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Optimum Size and Location for a Northern Utah Feed Mill

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OPTIMUM SIZE AND LOCATION FOR
A NORTHERN UTAH FEED MILL

by

Morris Duane Whitaker

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PREFACE AND ACKNOWLEDGEMENTS

Importance of Thesis

The State of Utah has comparatively high feed costs because: First, Utah is a feed grain deficit state and must import feed grains for manufacturing purposes, thus raising the cost of feed by the cost of transportation. Second, many of Utah's feed manufacturing plants are old and obsolete, and there is excess feed manufacturing capacity in Utah. These factors contribute to the high cost of manufacturing feed in Utah compared to other states.

In 1958, Roice Anderson, Professor of Agricultural Economics, College of Agriculture, Utah State University, made a study of the feed manufacturers in Utah. In 1963, a similar study was made by Dr. Anderson using a similar questionnaire. Thus, the changes taking place in this industry over the five year period were noted. In December of 1964, the writer, working as a Statistical Analyst for the Economics Department of the Extension Services, further explored the feed manufacturing industry in up-dating the 1963 study mentioned above. The results of these three studies were presented by Morris H. Taylor, Marketing Specialist, Utah Cooperative Extension Services, to the Feed Manufacturers Association's Annual Convention in February, 1964, and again in February, 1965.

In presenting this information, Dr. Taylor pointed out that the studies showed a marked contrast between Utah's feed manufacturing industry and feed manufacturing outside the state. He also noted that

Utah's industry had old equipment (relatively speaking) and utilized it at a low percent of total capacity.

Concerned about these problems, and with an eye to the future, a feed manufacturing firm within the state has expressed a desire to revamp its program. Engineers have indicated that one of the firm's main plants serving the Salt Lake and northern Utah-southern Idaho areas is obsolete and can not be remodeled. This firm has formally requested that Utah State University's Cooperative Extension Services suggest to them the best possible location and size for a new feed mill, considering access to feed grain and distribution of mixed feeds to the market. The following paragraph from one letter from this firm received by the Cooperative Extension Services illustrates the problem:

> We desire to get some statistics together so that we might be able to incorporate in our planning the very best site for a new feed mill. The feed mills we presently have are not as modern and up-to-date as we would like to have them. We are wondering, inasmuch as an expenditure will have to be made to modernize one or two of these mills, whether or not we should start from scratch and build a new mill in a more strategic location so far as access to grains and distribution to the market are concerned.

This study will identify as far as possible the optimum size and location of a new feed mill to serve the northern Utah-southern Idaho market area.

Approach Followed

The problem of identifying optimum size and location of the feed mill was viewed by the writer as two separate problems--one of size and one of optimum location. The two problems also became independent of each other if the production of the feed mill was held at a constant level as the plant location was varied.

Location problem

In solving the location problem, the writer developed a model and then gathered the data from firm X to fit into this model. The model (explained in Chapter 2) develops an "index" of transportation costs at various points. The main weakness of this approach is the lack of precise data for transportation rates from point to point for different feed ingredients and finished feed products. The rates used to develop the index at any of the points were gathered from the firm raising the question and other rate specialists in the State of Utah. The rates were based on their knowledge of the situation. The data for production outputs and inputs utilized were also obtained from this same firm. And so the indices of transportation costs are only as valid as the rates and production figures supplied.

One of the strengths of this model is that it can be used at any point in the future by simply plugging in the current transportation rates and input and production figures; also, it could be used by other firms with a minimum of adaptation. Since it involves discrete data, it does not optimize the location in the true sense of the word, but it does give the "optimum location" in terms of eight points on the curve. For example, an optimum solution using continuous data would indicate the optimum location irrespective of a trading center. Hence, it might indicate the optimal location as Sardine Canyon. Obviously, the decision makers would then choose between Brigham City area or the Logan area. This model scrutinizes only "feasible" locations such as Logan, Brigham City, etc. and then isolates the best one. Also, because this process requires no advanced mathematics (as with continuous data finding the maximum point on a curve) it can be used as a tool of analysis by almost anyone who can supply the data to plug into it.

And so the main strength of this model is in its simplicity and ability to yield a valid analysis and its main weakness would be in being able to gather the precise data needed.

Size problem

In solving the problem of optimum size of plant for firm X, the writer intended to get the actual cost data on several different sizes of plants and then plot the short run average total cost curves for these different sizes of plants by plotting them operating at different proportions of total capacity. A curve would then have been drawn connecting the low points of the short run curves which would be the long run average total cost curve. Intersection of the long run average total cost curve and the fixed demand would have indicated the size of plant where unit costs were the lowest. This would have been the optimum size of plant that firm X, operating at X percent of capacity, should have built, without considering future growth in demand. (Some excess capacity should have been left to meet growth in demand.)

In trying to gather cost data on general purpose mills of various sizes, the writer found that this area has not been probed at all except for one study of a "specialized" mill producing only poultry feed.[1]

In writing to Clark R. Burbee (one of the co-authors of the above) the writer was informed by Mr. Burbee that such data has not

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[1]Clark R. Burbee, Edwin T. Bardwell and Alfred A. Brown, Marketing New England Poultry, Economics of Broiler Feed Mixing and Distribution, Station Bulletin 484 (Durham, New Hampshire: University of New Hampshire Agricultural Experiment Station, 1965).

been prepared for a general purpose feed mill like the one needed by firm X. The writer also corresponded with several engineering firms and several experts from U.S.D.A. on the subject of availability of cost data for the overall operation of several different sizes of general purpose feed mills.[2]

All replies indicated that such data were not available. The writer also personally visited with one of the engineering firms and once again found that the data just were not available.[3]

Hence, the writer had to modify his approach in solving this problem. The approach followed by the writer does not directly answer the question for firm X of optimum size, but rather supplies a model with which they can answer the question as cost data for the general purpose mill becomes available from engineers retained by firm X.

From one of the foremost experts in feed milling in the United States (Dr. Robert Schoeff of Kansas State University) the writer received the data for the cost of equipment and buildings for four sizes of feed mills producing beef cattle feed.[4] The writer used this data to calculate costs and the short run average total cost curves for these four specialized beef feed mills. A long run average total cost curve was then constructed and a fixed demand assumed. From the intersection of the assumed demand curve and the long run average total cost curve, the optimum size of plant was determined for a firm which desired to build a specialized mill producing beef feed with a constant demand.

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[2]See Appendix A, p.48.

