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An Economic Analysis of the Costs of Manufacturing Commercial Feed in North Dakota

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SUMMARY

The results of this study indicate that reductions in cost are possible from increasing size in the commercial feed industry. The costs of producing one ton of feed fall from $7.71 in a 30 ton per day plant to $4.07 in a 200 ton per day plant. The per ton production cost in a 100 ton per day plant is $4.81. It does not appear that important reductions in cost are available beyond 50,000 tons annually (200 tons per day); and, therefore, it is concluded that this is an optimum size firm given the existing methods of manufacturing feed. The 200 ton per day plant definitely is the most efficient of the three used in this study.

The range in investment costs of a specific size feed plant does not appear to affect the average production costs of manufacturing a ton of feed. The differences between the average costs for the highest and lowest estimates for the 30, 100, and 200 ton models were 81 cents, 24 cents, and 18 cents per ton, respectively.

The per ton production costs of feed can be reduced substantially if a second eight-hour production shift is added. The major reason for this, of course, is that the fixed costs are spread over a larger output. The average costs in the 30, 100, and 200 ton plants drop from $7.71, $4.81, and $4.07 to $5.82, $3.66, and $3.05, respectively, when a second shift is added.

The problem of allocating costs common to all elevator enterprises was studied. Since the costs of an elevator-feed plant operation were not available, no specific relationships were found; however, it was possible to arrive at general relationships. It was concluded that the average costs of production in a small feed plant operated independently would be somewhat higher than those of a small feed plant operated as part of a multi-product firm.

The average production costs of the North Dakota firms used in the study were higher than the costs of the model plants. The costs the firms used in the study ranged from $11.50 to $23.50 per ton, with a mean of $18.00 and a median of $19.50. The average production costs of North Dakota plants with large capacities were $13.75, and those of the plants with small capacities were $20.50.

AN ECONOMIC ANALYSIS OF THE NORTH DAKOTA FEED MANUFACTURING INDUSTRY

Philip E. Austin and David C. Nelson[1]

The importance of feed production to the economies of both the United States and North Dakota has increased greatly in recent years, and prospects are for continued expansion.

The amount of feed purchased in the United States in 1963 was almost double that purchased in 1949. About $5,930,000 was spent for feed in 1963 as opposed to $3,024,000 in 1949.[2] During the period 1949-1962 the number of animal units fed annually in the United States rose from 163.8 million to 173.2 million.[3]

Concentrates fed to livestock rose almost 47 per cent during the post-war period from 103.7 million tons in 1947-1948 to 152.0 million tons in 1962-1963. During this same period the use of high-protein concentrate feeds increased about 75 per cent from 10.2 million tons to 17.9 million tons.[4]

The fact that the demand for commercial feed in North Dakota has risen considerably in recent years can be demonstrated by considering the changes in the number of livestock on feed. The number of cattle and calves on feed rose from 5,700 in 1950 to 158,000 in 1965. While the increase in the number of sheep and lambs on feed was not as substantial, it more than doubled during this period, rising from 52,000 in 1950 to 109,000 in 1965.[5]

The demand for feed is a derived demand; that is, the demand grows out of a need to satisfy the demand for another commodity such as meat. The quantity of meat consumed varies directly with the level of disposable income. Therefore, if the predictions of increasing prosperity and higher levels of living in the United States are realized, the demand for livestock and thus the demand for feed will increase in the future.

If the rate of population expansion of recent years continues, production of food must increase more than 25 per cent by 1975 to even maintain the

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[1]Research Project Assistant and Assistant Professor of Agricultural Economics.

[2]United States Department of Agriculture, Economic Research Service, Agricultural Statistics, Washington, D. C., 1964, p. 406.

[3]*Ibid.*, p. 58.

[4]Ahalt, J. Dawson, and Egbert, Alvin C., "The Demand for Feed Concentrates--A Statistical Analysis," Agricultural Economics Research, Vol. XVIII, Economic Research Service, United States Department of Agriculture, Washington, D. C., 1965, p. 42.

[5]Various issues of Livestock Market News Statistics, Agricultural Marketing Service, United States Department of Agriculture, Washington, D. C.

present per capita levels of consumption.[6] The impact of such an increase will be felt by the entire country but particularly by an agricultural state, such as North Dakota, in which the production of both feed and livestock is important to the economy.

OBJECTIVES

Feed is the largest single expense in the production of meat, ranging from 50 to 75 per cent of the total costs.[7] Ideally, a more efficient or lower cost method of producing feed would enable the feed producer to increase his profits somewhat and, at the same time, lower the price of the product. Lower feed prices would in turn enable the livestock producer to realize a greater profit and sell his product at a lower price. This means that meat would be available to the consumer at a lower price than before the improvement in production efficiency.

The general purpose of this study is to determine if more efficient methods of feed production are available. The specific objectives are:

1. To determine if economies of size exist in the North Dakota feed industry and to define the industry scale curve.

2. To synthesize a series of model feed plants which will be used for industry-model comparisons and aid in the construction of cost curves.

3. To identify the major factors affecting the costs of manufacturing feed and some possible methods for reducing these costs.

4. To identify and describe the important characteristics and general trends of the North Dakota feed industry.

METHOD OF STUDY

Three model feed mills were set up to determine the changes in cost as size of firm changed for the feed industry in the state. The equipment recommendations and operating standards were obtained from the 1961 Feed Production Handbook.[8] The equipment prices were derived by averaging the prices supplied by four different equipment manufacturers. The construction costs of the

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[6]Bynell, Wallin D., Structural Changes in the Feed Industry, paper given at the Minneapolis Grain Exchange, Minneapolis, Minnesota, 1964, p. 1.

[7]Schoeff, Robert W., "The Formula Feed Industry," 1961 Feed Production Handbook, Feed Production School, Kansas City, Missouri, p. 7.

[8]1961 Feed Production Handbook, Feed Production School, Kansas City, Missouri, pp. 66, 70, and 74.

buildings were determined by averaging estimates obtained from four contractors in Fargo.[9]

A survey was conducted to discover the actual costs of operating feed plants in the state and to obtain information helpful in describing the characteristics of the industry. The firms interviewed were selected from three different lists obtained from the North Dakota State Laboratories Department, the North Dakota Feed Manufacturers Association, and the Food and Drug Administration. By combining these lists, it was felt that all of the major manufacturers in the state would be included. The firms chosen for the study must have had pelleting equipment, since the pelleting capacity of the plants was to be the criterion used for the initial grouping of the mills.

Since some of the feed plants in this study are operated in connection with elevators, the common cost concept has special significance.[10] Realizing that the problem of common cost allocation would be present when analyzing the data collected from these plants, members of the North Dakota State University Department of Industrial Engineering were consulted for assistance in preparing a reliable set of time study forms. The forms called for the number of hours devoted to feed production by each of the plant employees involved in two or more enterprises, one of which was the feed division of the firm. The idea underlying the time study forms was that they would indicate the time each employee spent working in the feed division during a given period so that part of his salary could be charged against the feed division. The same principle applied to allocating investment costs. For example, if a secretary spent 40 per cent of her time working for the feed division, it could be assumed about 40 per cent of her office equipment should be charged against the feed division.

The seven plants in the sample operating in a situation where they faced common costs were provided with the forms and instructions for completing them. Only four plant managers agreed to cooperate with this phase of the project. Their main reasons for not cooperating were that completing the forms was too time consuming and would interfere with their normal operations. Three of the four who did cooperate failed to complete the forms in a way that could be used in the study. The major failure was in not reporting as often as called for (in one case a month between reports) and often not on the days selected for reporting. It was decided that these reports were not reliable, so cost figures from them were not used in computing the averages for this

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[9]The companies which provided estimates for the equipment were the Strong-Scott Company, Minneapolis, Minnesota; The California Pellet Mill Company, Crawfordsville, Indiana; Teco Products, Madera, California; and Sprout Waldron and Company, Incorporated, Muncy, Pennsylvania. The firms which provided building estimates were Olaf Anderson and Son Construction Company; Agsco, Incorporated; Smith, Incorporated; and Main Sales, Incorporated; all of Fargo.

[10]Common costs are those incurred in the production of two or more products but not for the sake of any one product. An example is a secretary employed by an elevator-feed plant. She will probably handle correspondence which refers to the operations of both the feed plant and the elevator. Consequently, the cost of employing here must be allocated between the two operations.

study. The forms returned by the remaining plant were completed correctly and were of great value in determining that firm's costs.

INDUSTRY CHARACTERISTICS

The methods employed by North Dakota feed manufacturers in such areas as delivery, credit, and output determination are important. The changes in methods of operation of the North Dakota feed industry are also important to this study.

Classification of Firms in Sample

Ten of the firms in the sample were independent, single plants, while eight were part of statewide or regional chains. Thirteen were corporations, four were cooperatives, and one was a state-owned facility. The average time in business was 13.6 years, with a range from 2 to 60 years and a median of 9 years.

The initial classifications were determined according to pelleting capacities. A standard working day of eight hours was used. Therefore, the pelleting capacities represent the number of tons the plant produces during a standard eight-hour period. The 18 cooperating firms were divided into three groups as follows: Group I, 60-80 tons; Group II, 32-40 tons; and Group III, 20-30 tons. The data indicate the average capacity of all the plants in the sample was 44.8 tons per eight-hour shift (Table 1).

TABLE 1. AVERAGE CAPACITIES, REPLACEMENT VALUES, AND OUTPUT LEVELS, NORTH DAKOTA FEED PLANTS, 1965

Group	Capacities Per Eight-Hour Shift	Replacement Values	Annual Output
	tons	dollars	tons
Group I	74.1	326,000	16,726
Group II	36.0	200,000	6,693
Group III	24.5	105,600	3,364
All Firms	44.8	216,600	9,255

Replacement Estimates

Because of the age of certain pieces of equipment and the fact that much of the equipment needed for manufacturing was a part of the elevator proper (where feed manufacturing was part of a multi-product firm), the replacement values are very general estimations. They do not include the land on which the plant is constructed or any equipment in the elevator not used in producing feed.

The question asked of the managers was, "What would it cost you to replace the feed plant you now have?" The estimates ranged from $80,000 to $500,000, with a median value of $200,000. The sample mean was $216,000, and the group replacement value means varied directly with the group capacity means.

Replacement estimates varied considerably within groups. One explanation for this is that these figures are, at best, general estimates and are subject to error. Also, the cost of a piece of equipment of one size can vary a great deal depending upon its quality. Another factor of importance is that many mills have only the necessary equipment needed to produce a given output, while others have all of the "extras", the costs of which, when added to the necessities, increase the total costs.

Annual Outputs

The annual outputs of the mills in the sample ranged from 1,600 tons to 35,000 tons. This figure will vary greatly from year to year depending upon a number of conditions.[11] The data in Table 1 indicate that the group output values varied directly with the group mill capacities. The sample mean was 9,255 tons, and the sample median was 5,950 tons.

Excess Capacity

Since the average capacity of Group I is about three times greater than that of Group III and the average annual output of Group I is about five times greater than Group III, it can be assumed that the per cent of capacity utilization in Group I is greater than in Group III.[12] The data in Table 2 support this assumption.

A significant amount of excess productive capacity exists in North Dakota feed mills. The 18 reporting plants had a total capacity of 837 tons per eight-hour shift but produced only 691 tons per shift in 1965. This means that about 82 per cent of the available capacity was utilized. The capacity utilization of the individual plants in the sample ranged from 48 per cent to

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[11]The figures used in this study should be meaningful because the managers were asked for figures representing a normal year. Most of the mills in Western North Dakota, for example, submitted 1964 figures, since the figures for 1965 were out of proportion due to the bad winter. Many more tons of range cubes were needed because of the blizzard.

