistical cost studies have used data from successive accounting periods and have failed to recognize that output is varied by both hours of operation as well as changes in output rates per hour. The total cost curves derived in such cases will be linear or curvilinear, depending on whether output varied due to hours of operation or output rates per hour.

Segmentation is another factor that tends to cause the total cost function to be linear. Segmentation results when fixed factors can be added or withdrawn from plant operations without affecting efficiency. Thus identical machines can be employed to vary the rate of output without changing the proportion of inputs. This results in constant marginal cost and a linear but discontinuous total cost function.

Segmentation causes the total cost function to be discontinuous in the rate dimension. Figure 2 illustrates a discontinuous total cost function due to segmentation. To produce output X_1 or less only requires one unit of a fixed factor such as a machine. To produce output X_2, however, requires an additional machine and worker. Thus producing X_2 output per time period will result in the two machines operating at less than their capacity. Consequently total costs will rise in "steps" due to the indivisibility of fixed factors.

Discontinuities also occur in the time dimension. For example, labor often receives overtime wages for all hours worked after 40 hours. Similarly, wages of a night shift often must be higher in order to attract employees. Changing factor prices will cause the total cost function to bend when the plant operates over 40 hours per week. Figure 3 illustrates the affect on the total cost function.

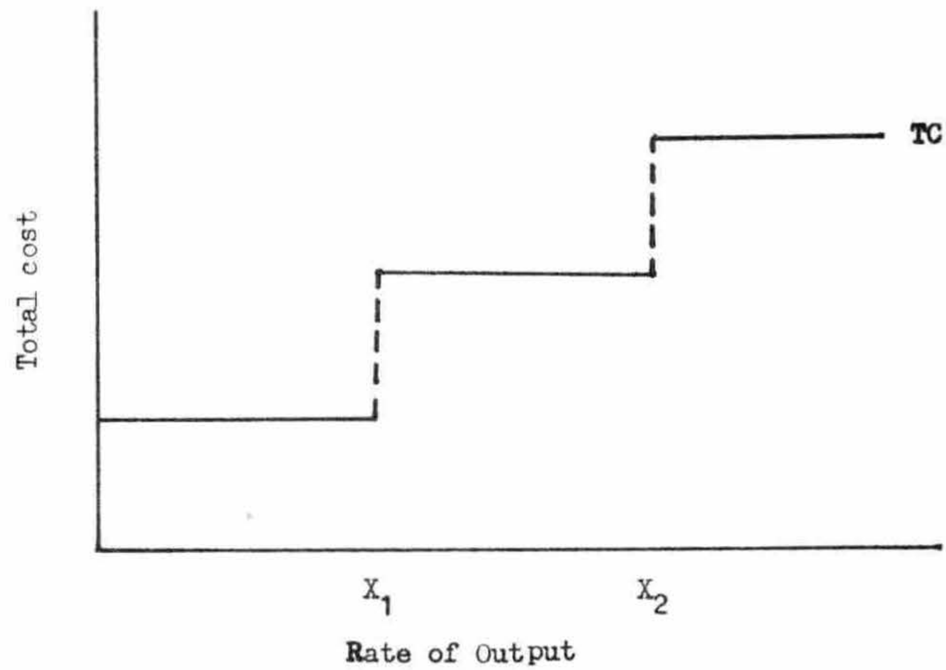

Figure 2. Discontinuous total cost function in the rate dimension

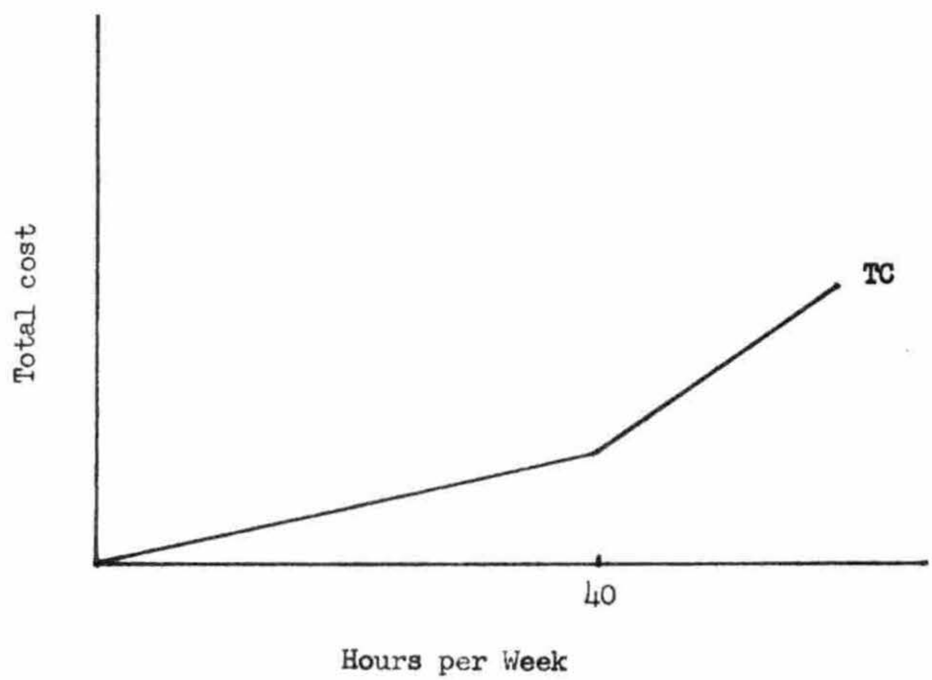

Figure 3. Discontinuous total cost function in the time dimension

The analysis of plant operations by each individual stage helps the economist when making cost studies. Plant operations consist of several technical stages, transportation links and storage points between and within stages.

Each technical stage is defined as consisting of all durable and nondurable productive services that perform a single operation (11, p. 545). Conventional theory of production more aptly applies to the plant stage. The total cost function is an integration and aggregation of the costs of the individual stages. This results in essentially two problems.

The first of these is finding "harmonious" combinations of capacities of the units of fixed (but discretely divisible) equipment used at each plant stage. This is essentially a problem of finding a common denominator of the capacities of all durable factors. For example, if machine A can operate at 30 units per hour and machine B at 45 units per hour, a harmonious combination of the two will be a minimum of three machine A's and two machine B's. With this combination, a minimum of 90 units per hour can be produced without any unused capacity.

Another problem in the aggregation and integration of plant stages is determining the appropriate type of equipment at each plant stage. Many machines are often able to perform the operations of a single stage. However, the economy of any piece of equipment will depend on how well it harmonizes with the rates of output of other equipment.

The problem of developing a long-run average cost function involves selecting and integrating alternative production techniques for various size plants. If there are many stages in a plant and many techniques in each stage, then the number of combinations of these could become quite large. In order to avoid analyzing each of the combinations, only the efficient techniques are aggregated into a long-run cost function.

To facilitate the economist in determining which techniques are efficient, the concept of economic stages are introduced. Economic stages are composed of one or several technical stages. The technical stages within an economic stage are interdependent. Technical stages in different economic stages are independent of each other.

Cost functions are developed for each technique in an economic stage. An envelope is then formed to determine the most efficient technique for any rate of output in an economic stage.

Figure 4 illustrates three alternative technologies in performing the necessary functions of an economic stage. Thus up to a rate of output of X_1 units per time period, technique I is most efficient. For rates of output between X_1 and X_2, technique II is most efficient, and for rates of output greater than X_2, technique III is the most efficient.

Similar envelopes can be obtained for other economic stages. These costs are then aggregated to determine the long-run internal plant cost function.

Distribution costs as well as internal plant costs must be considered when building various size feed mills. A large volume plant will require a bigger trade area. As the trade area expands, distributional costs will increase since the distance that the feed must be transported also increases. Thus the economies of internal plant costs and diseconomies of

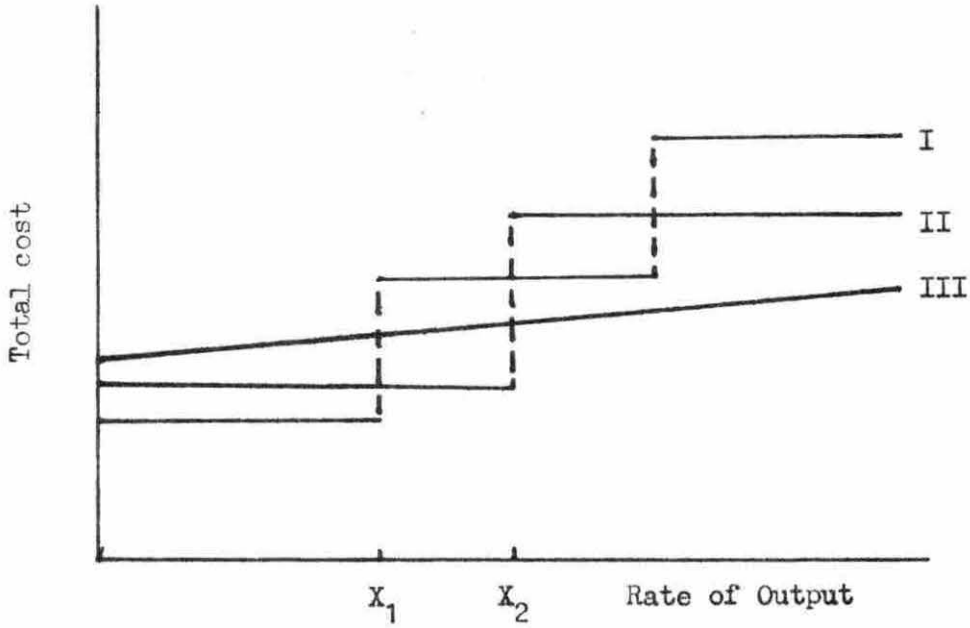

Figure 4. Alternative technologies in an economic stage

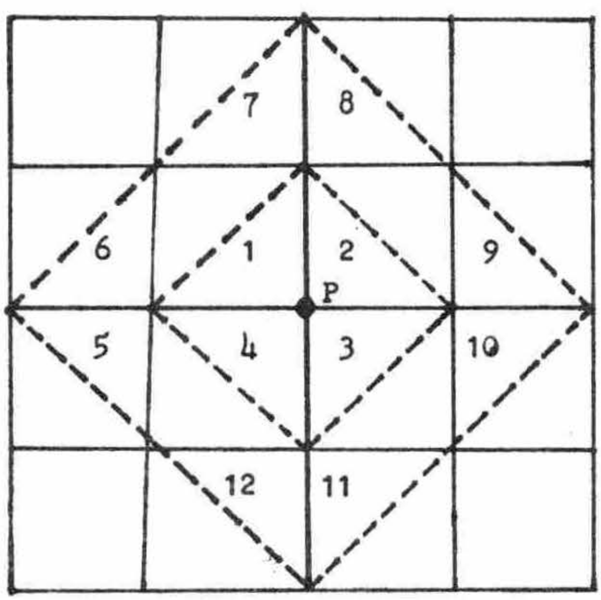

Figure 5. Theoretical trade area assuming various road distances from a plant located at point P

distribution costs must be balanced when determining the optimal size facility.