[3]Personal interview with P. R. McIntyre, President, Utah Machine and Mill Supply Company, Salt Lake City, Utah, March 10, 1966.

[4]See Appendix B, pp.60-69.

Thus, an analytical tool has been supplied by which firm X may answer the question of optimum size as data becomes available.

Source of Data

Data used in this study were gathered from several sources. The introduction relies on secondary data. Chief among the data is a talk given by Morris H. Taylor, (Marketing Specialist, Utah State University Extension Services) to the Utah Feed Manufacturers Association. Also referred to is Roice Anderson, Handling Concentrate Livestock and Poultry Feed in Utah, Utah Resource Series 25 (Logan, Utah: Utah State University Agricultural Experiment Station, 1965) p.3.

In developing the section on optimum location of the feed mill, the writer relied on primary sources of data. These data were supplied in several interviews with Merrill Rushforth, Manager in Charge of Feed Operations, Intermountain Farmers Association, Salt Lake City, Utah and an interview with L. H. Denkers, Traffic Manager for the Pillsbury Company, Ogden, Utah. The data for the section on optimum size of the feed mill were from secondary sources supplied by Robert Schoeff, Marketing Specialist in Formula Feeds, Kansas State University. Also used was a publication of the Agricultural Experiment Station, University of New Hampshire. The publication, Bulletin 484, Marketing New England Poultry, Economics of Broiler Feed Mixing and Distribution, by Clark R. Burbee, Edwin T. Bardwell and Alfred A. Brown, was used extensively by the writer. This publication was pointed out to the writer by Carl J. Vosloh, Agricultural Economist, Marketing Economics Division, United States Department of Agriculture.[5]

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[5]See Appendix A, pp.52-53.

Many of the ideas and the approach used by the writer have been borrowed freely from this latter publication. Full citations are given in each of the cases where any data or ideas are utilized by the writer.

Acknowledgements

The writer would like to acknowledge the kind and professional help of his committee. He is deeply indebted to Morris H. Taylor, Thesis Director, for his patient understanding and careful criticism. The writer is equally indebted to the other two members of the committee, Reed Durtschi and Bartell C. Jensen, both of whom have given most freely of their time.

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Morris Duane Whitaker

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CHAPTER I. INTRODUCTION

The Feed Industry Prior to 1958[1]

Over the years, Utah has enjoyed the advantage of having natural agricultural resources that favor the production of livestock. Sheep and beef cattle do well on the desert and high mountain ranges that cover much of the state, Dairy cattle and wintering beef cattle use the alfalfa and native hay along with some corn silage that is grown in the irrigated valleys. Feed grains are grown in rotation with forage crops on irrigated land and also on dry land. Before 1950, the quantities of feed grains produced had been sufficient to meet the needs of dairy, range livestock and poultry. However, with the realization that Utah had a natural market position in relation to the coast markets, there developed an extensive poultry and livestock fattening business. Since that time Utah has been in the position of a feed grain deficit state. This has tended to raise the cost of feed grain by $10 to $12 per ton due to the transportation factor.

Also, Utah's poultry industry relied partially upon feed wheat from northern Utah and southern Idaho, but with acreage allotments and price controls, the price of wheat increased to the point where it was no longer used as a poultry feed. As a consequence, poultry and egg producers also had to turn to importing more of their feed grains, which

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[1]Roice H. Anderson, Handling Concentrate Livestock and Poultry Feed in Utah, Utah Resource Series 25 (Logan, Utah: Utah State University Agricultural Experiment Station, 1965) p.3.

put them into a higher feed cost position along with the livestock feeder. In the past year, however, the price of feed wheat declined to the point where wheat was used extensively in livestock feed stuffs for the first time in years.

Utah a Feed Grain Deficit State[2]

Utah has long been a feed grain deficit state. Since 1950 the deficit in feed grain has ranged from 291,000 tons in 1950 to a high of 566,300 tons in 1961. 1963 recorded a deficit of 475,200 tons.

Therefore, Utah's feed processors have had to import 50-74 percent of their requirements during the last 15 years. The sharp increases in the deficit in the last few years reflect the increase in total numbers of beef cattle fed along with increases in concentrates fed to sheep and lambs and increased turkey production.

Fortunately for Utah, Idaho, Montana, Oregon and Washington are surplus feed grain states. However, Utah must compete with California, Arizona and Nevada for these surplus feed grains.

Utah producers import about 18,000 tons of hay per year and export over 17,000 tons and so is about in balance for roughage. However, thise close balance has brought about higher prices than excess hay producing areas experience for roughage and hence has caused feeders to be very conscious of the different conversion rates of feed to meat and high vs low concentrate rations.

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[2]Morris H. Taylor, Feasibility of Expanding Livestock Feeding and Meat Packing, Part 2 of 4 parts, "Should Utah Expand Livestock Feeding Operations?" Utah Cooperative Extension Services, Economics-1 (Logan, Utah: Extension Services Offset Press, 1965, p.27.

General Condition of the Feed Manufacturing Industry

Utah's commercial feed plant has not kept up with technology. There is excess capacity among commercial mills as well as among on-farm processors. Pricing policies are also obsolete from the standpoint of good business management, as is indicated by the policy of sacking feed for a small purchaser and charging the same price per cwt to bulk purchasers. Also included here may be the "selling" of services such as field service and charging the cost of this service to overhead which penalizes those who do not use the service. In general, delivery and credit services are costing more than many firms realize.

Because of these and other problems, many feeders have purchased their own mills and integrated feed manufacturing into their livestock or poultry operations. This has contributed to overall excess capacity.

All commercial feed manufacturers have had to face the problem of importing feed grains to produce their mixed feeds. Due to the fact that Utah is a feed grain deficit state, they have had to pay \$10 to \$12 per ton transportation cost for the feed they import. This has caused them to try and cut costs to compete with the pre-mixed feeds and on-farm produced feeds using home grown grains.

This introduction has given the reader some "feel" for the problem at hand. Firm X, who wishes to relocate a feed mill to reduce costs, has been forced into this position by the condition described above. This firm is faced with importation of feed grains, use of obsolete equipment, "hidden" costs for conventional services, and on-farm competition. The reader can now see why this firm is concerned and can probably safely predict that others should be also.