[12]Capacity utilization refers to the amount of product produced by a given plant during a given period of time as compared to the amount of output it is able to produce. For example, if a plant has the capacity to produce 100 tons of output during a given time and it produces only 80 tons, it is operating at only 80 per cent of capacity.

100 per cent with a median value of about 80 per cent. The plants in Group III had the greatest amount of excess capacity, operating at about 77 per cent. Groups I and II were utilizing about equal percentages of capacity, 84 per cent and 83 per cent, respectively.

TABLE 2. CAPACITIES, OUTPUTS, AND PER CENT OF CAPACITY UTILIZATIONS, NORTH DAKOTA FEED MILLS, 1965

Group	Capacities Per Eight-Hour Shift	Output Per Eight-Hour Shift	Utilization
tons	tons	tons	per cent
I (60-80)	465	390	84
II (32-40)	224	187	83
III (20-30)	148	114	77
Total	837	691	82

One possible reason for operating at a level less than full capacity is that the firm may anticipate expanding the size of its output and market over a period of years. Consequently, the plant was constructed to produce a larger output than is demanded at the present time. It is less costly to build a large plant than to add capacity to a smaller plant. The savings realized might offset the losses incurred by not operating at the 100 per cent capacity level.

A plant with capacity to produce a greater amount of output than is being produced has a degree of flexibility which is desired by some plant managers. If a breakdown should occur in a plant with a great deal of over capacity, the unused equipment can be brought into use, and production may remain at a constant level while the down equipment is repaired.

The values of these aspects of excess capacity must be determined by the individual plant managers. However, excess productive capacity does increase production costs.

Area Served

In general, the larger the feed plant, the larger the area served. The average sales radius for the entire group was 92.5 miles, with a range of from 4 to 400 miles. The data in Table 3 establish that the average sales radiuses of Groups I, II, and III were 133.9, 70.0, and 60.0 miles, respectively.

Assuming the level of output for an individual firm as fixed, it seems reasonable that the degree of density of livestock producers in the market area will be inversely related to the radius of the area it served. Other factors, such as services offered and prices of products relative to competitors' prices, also have an effect on the size of the service area. Many of the managers reported they believed the output of the firm and the size of its service area were directly related because as the individual manager increases output to realize economies of size in his operation, he must expand his sales area to market the increased output.

TABLE 3. AREAS SERVED, PERCENTAGE OF OUTPUT DELIVERED, AND PERCENTAGE OF OUTPUT SOLD IN BULK, NORTH DAKOTA FEED PLANTS, 1965

Group	Area Served	Per cent Delivered		Per cent Bulk	
		Average	Range	Average	Range
Group I	133.9	80.8	60-95	65.0	40-90
Group II	70.0	43.0	0-80	77.8	60-92
Group III	60.0	59.0	20-90	74.8	20-90
All Firms	92.5	62.0	0-95	72.5	20-90

Delivered Feed

Sixteen of the eighteen plants in the sample reported that their percentage of total output delivered was increasing each year. The other two plants did not deliver any feed and had no plans to begin doing so. The data contained in Table 3 indicate that the firms in the sample delivered about 62 per cent of their individual outputs.[13]

The simple average figures for Groups I, II, and III are 80.8 per cent, 43.0 per cent, and 59.0 per cent, respectively. The figures for Group II and Group III indicate an inverse relationship between output and delivery areas. Reasons for this relationship may be as follows:

1. The smaller firms have found it desirable (in terms of profit and/ or customer good will) to offer the delivery service within their somewhat smaller service areas even though they might not be able to realize the savings of long-distance trucking.

2. The number and density of customers. The smaller firms may have a few customers who place large orders as opposed to the medium-sized firms which may have many customers who place relatively smaller orders. The per ton costs of delivering larger orders would be, of course, less than delivering smaller orders.

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[13]These figures were derived by simply averaging the individual averages given by each firm. Another way of presenting these averages would have been to weight them according to output. The second method would have indicated the percentage of feed produced which was delivered. Since the purpose of this section is to describe the characteristics of the plants, the former method or the "arithmetic mean" method was chosen for presentation.

3. In some areas farmers and feeders prefer to have feed delivered; and, to get their business, the plant must provide this service. In this case the size of the plant is completely independent of the amount of feed delivered.

Bulk and Bagged Feed Sales

All managers except one stated the percentage of feed sold in bulk (as contrasted to bagged feed) was increasing. The plants sell about 72.5 per cent of their output in bulk.[14] The amounts ranged from 40 per cent to 99 per cent, with a median value of 75 per cent. The data indicate the larger plants sold less feed in bulk (65 per cent) than either Group II or Group III (77.8 per cent and 74.8 per cent, respectively)(Table 3). This probably occurs because much of their output is labeled and sold by other retailers. Many of the smaller firms produce only for their own market outlets. About half of the feed produced by Group I plants was sold to farmers and about half to other retailers, while in Groups II and III about 90 per cent and 95 per cent of the feed produced was sold to farmers.

Employee Requirements

The average number of men employed full time per ton of feed by the three groups varied inversely with the group outputs. Increasing efficiency of labor is indicated when the outputs and employee requirements of Groups I and III are compared. The average labor requirement of operating the plants of Group I (12.3 employees) is slightly more than double that of Group III (5.8 employees), while the output differential is just under five times greater (16,726 tons and 3,364 tons).

A larger capital investment is probably responsible for the increased efficiency of labor; the estimated replacement value of Group I ($326,000) was about three times that of Group III ($105,000). The labor requirement mean and median of the sample were 8.5 and 9.0, respectively. The larger equipment in the larger plants calls for a greater degree of specialization of labor which can be responsible for the greater output per man.

Contract Sales

Fourteen plants sold part of their feed output under contract. This type of arrangement means that the producer agrees to supply and the consumer agrees to buy a certain amount of feed at a specific date or over a specified period of time. Each plant in Group I sold some of its output under contract. Four of the six plants in both Groups II and III disposed of some of their feed in this manner.

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[14] In calculating the group averages, the same method was used as in the Delivered Feed section--simple averages or arithmetic means.

TABLE 4. EMPLOYEE REQUIREMENTS, CONTRACT SALES, AND ADVERTISING, NORTH DAKOTA FEED PLANTS, 1965

Group	Employees	Contract Sales		Advertising[a]		
		Dealers[b]	Output	Radio[b]	Salesmen[b]	Newspapers[b]
			per cent			
Group I	12.3	6/6	45	2/6	6/6	1/6
Group II	7.1	4/6	43	5/6	4/6	3/6
Group III	5.8	4/6	33	5/6	1/6	6/6
All Firms	8.5	14/18	40	12/18	11/18	10/18

[a]Some firms advertised in more than one outlet.

[b]Ratios denote the number of firms in groups using contract sales, radio, salesmen, and newspapers.

The per cent of total output each firm sold under contract ranged from zero to 60 per cent, with a mean of 40 per cent. A considerably larger percentage of the outputs in Groups I and II was sold under contract than in Group III. One reason for this may be that the larger firms usually supply other retailers and large feeders and ranchers. These groups usually place feed orders well in advance of the time of delivery.

Many of the plant managers indicated that they liked to operate with contracts because it reduced the amount of uncertainty involved in marketing their products.

Advertising

All firms in the sample advertised in several media. Radio appeared to be the most popular advertising medium, with 12 plants sponsoring programs or short commercials. Salesmen and newspaper advertising were second and third choices, with 11 of the plants employing salesmen and 10 advertising in newspapers.

While there was no great variation in the popularity of the three advertising media when the 18 firms were viewed collectively, definite emphasis on methods appeared when the plants were viewed as groups.

Each plant in Group I employed at least one salesman, while four plants in Group II and only one in Group III had paid salesmen. The smaller firms apparently thought newspaper and radio advertising was more effective for them. All plants in Group III advertised in newspapers, and five advertised on radio, while only one in Group I advertised in newspapers and two bought radio advertising.

One reason for the three groups using different forms of advertising is that they are directing their advertising appeals to different types of customers. The firms in Group I are apparently attempting to reach a few large-volume customers, while the firms in Group III are trying to reach many smaller-volume customers.

Five of the firms advertising in newspapers indicated they preferred the weekly or monthly newspapers over the dailies. The reason given was that the weekly or monthly is read repeatedly for several days after receipt; therefore, the feed manufacturer gets greater exposure for the same or less cost.

Pricing Practices

In general, the larger firms in the North Dakota feed industry are price leaders, and the smaller firms are price takers or price followers. The managers of the six firms in Group I revealed that they determined the prices of their products by adding a certain margin over costs, while five of the firms in Group III indicated that they considered competition also. Each of the firms in Group II indicated it uses the cost-plus margin system of pricing, and three of these said they were also responsive to competition prices.

Credit Policies

Twelve of the eighteen plant managers reported that credit arrangements and uncollected accounts were the greatest problems involved in the merchandising of commercial feed. Each of the firms extended credit to its customers, but the terms were extremely variable. There was noticeable difference between the groups in the area of credit extension.

Fourteen of the plants allowed a 30-day grace period. This means that there is a 30-day period between the time that the bill is due and the date that interest charges are made on the unpaid balance. One of the plants allowed 60 days, and three had no formal credit policy. The usual interest charge on the unpaid balance was 6 per cent, with a range of from 4 per cent to 7 per cent. Sixteen of the plant managers indicated that both the length of the grace period and the rate of interest would vary with the individual customer.

Plant Expansion

Three plant managers reported they had not expanded or added to their facilities in the past five years. Only two indicated that they did not intend to expand in the next five years. The remaining firms indicated they had increased their investment and intended to increase it more. The major reason given for expansion was that the managers anticipated a greater demand for feed in their particular areas. In many cases feed manufacturing was integrated with a livestock feeding enterprise. Two reasons were provided in support of this practice: (1) to provide an outlet for the feed and (2) to show the farmers in the area that profits were available in feeding cattle. Another reason for plant expansion given by feed plant managers was the incentive to realize lower costs per ton by increasing the level of output.

Most of the expansion was in storage and warehouse facilities. Fourteen managers revealed that the first additions to their facilities would be additional bins and/or warehousing space. Some also indicated a preference for additional pelleting equipment. The basis for the latter priority is based on the response to the question, "What services do your customers prefer most?" Sixteen of them replied, "Pelleting."

MODEL COMMERCIAL FEED PLANTS

One of the basic forms of methodology used in economic analysis is the model. A series of model feed mills will be used to determine the costs of production as the size of plant is increased. An economic model is simply a blueprint or a layout of the firm as it might exist in the real world. It includes all the equipment, labor, building, management, and storage facilities necessary to produce a given quantity of product--in this case commercial livestock feed.

When using models in economics, their connection to the real world must be considered. One obvious connection is through the assumptions that are made. The assumptions describe the type of world to which the model will apply. A model which begins with an assumption begins with a limitation; therefore, the model may not reflect conditions in every market. Thus, the conclusions may not fit all situations but can serve as a guideline to planning changes.

General Principles of Feed Mill Construction

Before considering the specific models in this study, some general ideas on feed mill construction should be reviewed. The layout of any feed plant will be affected by a number of variables. Probably the most important are (1) location, (2) the physical facilities already available, such as bins and buildings, (3) the arrangement and type of equipment and buildings, and (4) the traffic pattern.