In Iowa, county roads typically follow section lines, presenting a square grid system of roads. In situations such as this, the least costly area to distribute feed is a square tilted 45 degrees to the road net as illustrated in figure 5 (10, p. 767).

Thus plant P will serve a two square mile trade area if the maximum distance feed will be transported is one road mile. One half of the sections 1, 2, 3, and 4 would be served. If the trade area is allowed to expand to a maximum of two road miles from plant P, the trade area is then eight square miles. This is due to all of sections 1, 2, 3, and 4 plus one half sections 5, 6, 7, 8, 9, 10, 11, and 12.

The marginal area gained by extending the outer boundary of the square trade area from one to two miles is six square miles (8-2). The general formula for computing marginal area gained is as follows:

$$M = 4R_i - 2$$

where M is the marginal area gained by extending the outer boundary of the trade area one additional road mile from the plant and R_i is the distance from the plant to the outer boundary of the trade area by the road grid. Thus the marginal area gained by extending the outer boundary of the trade area an additional mile to three road miles would be ten square miles.

The total area of the trade area would be a summation of the marginal areas. In our example, the marginal areas of 2, 6, and 10 square miles would be added together to give a total area of 18 square miles when the road distance from the central plant to the outer boundary of the trade area is 3 miles.

If we assume that the density of feed consumption in our trade area is uniform, we can then calculate the volume of feed our plant can supply. This will simply be the result of multiplying the square miles of the trade area by the consumption density per square mile. The marginal volume of feed demanded may be expressed as follows:

$$D = (4R_i - 2)\ C$$

where D is the marginal volume of feed i road miles from the plant and C is the consumption density per square mile.

As an example, assume the trade area extends three road miles from the plant and that the consumption density is 20 tons per square mile. The marginal volume gained (assuming 100 percent market share) by extending our boundary from two to three miles from the plant will be 200 tons of feed.

In order to determine the total volume of feed consumed in the trade area, we must simply sum up the marginal volumes of feed. This may be expressed by the following:

$$TV = \sum_{i=1}^{R} (4R_i - 2)\ C$$

where TV is the total volume of feed demanded in the trade area. In our example total volume would be 360 tons (40 + 120 + 200).

The distribution costs involved in delivering a ton of feed can be separated into fixed and variable components. The time and effort involved in loading and unloading feed will be the same if the feed is transported 1 or 20 miles. Driving time, gasoline and other similar costs, however, will vary with the number of miles the feed is transported. The per unit cost of transportation could be represented by the following:

$$UT = a + b\ (i)$$

where UT is the per unit cost of transportation, a is the per unit fixed cost of delivering feed, b is the per unit variable cost of delivering a ton of feed one mile, and i is the number of miles the feed is delivered.

In order to determine the total distribution costs involved in delivering feed in a square trade area, we must simply sum the product of marginal volume and per unit transportation costs for each additional mileage increment from the plant. This could be expressed as follows:

$$TT = \sum_{i=1}^{R} (4R_i - 2)\ C\ \left[a + b\ (i)\right]$$

where TT is the total distribution cost of delivering feed.

To determine the average distribution cost (ADC) is simply a matter of dividing total distribution costs by the volume obtained in the trade area. Average distribution costs increase at a decreasing rate as volume expands with a larger trade area.

To combine average distributional and internal plant costs is simply a matter of addition. Figure 6 illustrates the forming of the combined average cost (CAC) function from distributional (ADC) and internal plant costs (LAC).

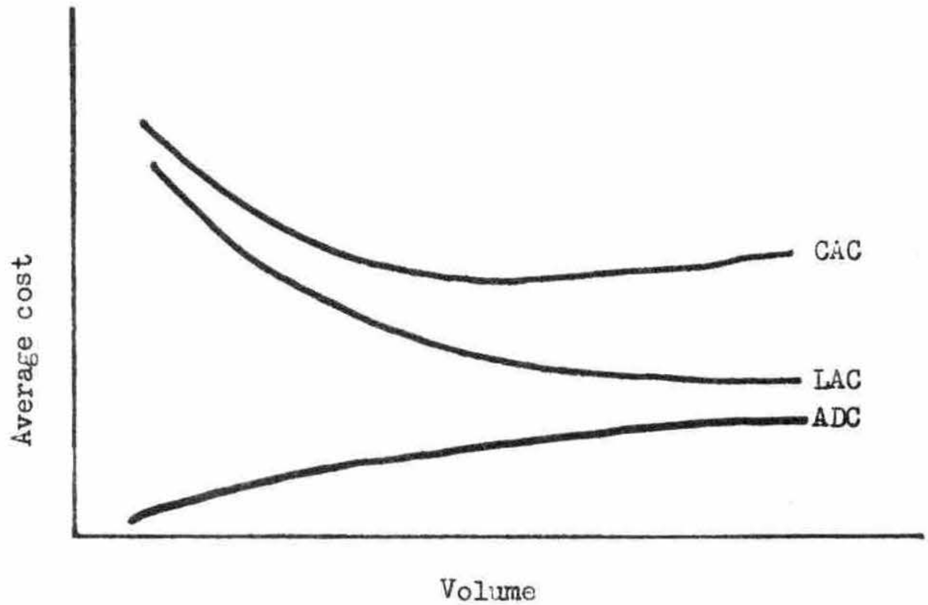

Figure 6. Combined average cost function

The combined average cost function may be used as a guide to evaluate cost advantages of various scales of operation considering alternative consumption densities. Inference can be made as to the number and location by spatially locating firms in optimal size trade areas in which economies of scale can be utilized. This is a simplified situation since various assumptions were made concerning uniform consumption density and a square road grid system.

Ideally, the Stollsteimer model for optimal plant size, number, and location could be utilized (18). However, this approach is expensive to use since the computer would make a large number of computations. It is also doubtful that the feed retailing industry would follow the results given from the Stollsteimer model. This approach is more applicable to an industry rather than to the individual firm situation. The Stollsteimer model does not require consumption density to be uniform, nor does it require the road net to be a square grid system. The model also allows locational factors to influence the internal plant cost function. The Stollsteimer model simultaneously solves the problem of determining the number, size and location of plants that minimize the combined transportation and processing costs involved in assembling and processing a given quantity of raw material produced in varying amounts at scattered production points (18, p. 631). This model will solve equally well the same problem involving distribution and processing costs.

This approach first minimizes transportation costs with respect to plant numbers under alternative locational patterns of plants. As plant numbers increase, the average distance from the plants to the demand points decreases, and thus transportation costs decline.

Although transportation costs decline as plant numbers increase, the annual long-run cost of establishing and maintaining additional plants increase as facilities are duplicated. Thus a solution must balance distribution and plant fixed costs in determining the optimal number, size and location of plants.

CHAPTER IV. METHOD OF ANALYSIS

The quantification of cost is usually done for one of the following purposes: (1) to test theoretical hypotheses; (2) to verify economic theory; or (3) to provide useful information for decision makers.

There are two principal approaches to estimating cost functions. The first of these, the synthetic method, is developed from the detailed study of plant stages and operations and the integration and aggregation of these stages into a total cost function. In other words, a model plant is developed on paper to represent an efficient plant in the real world from data obtained from engineers, equipment dealers, building contractors, and accounting records. The second, the statistical approach, derives relationships from the analysis of aggregate cost and volume data. This method uses the actual costs incurred by firms in the real world.

The synthetic method has several advantages. A primary one is that it reflects the best practice and technology available to use in operating a plant. Thus by changing technology, the researcher can determine the affect on cost and can choose the efficient practices. Synthetic models also are advantageous in that they have better comparability with respect to spatial differences in plants. On the other hand, statistical cost estimations are averages and normally do not adjust for spatial differences adequately. Simulation models have an additional advantage of being able to develop cost-output relationships for plants that are larger than ones which exist in the real world.

The synthetic method of cost estimation also has several disadvantages. A principal one is that it is expensive in its use of research inputs. In order to avoid intensive use of research inputs, the researcher will often update or adjust data from previous studies. Another disadvantage of this method is that the researcher cannot estimate parameters or apply statistical tests to determine the validity of the estimates. This approach also has an "unreal" connotation in that it does not reflect the costs being incurred in the real world. Further, it will not indicate to the researcher how far off the actual industry is from the frontier (efficiency) function. Ideally the researcher should compare his simulation model to a statistically derived one.

Statistical cost analysis has the following advantages: (1) uses readily available accounting data, (2) low in cost, (3) regression coefficients can be subjected to statistical tests, and (4) they reflect the real cost of plant operations. The principal disadvantage, however, is that they represent an average cost of operation and thus do not reflect the most efficient methods. This averaging effect can also be found in some synthetic models if the coefficients used are statistical averages.

The method of estimating a cost function is dependent on the resources available to the researcher and the specific objectives of the study. If resources are plentiful, the researcher could use the synthetic approach and estimate cost functions with detailed industrial engineering analysis or time and motion study. However, if research inputs are limited, perhaps the synthetic method of cost analysis using accounting records as a source of data would be more appropriate. A further limitation of research inputs might suggest that a statistical cost study might be most desirable. The specific objective and purpose of a cost study will also have important implications as to which method is most appropriate for the researcher.

The synthetic method of cost estimation was used in this study. Four model feed mills were developed and then analyzed and compared to each other with respect to their annual operating costs.