CHAPTER II. OPTIMUM LOCATION OF FEED MILL

In solving the location problem, the writer developed a model using discrete data. This model generated an index of transportation costs for inputs of feed ingredients and an index of transportation costs for production output. These added together gave an overall transportation cost per cwt of feed.[1] The writer will assume that the only variable in the cost of feed ingredients and sales is the transportation cost. This assumption implies that all the feed ingredients are purchased in a purely competitive factor market (with constant prices) and that all mixed feed products are sold in a purely competitive product market (with constant prices). Hence, this assumption implies that all other costs besides transportation costs are constant. This assumes that labor costs, utility costs, equipment repairs, and tax rates are the same at each location. It also assumes the same technology at each location. Then, by holding the production of plant X constant and varying its location, a minimum transportation index was generated which indicated an optimum location for feed mill X in terms of transportation costs of feed ingredients.

This optimum location was determined in the following manner: First, all feed produced by the firm located at Draper was determined from production records of firm X. This was determined for areas of sale of the finished product in the northern Utah-southern Idaho market area. There were 8 different areas of sale (Table 1). Also, total

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[1]In this chapter, all references to hundred-weight will follow the standard abbreviation, cwt.

amounts of each feed ingredient utilized were determined from the records of firm X. There were 19 different feed ingredients utilized (Table 2). Also determined from firm X and other transportation experts in the State of Utah were the transportation rates for feed grains and feed ingredients (hereafter referred to as inputs) and for the finished product (hereafter referred to as outputs). The total pounds of inputs and outputs were divided by 100 to get the data on a cwt basis. Then the transportation index of inputs at location W_j was determined by multiplying each input total in cwt's by its transportation rates (per cwt) to point W_j, summing, and dividing by the total of all inputs utilized:

$$z_{1j} = \frac{\sum_{i=1}^{19} (a_i)(r_n)}{A} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1)^2$$

Where there are 19 different inputs (a_i) and 19 corresponding rates (r_n)

and z_{1j} = Transportation index for inputs at location W_j $j=1, 2, \ldots .8$ (W_j is one of 8 different locations.)

a_i = Amount of specific input utilized at location W_j $j=1,2,\ldots .8$ $i=1,2,\ldots .19$

r_n = Transportation rate of specific input to location W_j $j=1,2,\ldots .8$ $n=1,2,\ldots .19$

and A = Total input utilized at location W_j $j=1,2,\ldots .8$

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[2]The formula is read as the sum of the product of a_i times r_n (where a_i is the amount of input used and r_n is that inputs' transportation rate) for 19 different inputs, each with its own rate.

The transportation index for output for location W_j was determined in the same way as the index for inputs:

$$z_{2j} = \frac{\sum_{k=1}^{8} (x_k)(r_\ell)}{X} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

Where there are 8 different outputs (x_k) and 8 corresponding rates (r_ℓ)

and z_{2j} = Transportation index for outputs to location W_j $j=1,2,....8$ (W_j is one of 8 different locations.)

x_k = Amount of output sold to location W_j $j=1,2,....8$ $k=1,2,....8$

r_ℓ = Transportation rate for output delivered to location W_j $j=1,2,....8$ $\ell=1,2,....8$

and X = Total output sold at location W_j $j=1,2,....8$

Where W_j is:

Draper = W_1	Brigham = W_5
Salt Lake = W_2	Tremonton = W_6
Layton = W_3	Logan = W_7
Ogden = W_4	Preston = W_8

$j=1,2,....8$

Equations 1 and 2, (the index of transportation costs for inputs plus the index of transportation costs for outputs) added together give the total index of transportation costs at W_j.

$$Z_j = \sum_{i=1}^{19} \frac{(a_i)(r_n)}{A} + \sum_{k=1}^{8} \frac{(x_k)(r_\ell)}{X} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

Where Z = Total index of transportation costs at W_j.

This is the general expression for determining the index of transportation costs at each of the points. The writer started then at Draper (W_1) utilizing the rates for input and inputs utilized, output rates at that point, and the sales to each area.

The plant was then moved to Salt Lake City (W_2) and the transportation rates for inputs and outputs were adjusted accordingly. Total inputs and individual inputs were held constant, as was output. (Output was assumed to be the same at Salt Lake as it was at Draper.) This process was repeated for Layton (W_3), Ogden (W_4), Brigham (W_5), Tremonton (W_6), Logan (W_7) and Preston (W_8).

Tables 1 and 2 give the inputs (a_i) that are utilized at Draper and the outputs (x_k) that are produced by Draper and sold from Draper northward into southern Idaho. The outputs are the values that are held constant as the locations are varied. Table 3 gives the transportation rates (r_n) for inputs at the eight different locations. Table 4 gives the transportation rates (r_ℓ) for outputs from the eight different locations to the eight different sales areas.

Table 1. Feed sold (x_k) in the market area and total feed produced at Draper, 1965[a]

Location	Pounds sold	Cwt sold (x_k)
Draper	51,384,000	513,840
Salt Lake	9,242,600	92,426
Layton	1,456,000	14,560
Ogden	2,472,080	24,721
Brigham	165,848	1,658
Tremonton	939,803	9,398
Logan	1,049,067	10,491
Preston	651,900	6,519
Total feed produced	67,361,297	$\Sigma x_k = X = 673,613$

[a]Compiled by the writer from the records of firm X.

Table 2. Inputs utilized (a_i's) at Draper, 1965[a]

Inputs	Cwt utilized (a_i)
a_1 - Local barley	94,306
a_2 - Idaho barley	141,459
a_3 - Local oats	26,944
a_4 - Montana oats	40,417
a_5 - Local feed wheat	43,111
a_6 - Idaho feed wheat	10,778
a_7 - Corn	67,361
a_8 - Milo	134,723
a_9 - Bran	47,153
a_{10} - Beet pulp	6,736
a_{11} - Soybean meal	13,472
a_{12} - Cottonseed	13,472
a_{13} - Linseed, Midwest	1,684
a_{14} - Linseed, Montana	1,684
a_{15} - Di-Cal	6,736
a_{16} - Meat meal	13,472
a_{17} - Molasses, California	3,368
a_{18} - Molasses, local	3,368
a_{19} - Fat	3,368
	$\Sigma a_i = A = 673,613$

[a]Inputs used were determined by multiplying the total volume of feed by the proportion of each ingredient used. The proportions were obtained from Merrill Rushforth in an interview on February 15, 1966. This procedure was used to obtain amounts of feed ingredients because there was no record kept of inputs to the plant at Draper.

Source: Interview with Merrill Rushforth, February 15, 1966. Mr. Rushforth in Manager in Charge of Feed Operations, Intermountain Farmers Association, Salt Lake City, Utah.