The potential location of the mill is important. Adequate space must be available for truck and rail access as well as for future expansion. Bins constitute from 30 to 40 per cent to as high as 60 per cent of the cost of a feed mill; therefore, bins determine what type of building will be used. Often bins are made a permanent part of the building. Before the machinery can be located, the location of the bins must be selected. The type of building used will depend upon the desired output of the potential plant. Normally, plants which produce up to 100 tons of feed per eight-hour shift can be constructed more economically with steel. Larger mills with capacities of 200 or more tons per shift and 1,000 or more tons of storage will be constructed with slip-form concrete.[15] Arrangement of the machinery and equipment will be based on factors,

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[15] <u>1961 Feed Production Handbook</u>, Feed Production School, Kansas City, Missouri, p. 90.

such as quality control, reliability, expandability, and simplicity. The traffic pattern will be determined by the relative amounts of rail, truck, and water movements which are to take place. For example, if a great deal of movement is planned by truck, it is desirable to leave both sides of the plant open for truck access.

The models used in this study were taken from the 1961 Feed Production Handbook. The equipment recommendations for each model are given in the appendix. The total cost figure in each case is the sum of the estimated costs of each piece of equipment and estimated construction costs. Neither the cost of the land upon which the plant is built nor the cost of building and railway loading and unloading facilities is considered in the estimates. The office costs, including office equipment, are included in the estimates. The size of the office varied with the number of employees using it. It was assumed that 100 square feed of office space would be provided for each employee at a cost of $10 per square foot.

The equipment recommendations for these models indicate a combination of machinery capable of producing a certain level of output during a given time. The implication is neither that this is the only combination of equipment capable of performing this task nor that one equipment manufacturer's product is better than another's. The models represent mills which would be able to operate within the accepted practices of the industry and comply with health and safety regulations.

When determining the labor requirements of one of the model plants, only average figures can be used. Seldom will the theoretical requirements for one eight-hour shift match the actual time allotted in a real plant. Men must be provided to handle unexpected occurrences. Therefore, the utilization of labor will vary from day to day and from season to season. If the work force is kept flexible, men can be moved from one job to another to accomplish the production objectives. The assumption is that the plants are being operated eight hours per day, 260 days per year.[16]

Ranges of Investment Estimates

There was a considerable range between the high and the low investment cost estimates for each of the three model plants (Appendix). The quality of the equipment used in the mill and the quality of the building construction are two of the major factors accounting for this difference. Buildings and equipment of inferior quality are usually less costly. The usable lives of low cost buildings and equipment will probably be shorter than the more expensive items; however, in the short run, they may be able to perform the same task; that is, they may be able to manufacture the same tonnage of feed during a given period of time.

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[16]A working year of 260 eight-hour days is the standard used by the Feed Production School.

Usefulness of Investment Estimates

Because of variations in cost it is difficult to arrive at a definite investment figure. However general the estimates may be, they aid in defining relationships which exist in the industry. For example, when the capacity of a plant is doubled, the required investment outlay is considerably less than doubled. As the following analysis will demonstrate, the average investment estimate provided for the 200 ton mill in this study was only three to four times greater than estimates provided for the 30 ton mill. Another reason for procuring these estimates, and a much more important reason for a study of this nature, is to provide some basis for estimating costs, such as insurance, depreciation, and taxes. These costs are vital to construction of short-run average cost curves which, of course, must be known before the industry long-run cost can be determined. The short-run average cost curve indicates the cost per unit of output at the various levels of production.

With these limitations in mind, the following investment estimates can be presented. It should be reemphasized that a mill with equipment and facilities unlike those in the models could be producing the same tonnage per shift and could be constructed for considerably more or less than the models used in this study.

30 Ton Mill

The total estimated investment costs of constructing the 30 ton mill ranged from $79,048 to $100,260. The mill is designed to manufacture 30 tons of feed per eight-hour day, 12 tons of which are pelleted. About 75 per cent of the output will be sold in bulk, while 25 per cent will be moved in bags. Five bins with 250 tons of total capacity are recommended for storage. The recommended building is constructed of prefabricated steel.[17]

To operate the 30 ton mill at capacity requires the services of six men. This number was arrived at by breaking the workday into the several jobs that must be performed and assigning each of these jobs a certain time requirement. To process 30 tons of feed, 12 of which are pelleted, requires about 3,059 minutes. This figure divided by the 480 minutes available for each man indicates the need for about six men to complete a day's work when the mill is being operated at capacity. These six men would be responsible for all of the work required for the production of feed.

It is usually assumed that the manager of a plant will perform only a limited role in the actual production of feed. The justification for this assumption is that the manager will usually be involved in sales activities and administrative functions. No provision has been made for individuals who perform staff functions, such as accounting, sales, purchasing, scheduling, and product control. In a plant of this size all of these functions are

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[17]The dimensions of the building are 50' X 100' X 10' with a 50' X 13' X 7' concrete basement. Warehouse storage space was calculated to be about 50' X 80'.

usually performed by the manager or a dependable second man. Therefore, when considering the wages and salaries to be used for this plant, the wages of six laborers and one manager will be used. The organization chart for this plant is shown in Appendix Figure 1.

The manpower requirements for this mill may seem rather high to an individual who is familiar with an operation of similar size and is operating with only three or four men. There are many jobs which should be performed daily in a feed mill but in reality might be performed only once a week or even less often. Examples of this type of work are daily cleaning of all equipment and rooms in the mill, daily check of all equipment for possible trouble, and daily reviews of production records.

100 Ton Mill

It was estimated that the 100 ton mill could be put into operation for from $195,025 to $216,101. This mill is designed to manufacture 100 tons of feed per eight-hour shift. Thirty-five tons of this total output are pelleted. It is assumed that 45 per cent of the feed will be sold in bulk, and 55 per cent will be sacked.

There are five grain processing bins with a feeder under each to supply the grinders, crimper, and transfer conveyor with raw products. Twenty-four bins with capacities from 20 to 60 tons each are called for in this model. These bins hold the carload shipments of the various ingredients. Two pellet mills are required to handle that 70 per cent of the total output which is comprised of pellets and crumbles. Warehousing space is provided for 100 tons of ingredients and 100 tons of finished feed.[18]

It was determined the functions of the plant would require 90.5 man-hours per eight-hour day with no provisions for miscellaneous jobs, such as cleaning offices, locker rooms, and so forth. This indicates 13 men are needed to operate this plant and perform miscellaneous duties. A situation similar to the 30 ton mill exists with regard to the manager's duties. In this case some of the staff functions would be handled by the foreman. In a mill of this size it is possible that a secretary will be employed to handle the correspondence and to keep books. The operating organization for this plant is shown in Appendix Figure 2.

200 Ton Mill

According to the estimates received from the various builders and equipment manufacturers, it is possible to construct the 200 ton mill for from $296,125 to $330,885. This mill is designed to produce 200 tons of feed per eight-hour shift, 60 tons of which are pelleted. The other 140 tons of output are divided into 60 tons of crumbles and 80 tons of meals. About 60 per cent

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[18]The recommended building for this plant was 74' X 98' X 30' with a 43' X 54' X 11' basement.

of the output is sold in sacks and 40 per cent in bulk.[19]

It was estimated that 20 men would be required to operate this mill. The various operational subdivisions and the number of men required in each are given in the organization table in Appendix Figure 3.

Investment Costs

The investment cost figures used in this study are provided in Table 5. The investment cost per ton decreases by almost $2 when the size of plant is increased from 100 tons per eight-hour shift to 200 tons per eight-hour shift, and by almost 50 per cent (from $11.49 per ton to $6.03 per ton) when the size is increased from 30 to 200 tons.

Operating Costs

Operating costs are the components of both fixed (sunk) and variable (out-of-pocket) costs. Each of these components is included in the following analysis.

TABLE 5. TOTAL AND PER TON INVESTMENT COSTS, MODEL FEED MILLS, 1965

	Model		
Cost Item	30 Ton Per Eight-Hour Shift	100 Ton Per Eight-Hour Shift	200 Ton Per Eight-Hour Shift
Equipment	$68,654	$140,563	$213,505
Building	21,000	65,000	100,000
Total Investment	$89,654	$205,563	$313,505
Per Ton Investment	$11.49	$7.91	$6.03

Fixed Costs

Depreciation

The total investment costs calculated for each of the three models are not considered as a single entry in the accounting records of a firm. These

[19]The warehouse building required for this mill is 50' X 140' X 12'. The mill itself is housed in a 61' X 70' building which is 107' high in the area housing the mill equipment. Another 96' X 32' building is needed to house general offices, the shop, and boiler room. An extensive canopy system is also called for to cover the loading docks and rail platforms.

costs are spread over the usable life of the building or equipment under the heading of depreciation. The depreciation rates used in this study were recommended by the equipment manufacturers and building contractors who provided the initial investment estimates. The equipment in the feed mill (including the equipment used in both the plant and the office) is depreciated by the straight-line method over ten years. The buildings are depreciated by the straight-line method over a 25-year period.[20]

Taxes

Tax expenditures are items which also must be paid regardless of the level of output. The tax rates in North Dakota vary from region to region; therefore, no specific cost can be used which will apply to all areas. The rate used in this study is $15.50 per $1,000 of investment.[21] This figure represents all state, county, local, and township taxes incurred by the firm.

Insurance

Insurance rates vary greatly in response to such items as location of the plant, type of building construction, and the location of buildings and equipment. The rates are considerably less if the plant is located within a city where fire department facilities are available and/or if concrete construction is used instead of frame construction. The rates are also lower if high risk equipment such as a boiler is located in a separate building.

The rates for fire insurance coverage in North Dakota ranged from $2.75 to $3.50 per $100 of investment for 100 per cent coverage. An additional 18 cents per $100 of investment is added if the "extended coverage" arrangement is desired.[22] This option, which is carried by most North Dakota feed producers, insures against damage caused by elements, such as hail, windstorm, riots, and floods. In this study a rate of $3.25 per $100 of investment is used. This insurance covers all buildings and anything within the building property including equipment.

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[20]Under the straight-line method of depreciation an equal amount is depreciated each year. This annual amount is determined by dividing the initial investment figure by the years of usable life of the building or equipment involved. For example, if a machine cost $10,000 and was to be depreciated out over a ten-year period, an annual depreciation figure of $1,000 would be used. In some cases the equipment might be depreciated over a period of longer than ten years.

[21]This rate was determined after talking with members of the North Dakota Tax Commissioner's office on February 15, 1966.

[22]These rates were obtained from the North Dakota Insurance Commissioner's office and the Fire Underwriters Insurance Company.

Interest

In most cases the firm will not own sufficient capital to cover the total investment. Therefore, money must be borrowed and interest paid for the use of this money. This must be considered a cost.

Three area bankers indicated that a loan of this type would probably be made for not longer than ten years at an interest rate of about 6 per cent. In this study it is assumed that the borrower will amortize the principal in ten equal annual installments. The annual interest payment will be equal to 6 per cent of the unpaid balance. The assumption here is that the amortization is in its fifth year. In many instances the banker and the borrower will work out an arrangement whereby the total annual payment (principal plus interest) will be equal over the entire period.

Maintenance

To insure building and equipment efficiency, the firm must make expenditures for maintenance. In this study a rate of 1 per cent of the initial investment is used to derive the annual maintenance costs for the models. This figure was determined after studying the reports submitted by the North Dakota feed plants in the sample. The figures these firms reported as maintenance costs were about 1 per cent of the replacement values reported.

The assumption in this study is that a fixed level of maintenance is required regardless of the level of output of the firm per unit of time. Therefore, maintenance costs are considered fixed.

Salaries

The costs of employing some of the men in a typical feed plant are fixed and some are variable. The criterion used in classifying these costs is whether that individual will remain on the payroll regardless of the level of production. In this study it is assumed that anyone who is paid a monthly salary will remain on the payroll at least to the point at which the plant is producing at only 40 per cent of capacity. Personnel falling within this category are managers, superintendents, foremen, and bookkeeper-stenographers. If the output of the plant begins to fall, the foremen and superintendents will begin to substitute for suspended labor. The salaries used in the models for these people are based on salaries being paid to individuals in comparable positions in North Dakota feed plants.