In order to obtain a better understanding and appreciation of the problems facing feed mills, the author visited eight central Iowa elevators and observed the operation of their feed mills. Labor, administrative, equipment, land, and output data were gathered from these feed mills as a source of information in synthesizing the four model feed mills developed in this study. The annual cost involved in operating these eight central Iowa feed mills was computed to use as a benchmark for comparison with the operating costs synthesized in the model feed mills. The costs incurred by the feed mills surveyed were difficult to compute due to the accounting procedures used by elevators. Elevators do not separate or distinguish costs incurred by their multiple departments. For example, the cost of electricity is lumped together for the entire elevator and is not broken down into the feed, fertilizer, grain, or other departments. This makes the cost analysis of an individual department difficult.

Another problem encountered when computing the cost of operating the eight central Iowa feed mills is the cost of durables. In order to be able to compare the cost of operating the feed mills surveyed with the model feed mills synthesised, equipment and building costs were updated to present day dollars. This was done by adjusting the equipment and mill building costs upwared to 1971 values by using equipment and construction price indices to compensate for inflation and to allow comparison of their individual cost of operations.

Investment data required to build and equip the model feed mills were obtained from Todd and Sargent Inc. of Ames. Associated with the investment cost are fixed costs such as depreciation, insurance, interest, and property taxes. Administrative costs were computed using data from the feed mills surveyed by the author.

Labor costs were computed using labor standards developed in previous studies and from hourly wages paid by the elevators surveyed. Utility costs are taken from a previous study. Miscellaneous and repair costs are derived from data of the survey of eight central Iowa feed mills.

The above costs are computed under the following assumptions which will be discussed further in the following chapter:

1. Grain is received directly from the main elevator by gravity flow directly into the grain storage tanks next to the feed mill. This is a reasonable assumption since most grain used in custom feed is either bought from the elevator by the farmer or is stored by the elevator for the farmer under a grain banking system. This assumption also will simplify the distribution analysis in a later study that will assume all feed is delivered by the feed mill trucks. A large percentage of feed is delivered to farmers in delivery trucks from feed mills in central Iowa.

2. The cost of grain, feed ingredients, supplements, sacks, or other raw materials is not considered in this study. Only the cost of receiving, processing, mixing, pelleting, sacking, and loading out feed is considered. Distribution costs will be combined with the inplant costs developed in this study in a later study.

3. Adequate land for the feed mill facilities and surrounding area can be purchased for 2,000 dollars.

4. The annual labor cost of a mill worker to the elevator is 7,523 dollars.

5. Feed mills are assumed to operate 280 days per year. This figure was used since elevators are normally open five and a half days per week except for six holidays.

CHAPTER V. ANALYSIS OF DATA

Model Feed Mills

Each feed mill in Iowa is designed and equipped for a specific purpose and situation peculiar to its own particular area. Because each feed mill is different, it is difficult to describe any "typical" feed mill. It is necessary to be specific as to the type of building and size of equipment.

This study is made of four model feed mills having capacities of 48, 160, and 240 tons of feed per eight hour day. There are two 240 ton model mills. One is equipped to pellet a portion of its output while the other 240 ton model is assumed to produce all mash feed.

The 48 ton model is not a duplicate of an actual feed mill as are the other model feed mills. The 48 ton model was synthesized by the author with help from personnel at Todd and Sargent Inc. of Ames, Iowa. This model was developed to synthesize operating costs of a low volume feed mill with a relatively low investment.

The feed mill building is made of steel as is the 5,380 bushel stilted grain storage tank. Grain is transferred to this grain tank directly from the main elevator. In addition to the grain storage, 132 tons of bulk storage are available in eight 12-ton ingredient bins and six 6-ton load-out bins. The mill building does not have a full basement but only a pit for the receiving leg.

The 48 ton model is equipped to grind, crimp, and mix feed. A one and one-half ton vertical mixer is used for mixing feed. A small amount of feed can be bagged directly from this mixer. Ingredients are gathered from the ingredient bins, weighed, and moved to the vertical mixer in a weigh buggy. The grinder is a 60 horsepower full circle gravity mill capable of grinding 12 to 15 tons per hour according to personnel at Todd and Sargent Inc. A 10 horsepower rollermill is used for crimping grain. A 10 by 50 foot scale is assumed to be used 25 percent of the time by the feed department. Table 13 lists the major equipment included in the 48 ton model feed mill.

The 160 ton model feed mill is a duplicate of an actual feed mill with grain storage and warehouse space added. This model represents a medium size feed mill capable of mixing 160 tons of feed in an eight hour day.

The mill building and 11,000 bushel stilted grain tank are both constructed of steel. Grain is again assumed to be transferred directly from the main elevator to the grain tank. A total of 226 tons of bulk storage is available in ten ingredient and eight load-out bins.

The 160 ton model is designed to grind, crimp, mix, and bag feed. A two ton horizontal mixer with a hopper scale and semiautomatic controls is used for mixing feed. A 100 horsepower grinder and a 15 horsepower rollermill are used for processing grain. A 10 by 50 foot scale is assumed to be used 50 percent of the time by the feed department. The other 50 percent of the time it is used by other departments of the elevator. Table 14 lists the basic equipment included in the 160 ton model feed mill.

The 240 ton model mill is a duplicate of an actual feed mill with pelleting operations. The 240 ton model without pelleting operations is the same model feed mill with the removal of the pelleting equipment.

This model represents a large volume feed mill with a relative large investment.

A steel mill building and two 11,000 bushel stilted grain tanks make up the building facilities. The bulk storage capacity is 528 tons in 13 ingredient, 2 pelleting, and 13 load-out bins.

The equipment in the 240 ton model feed mills is listed in table 15. The only difference between the pelleting and nonpelleting models is the equipment listed under the pelleting work center. Naturally, no pelleting equipment is in the nonpelleting 240 ton model. A 100 horsepower full circle gravity mill, 20 horsepower rollermill, 100 horsepower pellet mill, and a 3 ton horizontal mixer make up the basic equipment of this model.

Capacity

The capacity of the model feed mills was determined by the size of the mixer and the length of time a mixing cycle required. The mixing cycle includes the following: move the feed ingredients into the mixer, mix the feed, and empty the mixer.

The 48 ton model assumes a mixing cycle of 15 minutes. This is a relatively long cycle in comparison to the other models. This cycle is longer since the millman must obtain and weigh the feed ingredients in a weigh buggy. This method of weighing and moving feed ingredients is more labor consuming in comparison to the methods used in the other feed mills. The 48 ton per eight hour day capacity is computed by multiplying 1.5 tons (size of the vertical mixer) times 32 cycles (4 cycles per hour times 8 hours per day = 32 cycles).

The mixing cycle for the 160 and 240 ton model feed mills is six minutes. The feed ingredients are moved to a hopper scale above a 2 ton or 3 ton horizontal mixer by gravity and feeder screws in the 160 and 240 ton models respectively. The feed is mixed for 3.5 minutes per batch and then discharged from the mixer in 2.5 minutes. Another batch of feed can be dumped into the mixer from the hopper scale immediately after the mixer is empty. The 160 ton per eight hour day capacity is computed by multiplying 2 tons (size of the horizontal mixer) times 80 cycles (10 cycles per hour times 8 hours per day = 80 cycles). Similarly the 240 ton per eight hour day capacity is computed by multiplying 3 tons (size of the mixer) times 80 cycles (10 cycles per hour times 8 hours per day = 80 cycles).

It should be noted that these are theoretical capacities of the mixer. These capacities assume the following: no major equipment breakdowns, sufficient feed orders, and no other major problems or shortages. These conditions are necessary to operate the model feed mills at their theoretical capacities.

Output

Many feed mills in Iowa perform four basic services for farmers. These are: crimping grain, grinding grain, mixing feed, and also sacking a relatively small amount of custom feed. In addition, a feed mill with pelleting equipment may pellet a small amount of custom feed. The pelleting equipment is normally used more extensively to pellet formula feed mixed by the feed mill.

Formula feed in this study is defined as feed containing two or more ingredients that are processed or mixed according to set or formula specifications. Examples of formula feed are concentrates such as cattle supplement or a complete feed such as pig prestarter.

Custom feed will be defined as feed made to the customer's specifications. This usually includes grinding or crimping the farmer's grain and mixing supplements and/or other ingredients with them. Grain banking is often used in connection with the making of custom feed.

In order to determine how much grain should be crimped or ground, and how much feed should be mixed, sacked, or pelleted in the model feed mills, the author used the average output of eight central Iowa feed mills as a source of information.

The annual output (tons of grain crimped or ground and feed mixed, pelleted, or bagged) of feed mills is not readily obtainable from elevators. Elevator records usually contain only dollar sales of feed retailed and do not reveal the physical tons of feed processed or mixed in the feed mill.

The annual output of feed mills can be accurately estimated by analyzing the annual service charge income from mill operations. Feed mills charge their patrons service charges at rates comparable to the following:

grinding	$2.00/ton
crimping	$1.00/ton
mixing	$1.00/ton
bagging	$3.00/ton
pelleting	$3.00/ton

After obtaining the annual service charge incomes from elevator records, the author estimated the percentage that each of the above service charges represented of the total annual service charges. This was done by going through three months of feed receipts and determining the service income attributable to grinding, crimping, mixing, bagging, and pelleting. The next step in estimating annual output was to multiply the estimated percentage income attributable to each service by the annual service income. The product would represent the estimated annual income from each service. The estimated annual income from each service could then be converted to physical tons by dividing by the service charge per ton.

A hypothetical example of the above might help clarify the procedure. First, assume an elevator has an annual income of 10,000 dollars from various feed mill service charges. The problem is to determine how much of this 10,000 dollars is brought in by each service since elevator records reveal only total service income. This can be done by examining three months (for example March, July, and November) of daily feed receipts. The researcher then adds up the service income for each service (crimping, grinding, mixing, pelleting, and bagging) in these three months.