Table 3. Transportation rates (r_n) for inputs from point of origin to various points in Utah February, 1966

Feed ingredients	Point of origin	Point of destination							
		Draper	Salt Lake	Layton	Ogden	Brigham	Tremonton	Logan	Preston
		Cents							
Barley	Local	10	10	10	10	10	10	10	10
Barley	Soda Springs, Ida.	20.5	20.5	20.5	20.5	16.5	16.5	16.5	16.5
Oats	Local	10	10	10	10	10	10	10	10
Oats	Montana	60	60	60	60	50	50	50	50
Feed wheat	Local	10	10	10	10	10	10	10	10
Feed wheat	Idaho	30	30	30	30	20	20	20	20
Corn	Denver	30	30	30	30	40	40	40	40
Milo	Denver	30	30	30	30	40	40	40	40
Bran	Local	10	10	10	10	15	15	15	15
Beet pulp	Local	10	10	10	10	10	10	10	10
Soybean meal	Decatur, Ill.	110	110	110	110	120	120	120	120
Cottonseed	Phoenix, Ariz.	40.5	40.5	40.5	40.5	50.5	50.5	50.5	50.5
Linseed	Midwest	110	110	110	110	120	120	120	120
Linseed	Montana	60	60	60	60	50	50	50	50
Di-Cal	Florida	110	110	110	110	120	120	120	120
Meat meal	Local	10.5	10.5	10.5	10.5	10.5	10.5	10.5	10.5
Molasses	California	75	75	75	75	85	85	85	85
Molasses	Local	10	10	10	10	10	10	10	10
Fat	Local	10	10	10	10	10	10	10	10

Source: Interview, February 9, 1966, with L. H. Denkers, Traffic Manager for the Pillsbury Company, Ogden, Utah.

Interview, February 15, 1966, with Merrill Rushforth, Manager in Charge of Feed Operations, Intermountain Farmers Association, Salt Lake City, Utah.

Table 4. Transportation rates (r_ℓ) for output of feed products of firm X to eight locations, 1965

Point of origin	Draper	Salt Lake	Layton	Ogden	Brigham	Tremonton	Logan	Preston
	Cents							
Draper	5.9[a]	8	10	13.5	13.5	19	19	19
Salt Lake	8	5.9	8	10	13.5	19	19	19
Layton	10	8	5.9	8	10	13.5	19	19
Ogden	13.5	10	8	5.9	8	13.5	19	19
Brigham	13.5	13.5	10	8	5.9	8	13.5	19
Tremonton	19	19	13.5	13.5	8	5.9	13.5	19
Logan	19	19	19	19	13.5	13.5	5.9	8
Preston	19	19	19	19	19	19	8	5.9

[a]5.9¢ was computed by the writer by taking a weighted average of the direct deliveries by Draper at different rates. The same 5.9¢ is assumed to apply to all local deliveries.

Source: Interview February 9, 1966, with L. H. Denkers, Traffic Manager for the Pillsbury Company, Ogden, Utah.

Interview February 15, 1966, with Merrill Rushforth, Manager in Charge of Feed Operations, Intermountain Farmers Association, Salt Lake City, Utah.

The computations following calculate the index of transportation costs per cwt of input and output at the eight different locations, using the following formula which has already been derived:

$$Z_j = \sum_{i=1}^{19} \frac{(a_i)(r_n)}{A} + \sum_{k=1}^{8} \frac{(x_k)(r_\ell)}{X}$$

Transportation Index at Draper

(94,306)(.10) + (141,459)(.205) + (26,944)(.10) + (40,417)(.60) + (43,111)(.10) + (10,778)(.30) + (67,361)(.30) + (134,723)(.30) + (47,153)(.10) + (6,736)(.10) + (13,472)(1.10) + (13,472)(.405) + (1,684)(1.10) + (1,684)(.60) + (6,736)(1.10) + (13,472)(.105) + (3,368)(.75) + (3,368)(.75) + (3,368)(.10) + (3,368)(.10) / 673,613 + (513,840)(.059) + (92,426)(.08) + (14,560)(.10) + (24,721)(.135) + (1,658)(.135) + (9,398)(.19) + (10,491)(.19) + (6,519)(.19) / 673,613 =

$$\frac{174,094.82}{673,613} + \frac{47,745.33}{673,613} = .25844 + .07087 = 32.931¢/\text{cwt}$$

Transportation Index at Salt Lake

Since input rates do not change from Draper to Salt Lake (Table 3) and production is held constant, the input transportation index will not change. The output index will change at every point as the rates change with each new location (Table 4).

(513,840)(.08) = (92,426)(.059) + (14,560)(9.08) + (24,721)(.10) + (1,653)(.135) + (9,398)(.19) + (10,491)(.19) + (6,519)(.19) = 51,171.27 / 673,613

$$\frac{174,094.82}{673,613} + \frac{55,438.58}{673,613} = .25844 + .0823 = 34.07¢/\text{cwt}$$

Transportation Index at Layton

Since input rates do not change from Draper to Layton and production is held constant, the input transportation index will not change (Table 3). The output index will change at every point as the rates change with each new location (Table 4).

(513,840)(.10) + (92,426)(.08) + (14,560)(.059) + (24,721)(.08) +

(1,658)(.10) + (9,398)(.135) + (10,491)(.19) + (6,519)(.19) =

$$\frac{174,094.82}{673,613} + \frac{66,281.23}{673,613} = .25844 + .09839 = 35.683¢/cwt$$

Transportation Index at Ogden

Since input rates do not change from Draper to Ogden and production is held constant, the input transportation index will not change (Table 3). The output index will change at every point as the rates change with each new location (Table 4).

(513,840)(.135) + (92,426)(.10) + (14,560)(.08) + (24,727)(.059) +

(1,658)(.08) + (9,398)(1.35) + (10,491)(.19) + (6,519)(.19) / 673,613 =

12,747

$$\frac{174,094.82}{673,613} + \frac{85,867.61}{673,613} = .25844 + .12747 = 38.591¢/cwt$$

Transportation Index at Brigham

Since rate differ from Ogden to Brigham for inputs, an input index must be computed as well as an output index (Tables 3 and 4).