The salaries of the managers ranged from $425 to $700 per month, with a mean salary of $500 per month. Three of the larger plants didn't report the manager's salary, so this mean figure may be somewhat lower than if all plants had reported. The manager of a plant is often the owner or part-owner of the plant and, therefore, shares in the profits. His salary, however, is considered as part of the operating expenses and is usually in line with the salaries of managers who have no part in the ownership. For this reason the salary figures used for plant managers may seem low. In most instances the manager will be operating under a bonus or commission arrangement. This is included in the salaries used in this study.

The salaries and wages are higher for individuals working in the larger plants. This is reasonable because of additional management responsibilities in a 200 ton plant. The responsibility of superintendents and foremen also tends to increase as the capacity of the mill increases. As a mill increases in size, division of labor becomes more evident; consequently, the laborers become more specialized. This partially explains the reason for higher labor rates in larger plants. An example of this specialization of labor is evident in the 200 ton mill, where every man has a specific job to perform. The differences in secretarial and stenographic salaries paid by the plants were very small. Salaries paid by the larger plants were somewhat higher than those paid by the smaller plants. This may be explained by the fact that in many of the smaller communities the competition for employment among women is greater because of the shortage of jobs. They may, therefore, be willing to work at lower wage rates than they would if employed in a comparable job in the city.

Variable Costs

Wages

The costs of employing anyone who is paid hourly wages are considered variable costs in this study. In this category are included all maintenance men and laborers. It is assumed that these individuals will be dismissed as production is decreased. The wage rates paid in the reporting plants ranged from $1.25 to $2.00 per hour for laborers and $1.65 to $2.40 per hour for the more specialized workers.[23]

Salary and wage payments assumed for this study are shown in Table 6. The figures presented are the total amounts paid annually.

TABLE 6. SALARY AND WAGE PAYMENTS, TOTAL AND PER TON, MODEL FEED PLANTS, 1965[a]

	30 Ton Per Eight-Hour Shift	100 Ton Per Eight-Hour Shift	200 Ton Per Eight-Hour Shift
Manager	$ 6,000	$ 8,000	$ 10,000
Superintendent	---	---	7,000
Foreman	5,000	11,500(2)	11,500(2)
Bookkeeper	---	---	9,000(2)
Secretary	1,800(½ time)	3,600	7,600(2)
Total Fixed Cost	$12,800	$23,100	$ 45,100
Maintenance	$ 4,000	$ 4,500	$ 10,000(2)
Laborers	16,000(4)	36,000(9)	63,000(15)
Total Variable Cost	$20,000	$40,500	$ 73,000
Total Wages and Salaries	$32,800	$63,600	$118,100
Wages and Salaries Per Ton	$4.20	$2.44	$2.27

[a]Figures in brackets represent the number of men required.

[23]Since bonuses and commissions are included in the wage and salary figures for the models, the annual income figures from the cooperating plants were used to determine the labor costs for the models.

Repairs and Replacements

All outlays made to repair or replace equipment that has deteriorated due to use fall within this category. An example of this type of cost is replacement of a broken or worn machine part. It is assumed that repairs and replacement costs, when the firm is operating at 100 per cent of capacity, are equal to 5 per cent of the equipment investment. This rate is based on the reports of the feed mill managers who completed the questionnaire for this study. The feed plants in this sample spent between 3.5 and 7.0 per cent of the reported replacement costs on repairs.

Utilities

Utility costs will also vary with the level of production. Electricity, fuel oil, gas, and water expenses are placed in this category. Cost data obtained from feed plants in North Dakota indicated that the costs of all utilities ranged from 5 to 7 per cent of the total plant investment. In this study the assumption is that the total utility bill is 6 per cent of the total investment.[24]

Administrative

Some administrative costs are considered variable costs. Telephone, travel expense, office supplies, auditing, dues, and subscriptions are in this category. These administrative costs are assumed to be about 15 per cent of the total investment. This rate was determined by comparing the administrative expenditures of the reporting firms with their replacement values.

The total and per ton costs which apply to the models are listed in Table 7.

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[24]This figure is subject to variation for a number of reasons, the most basic of which is that the rates charged by the utility companies are usually reduced as consumption is increased. Two companies supplying electricity to various areas in North Dakota indicated that they used very complex schedules for determining the rates charged to different consumers. Under normal conditions the charge per kilowatt hour will be reduced as electricity consumption is increased. A mill with more electrical equipment would, of course, consume more electricity.

TABLE 7. FIXED AND VARIABLE COSTS, TOTAL AND PER TON, MODEL FEED MILLS AT 100 PER CENT CAPACITY[a]

Cost Item	Model: 30 Ton Per Eight-Hour Shift	100 Ton Per Eight-Hour Shift	200 Ton Per Eight-Hour Shift
		Fixed Costs	
Depreciation			
Building	$ 840	$ 2,600	$ 4,000
Equipment	6,865	14,056	21,350
Taxes	1,390	3,185	4,851
Insurance	2,912	6,678	10,189
Interest	3,227	7,400	11,280
Maintenance	897	2,055	3,135
Salaries	12,800	23,100	45,100
Total Fixed Cost	$28,931	$ 59,074	$ 99,905
Average Fixed Cost Per Ton	$3.71	$2.27	$1.92
		Variable Costs	
Wages	$20,000	$ 40,500	$ 73,000
Repairs and Replacements	4,482	10,278	15,675
Utilities	5,379	12,333	18,810
Administrative	1,344	3,083	4,702
Total Variable Cost	$31,205	$ 66,194	$112,187
Average Variable Cost Per Ton	$4.00	$2.54	$2.15
Total Cost	$60,136	$125,268	$212,092
Average Total Cost Per Ton	$7.71	$4.81	$4.07

[a]All costs apply to plants operating at 100 per cent capacity. At the 100 per cent capacity level of production all costs are minimum. The plant might be able to produce a greater physical product; however, as production is moved beyond the 100 per cent capacity level, average costs increase.

Costs at Varying Levels of Output

Unused capacity causes the production costs per ton of feed to increase. The data presented in Table 8 support this statement and provide the data necessary for construction of short-run average cost curves. The costs in this table were derived by using specified percentages of the average investment estimates discussed above.

By dropping the level of production from 100 per cent of capacity to 60 per cent of capacity, the manager of a 30 ton plant increases his per ton production costs by more than $3.00. The data indicate similar relationships exist in each of the models. The average cost figures increase because both the average fixed cost and average variable cost figures increase as capacity utilization is decreased. The major factor contributing to the average cost increase, however, is the increase in average fixed cost. The relatively greater increase in average fixed cost over average variable cost is explained by simple mathematics. The total fixed cost figure remains constant regardless of the level of capacity utilization, while the total variable cost figure is reduced as capacity utilization is reduced. Since both the total fixed cost and total variable cost figures are divided by the same output at any given level of capacity utilization, the average fixed cost must increase more than average variable cost when the utilization of capacity is decreased.

TABLE 8. ANNUAL OPERATING COSTS, MODEL FEED MILLS, 1965[a]

Model and Per Cent Utilization	Fixed Cost	Average Fixed Cost Per Ton	Variable Cost	Average Variable Cost Per Ton	Total Cost	Average Total Cost Per Ton
30 Ton						
100% (7,800)[b]	$28,931	$3.71	$ 31,205	$4.00	$ 60,136	$ 7.71
80% (6,140)	28,931	4.71	28,084	4.57	57,015	9.28
60% (4,680)	28,931	6.18	21,843	4.66	50,774	10.84
40% (3,120)	28,931	9.27	15,602	5.00	44,533	14.27
100 Ton						
100% (26,000)	$59,074	$2.27	$ 66,194	$2.54	$125,268	$ 4.81
80% (20,800)	59,074	2.84	59,574	2.86	118,648	5.70
60% (15,600)	59,074	3.78	46,335	2.97	105,409	6.75
40% (10,400)	59,074	5.68	33,097	3.18	92,171	8.86
200 Ton						
100% (52,000)	$99,905	$1.92	$112,187	$2.15	$212,092	$ 4.07
80% (41,600)	99,905	2.40	100,968	2.42	200,873	4.82
60% (31,200)	99,905	3.20	78,530	2.51	178,435	5.71
40% (20,800)	99,905	4.80	56,093	2.69	155,998	7.49

[a]The costs at the various capacity levels are derived by holding total fixed costs constant regardless of the level of output and by reducing total variable costs by 10 per cent less than output is reduced. For example, if the plant is operating at 80 per cent capacity, total fixed costs are assumed to be the same as when the plant is operating at full capacity; and total variable costs are assumed to equal 90 per cent of the total variable costs incurred when the plant is operating at full capacity. The reason for not reducing variable costs by the same percentage as output is that there are some costs in the variable category that have some "fixed" characteristics. An example is the utility section. A certain amount of power and fuel will be required to light and heat the building regardless of the level of production. Similarly with labor, it is assumed that a man will stand idle for a certain percentage of a workday before he is laid off. The extra 10 per cent is meant to allow for these factors.

[b]Figures in brackets refer to the number of tons produced at the various levels of capacity utilization.

Cost Savings From Increased Size of Plant

The short-run average cost curves applicable to the three models are presented in Figure 1. Observation of Figure 1 reveals significant economies from increasing size in the feed industry. If the 30, 100, and 200 ton models are operated at 100 per cent of capacity, the average production costs per ton are $7.71, $4.81, and $4.07, respectively. The industry scale curve or the long-run planning curve is found simply by drawing a line tangent to three short-run average cost curves. This curve is shown as the heavy, broken line in Figure 1. Since this curve appears to level off and become horizontal at about the 50,000 ton level of production, it can be concluded that the optimum size of plant is close to the 200 ton plant. The optimum size of plant is the one whose short-run average cost curve forms the low point of the long-run average cost curve. It is the most efficient plant size which can be built, given current technology. The long-run planning curve in this figure establishes that, of the three plant sizes available, the 200 ton model is the most efficient or optimum. In other words, if the demand for feed is present (as was assumed in this study), the firm will realize economies by increasing its plant size to a capacity of at least 200 tons per eight-hour shift.

High and Low Investment Estimates

Since percentages of total investment are used to determine some components of each model's operating costs, a variation in investment causes a direct variation in the operating costs. The costs applicable to the highest and lowest investment estimates for each model are presented in Tables 9, 10, and 11. The curves constructed from these data are found in Figure 2.

Tables 11 and 12 and Figure 2 indicate that the operating costs per ton for the highest and lowest investment estimates are not substantially different. The differences between the average costs per ton for the highest and lowest estimates of the 30, 100, and 200 ton output models are 81 cents, 24 cents, and 18 cents, respectively.

Two Production Shifts

For any given period of time the full-capacity level of plant utilization is the output level at which the average costs of production are at the minimum. In this study the "given period of time" refers to one eight-hour shift. It is logical to assume that if the plant can be operated during all or part of the other 16 hours of each day the average fixed costs will decrease because the total fixed costs are spread over a greater output. If the average fixed costs decrease more than the average variable costs increase when an additional shift is added, the average total costs, of course, decrease. If factors such as available market for feed and available labor for an additional shift are favorable, the feed plant manager should consider adding another shift.