Assume the service charges and their respective percentages during the three months are as presented in table 1. To determine the estimated annual service income from grinding, the researcher simply multiplies 48 percent (from table 1) times 10,000 dollars to get 4,800 dollars. Thus of the 10,000 dollars in service income, 4,800, 1,200, 3,700, 100, and 200 dollars are estimated to result from grinding, crimping, mixing, bagging, and pelleting services respectively. These annual dollar figures

Table 1. Hypothetical service income for a feed mill for three months

Service	Income (dollars)	Percent of total (percent)
Grinding	1,680	48
Crimping	420	12
Mixing	1,295	37
Bagging	35	1
Pelleting	70	2
Total	3,500	100

can be converted to tons by dividing each by their service charge per ton. Thus 2,400 tons of feed were ground ($4800 ÷ $2.00/ton = 2400 tons). Similarly annual output estimates of 1,200, 3,700, 33, and 67 tons were crimped, mixed, bagged, and pelleted respectively.

The output of different feed mills in central Iowa vary with the type of livestock produced in the area. For example, an area with a large number of turkey producers will have more crimping service charges than an area predominantly of hog producers. Turkey feed often contains crimped corn while hog feed normally contains ground corn explains this difference. An average output of eight central Iowa feed mills was used to determine the output of the model feed mills in this study.

Table 2 lists the output of three model feed mills without pelleting operations. Total output of the feed mill is considered all feed that passes through the mixer plus any crimped grain not going through the mixer. The tons ground, crimped, mixed, and bagged was determined by multiplying the mill capacity times the percent of total output. The percent of total output does not add to 100 percent in table 2 since feed normally has more than one operation performed on it (for example, grain is ground and then mixed). An average of eight central Iowa feed mills crimped 25 percent of their total output. Thus if the 48 ton model feed mill was operating at 100 percent capacity, then 12 tons of grain would be crimped. Of this 12 tons of crimped grain, 6 tons on the average would then be mixed with a supplement in the mixer. The other 6 tons of crimped grain would not be mixed but would be loaded out as crimped grain. The farmer could then simply add supplement to the crimped grain himself.

Table 2. Output of three model feedmills

Operation	Percent of total output[a]	48 ton model (tons)	160 ton model (tons)	240 ton model (tons)
Crimping	25.0	12.0	40.0	60.0
Grinding	66.9	32.1	107.0	160.6
Mixing	87.5	42.0	140.0	210.0
Bagging	1.4	0.7	2.2	3.4

[a]Total output is defined as the number of tons going through the mixer plus the crimped grain that is not mixed. One-half of the crimped grain (12.5 percent of the total output) is mixed with supplement in the mixer. The remaining one-half of the crimped grain is loaded out by itself.

The 6 tons of crimped grain that was mixed is also included in the 42 tons of feed mixed in the 48 ton model in table 2. Very little bagging is done of custom feed in feed mills (1.4 percent of total output). The amount of grain in custom mixed feed averaged 79 percent. Thus 21 percent of custom mixed feed was made up of supplements and/or other ingredients such as salt, mineral, premix, bonemeal, linseed meal, alfalfa meal, soybean meal, etc.

Table 3 presents the output of the 240 ton model feed mill with pelleting operations. In this model 36.7 tons of formula feed is assumed to be made per day. This was based on an average of three central Iowa feed mills who manufactured formula feed. An average of 15.3 percent of output was formula feed (36.7 tons). The custom services done on the remaining 203.3 tons of custom feed are based on the same percentages used in table 2 with the exception of custom pelleting which was done on 2 percent of the custom feed in table 3. Formula feed usually contains less grain because it is generally a protein supplement. It is also assumed that 50 percent of the formula feed is bagged and 50 percent is pelleted.

Investment

The investment required to build and equip a specific size mill can vary substantially due to a number of factors. Some of these factors are: (1) location, (2) grain and bulk storage facilities, (3) quality and type of equipment, and (4) building materials.

The location where a feed mill is being built may have a substantial effect on building costs. Labor normally accounts for 25 percent of the

Table 3. Output of the 240 ton model feed mill with pelleting equipment

Operation	Custom feed[a] (tons)	Formula feed[b] (tons)	Total (tons)
Crimping	50.8	0.0	50.8
Grinding	136.0	22.0[c]	158.0
Mixing	177.9	36.7	214.6
Bagging	2.8	18.3	21.1
Pelleting	4.1	18.3	22.4

[a]Based on the same percentage of output used in table 2.

[b]One-half of the formula feed is bagged and one-half is pelleted.

[c]Assumes 60 percent of formula feed is grain. All grain is assumed to be ground.

cost of building and equipping a feed mill according to personnel at Todd and Sargent Inc., a designer and builder of feed mills and grain elevators. Thus building costs will be significantly higher near large urban centers where labor unions may be strong. For example, the cost to Todd and Sargent of building a fully equipped feed mill in Iowa is less than building a similar feed mill without equipment in St. Paul, Minnesota. The distance the building site is from a source of building materials and equipment will also affect the cost of building a feed mill.

The grain, ingredient, and load-out storage requirements also affect the cost of building. The cost of welding bulk bin wall seams is greater than if they are bolted together. Grain storage facility costs will vary significantly if grain is stored in steel stilted grain tanks or in overhead bins.

The quality and type of equipment also affects investment requirements. High quality equipment will probably have a longer useful life but will require a larger initial investment. Inferior equipment, on the other hand, will usually be less costly. Their useful life will be shorter than the higher quality equipment, but in the short-run they may be able to perform the same task. In other words, they may be able to produce the same tonnage of feed during a given period of time.

Building materials affect the cost of the feed mill building directly. Normally, steel is less expensive for smaller buildings while slip-form concrete becomes more economical as the height and size of the building increases. The type of building material also has an affect on the insurance rates paid by the feed mill.

The investment cost figures used for the model feed mills in this study are provided in table 4. The cost figures provided represent the cost of equipment, building materials, labor, subcontractors fees, rent, and miscellaneous costs to the contractor. An additional 15 percent of the above costs is included to cover overhead costs and profit.

The cost of land is assumed to be 2,000 dollars in all models. This should buy enough land in a rural Iowa community to provide sufficient area for the feed mill building, grain storage tanks, warehouse, and truck accessibility.

Operating Costs

Operating costs in this study do not include the cost of ingredients, sacks, transportation, or other similar costs. In the short-run, operating costs can be separated into variable and fixed costs. Fixed costs do not vary with the rate of output while variable costs do. Fixed costs include depreciation, property taxes, insurances, interest on investment, and administrative costs.

Depreciation is the allocation of the initial cost of equipment and buildings over their useful life. This study assumed the useful life of the feed mill equipment at 10 years and the useful life of the feed mill building at 25 years. A ten percent straight-line rate of depreciation for equipment and a four percent straight-line rate of depreciation for the mill building is both consistent and representative of depreciation rates used by cooperative elevators in central Iowa.

Interest on investment was assumed to be six percent in this study.

Table 4. Total and per ton investment costs in four model feed mills

Cost item	48 ton	160 ton	240 ton mash	240 ton pellet
Equipment	$ 35,700	$ 51,500	$ 73,430	$124,430
Buildings	79,000	102,000	150,660	150,660
Land	2,000	2,000	2,000	2,000
Total investment	$116,700	$155,500	$226,090	$277,090

This rate is currently being used by the Omaha Bank of Farmer Cooperatives for long-term loans. Cooperative elevators normally use this bank for long-term credit needs. The annual interest cost was estimated by applying three percent, or one-half the normal rate of six percent, times the total capital investment in equipment and facilities. The assumption here is that this represents the average investment in buildings and equipment over their useful life. The annual interest cost on the nondepreciable land investment was calculated at six percent.

Insurance rates were based on information obtained from a conversation with Mr. Darrell Bluebaker of the Farmers Elevator Mutual Insurance Company of Des Moines, Iowa. Most cooperative elevators in Iowa are insured by this organization. Insurance rates on feed mills vary significantly depending on such factors as building materials, equipment, building foundation, electrical wiring, fire detection equipment, sprinkler system, public fire protection and cleanliness. This study assumed a rate of $5.50 per $1,000.00 of coverage on a noncombustible steel building with equipment and inventory inside. Inventories for the 48, 160, and 240 ton models were assumed to be valued at 10,000, 30,000, and 40,000 dollars respectively. The level of inventory was based on actual inventory levels of similar volume feed mills in central Iowa. In addition to the above insurance costs, an additional 75 dollar premium was allocated to the 240 ton model mill with pelleting equipment for coverage of the boiler.

Property taxes were calculated by assuming a millage rate of 100. This is representative of many rural communities in Iowa. The property tax is levied on the taxable value which is 27 percent of the assessed value. For example, if the assessed value is 100,000 dollars, then the taxable value is equal to 27,000 dollars (100,000 x 0.27). A property tax of 100 mils results in a property tax cost of 2,700 dollars (27,000 x 100/1,000). The assessed value in this study was assumed to be the total investment in land, equipment, and buildings.

A final element of fixed costs is that associated with administrative personnel. The cooperative elevator normally has three persons in the office who perform functions directly related to the feed department. These personnel include the elevator manager, counterman (often the assistant manager), and a bookkeeper. The manager performs such functions as ordering ingredients and merchandise for the feed mill, talking to customers, talking to mill employees about routine operations and maintenance, and reviewing the performance of employees. The counterman performs such functions as taking orders, talking with customers, and helping load-out bagged feed out of the warehouse. The bookkeeper is involved with such tasks as posting accounts receivable, posting accounts payable, and checking and paying invoices associated with the feed department. The salaries, wages, payroll taxes and benefits associated with these administrative personnel are considered fixed costs since they will not vary directly with different levels of output in the feed mill.

The salaries for administrative personnel used in this study are an average of those paid by eight cooperative elevators in central Iowa. An average figure was used since the author could find no relationship to exist between salaries paid and the size of the feed mill. The portion of administrative time allocated to the feed department is based on estimates made by elevator managers of similar size feed mills in central Iowa.

In addition to the salary of the administrative personnel, other costs such as payroll taxes (unemployment and social security) and employee benefits (retirement, medical insurance, life insurance) were included in the cost of administration. The amount of benefits provided to employees of cooperative elevators varies considerably from elevator to elevator. Because of the diversity of benefits provided, this study assumed that payroll taxes and benefits amounted to 9.6 percent of the salary paid. This was the average of eight elevators in central Iowa. For example, if the payroll for an elevator was 100,000 dollars, then on the average an additional 9,600 dollars would be paid in payroll taxes and benefits. Table 5 illustrates the administrative personnel cost of the model feed mills.