(94,306)(.10) + (141,459)(.165) + (26,944)(.10) + (40,417)(.50) +

(43,111)(.10) + (10,778)(.20) + (67,367)(.40) + (134,723)(.40) +

(47,153)(.15) + (6,736)(.10) + (13,472)(1.20) + (13,472)(.505) +

(1,684)(1.20) + (1,694)(.50) + (6,736)(1.2) + (13,472)(.105) +

(3,368)(.85) + (3,368)(.10) / 673,613 + (513,840)(1.35) + (92,426)(1.35) + (14,560)(.10) + (24,721)(.08) + (1,658)(5.9) + (9,398)(.08) + (10,491)(1.35) + (6,519)(.19) / 673,613 =

$$\frac{189,587.81}{673,613} + \frac{88,784.15}{673,613} = .28144 + .13180 = 41.324¢/cwt$$

Transportation Index at Tremonton

Since input rates are the same at Tremonton as Brigham, the input index will not change from Brigham (Tables 3 and 4).

(513,840)(.19) + (92,426)(.19) + (14,560)(1.35) + (24,721)(1.35) + (1,653)(.09) + (9,398)(.059) + (10,491)(.135) + (6,519)(.19) / 673,613 =

$$\frac{189,587.81}{673,613} + \frac{123,835.49}{673,613} = .28144 + .18383 = 46.527¢/cwt$$

Transportation Index at Logan

Since input rates are the same at Logan as Tremonton and Brigham, the input index will not change (Tables 3 and 4).

(513,840)(.19) + (92,426)(.19) + (14,560)(.19) + (24,721)(.19) + (1,658)(1.35) + (9,398)(.135) + (10,491)(.059) + (6,519)(.08) / 673,613 = .18599

$$\frac{189,587.81}{673,613} + \frac{125,286.98}{673,613} = .28144 + .18599 = 46.743¢/cwt$$

Transportation Index at Preston

Since one input rate chantes, the input index will change slightly (Tables 3 and 4).

(94,306)(.10) + (141,459)(.165) + (26,944)(.10) + (40,417)(.50) + (43,111)(.10) + (10,778)(.15) + (67,361)(.40) + (134,723)(.40) + (47,153)(.15) + (6,736)(.10) + (13,472)(1.2) + (13,472)(.505) +

(1,684)(1.2) + (1,684)(.50) + (6,736)(1.2) + (13,472)(1.05) +

(3,368)(.85) + (3,368)(.10) + (3,368)(.10) / 673,613 + (513,840)(.19) +

(92,426)(.10) + (14,560)(.19) + (24,721)(.19) + (1,658)(.19) +

(9,398)(.19) + (10,491)(.08) + (6,519)(.059) / 673,613 =

$$\frac{189,048.91}{673,613} + \frac{125,978.47}{673,613} = .28064 + .18701 = 46.756¢/\text{cwt}$$

Conclusions

Constant demand

From the above analysis, Draper is still the optimum location in terms of transportation costs, as it has the lowest index of transportation costs per cwt. The extra cost of transporting outputs from points north of Draper back to the Draper-Salt Lake area offsets any advantages gained by moving closer to the supply of feed grains. The exact relationship can be determined by looking at the z_{1j} and z_{2j} (index of inputs and index of outputs). By looking at the z_{2j} as we move from Draper we see the index of output increases from 7¢ to 19¢. At the same time, the index of inputs (z_{1j}) stays constant to Ogden but rises from Brigham City northward (from 25¢ to 28¢, indicating that the cost of ingredients moving from the Midwest more than offsets gains in lower barley prices to the north without considering the cost of moving the output back to the market area.

Change in demand[3]

In making the above analysis, we have assumed that the demand for firm X's product has stayed constant. But suppose firm X were still interested in a more northerly location. How much would they have to increase their market in the northern part of the state to make it feasible to locate the plant to the north of Draper? In order to answer this question, the kind of feed to be produced would have to be known. Since the index of transportation costs for inputs rises with a fixed demand as the firm moves further north, we would expect that, unless the firm changes the composition of its inputs considerably, (so as to have a higher proportion of barley and feed wheat) there would be no advantage in moving north.

Since firm X gains by having lower costs on barley and feed wheat by moving north, it must, in order to achieve a lower cost per cwt for inputs, increase the proportion of the inputs that give a cost advantage as the firm increases its share of the market. Otherwise, if the firm increased the amounts of input by the same proportion, by increasing demand it would gain no advantage in moving farther north.

The question that needs to be answered is how much will demand have to increase before a plant located to the north would have per unit output costs equal to the index of transportation costs for outputs at Draper (.07087¢/cwt).

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[3]It should be noted that a change in demand from location to location changes one of the writer's basic assumptions. That is, when demand (sales) changes from location to location, the size problem is no longer independent of the location problem. This is because a different volume of sales would require a different size of plant whereas the writer has assumed constant sales and hence, a plant of the same size at each location.

The actual figures in computing the index of transportation costs for outputs at Draper is:

$$\frac{\$47,745.33}{673,613\text{ cwt}} = .07087¢/\text{cwt}$$

If the index and total costs were known, the amount of product required to be sold could be easily computed as follows:

$$\frac{\$47,745.33}{.07087¢/\text{cwt}} = .673,613\text{ cwt}$$

And so, if firm X wanted to move into the north part of the market area (Box Elder, Cache or Franklin counties) and manufacture feed, the amount of feed they would have to sell in this northern area in order to get the index of transportation costs for output equal to the Draper location would be:

$$\frac{\$115,971.27}{.07087¢/\text{cwt}} = 1,636.394\text{ cwt}$$

Where \$115,971.27 is the simple average total transportation, costs of outputs at locations W_5, W_6, W_7 and W_8.

This indicates that in order for a location in Box Elder, Cache, or Franklin counties to even be considered, firm X must increase its total sales from 673,613 cwt to 1,636,394 cwt, an increase of 962,781 cwt.

According to a survey of Box Elder, Cache and Franklin counties made by the writer, the total volume of feed grain utilized in the area which was produced by commercial mills in 1965 was 1,275,300 cwt.[4] In

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[4]Data collected by the writer in a survey of feed manufacturers during December, 1965, is not a part of this study and is unpublished. Data is in the possession of the Extension Economics Department of the Extension Services, Utah State University. This figure represents the amount produced in the market area of Cache, Franklin, Oneida and Box Elder counties that was actually consumed.

order for firm X to even consider moving north, they would have to capture or take away from competitors in the Box Elder, Cache and Franklin county areas 77.9 percent of the existing market.

Or examining from another angle, total mixed feed utilized in the area, including that sold by firm X, was 1,303,366 cwt. Of this, firm X sold 28,066 cwt or 2.2 percent. In order to get the index of transportation costs per cwt equal to Draper's cost per cwt, they would have to increase their share of the market by 962,781 cwt or from 2.2 percent of total sales in the area to 73.8 percent.