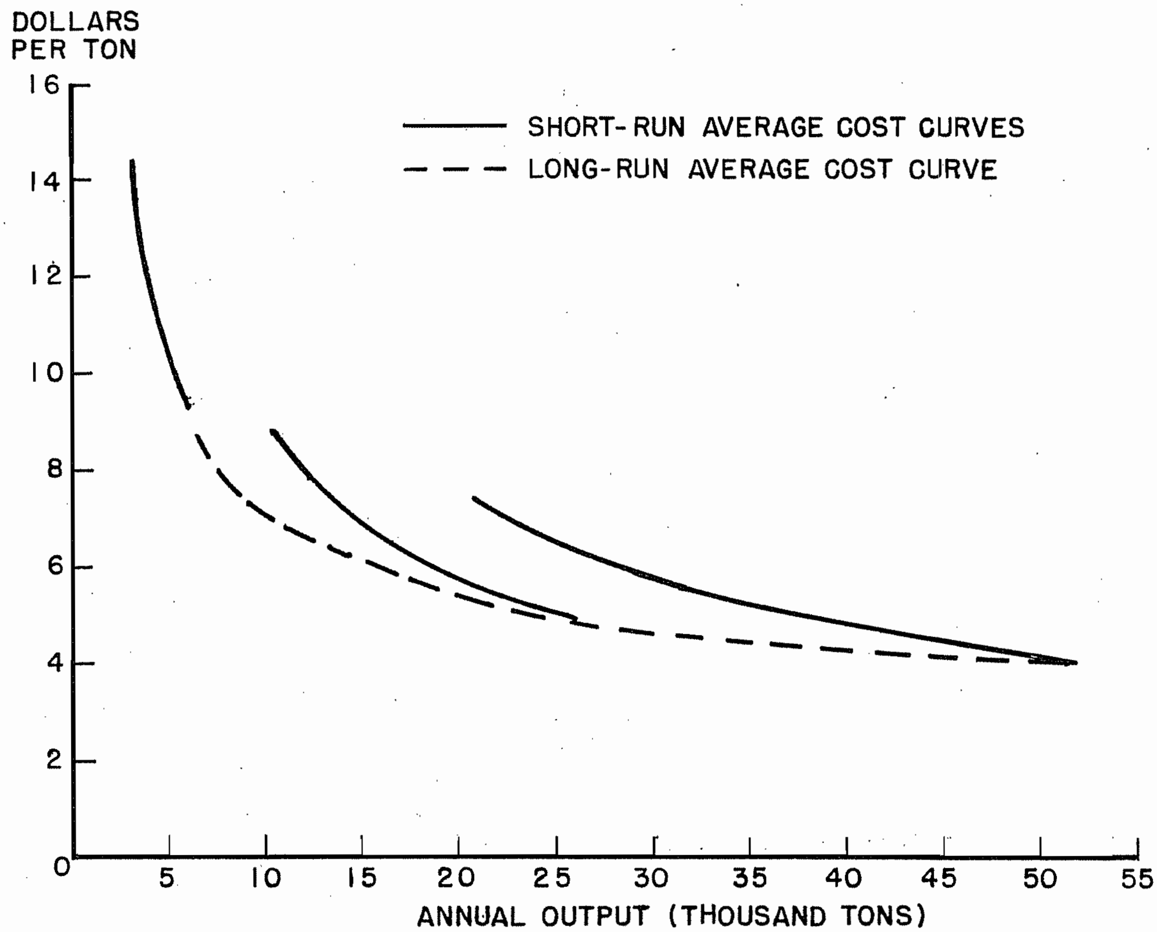

Figure 1. Annual Average Operating Costs of Model Feed Mills, Average Investment Estimates

TABLE 9. HIGH ESTIMATES OF INVESTMENT, FIXED AND VARIABLE COSTS (TOTAL AND PER TON), MODEL FEED MILLS, 1965

Cost Item	Model: 30 Ton Per Eight-Hour Shift	Model: 100 Ton Per Eight-Hour Shift	Model: 200 Ton Per Eight-Hour Shift
		Investment Costs	
Equipment	$ 75,260	$147,101	$220,885
Building	25,000	69,000	110,000
Total	$100,260	$216,101	$330,885
Investment Per Ton	$12.85	$8.31	$6.36
		Fixed Costs	
Depreciation			
Building	$ 1,000	$ 2,760	$ 4,400
Equipment	7,526	14,701	22,088
Taxes	1,550	3,348	5,130
Insurance	3,250	7,023	10,750
Interest	3,609	7,779	11,911
Maintenance	1,002	2,161	3,308
Salaries	12,800	23,100	45,100
Total Fixed Cost	$ 30,737	$ 60,872	$102,687
Average Fixed Cost Per Ton	$3.94	$2.34	$1.97
		Variable Costs	
Wages	$ 20,000	$ 40,500	$ 73,000
Repairs and Replacements	5,013	10,805	16,544
Utilities	6,015	12,966	19,853
Administrative	1,503	3,241	4,963
Total Variable Cost	$ 32,531	$ 67,512	$114,360
Average Variable Cost Per Ton	$4.17	$2.59	$2.19
Total Cost	$ 63,268	$128,384	$217,047
Average Total Cost Per Ton	$8.11	$4.93	$4.17

TABLE 10. LOW ESTIMATES OF INVESTMENT, FIXED AND VARIABLE COSTS (TOTAL AND PER TON), MODEL FEED MILLS, 1965

Cost Item	Model: 30 Ton Per Eight-Hour Shift	Model: 100 Ton Per Eight-Hour Shift	Model: 200 Ton Per Eight-Hour Shift
		Investment Costs	
Equipment	$ 61,048	$133,025	$216,125
Building	18,000	62,000	80,000
Total	$ 79,048	$195,025	$296,125
Investment Per Ton	$10.13	$7.50	$5.69
		Fixed Costs	
Depreciation			
Building	$ 720	$ 2,480	$ 3,200
Equipment	6,104	13,302	21,612
Taxes	1,224	3,022	4,548
Insurance	2,567	6,337	9,623
Interest	2,845	7,021	10,660
Maintenance	790	1,950	2,961
Salaries	12,800	23,100	45,100
Total Fixed Cost	$ 27,050	$ 57,212	$ 97,704
Average Fixed Cost Per Ton	$3.47	$2.20	$1.88
		Variable Costs	
Wages	$ 20,000	$ 40,500	$ 73,000
Repairs and Replacements	3,952	9,751	14,806
Utilities	4,742	11,701	17,767
Administrative	1,185	2,925	4,441
Total Variable Cost	$ 29,879	$ 64,877	$110,014
Average Variable Cost Per Ton	$3.83	$2.49	$2.11
Total Cost	$ 56,929	$122,089	$207,718
Average Total Cost Per Ton	$7.30	$4.69	$3.99

TABLE 11. ANNUAL OPERATING COSTS OF MODEL MILLS, HIGHEST INVESTMENT ESTIMATES, 1965

Model and Per Cent Utilization	Fixed Cost	Average Fixed Cost Per Ton	Variable Cost	Average Variable Cost Per Ton	Total Cost	Average Total Cost Per Ton
30 Ton						
100% (7,800)[a]	$ 30,737	$3.94	$ 32,531	$4.17	$ 63,268	$ 8.11
80% (6,140)	30,737	5.01	29,277	4.76	60,014	9.77
60% (4,680)	30,737	6.57	22,771	4.86	53,508	11.43
40% (3,120)	30,737	9.85	16,265	5.21	47,002	15.06
100 Ton						
100% (26,000)	$ 60,872	$2.34	$ 67,512	$2.59	$128,384	$ 4.93
80% (20,800)	60,872	2.92	60,760	2.91	121,632	5.85
60% (15,600)	60,872	3.90	47,258	3.03	108,130	6.93
40% (10,400)	60,872	5.85	33,756	3.24	94,628	9.09
200 Ton						
100% (52,000)	$102,687	$1.97	$114,360	$2.19	$217,047	$4.17
80% (41,600)	102,687	2.47	102,924	2.47	205,611	4.94
60% (31,200)	102,687	3.29	80,052	2.56	182,739	5.85
40% (20,800)	102,687	4.93	57,180	2.75	159,867	7.68

[a]Figures in brackets refer to the number of tons produced at the various levels of capacity utilization.

TABLE 12. ANNUAL OPERATING COSTS OF MODEL MILLS, LOWEST INVESTMENT ESTIMATES, 1965

Model and Per Cent Utilization	Fixed Cost	Average Fixed Cost Per Ton	Variable Cost	Average Variable Cost Per Ton	Total Cost	Average Total Cost Per Ton
30 Ton						
100% (7,800)[a]	$ 27,050	$3.47	$ 29,879	$3.83	$ 56,929	$ 7.30
80% (6,140)	27,050	4.40	26,891	4.38	53,941	8.78
60% (4,680)	27,050	5.78	20,915	4.46	47,965	10.24
40% (3,120)	27,050	8.67	14,939	4.78	41,989	13.45
100 Ton						
100% (26,000)	$ 57,212	$2.20	$ 64,877	$2.49	$122,089	$ 4.69
80% (20,800)	57,212	2.75	58,389	2.80	115,601	5.55
60% (15,600)	57,212	3.66	45,413	2.91	102,625	6.57
40% (10,400)	57,212	5.50	32,438	3.12	89,650	8.62
200 Ton						
100% (52,000)	$ 97,704	$1.88	$110,014	$2.11	$207,718	$ 3.99
80% (41,600)	97,704	2.35	99,012	2.38	196,716	4.73
60% (31,200)	97,704	3.13	77,009	2.46	174,713	5.59
40% (20,800)	97,704	4.70	55,007	2.64	152,711	7.34

[a]Figures in brackets refer to the number of tons produced at the various levels of capacity utilization.