Variable costs are those costs that vary with the level of output in the short-run. These include the cost of labor, repairs, supplies, utilities, and other miscellaneous items.

The source of labor input requirements were obtained from the Tamashunas study and from several Marketing Research Reports done by the Economic Research Service of the United States Department of Agriculture (4, 5, 6, 7, and 8). The source used for any particular job depended on the type of equipment used or on the volume of feed or ingredients handled. For example, the 48 ton model feed mill used a vertical mixer. Thus the mixing labor standards developed by Tamashunas were used since they were developed for vertical mixers.

The standard time needed in minutes per ton to receive bulk and sack

Table 5. Administrative cost of operating model feed mills

Personnel	48 ton model (dollars)	160 ton model (dollars)	240 ton model[a] (dollars)
Manager	1,730 (1/10)[b]	4,325 (1/4)	5,770 (1/3)
Counterman	4,450 (1/2)	8,900 (1)	13,350 (1 1/2)
Bookkeeper	3,550 (1/2)	7,060 (1)	10,590 (1 1/2)
Total salary	9,710	20,285	29,710
Payroll taxes and benefits[c]	932	1,947	2,852
Total administrative cost	10,642	22,232	32,562

[a]Administrative costs are assumed to be identical for both the pelleting and mash 240 ton models.

[b]Figures in brackets indicate the number of men required.

[c]Payroll taxes and benefits are computed at 9.6 percent of the total salary.

ingredients were taken from the Tamashunas 25 ton model mill since the tons received in all 4 model feed mills were about equal to or greater than his 25 ton model. The labor standards used were also comparable to labor requirements used in a Marketing Research Report on receiving feed ingredients (4). It was assumed that bagged ingredients received for the 48, 160, and 240 ton models were one-third, one-fourth, and one-fifth of the total tons of ingredients received respectively. These fractions were obtained by examining the invoices of feed ingredients received of five central Iowa elevators. An exception was made in the receiving of grain since the author assumes that all grain received into the feed mill grain tanks was obtained from the main elevator. A flat ten minute per day allocation of labor was made since the labor involved in turning the distributor, starting the elevator leg, and stopping the leg is the same in all 4 model feed mills, regardless of the number of tons of grain received.

The processing center labor standards were developed from a Marketing Research Report on grinding and crimping grain (8). The per ton labor standards developed varied substantially since the labor needed to start, adjust, and stop the hammermill or rollermill and clean up are about the same for all 4 model feed mills. However, the number of tons of grain ground or crimped was much larger with the 160 and 240 ton models. Thus the mill labor required per ton in the larger mills was substantially less. The computation of the labor standard for processing grain is illustrated in tables 16, 17, 18, 19, 20, and 21.

Tamashunas used vertical mixers similar to the 48 ton model feed mill of this study. Thus the labor standards developed by him for mixing feed were felt to be appropriate. The 160 and 240 ton models use horizontal mixers. Thus labor standards were developed using data from a Marketing Research Report on mixing feeds with horizontal mixers (5). Tables 22 and 23 present the computation of the labor standards for mixing in the 160 and 240 ton model feed mills respectively.

Table 24 illustrates the computation of the labor standard necessary to pellet feed for the 240 ton model with pelleting equipment. A Marketing Research Report on pelleting feed was used as a source for developing the labor standard (6).

The sacking cost center used the Tamashunas study as a source of labor standards in bagging feed. He found that the time needed to bag a ton of feed in his larger models was less than in the smaller model. The Tamashunas labor standard used depended upon the quantity of feed bagged per day. It was assumed that all feed bagged was put in 50 pound sacks and then closed with a sewing head.

The labor involved in warehousing feed was simply the loading of bulk and bagged feed on the delivery truck. The Tamashunas study again was used as a source of data for an appropriate labor standard. The labor standard used for loading bulk feed was three minutes per ton in all models. The labor standard for loading bagged feed was 16.4 minutes per ton in the 48 and 160 ton models while it was 13.9 minutes per ton for the 240 ton models.

After labor standards were obtained for all cost centers, they were multiplied by the number of tons of feed or ingredients to compute the number of man-minutes needed to operate the model feed mills. It was assumed that each man worked nine hours a day which is representative of most retail feed mills in Iowa. Tables 6, 7, 8, and 9 summarize the labor requirements of each cost center and also illustrate the computation of the number of men required to operate the model feed mills at capacity. This resulted in 1.4, 3.0, 3.9, and 6.1 men needed to operate the 48, 160, 240 (without pelleting), and 240 (with pelleting) ton models respectively.

This study assumes the marginal millman (unused part of a laborer) uses his excess time performing tasks for the other departments of the elevator. The cost per man is calculated assuming an hourly wage of $2.40. The mill worker labors 50 hours a week and is paid time and a half overtime for all work over 40 hours. These figures are representative for similar businesses in central Iowa. The annual wage of the mill worker computed on the above figures would be 6,864 dollars. In addition to these wages, the elevator must pay social security taxes, unemployment taxes, retirement benefits, group life insurance, and group hospitalization insurance. These additional costs were estimated to be 9.6 percent of his annual wage. This resulted in a total annual cost per mill worker of 7,523 dollars. The total number of workers required, multiplied by 7,523 dollars, results in the total labor cost for each model feed mill.

Another variable cost, utilities, was calculated using data from a study done by the Economic Research Service of the U.S.D.A. (2). Utility costs per ton decreased as the size of the feed plant increased. Utility costs were calculated at 34, 23, and 18 cents a ton for the 48, 160, and 240 ton model feed mills respectively. The utility costs incurred in the

Table 6. Labor requirements for the 48 ton model feed mill

Work center	Tons/day	Standard time, min./ton	Minutes required/day
Receiving:			
Grain	44.1	---[a]	10
Bulk ingredients	2.6	3.6	9
Bagged ingredients	1.3	10.2	13
Processing:			
Grind grain	32.1	3.1	100
Crimp grain	12.0	2.8	34
Mixing	42.0	8.7	365
Sacking	0.7	52.3	37
Warehousing:			
Load bulk	47.3	3.0	142
Load sacks	0.7	16.4	11
Total labor			721

Man-days at 540 minutes per day, $\frac{721}{540} = 1.4$[b] man-days

[a]The grain is received from the main elevator. The labor is the same if 1 ton or if 100 tons of grain is transferred to the feed mill grain tank.

[b]Rounded upward to the nearest tenth.

Table 7. Labor requirements for the 160 ton model feed mill

Work center	Tons/day	Standard time, min./ton	Minutes required/day
Receiving:			
Grain	147.0	---[a]	10
Bulk ingredients	9.8	3.6	35
Bagged ingredients	3.2	10.2	33
Processing:			
Grind grain	107.0	1.0	107
Crimp grain	40.0	2.1	84
Mixing	140.0	5.3	742
Sacking	2.2	40.7	90
Warehousing:			
Load bulk	157.8	3.0	473
Load sacks	2.2	16.4	36
Total labor			1,610

Man-days at 540 minutes per day, $\frac{1610}{540} = 3.0^{b}$ man-days

[a]The grain is received from the main elevator. The labor is the same if 1 ton or if 100 tons of grain is transferred to the feed mill grain tank.

[b]Rounded upward to the nearest tenth.

Table 8. Labor requirements for the 240 ton model feed mill producing all mash feed

Work center	Tons/day	Standard time, min./ton	Minutes required/day
Receiving:			
Grain	220.6	---[a]	10
Bulk ingredients	15.5	3.6	56
Bagged ingredients	3.9	10.2	40
Processing:			
Grind grain	160.6	0.7	112
Crimp grain	60.0	1.5	90
Mixing	210.0	4.1	861
Sacking	3.4	39.0	133
Warehousing:			
Load bulk	236.6	3.0	710
Load sacks	3.4	16.4	56
Total labor			2,068

Man-days at 540 minutes per day, $\frac{2068}{540} = 3.9^{b}$ man-days

[a]The grain is received from the main elevator. The labor is the same if 1 ton or if 100 tons of grain is transferred to the feed mill grain tank.

[b]Rounded upward to the nearest tenth.

Table 9. Labor requirements for the 240 ton model feed mill pelleting part of its output

Work center	Tons/day	Standard time, min./ton	Minutes required/day
Receiving:			
Grain	208.8	---[a]	10
Bulk ingredients	25.0	3.6	90
Sack ingredients	6.2	10.2	63
Processing:			
Grind grain	158.0	0.8	126
Crimp grain	50.8	1.8	91
Mixing	214.6	4.0	858
Pelleting	22.4	11.0	246
Sacking	21.1	39.0	823
Warehousing:			
Bulk load	218.9	3.0	657
Sack load	21.1	13.9	293
Total labor			3,257

Man-days at 540 minutes per day, $\frac{3257}{540} = 6.1$[b] man-days

[a]The grain is received from the main elevator. The labor is the same if 1 ton or if 100 tons of grain is transferred to the feed mill grain tank.

[b]Rounded upward to the nearest tenth.

240 ton model with pelleting equipment was computed at 18 cents a ton for 217.6 tons of mash feed and at 59 cents a ton for 22.4 tons of pelleted feed.

Supplies and repairs are an additional variable cost. It is difficult to obtain representative data on this expense since most elevators do not separate their repair and supply cost into individual departments. Of eight cooperatives studied in central Iowa, only one separated their repair and supply costs of the feed department. The cost of repairs and supplies in this study was assumed to have a linear relationship with the number of tons produced. Thus the per ton cost of repairs and supplies incurred by one central Iowa cooperative was used as a point estimate of this linear relationship. This cost was 26 cents per ton.

A final variable cost is classified as miscellaneous. This includes such things as meetings, travel, audit fees, legal fees, director fees, dues, subscriptions, and other minor expenses. These costs were assigned to the four model feed mills by assuming they would incur the same miscellaneous costs of similar size feed mills of cooperatives in central Iowa. The 48 and 160 ton models were assumed to have miscellaneous costs of 25 and 15 cents a ton respectively. The 240 ton models were assumed to have miscellaneous costs of 13 cents a ton.