Since it is virtually impossible for a firm to take this much of a market over from competitors (and even if they did, they would have to shift proportions of feed inputs heavily enough to barley and feed wheat to overcome a 3¢ deficit in the transportation index of inputs). The only course of action to be followed by firm X is to remain in the Draper area.

CHAPTER III. OPTIMUM SIZE OF PLANT

Since there is no cost data available for a general type feed mill, the writer developed a model which can be used by firm X to answer the question of optimum size.[1]

The writer developed cost data for four specialized feed mills producing only beef cattle feed. The costs of equipment, construction and buildings were supplied for the four mills by Carl Stevens, Jr. of the Flour and Feed Milling Department of Kansas State University.[2] The mill sizes were 4 ton per hour, 9 ton per hour, 20 ton per hour, and 30 ton per hour. (These mills are hereafter referred to as mills A, B, C, and D respectively.) From the cost data, the short run average total cost curves were plotted by letting the firms operate at different proportions of total capacity.[3] From this, the long run average total cost curve was plotted. Assuming a fixed demand of 35,100 tons per year, the intersection of the fixed demand and the long run average total cost curve indicated the optimum size of plant in order to have the lowest unit cost.

In developing the costs, the writer relied heavily upon a publication by Clark R. Burbee, Edwin T. Bardwell and Alfred A. Brown, entitled, Marketing New England Poultry, Economies of Broiler Feed Mixing

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[1]See Preface and Acknowledgements, p.v.

[2]See Appendix B, pp.60-69.

[3]Total capacity is defined as operating a full eight hour day using full capability. For the rest of this chapter, whenever full (total) capacity is mentioned, it will have meaning as defined in this footnote.

and Distribution, published by the Agricultural Experiment Station of the University of New Hampshire as Bulletin 484. This publication is referred to many times in this chapter in tables and in the text. Because it is mentioned so often, it will hereafter be referred to as the Broiler Feed Mill Study.

It should be noted that the writer had developed a model for this section before he became acquainted with the Broiler Feed Mill Study and before he found that cost data were not available for a general purpose feed mill.[4] The modifying of the approach and the fact that cost data were not available made the Broiler Feed Mill Study a valuable aid to the writer.

In developing cost data for fixed and variable costs, the writer tried to make all assumptions fit what would happen in the real world. But since the costs are being imputed, it is possible that there may be inconsistencies. However, this will not invalidate what is being done. The writer will not use the final cost curves to make a decision but will illustrate to firm X an analytical method by which they can answer the question of optimum size of plant as data becomes available to them.

Determination of Costs

Variable costs

Production and maintenance labor costs. Production and maintenance labor is used in receiving, mixing, grinding and performing miscellaneous duties in the feed mill. The maintenance labor is only used for maintenance in the general sense of the word. Specialized jobs such as rewinding a burned-out motor are covered under another

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[4]See Appendix A, pp. 52-53.

category, equipment repairs and services. In determining the production and maintenance labor costs (Table 5) the number of man equivalents required per 8 hour day for mill C for production and maintenance were taken from the Broiler Feed Mill Study, page 12, Table 3, from mill C. The number of man equivalents needed for mills A, B, and D were estimated by the writer (on the basis of differences in size of output) using as a guide the man equivalents required by mills A', B', and E in the Broiler Feed Mill Study, page 12, Table 3.

Wage rates were supplied by a feed manufacturer in the Salt Lake area. The rate of $2.39 per hour was used and was a simple average of the high and low wage including a fringe benefit of $.37 per hour.

Utility costs. Utility costs include costs for electricity, water and fuel. Electricity costs were determined by estimating the kilowatt hours consumed per day and multiplying this by the current rate per kilowatt hour. Kilowatt hours were derived by multiplying the number of horsepower hours used per day times a conversion factor of .746. (The conversion factor was developed in the Broiler Feed Mill Study, page 23.) The rate per kilowatt hour of $.0164 was supplied by a feed manufacturer in the Salt Lake area.

Water and fuel costs were used from the Broiler Feed Mill Study, Table 10, page 25, as this data was not available for other sources for the specialized beef feed mills (Table 6).

Table 5. Annual production and maintenance labor costs for four feed mills producing beef cattle feed[a]

Mill	Annual output in tons[b]	Costs: Production Annual	Production Per ton	Maintenance Annual	Maintenance Per ton	Total Annual	Total Per ton
		Dollars					
A	8,320	14,913.60	1.79	2,485.60	.30	17,399.20	2.09
B	18,720	20,879.04	1.12	4,971.20	.27	25,850.24	1.39
C	36,400	21,873.28	.60	4,971.20	.14	26,844.48	.74
D	62,400	23,861.76	.38	7,456.80	.12	31,318.56	.50

[a]Computed by the writer from the Broiler Feed Mill Study, p.12, and cost data for the four beef feed mills (Appendix B). Also, see text above.

[b]Operating at 100 percent of capacity.

Table 6. Utility costs for four feed mills producing beef cattle feed[a]

Item	A	B	C	D
Annual input in tons	8,320	18,720	36,400	62,400
	Dollars per year			
Electricity	4453.80	5597.80	8143.20	10,179.00
Water	121.00	187.00	278.00	483.00
Fuel Oil	2088.00	4134.00	6094.00	11,318.00
Total	6662.80	10,018.00	14,515.20	21,980.00
Per ton	$.80	$.54	$.40	$.35

[a]Computed by the writer from the Broiler Feed Mill Study, p.25, and cost data for the four beef feed mills (Appendix B). Also see text above.

[b]Operating at 100 percent of capacity.

Equipment repairs and services. This category of variable costs represents costs for replacing worn-out equipment and the hiring of special maintenance people to do such things as rewind an electric motor or make other repairs that ordinary personnel are not qualified to make. The Broiler Feed Mill Study, page 26, was again used as a basis for determining these costs. The relationship used to estimate equipment repair and service costs is that of the percent of new equipment invested and the percent of capacity under which the mill is operated. At 100 percent of capacity, the annual repair cost is 6.5 percent of the equipment investment (Table 7).

Mill supplies, inventory costs and shrink. Since the writer had no emperical cost data on the four feed mills, the costs for these three areas were taken directly from the Broiler Feed Mill Study, Table 11, page 27, from mills A', B', C and E which correspond in size to beef feed mills A, B, C, and D. Mill supplies include lubricants, housekeeping materials, and a number of miscellaneous materials. Inventory costs consist mainly of insurance and interest on the cost of investment.