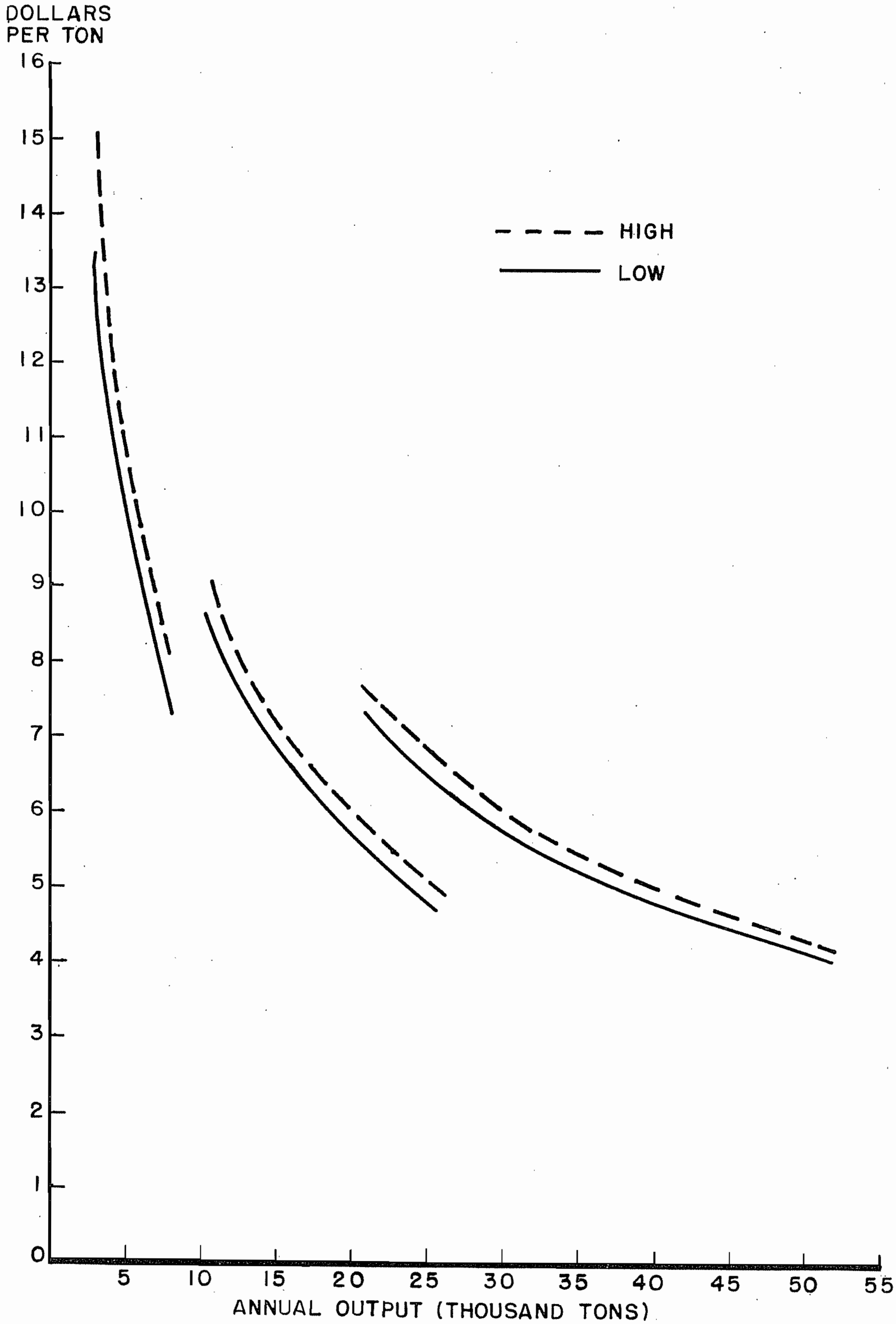

Figure 2. Annual Average Operating Costs of Model Feed Mills, High and Low Investment Estimates

A set of curves is constructed which represents the costs incurred by the three model plants when a second eight-hour shift is introduced (Figure 3). The data in Table 13 are the costs applicable to this figure. These costs were derived by holding all fixed costs, except maintenance, constant. Maintenance costs were assumed to double. All variable costs except administrative costs were doubled. Administrative costs were held constant.

The wages of the employees working the second shift may be, in some cases, somewhat higher if men are required to work at night. It is assumed in this study that any increase in wage rates for production workers will be offset by a reduction in the amount spent on maintenance labor. The manager of one North Dakota plant that operated two shifts indicated that all of his men were paid the same rate. The men who had been with the firm the longest time had the opportunity to choose the shift they wanted.

The data in Table 14 and Figure 3 establish that the introduction of a second shift reduces the operating costs per ton of feed. The average costs of producing a ton of feed in each of the three models operating at full capacity were reduced from $7.71, $4.81, and $4.07 to $5.82, $3.66, and $3.05, respectively, as a second shift was introduced. This supports the statement made above that if an effective demand is present the feed mill manager should consider adding another shift to his production schedule to lower his per ton production costs.

TABLE 13. PRODUCTION COSTS AT 100 PER CENT CAPACITY, ONE AND TWO EIGHT-HOUR SHIFTS, MODEL FEED MILLS, 1965

Cost Items	Model					
	30 Ton		100 Ton		200 Ton	
	1 Shift	2 Shifts	1 Shift	2 Shifts	1 Shift	2 Shifts
			Fixed Costs			
Depreciation						
Building	$ 840	$ 840	$ 2,600	$ 2,600	$ 4,000	$ 4,000
Equipment	6,865	6,865	14,056	14,056	21,350	21,350
Taxes	1,390	1,390	3,185	3,185	4,851	4,851
Insurance	2,912	2,912	6,678	6,678	10,189	10,189
Interest	3,227	3,227	7,400	7,400	11,280	11,280
Maintenance	897	1,784	2,055	4,110	3,135	6,270
Salaries	12,800	12,800	23,100	23,100	45,100	45,100
Total Fixed Cost	$28,931	$29,828	$ 59,074	$ 61,129	$ 99,905	$103,040
Average Fixed Cost Per Ton	$3.71	$1.91	$2.27	$1.17	$1.92	$0.99
			Variable Costs			
Wages	$20,000	$40,000	$ 40,500	$ 81,000	$ 73,000	$140,600
Repairs and Replacements	4,482	8,964	10,278	20,556	15,675	31,350
Utilities	5,379	10,758	12,333	24,666	18,810	37,620
Administrative	1,344	1,344	3,083	3,083	4,702	4,702
Total Variable Cost	$31,205	$61,066	$ 66,194	$129,305	$112,187	$214,272
Average Variable Cost Per Ton	$4.00	$3.91	$2.54	$2.49	$2.15	$2.06
Total Cost	$60,136	$90,894	$125,268	$190,434	$212,092	$317,312
Average Total Cost Per Ton	$7.71	$5.82	$4.81	$3.66	$4.07	$3.05

TABLE 14. ANNUAL OPERATING COSTS WITH TWO SHIFTS, MODEL FEED MILLS, 1965

Model and Per Cent Utilization	Fixed Cost	Average Fixed Cost Per Ton	Variable Cost	Average Variable Cost Per Ton	Total Cost	Average Total Cost Per Ton
30 Ton						
100%(15,600)	$ 29,828	$1.91	$ 61,066	$3.91	$ 90,894	$5.82
80%(12,480)	29,828	2.39	54,959	4.40	84,787	6.79
60%(9,360)	29,828	3.18	42,746	4.57	72,574	7.75
40%(6,240)	29,828	4.78	30,533	4.89	60,361	9.67
100 Ton						
100%(52,000)	$ 61,129	$1.17	$129,305	$2.49	$190,434	$3.66
80%(41,600)	61,129	1.46	116,374	2.80	177,503	4.26
60%(31,200)	61,129	1.96	90,513	2.90	151,642	4.86
40%(20,800)	61,129	2.93	64,652	3.11	125,781	6.04
200 Ton						
100%(104,000)	$103,040	$0.99	$214,272	$2.06	$317,312	$3.05
80%(83,200)	103,040	1.24	192,844	2.31	295,884	3.55
60%(62,400)	103,040	1.65	149,990	2.40	253,030	4.05
40%(41,600)	103,040	2.48	107,136	2.57	210,176	5.05

Industry-Model Comparisons

The per ton production expenses reported by the North Dakota plants in this study were considerably higher than those found for the models. The actual costs ranged from $11.50 to $23.50 per ton, with a mean of $18.00 and a median of $19.50. The average production cost per ton of the plants in Group I (74.1 tons per eight hours) was the lowest of the group averages at $13.75 per ton. The averages of Groups II (36 tons per eight hours) and III (24.5 tons per eight hours) were $17.00 and $20.50, respectively.

TABLE 15. AVERAGE PER TON PRODUCTION COSTS AND RANGES, NORTH DAKOTA FEED PLANTS, 1965

	Sample	Group I	Group II	Group III
Average Production Cost Per Ton	$18.00	$13.75	$17.00	$20.50
Production Cost Range	$11.50-23.50	$11.50-17.50	$14.75-20.50	$16.75-23.50

These figures suggest there are efficiency improvements which can be made in North Dakota feed mills. Some of the possible reasons for the higher-than-model production costs may be operating at less than full capacity, too

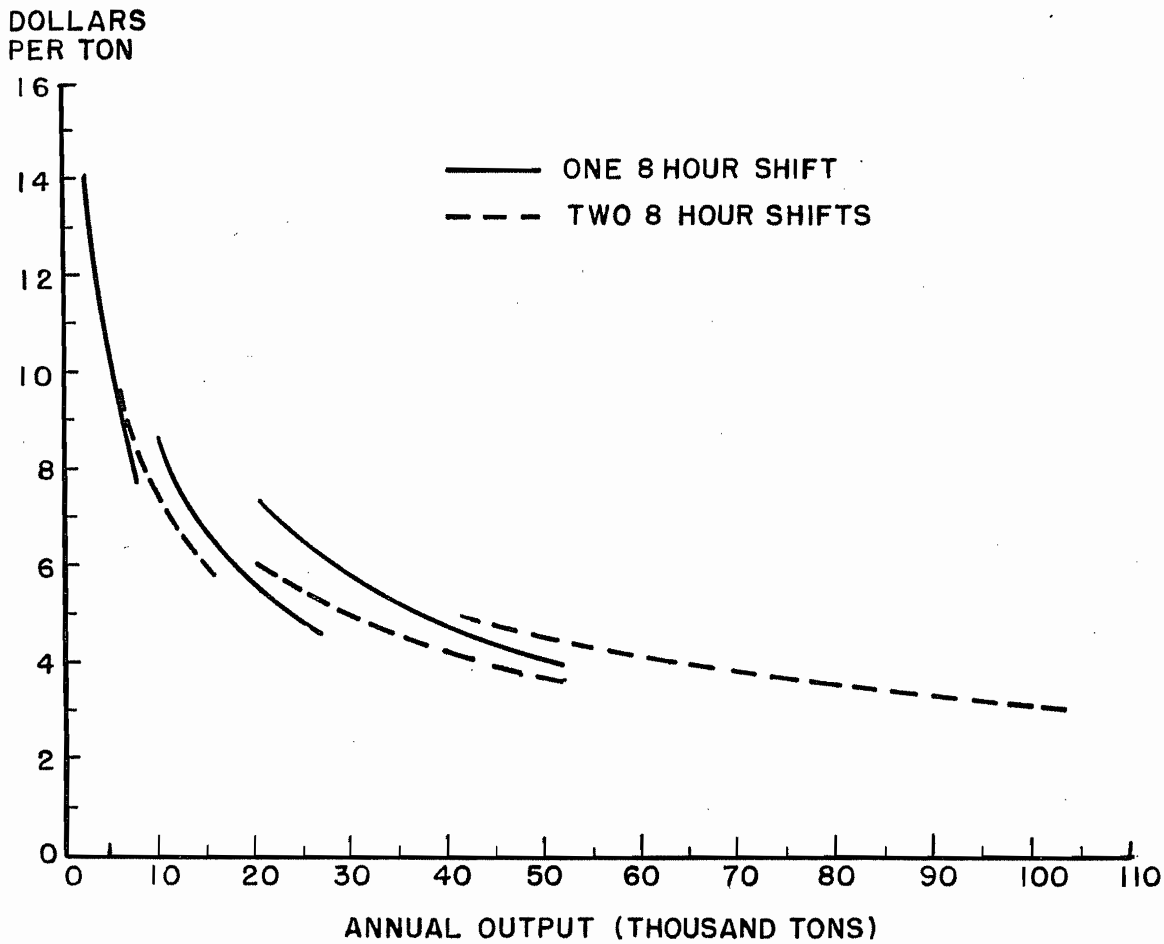

Figure 3. Annual Average Operating Costs of Model Feed Mills, One and Two Shifts

much idle time on the parts of employees, outdated and inefficient machinery, and lack of management.

The estimated replacement values of the North Dakota mills and the estimated costs of the models were relatively close. The average replacement value of Group I plants was $326,000, and the estimated cost of constructing a 200 ton plant was $313,505 (Table 16). The average pelleting capacity was 14 tons per eight-hour shift more than the 200 ton model. The estimated cost of the 100 ton model was only $5,563 more than the average replacement value of a Group II plant. The pelleting capacity of the 100 ton model was 35 tons per eight-hour shift as opposed to an average capacity of 36 tons for Group II plants.