Table 10 presents the annual cost of operating the model feed mills at full capacity. Table 11 illustrates the annual operating cost of the model feed mills under alternative rates of capacity utilization.

The costs at various utilization levels are derived by holding total fixed costs constant regardless of the level of output. Total variable

Table 10. Annual operating cost of four model feed mills

Cost item	48 ton (dollars)	160 ton (dollars)	240 ton mash (dollars)	240 ton pellet (dollars)
Fixed:				
Depreciation	6,730	9,230	13,369	18,469
Property taxes	3,151	4,198	6,104	7,481
Insurance	686	1,009	1,452	1,808
Interest	3,561	4,725	6,843	8,373
Administrative	10,642	22,232	32,562	32,562
Total fixed	24,770	41,394	60,330	68,693
Variable:				
Labor	10,532	22,569	29,340	45,890
Utilities	4,570	10,304	12,096	14,667
Repairs and supplies	3,494	11,648	17,472	17,472
Miscellaneous	3,360	6,720	8,736	8,736
Total variable	21,956	51,241	67,644	86,765
Total cost	46,726	92,635	127,974	155,458

Table 11. Annual operating cost of four model feed mills under alternative utilization of capacity rates

Model and percent utilization	Fixed cost	Average fixed cost per ton	Variable[b] cost	Average variable cost per ton	Total cost	Average[a] total cost per ton
48 ton						
100(13,440)[c]	$24,770	$1.84	$21,956	$1.63	$46,726	$3.48
80(10,752)	24,770	2.30	17,565	1.63	42,335	3.94
60(8,064)	24,770	3.07	13,174	1.63	37,944	4.71
40(5,376)	24,770	4.61	8,782	1.63	33,552	6.24
20(2,688)	24,770	9.22	4,391	1.63	29,161	10.85
160 ton						
100(44,800)	$41,394	$0.92	$51,241	$1.14	$92,635	$2.07
80(35,840)	41,394	1.15	40,993	1.14	82,387	2.30
60(26,880)	41,394	1.54	30,745	1.14	72,139	2.68
40(17,920)	41,394	2.31	20,496	1.14	61,890	3.45
20(8,960)	41,394	4.62	10,246	1.14	51,642	5.76
240 ton mash						
100(67,200	$60,330	$0.90	$67,644	$1.01	$127,974	$1.90
80(53,760)	60,330	1.12	54,115	1.01	114,445	2.13
60(40,320)	60,330	1.50	40,586	1.01	100,916	2.50
40(26,880)	60,330	2.24	27,058	1.01	87,388	3.25
20(13,440)	60,330	4.48	13,529	1.01	73,859	5.50
240 ton pelleting						
100(67,200)	$68,693	$1.02	$86,765	$1.29	$155,458	$2.31
80(53,760)	68,693	1.27	69,412	1.29	138,105	2.57
60(40,320)	68,693	1.70	52,059	1.29	120,752	2.99
40(26,880)	68,693	2.56	34,706	1.29	103,399	3.85
20(13,440)	68,693	5.11	17,353	1.29	86,046	6.40

[a]Totals may not add due to rounding.

[b]The cost of various utilization levels is computed by holding total fixed costs constant regardless of the level of output. Total variable costs are reduced the same percent that output is reduced.

[c]Numbers in brackets represent the number of tons produced at various levels of utilization of capacity annually.

costs are reduced the same percentage as the level of output. For example, if output is 80 percent of capacity, then total fixed costs are the same as they were at full capacity while total variable costs are 80 percent of what they were at full capacity. The rationale for reducing total variable costs the same amount as output is that variable costs vary directly with the level of output.

Operating Costs of Eight Central Iowa Feed Mills

The cost of operating eight central Iowa feed mills was computed as a comparison to the costs synthesized in the model feed mills in this study. Output was estimated by analyzing the feed mill service income as previously described in this chapter. The annual output of these feed mills ranged from 2,407 to 34,374 tons. Three of the eight feed mills had pelleting equipment and manufactured some feed.

The investment required to build and equip these central Iowa feed mills was adjusted to 1971 dollars in order to compensate for inflation. This adjustment also allows the comparison of depreciation costs of the cooperative elevators. As was done in the model feed mills, depreciation was computed using the straight-line method at a rate of ten percent on equipment and four percent on buildings.

Interest on investment was assumed to be six percent. The annual interest cost was computed at three percent, or one-half the normal rate of six percent, times the total adjusted cost of buildings and equipment. The annual interest cost on the nondepreciable land investment was calculated at six percent.

The cost of insurance was not taken from elevator records since they do not separate feed mill insurance costs from the total elevator insurance premiums. Thus, insurance rates were used from the Farmer's Elevator Mutual Insurance of Des Moines, Iowa. Insurance was computed at 3, 5, and 8 dollars per 1,000 dollars of adjusted cost for reinforced concrete, steel, and wood frame feed mills respectively. In addition, a 75 dollar premium was assessed to the three feed mills having boilers.

Elevator records do not distinguish the proportion of property taxes that are attributable to the feed department. To approximate this proportion, the author divided the cost of feed mill fixed assets by the cost of the total elevator fixed assets. This proportion was then multiplied by the property tax expense to determine the amount attributable to the feed mill.

Administrative costs were determined by examining payroll records. The elevator managers were asked what percent of his time, the counterman's time, and the bookkeeper's time was spent working with the feed department. This percentage was then multiplied by their total salary to determine administrative costs. An average of the managers' salaries was used since some preferred not to reveal this information. The cost of mill labor was determined in the same manner as administrative costs.

The cost of utilities was determined using the same method employed with the model feed mills since elevators do not have separate electric, gas, or water meters for their various departments. Similarly, the cost of repairs and supplies were also computed in the same manner as the synthetic models since only one elevator separated repair and supply cost to the feed department.

Payroll taxes and employee benefits were taken from accounting records and multiplied by the proportion that feed department salaries and wages made of the total elevator payroll. Miscellaneous and other variable costs were allocated to the feed department by multiplying these costs by the percent that feed sales made of total elevator sales.

The annual cost of operating eight central Iowa feed mills are presented in table 12. These costs were obtained from elevator accounting records in which the fiscal year ended in 1971.

Comparison of the Model Feed Mills and the Eight Central Iowa Feed Mills

The costs incurred in the model feed mills and the central Iowa feed mills can best be compared graphically. In figure 7 the short-run average cost curves of the three model feed mills producing mash feed are illustrated by the solid black curves. The average per ton costs of the five central Iowa feed mills producing all mash feeds are illustrated by black dots.

Each real feed mill may have characteristics of two or more of the model feed mills presented. For example, feed mill 2 has a horizontal mixer like the 160 and 240 ton models but uses the weigh buggy method of weighing and moving feed ingredients as used in the 48 ton synthetic model. The five feed mills illustrated, however, are more similar to the 160 and 240 ton models. The real feed mill costs, represented by the black dots in figure 7, may be similar in some respect to all three model feed mills presented.

Table 12. Annual operating cost of eight central Iowa feed mills

Cost item	Feed mill (1)	(2)	(3)	(4)
Fixed:				
Depreciation	$ 7,072	$ 4,563	$ 5,062	$ 9,126
Property taxes	1,168	1,129	1,104	1,079
Interest	3,143	2,526	2,832	4,611
Insurance	535	703	750	1,263
Administrative	3,310	5,424	2,759	8,689
Total fixed	$15,228	$14,345	$12,507	$24,768
Variable:				
Labor	$ 2,051	$ 5,550	$ 5,614	$ 7,993
Utilities	818	1,332	1,669	2,062
Repairs and supplies	626	1,019	1,277	1,577
Employee benefits	697	---[a]	650	1,939
Miscellaneous	776	1,555	1,580	1,499
Total variable	$ 4,968	$ 9,456	$10,790	$15,070
Total cost	$20,196	$23,801	$23,297	$39,838
Output (tons)	2,407	3,919	4,910	6,065
Average admin. cost/ton	$ 1.38	$ 1.38	$ 0.56	$ 1.43
Average labor cost/ton	0.85	1.42	1.14	1.32
Average fixed cost/ton	6.33	3.66	2.55	4.08
Average variable cost/ton	2.06	2.41	2.20	2.48
Average total cost/ton[b]	$ 8.39	$ 6.07	$ 4.74	$ 6.57

[a]Included in miscellaneous costs.

[b]Totals may not add due to rounding.

Table 12. (contd)

Cost item	Feed mill			
	(5)	(6)	(7)	(8)
Fixed:				
Depreciation	$12,542	$18,751	$16,199	$26,276
Property taxes	4,847	4,210	3,623	6,804
Interest	7,893	9,196	6,926	12,789
Insurance	2,278	975	2,066	3,632
Administrative	8,920	8,882	11,620	17,377
Total fixed	$36,480	$42,014	$40,434	$66,678
Variable:				
Labor	$ 5,823	$ 9,515	$ 6,680	$31,671
Utilities	2,614	1,864	2,785	7,911
Repairs and supplies	1,999	2,089	2,767	8,937
Employee benefits	1,533	1,184	1,625	4,633
Miscellaneous	1,178	1,534	3,229	4,439
Total variable	$13,147	$16,186	$17,086	$57,591
Total cost	$49,627	$58,200	$57,520	$124,269
Output (tons)	7,687	8,034	10,643	34,374
Average admin. cost/ton	1.16	1.11	1.09	0.51
Average labor cost/ton	0.76	1.18	0.63	0.92
Average fixed cost/ton	4.75	5.23	3.80	1.94
Average variable cost/ton	1.71	2.01	1.61	1.68
Average total cost/ton[b]	$ 6.46	$ 7.23	$ 5.40	$ 3.62