Shrinkage costs occur through loss of ingredients during handling, grinding or mixing processes. Also, they may result from a loss of moisture from the ingredients (Table 7).

Table 7. Other costs[a] for four feed mills producing beef cattle feed[a]

Mill	Annual output in tons[b]	Equipment repairs & services		Mill supplies		Miscellaneous costs		Inventory costs		Shrink	
		Annual	Per ton	Annual	Per ton	Annual	Per ton	Annual	Per ton	Annual	Per ton
A	8,320	3,747.90	.45	978	.12	3,110	.37	891	.11	1,810	.22
B	18,270	4,608.50	.25	1,957	.10	5,250	.28	1,781	.10	3,617	.19
C	36,400	6,750.00	.19	2,935	.08	6,829	.19	2,673	.07	5,429	.15
D	62,400	7,543.25	.12	6,114	.10	12,017	.19	5,569	.09	11,310	.18

[a]Computed by the writer from the Broiler Feed Mill Study, pp. 26-27, and cost data for the four beef feed mills (Appendix B).

[b]Operating at 100 percent of capacity.

Fixed costs

Ownership costs. The initial cost of a durable good is spread over its productive life by depreciation. Also, other costs such as taxes, insurance, interest on investment, and maintenance overhead are fixed in the short run since they do not vary with output. All equipment for the mill was depreciated by the straight line method over a 10 year period, except the boiler which was depreciated over a 15 year period. All buildings, grain storage, and finished storage are depreciated by the straight line method over a 25 year period. Interest on investment was assumed at a rate of 3.5 percent on the initial investment in equipment, buildings and other facilities. Property taxes were based on the Salt Lake City, Utah valuation of 98.5 mills on 26 percent of all property. The writer included real property (buildings) in this (which is also valued at 98.5 mills)[5]. The tax was then $9.85 per $100 of taxable property. Insurance and maintenance overhead are fixed costs and are each determined at a rate of 1 percent of the initial investment. The process for finding these costs were taken from the Broiler Feed Mill Study, pages 19-21 (Table 8).

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[5]This data was supplied by a Salt Lake feed manufacturer and is in the possession of the writer.

Table 8. Ownership costs for four feed mills producing beef cattle feed[a] (annual and per ton)

Item	A	B	C	D
Annual output in tons[b]	8,320	18,720	36,400	62,400
Depreciation				
Equipment	5,682.67	6,990.00	10,185.00	11,438.33
Building & Facilities	496.00	1,094.00	1,852.00	2,700.00
Interest	3,007.90	4,436.25	6,777.75	8,391.25
Taxes	2,200.88	3,249.36	4,959.37	6,140.00
Insurance	859.40	1,267.50	1,936.50	2.397.50
Maintenance	859.40	1,267.50	1,936.50	2,397.50
Total	13,106.25	18,304.61	27,647.12	33,464.58
Cost per ton	$1.53	$.98	$.76	$.54

[a]Computed by the writer from the Broiler Feed Mill Study, pp. 19-21, and cost data for the four beef feed mills (Appendix B).

[b]Operating at 100 percent of capacity.

Administration and supervisory personnel costs. Many administrative functions must be performed in a feed mill, including management, purchasing, quality control, office work and supervision of personnel. Since no emperical data were available, costs were assumed to be the same as for mills A', B', C and E in the Broiler Feed Mill Study, page 24 (Table 9).

Miscellaneous costs. These costs are such things as telephone, licenses, legal fees, management travel expenses, subscriptions to professional magazines, office supplies, etc. Once again, these costs were assumed to be the same as for the Broiler Feed Mill Study, page 7 (Table 7).

Total costs. Table 12 is a summary of all costs for mills A, B, C, and D operating at 100 percent of capacity.

Effect On Costs When Mill Was Operated At Different Proportions Of Total Capacity

Variable costs

Several assumptions were made in determining what happened to variable costs when the firm operated at different proportions of total capacity. Since the writer is estimating variable costs from various sources (mainly the Broiler Feed Mill Study, and cost brochures for 4 ton per hour, 9 ton per hour, 20 ton per hour, and 30 ton per hour mills from the Feed and Flour Milling Department, Kansas State University) as opposed to data collected from feed mills, a number of simplifying assumptions had to be made.[6]

When the writer says total capacity, he means that which is produced in one eight hour day. At less than full or total capacity would

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[6]It should be noted the writer intended to make these assumptions fit the real world as closely as possible. However, these data are not emperical observations and hence cannot be used directly as a decision making tool. But the point of this chapter is not to develop a cost data that must closely represent the real world; it is to provide a method or model for firm X to utilize in determining the optimum size of their plant as data becomes available. It should be obvious that the assumption which will be made in regard to what happens to the variable costs as the firm operates at different proportions of total capacity will not detract from the model. The only way to know for certain what happens to variable costs is to have emperical evidence which the writer does not have. Even if he did, the evidence would indicate different relationships among changes in variable costs as output changed among different kinds of feed mills. It might even indicate different relationships among changes in variable costs as mills operated at different proportions of total capacity among similar feed mills at varied locations.

be some operating time of less than eight hours while greater than total capacity refers to operating the mill for longer than eight hours.

Table 9. Administrative personnel costs[a] for four feed mills producing beef cattle feed (annual and per ton)[b]

Personnel	A	B	C	D
	8,320[c]	18,720[c]	36,400[c]	62,400[c]
Manager	4,375	6,875	10,000	12,500
Assistant manager	------	------	------	3,500
Formulation, analysis and quality control	1,350	1,800	2,250	3,150
Foreman	3,150	4,900	7,000	7,000
Assistant foreman	------	------	------	3,900
Bookkeeper	1,625	2,925	4,225	7,800
Typist records	1,400	2,450	3,325	5,775
Steno bookkeeper	675	900	1,125	1,575
Total	12,575	19,850	27,925	45,200
Cost per ton	$1.51	$1.06	$.77	$.72

[a]Salaries based on an annual salary for manager, $12,500, assistant manager, $10,000, formulation, $9,000, foreman, $7,000, assistant foreman, $6,000, bookkeeper, $6,500, typist records, $3,500, steno bookkeeper, $4,500.

[b]Taken from the Broiler Feed Mill Study, p.24.

[c]Annual output in tons operating at 100 percent of capacity.