TABLE 16. EMPLOYEE REQUIREMENTS AND REPLACEMENT VALUES, NORTH DAKOTA FEED PLANTS AND MODEL FEED MILLS, 1965

	North Dakota Plants			Models		
Pelleting Capacities	Group I (74 tons)	Group II (36 tons)	Group III (24 tons)	200 Tons Total Output (60 tons)	100 Tons Total Output (35 tons)	30 Tons Total Output (12 tons)
Employee Requirements	12.3	7.1	5.8	20	13	6
Replacement Values	$326,000	$200,000	$105,600	$313,505	$205,563	$ 89,654

The number of employees required to operate the mill in each case was considerably higher for the models than for the cooperating firms. One reason for this may be the model mills were assumed to be operating under ideal conditions with many jobs being performed that are not always performed in reality. Examples of this type of job are daily cleaning activities and daily machinery inspection.

COMMON COST FEED PLANTS

Often a grain elevator will offer feed services in addition to its normal elevator activities. There are a number of reasons for adding a feed enterprise to an existing elevator. Two of the most common reasons are to increase the net profit of the firm and to provide a service for the grain customers of the firm. In a large elevator the feed plant will probably be organized as a separate corporation, and a completely separate set of physical facilities will be constructed. While items such as scales might be used jointly by both enterprises in these larger firms, one is usually provided for both enterprises to eliminate confusion and congestion. The 100 and 200 ton models may fall into this category. In a smaller elevator, however, feed manufacturing equipment will probably be added to the existing elevator plant, and many pieces of equipment will be used commonly by both enterprises. Examples of this type of equipment are office equipment and scales. The purpose of this chapter is to determine how the investment costs and average production costs are affected when a 30 ton mill is operated in conjunction with an elevator.

Investment Costs

The equipment recommendations for the 30 ton model are provided in Appendix Table 1. The following pieces of equipment are assumed to be usable by both the elevator and the feed plant: rail car receiving hopper, truck receiving hopper, receiving elevator, receiving distributor, weigh buggy, bulk load out distributor, and truck scales. Since both the elevator and feed plant can use this equipment, only one-half of the original costs can be charged against the feed plant. The one-half figure is used because it is assumed that both enterprises use these facilities about the same amount of time.

The investment cost of the 30 ton model in this case, therefore, would be $5,788 less than if the plant were organized independently.[25] Since the equipment investment requirement for the 30 ton mill operated independently was $68,654, the investment outlay for equipment when the feed mill is operated in connection with an elevator would be $62,876. The cost of the building for an independent plant is $21,000. Since most of the equipment will be housed in the elevator building when a feed plant and elevator are operated concurrently, this figure will be reduced substantially. It is assumed that some remodeling and additions will have to be made when the feed equipment is added to the elevator, so a cost of $5,000 was estimated for the building. This makes a total investment cost of $67,876 for a 30 ton mill operated with an elevator. The per ton investment cost of a 30 ton mill under these circumstances is $8.65 as opposed to $11.49 when the mill is operated independently.

Operating Costs

It is difficult to derive specific relationships between the average production costs of a feed plant operated independently and one operated in connection with an elevator; however, it is possible to present and support general relationships.

The difficulty in determining specific relationships is in the methods used to calculate costs. To allocate the common costs between two enterprises, the total cost figures must be known. In this study the operating costs of feed mills are known, but elevator costs are unknown; therefore, the total cost figures are not available. For example, the collective utility bill for

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[25] The estimated cost of these pieces of equipment was $11,576. Only one-half of this amount is charged to the feed plant when the plant is operated with an elevator.

both enterprises is not known, so no meaningful allocation can be made.

It is possible to establish general relationships by applying apparent facts to the analysis. For example, it would seem that the production costs of a feed plant being operated independently would be somewhat higher than one being operated jointly with an elevator if both plants were performing at maximum efficiency.

One reason for this is the possibility of pooling resources. If, for example, an employee assigned to the elevator has some idle time, he can be assigned to the feed plant to perform a task which, in an independent feed plant, would require the hiring of another man. Similarly with utilities, the power required to provide heat and light for a single plant will be less than if two separate sets of physical plants are provided for independently. This would also be the case with insurance, taxes, and maintenance. Normally, the costs of insuring, paying taxes, and maintaining one large building are less than if two buildings are involved.

Therefore, even though no absolute figures can be presented, it is possible to state that the average cost of producing feed in a plant operating under a common cost situation is less than in an independent feed plant if both are performing at maximum efficiency.

APPENDIX

APPENDIX TABLE 1. EQUIPMENT RECOMMENDATIONS AND COSTS FOR A 30 TON PER DAY MODEL FEED MILL

30 Ton Mill	Ranges of Estimates		
Power shovel	$ 2,250	-	$ 2,650
Rail hopper car receiving hopper			
Truck receiving hopper - drive over	2,800	-	3,800
Receiving conveyor	1,500	-	2,000
Permanent type hopper magnet	250	-	500
Receiving elevator	2,500	-	2,800
Receiving distributor	250	-	500
55 ton grain bin			
55 ton grain bin			
50 ton meal or concentrate bin			
50 ton meal or concentrate bin			
50 ton meal or concentrate bin	7,000	-	8,000
Weigh buggy	923	-	1,500
2 ton vertical mixer	1,500	-	2,000
Screw conveyor - mash	500	-	1,000
Permanent type hopper magnet	100	-	210
Bucket elevator - mash	1,850	-	2,500
2-way valve and connectors	50	-	100
Bulk load out distributor	225	-	250
4 bulk load out bins at 6 tons each	2,250	-	3,000
Permanent type magnet			
Hammer mill, fan, etc.	4,250	-	4,500
Hammer mill collector and piping	750	-	1,250
Two (2) 6 ton ground grain bins	1,100	-	1,400
2 ton hopper and dial scale	400	-	800
2 ton vertical mixer	850	-	1,350
Bagging scale - gross type	1,000	-	1,500
2 ton bagging bin	250	-	500
Portable type sewing belt and machine	1,300	-	1,900
Cold type molasses mixer, pump, meter, etc.			
2 ton molasses feed bin			
4,000 gallon molasses tank	2,300	-	4,300
Pellet mill			
Pellet cooler			
Pellet crumbler			
Pellet grader	12,350	-	16,500
Two (2) 2 ton pellet mill mash bins	750	-	900
Truck scales	5,500	-	8,500
Alternate custom truck hoist	1,300	-	2,300
Bucket elevator - finished pellets	2,000	-	2,750
	$58,048	-	$79,260

Source: 1961 Feed Production Handbook, Feed Production School, Kansas City, Missouri, p. 66, and equipment manufacturers.

APPENDIX TABLE 2. EQUIPMENT RECOMMENDATIONS AND COSTS FOR A 100 TON PER DAY MODEL FEED MILL

100 Ton Mill	Ranges of Estimates		
Power shovel	$ 1,000	-	$ 1,500
Truck and rail dump hopper	1,500	-	2,300
Unloading conveyor	1,500	-	2,000
Bucket elevator			
Magnet	2,000	-	2,600
Surge bin (7)			
High level bin fill control	3,000	-	3,500
Automatic receiving scale	700	-	850
Scalping machine	750	-	1,000
Sack dump hopper	800	-	1,000
Bucket elevator	2,000	-	2,500
Drag conveyor	750	-	1,000
Turn head distributor			
Grain bins (6)	7,500	-	8,000
Drag conveyor (2)	1,200	-	1,500
Hammer mill			
Hammer mill fan			
Magnet	5,000	-	6,000
Grain steamer			
Roller mill	2,200	-	2,500
Pneumatic conveyor	2,000	-	2,500
Crimped (flaked) grain cooler	2,300	-	2,500
Ingredient supply bins (25)			
Feed screw conveyors (25)	20,000	-	23,000
Batch scale hopper	300	-	351
Horizontal mixers (2)	3,875	-	5,000
Bucket elevator			
Magnet	1,700	-	2,000
Scalper	1,400	-	1,500
Feed finisher	1,300	-	1,500
Bucket elevator	1,300	-	1,500
Drag conveyor	800	-	1,000
Turn head distributor			
Finished feed bins (16)	2,500	-	3,000
Drag conveyors (3)	2,000	-	2,500
Feeder (2)	750	-	1,000
Mash and molasses sacking scale	750	-	1,000
Liquid fat applicator	800	-	1,000
Pellet sacking scale	800	-	1,000
Pellet mills (3)			
Vertical pellet cooler and crumbler (2)			
Bucket elevator (2)			
Graders, pellets and crumbles (2)			
Drag conveyor (2)	54,000	-	60,000
Belt conveyor			
Trough belt conveyor	1,500	-	2,000
Bucket elevator	1,300	-	1,500
Passenger elevator	750	-	1,000
	$130,025	-	$151,101

Source: <u>1961 Feed Production Handbook</u>, Feed Production School, Kansas City, Missouri, p. 70, and equipment manufacturers.

APPENDIX TABLE 3. EQUIPMENT RECOMMENDATIONS AND COSTS FOR A 200 TON PER DAY MODEL FEED MILL

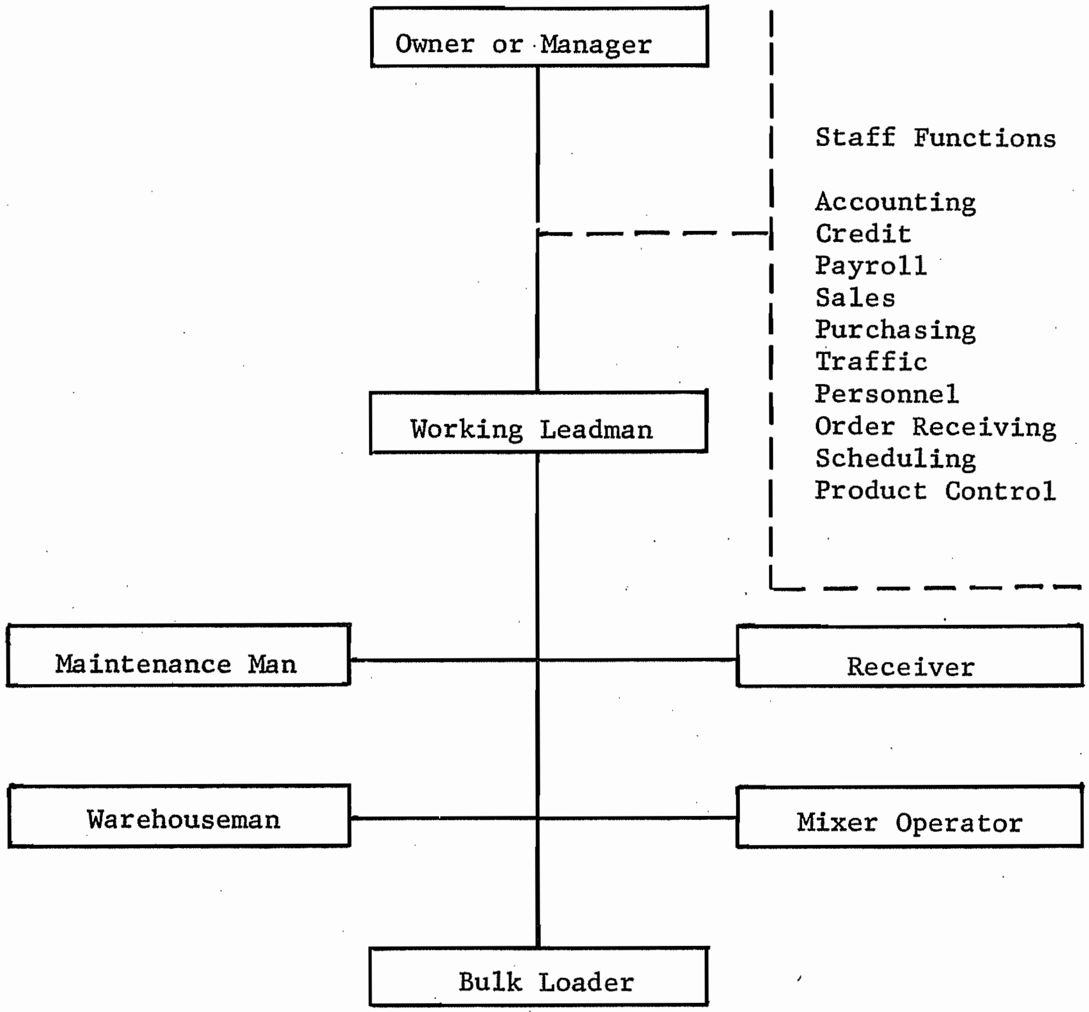
200 Ton Mill	Ranges of Estimates		
Power shovels	$ 2,000	-	$ 2,600
Truck scale and track scale	10,500	-	12,000
Bulk unloading hoppers (2)			
Unloading conveyors (2)			
Unloading/transfer elevators (2)			
Magnetic separators (2)			
Grain separator/cleaner (2)			
Grain separator/cleaner cyclone	12,000	-	15,400
Grain distributing conveyor	2,000	-	2,500
Bin level controls	75	-	100
Transfer conveyor	800	-	850
Magnetic separators (3)	900	-	1,100
Hammer mills (2)	10,500	-	12,000
Gravity bag dump	550	-	650
Oat crimping equipment:			
Steamer			
Crimper			
Vertical cooler			
Air conveyor	8,000	-	10,000
Hammer mill cyclones (3)			
Crimped oat cooler cyclone	2,150	-	3,500
Incoming feed conveyor	2,200	-	2,500
Ingredient supply conveyor	2,000	-	2,300
Sacked dump hoppers (6)	19,500	-	21,000
Premix equipment:			
Scale			
Batch mixer			
Scalping screen			
Air conveyor	3,200	-	3,950
Premix work bins (8)	3,500	-	4,000
Automatic scale	1,200	-	1,850
Conveyor feeders (23)	7,000	-	8,000
Liquid work tanks (2)	350	-	500
Scale hopper	650	-	750
Batch mixers with surge hoppers (2)	3,000	-	3,600
Mixed feed elevator	2,800	-	3,100
Magnetic separator	700	-	785
Mixed feed finisher/cleaner	2,000	-	2,500
Mixed feed distributing conveyor	3,150	-	3,800
Molasses mixer equipment:			
Air operated gates to dry dairy			
Feed belt weighers			
Ratio flow controller			
Preheat molasses work tank			
Flow meter			
Continuous horizontal mixer			
Load out counter	8,500	-	10,000