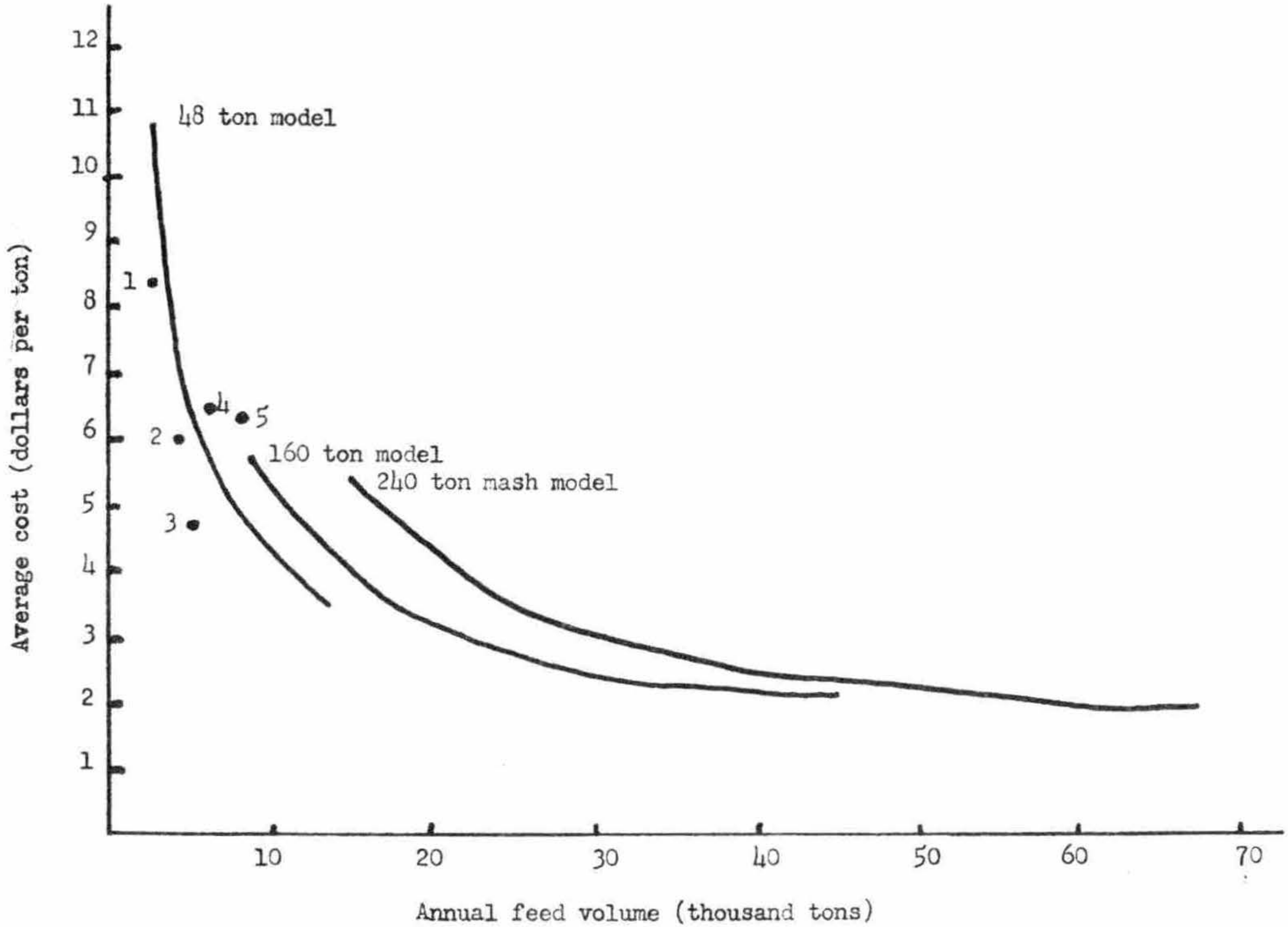

Figure 7. Short-run average costs of three model and five central Iowa feed mills

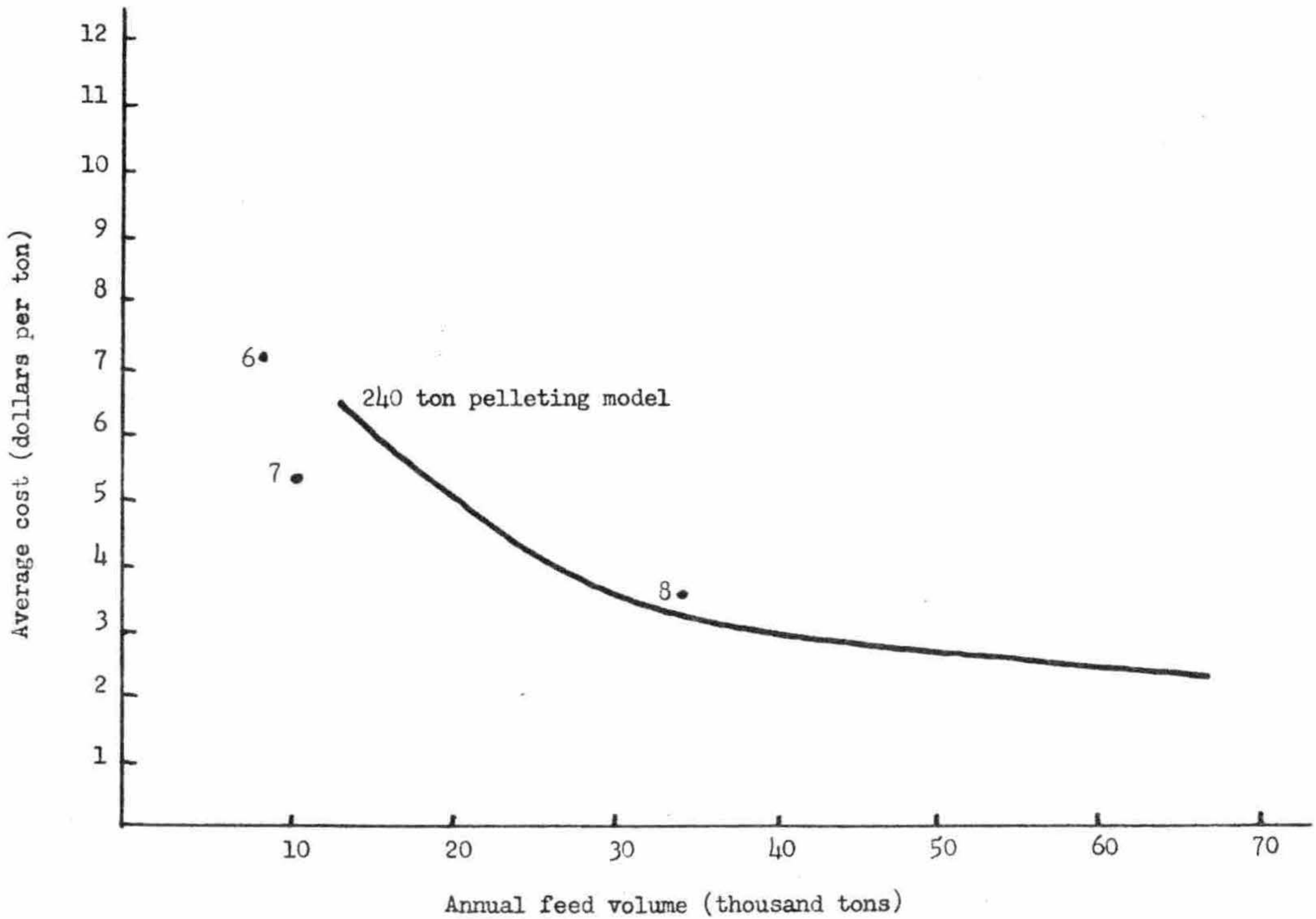

Figure 8. Short-run average costs of the 240 ton pelleting model and three central Iowa feed mills with pelleting operations

Figure 8 illustrates the short-run average cost curve of the 240 ton pelleting model and three central Iowa feed mills with pelleting facilities. Again the solid black line represents the synthetic model and the black dots represent actual feed mill costs. The equipment and buildings used by the three central Iowa feed mills are different except that all have pelleting equipment. These real feed mills all have the capacity to produce at least 240 tons of feed per eight hour day.

An interesting observation in both figures 7 and 8 is the low volume of feed handled by central Iowa feed mills with the exception of feed mill 8. This underutilization of facilities and the resultant high average fixed cost per ton causes their average cost per ton to be relatively high in relation to the average cost per ton incurred by the model feed mills when utilization of capacity is 50 percent or greater. Feed mill 8 utilizes its facilities more than the other real feed mills and thus has a lower average per ton cost.

The average cost of producing a ton of feed in the central Iowa feed mills varies significantly. Part of this variance is due to the estimates made by elevator managers of administrative and labor time spent in the feed department. The average administrative cost per ton varied from a low of 51 cents in feed mill 8 to a high of $1.43 in feed mill 4. Similarly, labor cost per ton varied from a low of 63 cents in feed mill 7 to a high of $1.42 in feed mill 2.

CHAPTER VI. SUMMARY AND CONCLUSIONS

Feed was produced at $3.48, $2.07, $1.90, and $2.31 per ton in the 48 ton, 160 ton, 240 ton mash, and 240 ton pelleting model feed mills respectively. Economies of size did exist in the model feed mills with the 240 ton all mash model having the lowest cost per ton of feed. Cost reductions apparently can result operating larger feed mills if sales are realized. The costs incurred by central Iowa cooperative elevators were similar to the costs of the model feed mills at very low utilization rates.

In addition to lower average costs due to larger feed mills, substantial cost savings can be gained by utilizing feed mill capacity. This is borne out by the observations on the real feed mills. For example, average costs for the real feed mills were $8.39, $6.07, $4.74, $6.57, $6.46, $7.23, $5.40, and $3.62 per ton with costs falling rapidly as utilization rates increased. Operating feed mills from 60 to 100 percent of capacity would result in substantial cost savings to cooperative elevators. For example, the average cost of all eight central Iowa feed mills was $6.06 per ton. In contrast, the average cost of the four model feed mills operating at 80 percent of capacity was $2.74 per ton. This is a difference of $3.32 per ton of feed. If this cost savings could be passed on to the farmer in the form of lower prices or larger dividends, substantial savings would result. The magnitude of this potential savings can be visualized by the following example. If we assume a market hog weighs 220 pounds when sold and that each pound required 3.2 pounds of feed, then each hog would consume 704 pounds of feed. If feed grinding and mixing costs are reduced $3.32 per ton, then the cost of producing each

220 hog could be reduced $1.17. It is concluded that underutilization of capacity by local retail feed distribution establishments is a serious problem.