(continued)

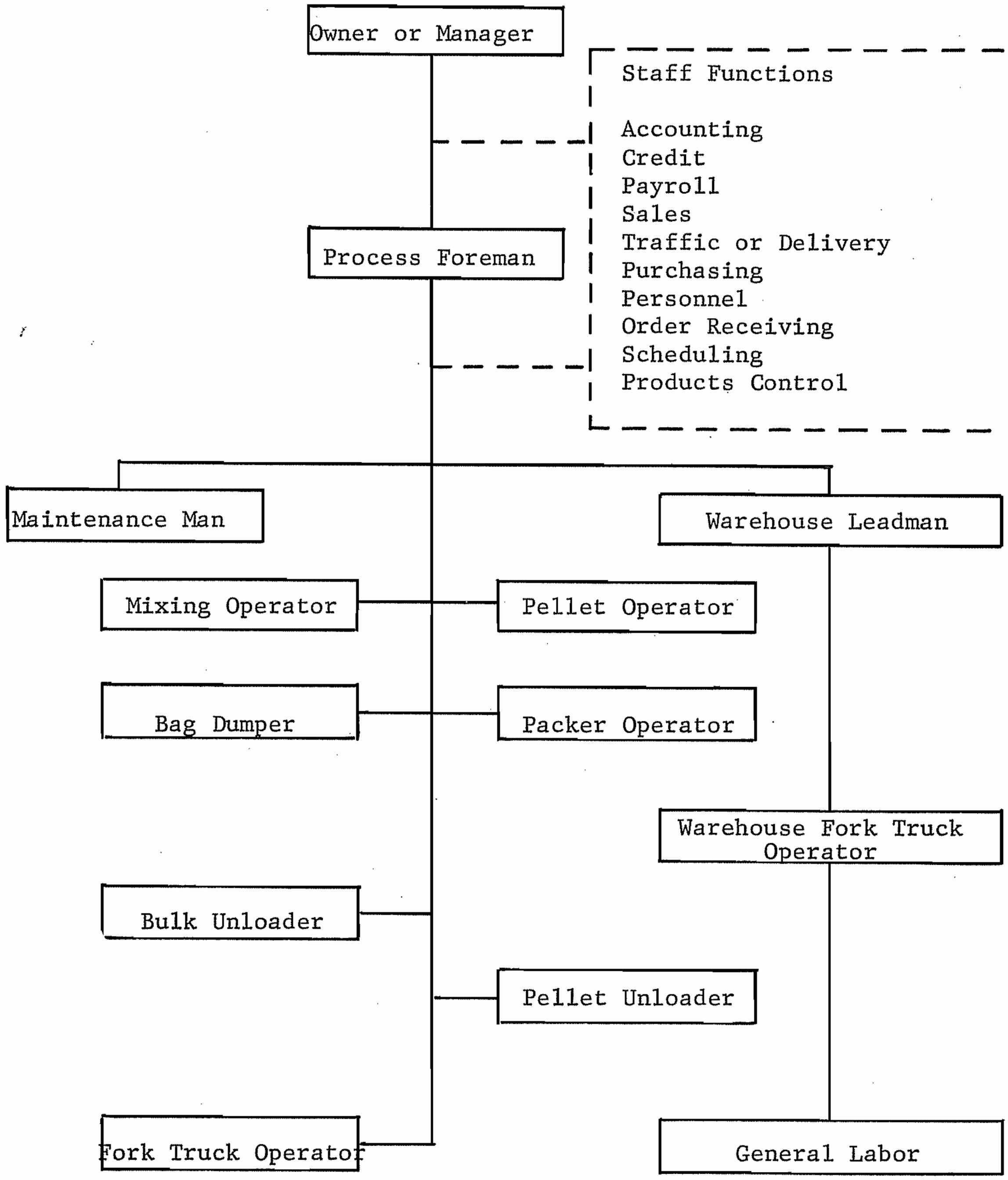
APPENDIX TABLE 3. EQUIPMENT RECOMMENDATIONS AND COSTS FOR A 200 TON PER DAY MODEL FEED MILL (continued)

200 Ton Mill	Ranges of Estimates		
Automatic dairy scale with vibrator			
Sewing machine and belt -	$ 1,700	-	$ 2,000
Pellet mill			
Two speed pellet mills			
Vertical coolers			
Crumblers			
Cooler cyclones			
Pellet/crumble elevators			
Pellet/crumble graders			
Pellet/crumble distributing conveyor - - - - - - - - - - - -	$68,000	-	$77,000
Liquid fat applicator system:			
Preheat liquid fat working tank			
Air operated gate to belt weigher			
Ratio flow controller			
Flow meter			
Liquid fat applicator -	12,500	-	17,000
Automatic scale -	700	-	750
Sewing machine and belt -	1,200	-	1,500
Bulk loading scale -	600	-	800
Conveyor -	2,200	-	2,500
	$196,125		$230,885

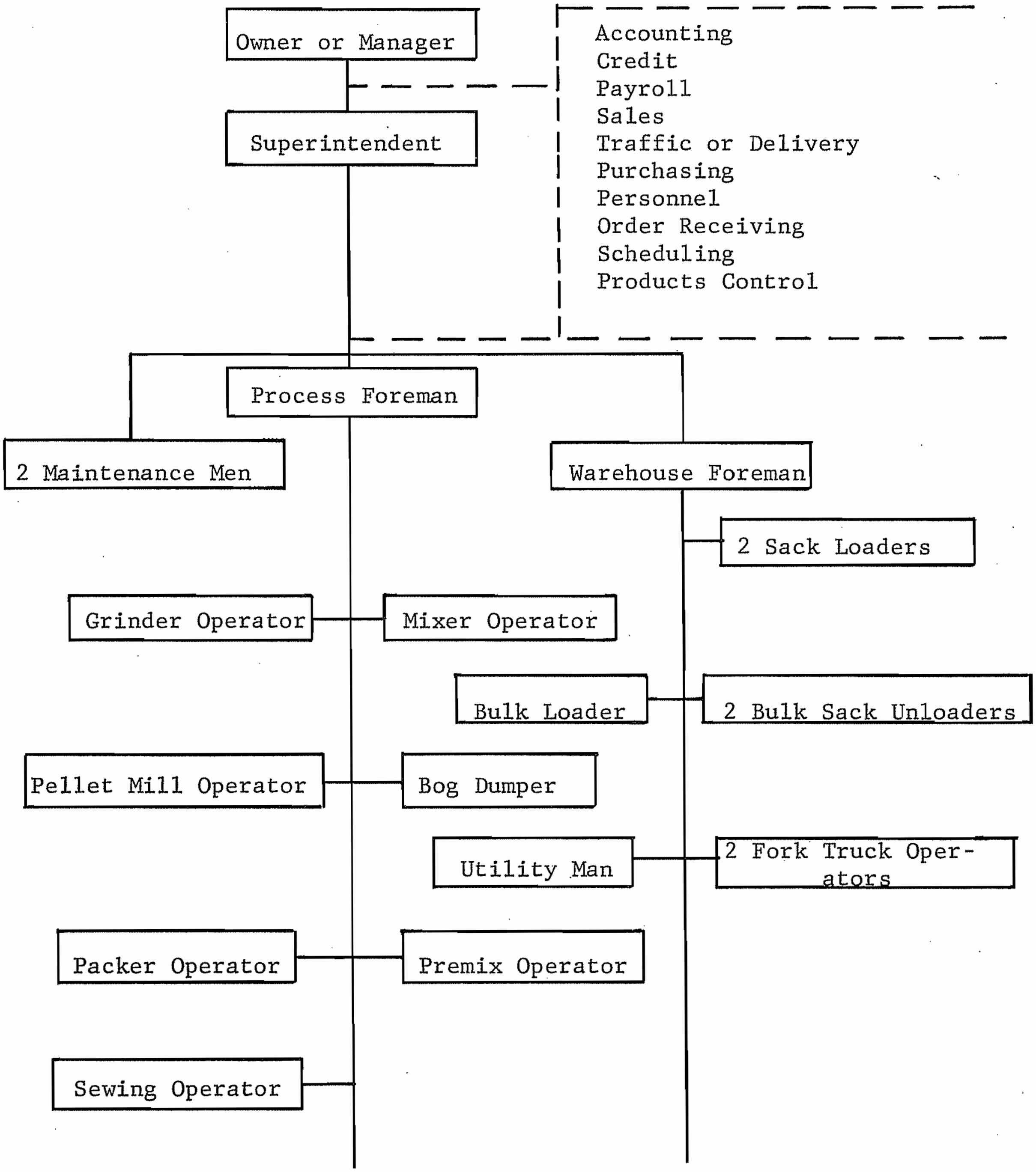
Source: 1961 Feed Production Handbook, Feed Production School, Kansas City, Missouri, p. 74, and equipment manufacturers.



Appendix Figure 1. Thirty-Ton Feed Mill, Operating Organization, One 8-Hour Shift



Appendix Figure 2. One Hundred-Ton Feed Mill, Operating Organization, One 8-Hour Shift



Appendix Figure 3. Two Hundred-Ton Feed Mill, Operating Organization, One 8-Hour Shift