This study has not considered distributional costs. The example above and this study refers only to internal plant costs. The diseconomies of distributing feed should be included to determine the optimum size feed mill and trade area in Iowa. The optimal size elevator and trade area must also consider other departments such as grain handling and fertilizer retailing. In addition, the type of ownership, cooperative or private, will also have important implications as to the optimal size elevator and trade area.

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APPENDIX A: EQUIPMENT OF THE MODEL FEED MILLS

Table 13. Basic equipment for the 48 ton model feed mill

Equipment	Number	Size or horsepower
Receiving:		
Scale[a]	1/4	10' x 50'
Receiving leg	1	5 HP
Truck hoist	1	3 HP
Distributor	2	8", 4 & 8-way
Processing:		
Hammermill	1	50 HP
Rollermill	1	10 HP
Screw feeder	1	9", 3 HP
Mixing:		
Vertical mixer	1	1 1/2 ton
Weigh buggy	1	500 lb.
Distributor	1	8", 6-way
Leg	1	5 HP
Portable scale	1	1,000 lb.
Bagging:		
Sewing head	1	1/3 HP

[a]Scale assumed to be used 25 percent of the time by the feed department.

Table 14. Basic equipment for the 160 ton model feed mill

Equipment	Number	Size or horsepower
Receiving:		
Scale[a]	1/2	10' x 50'
Receiving leg	1	10 HP
Truck hoist	1	3 HP
Distributor	1	8", 8-way
Pit screw	1	14", 5 HP
Processing:		
Hammermill	1	100 HP
Rollermill	1	15 HP
Rollermill leg	1	5 HP
Mixing:		
Hopper scale	1	2 ton
Horizontal mixer	1	2 ton
Distributor	1	8", 11-way
Screw feeders	3	3 HP
Molasses system	1	1 1/2 HP
Bagging:		
Bagging scale	1	
Sewing head	1	1/3 HP

[a]Scale assumed to be used 50 percent of the time by the feed department.

Table 15. Basic equipment in the 240 ton model feed mills

Equipment	Number	Size or horsepower
Receiving:		
Truck hoist	1	7 1/2 HP
Scale	1	10' x 50'
Drag conveyor	1	12", 2 HP
Receiving leg	1	10 HP
Distributor	1	8", 14-way
Tube screw	2	9", 3 HP
Processing:		
Hammermill	1	100 HP
Rollermill	1	20 HP
Leg	1	5 HP
Distributor	1	8", 6-way
Mixing:		
Feeder screws	3	9", 5 HP
Hopper scale	1	3 ton
Batch controls	1	semiautomatic
Horizontal mixer	1	3 ton
Leg		10 HP
Distributor		8", 5-way
Molasses system	1	1 1/2 HP

Table 15. (contd)

Equipment	Number	Size or horsepower
Pelleting[a]:		
Pellet mill	1	100 HP
Pellet cooler	1	15 HP
Pellet crumbler	1	10 HP
Pellet leg	1	3 HP
Distributor	1	8", 14-way
Boiler	1	50 HP
Bagging:		
Sewing head	1	1/3 HP
Bagging scale		
Miscellaneous:		
Manlift		
Air compressor		

[a]The 240 ton all mash model does not include the pelleting equipment.

APPENDIX B: LABOR STANDARDS FOR THE MODEL FEED MILLS

Table 16. Labor standard for crimping 12 tons of grain in the 48 ton model feed mill

Job	Minutes required[a]	Times per day	Total minutes
Start and adjust rollermill	10.2	1	10.2
Check back[b]	3.0	1(time per hr)	3.6
Stop	10.2	1	10.2
Clean-up	6.0	1	6.0
Allowance[c]			3.0
Total mill labor			33.0

Labor standard, $\frac{33.0}{12}$ = 2.8 minutes per ton

[a]Source: (8).

[b]A total of 12 tons of grain is crimped per day. Equipment operates 1.2 hours (12 tons per day at 10 tons per hour = 1.2 hours per day).

[c]10 percent of the worker's time is allowed for personal requirements.

Table 17. Labor standard for grinding 32.1 tons of grain in the 48 ton model feed mill

Job	Minutes required[a]	Times per day	Total minutes
Start and adjust hammermill	10.2	3	30.6
Check back[b]	3.0	1(time per hr)	8.1
Stop and change over	10.2	3	30.6
Clean-up	20.0	1	20.0
Allowance[c]			8.9
Total mill labor			98.2

Labor standard, $\frac{98.2}{32.1}$ = 3.1 minutes per ton

[a]Source: (8).

[b]A total of 32.1 tons of grain is ground per day. Equipment operates 2.7 hours (32.1 tons per day at 12 tons per hour = 2.7 hours per day).

[c]10 percent of the worker's time is allowed for personal requirements.

Table 18. Labor standard for crimping 40 tons of grain in the 160 ton model feed mill

Job	Minutes required[a]	Times per day	Total minutes
Start and adjust rollermill	10.2	3	30.6
Check back[b]	3.0	1(time per hr)	9.9
Stop	10.2	3	30.6
Clean-up	6.0	1	6.0
Allowance[c]			7.7
Total mill labor			84.8

Labor standard, $\frac{84.8}{40.0}$ = 2.1 minutes per ton

[a]Source: (8).

[b]A total of 40.0 tons of grain is crimped per day. Equipment operates 3.3 hours (40 tons per day at 12 tons per hour = 3.3 hours).

[c]10 percent of the worker's time is allowed for personal requirements.

Table 19. Labor standard for grinding 107 tons of grain in the 160 ton model feed mill

Job	Minutes required[a]	Times per day	Total minutes
Start and adjust hammermill	10.2	3	30.6
Check back[b]	3.0	1(time per hr)	16.2
Stop and change over	10.2	3	30.6
Clean-up	24.0	1	24.0
Allowance[c]			10.1
Total mill labor			111.5

Labor standard, $\frac{111.5}{107.0}$ = 1.0 minutes per ton

[a]Source: (8).

[b]A total of 107.0 tons of grain is ground per day. Equipment operates 5.4 hours (107.0 tons per day at 20 tons per hour = 5.4 hours per day).

[c]10 percent of a worker's time is allowed for personal requirements.

Table 20. Labor standard for crimping 60 tons of grain in the 240 ton model feed mills

Job	Minutes required[a]	Times per day	Total minutes
Start and adjust rollermill	10.2	3	30.6
Check back[b]	3.0	1(time per hr)	15.0
Stop	10.2	3	30.6
Clean-up	6.0	1	6.0
Allowance[c]			8.2
Total mill labor			90.4

Labor standard for all mash model, $\frac{90.4}{60.0}$ = 1.5 minutes per ton

Labor standard for the pelleting model, $\frac{90.4}{50.8}$ = 1.8 minutes per ton

[a]Source: (8).

[b]A total of 60 tons of grain is crimped per day. Equipment operates 5.0 hours (60 tons per day at 12 tons per hour = 5.0 hours).

[c]10 percent of a worker's time is allowed for personal requirements.

Table 21. Labor standard for grinding grain in the 240 ton model feed mills

Job	Minutes required[a]	Times per day	Total minutes
Start and adjust hammermill	10.2	3	30.6
Check back[b]	3.0	1(time per hr)	24.0
Stop and change over	10.2	3	30.6
Clean-up	24.0	1	24.0
Allowance[c]			10.9
Total mill labor			120.1

Labor standard for the all mash model, $\frac{120.1}{160.6}$ = 0.7 minutes per ton

Labor standard for the pelleting model, $\frac{120.1}{158.0}$ = 0.8 minutes per ton

[a]Source: (8).

[b]A total of 160.6 tons of grain is ground per day. Equipment operates 8.0 hours (136.6 tons per day at 20 tons per hour = 8.0 hours).

[c]10 percent of a worker's time is allowed for personal requirements.

Table 22. Labor standard for mixing 140 tons of feed in the 160 ton model feed mill

Job	Minutes required[a]	Quantity per day	Total minutes
Move ingredients with handtruck	10.0	7.5 tons	75.0
Open bags	4.0	7.5 tons	30.0
Dump bags	3.0	7.5 tons	22.5
Weigh bulk ingredients	2.0	80 batches	160.0
Start machines	0.2 per day	1 time	0.2
Clean-up	3.6	80 batches	288.0
Change formula	5.0	20 changes	100.0
Allowance[b]			67.6
Total mill labor			743.3

Labor standard, $\frac{743.3}{140.0} = 5.3$ minutes per ton

[a]Source: (5).

[b]10 percent of a worker's time is allowed for personal requirements.

Table 23. Labor standards for mixing feed in the 240 ton model feed mills

Job	Minutes required[a]	Quantity per day	Total minutes
Move ingredients with handtruck	10.0	10.7 tons	107.0
Open bags	4.0	10.7 tons	42.8
Dump bags	3.0	10.7 tons	32.1
Weigh bulk ingredients	2.0	80 batches	160.0
Start machines	0.2	1 time	0.2
Clean-up	3.6	80 batches	288.0
Change formula	5.0	30 changes	150.0
Allowance[b]			78.0
Total mill labor			858.1

Labor standard for all mash model, $\frac{858.1}{210.0} = 4.1$ minutes per ton

Labor standard for the pelleting model, $\frac{858.1}{214.6} = 4.0$ minutes per ton

[a] Source: (5).

[b] 10 percent of a worker's time is allowed for personal requirements.

Table 24. Labor standard for pelleting 22.4 tons of feed in the 240 ton pelleting model feed mill

Job	Minutes required[ab]	Times per day	Total minutes
Set up and adjust machines	15.0	1	15.0
Change die	1.0	30	30.0
Change formula	15.0	3	45.0
Check back to equipment	6.0	11	66.0
Clean-up	60.0	1	60.0
Miscellaneous[c]	30.0		30.0
Total mill labor			246.0

Labor standard, $\frac{246}{22.4}$ = 11.0 minutes per ton

[a]An allowance of 10 percent for worker's personal requirements is included in each standard and allocation.

[b]Source: (6).

[c]Includes such items as observation of equipment, lubrication, cleaning bins and machines, etc.