First of all, as a firm operates at smaller and smaller or larger and larger proportions of its total capacity, its labor requirements both for production and maintenance also get smaller or larger. But how the need for labor decreases or increases would depend on the kind of feed mill being considered. The writer will assume that the labor costs change by one-half as much the change in production. For example, production labor costs were $21,873.28 for firm C at full capacity (operating at full capability for eight hours). Under the writer's assumption, at 90 percent of capacity, (7.2 hours) labor costs would be $20,771.62, or 95 percent of $21,873.28. The same assumptions will be made for utilities. For utilities in actual experience, it is found that as fewer kilowatt hours are used, the rate per hour will tend to rise. Since these data are not available nor necessary for the writer's purposes, the assumptions will not invalidate the model.

Equipment repairs and services were determined at less than total capacity according to a function developed in the Broiler Feed Mill Study, page 26. At full capacity (100 percent of capacity) the total cost for equipment repair was 6.5 percent of initial equipment investment. Then as the mill operated at less than total capacity, the percentage became less and less according to a linear relationship. That this linear relationship is valid when the mill is operated at greater than total capacity is not clear to the writer. It seems that the function would become more nearly vertical and the expenditures on equipment repairs would increase at a greater rate. At 125 percent of total capacity, the writer will assume a rate of 9 percent of the initial equipment investment and at 150 percent of capacity, a rate of 12 percent will be assumed.

All other variable costs will be assumed to increase or decrease in the same proportion as increases or decreases in production (Table 10--16).

Fixed costs

Since in the short run the fixed costs do not vary with output, the calculation of fixed cost per unit is uncomplicated. The number of units produced is divided into the unchanged total fixed cost for each cost area at all levels of production (Tables 10--16).

Table 10. Summary of feed manufacturing costs for operating four feed mills producing beef cattle feed operating at 150 percent of capacity[a]

Item	A	B	C	D
Tons manufactured annually	12,480	28,080	54,600	93,600
	Dollars per ton			
Labor:				
Production	1.49	.93	.50	.32
Maintenance	.25	.22	.11	.10
Utilities	.67	.45	.33	.29
Equipment repairs	.55	.30	.23	.15
Mill supplies	.12	.10	.08	.10
Inventory costs	.11	.10	.07	.09
Shrink	.22	.19	.15	.18
Total variable costs	3.41	2.29	1.47	1.23
Ownership costs	1.05	.65	.50	.36
Administrative & supervisory	1.01	.71	.51	.48
Miscellaneous	.25	.19	.13	.13
Total fixed cost	2.31	1.55	1.14	.97
Total cost	5.72	3.84	2.61	2.20

[a]Computed by the writer from Tables 5--9 and from assumptions made by the writer (see text).

Table 11. Summary of feed manufacturing costs for operating four feed mills producing beef cattle feed operating at 125 percent[a] of capacity[b]

Item	A	B	C	D
Tons manufactured annually	10,400	23,400	45,400	78,000
	Dollars per ton			
Labor:				
Production	1.61	1.00	.54	.34
Maintenance	.27	.24	.12	.11
Utilities	.72	.48	.36	.32
Equipment repairs	.50	.27	.21	.13
Mill supplies	.12	.10	.08	.10
Inventory costs	.11	.10	.07	.09
Shrink	.22	.19	.15	.18
Total variable cost	3.55	2.38	1.53	1.27
Ownership costs	1.26	.78	.61	.43
Administrative & supervisory	1.21	.85	.61	.58
Miscellaneous	.30	.22	.15	.15
Total fixed cost	2.77	1.85	1.37	1.16
Total cost	6.32	4.23	2.90	2.43

[a]Total capacity is based on an 8-hour day. Hence, 125 percent of total capacity would be the amount produced in 10 hours.

[b]Computed by the writer from Tables 5--9 and from assumptions made by the writer (see text).

Table 12. Summary of feed manufacturing costs for operating four feed mills producing beef cattle feed operating at 100 percent of capacity[a]

Item	A	B	C	D
Tons manufactured annually	8,320	18,720	36,400	62,400
	Dollars per ton			
Labor:				
Production	1.79	1.12	.60	.38
Maintenance	.30	.26	.14	.12
Utilities	.80	.54	.40	.35
Equipment repairs	.45	.25	.19	.12
Mill supplies	.12	.10	.08	.10
Inventory costs	.11	.10	.07	.08
Shrink	.22	.19	.15	.18
Total variable cost	3.79	2.56	1.63	1.34
Ownership costs	1.58	.98	.76	.54
Administrative & supervisory	1.51	1.06	.77	.72
Miscellaneous	.37	.28	.19	.19
Total fixed cost	7.25	4.88	3.35	2.79
Total cost	7.25	4.88	3.35	2.79

[a]Computed by the writer from Tables 5--9 and from assumptions made by the writer (see text).

Table 13. Summary of feed manufacturing costs for operating four feed mills producing beef cattle feed operating at 90 percent of capacity[a]

Item	A	B	C	D
Tons manufactured annually	7,488	16,848	32,760	56,160
	Dollars per ton			
Labor:				
Production	1.89	1.18	.63	.40
Maintenance	.32	.28	.14	.13
Utilities	.85	.56	.42	.37
Equipment repairs	.45	.25	.19	.12
Mill supplies	.12	.10	.08	.10
Inventory costs	.11	.10	.07	.09
Shrink	.22	.19	.15	.18
Total variable cost	3.96	2.66	1.68	1.38
Ownership costs	1.75	1.09	.84	.60
Administrative & supervisory	1.67	1.18	.85	.80
Miscellaneous	.41	.31	.21	.21
Total fixed cost	3.83	2.58	1.90	1.61
Total cost	7.79	5.24	3.58	3.00

[a]Computed by the writer from Tables 5--9 and from assumptions made by the writer (see text).

Table 14. Summary of feed manufacturinc costs for operating four feed mills producing beef cattle feed operating at 80 percent of capacity[a]

Item	A	B	C	D
Tons manufactured annually	6,656	14,976	29,120	49,920
	Dollars per ton			
Labor:				
Production	2.02	1.25	.68	.43
Maintenance	.34	.30	.15	.13
Utilities	.90	.60	.45	.40
Equipment repairs	.45	.25	.19	.12
Mill supplies	.12	.10	.08	.10
Inventory costs	.11	.10	.07	.09
Shrink	.22	.19	.15	.18
Total variable cost	4.16	2.79	1.77	1.45
Ownership costs	1.97	1.22	.95	.67
Administrative & supervisory	1.90	1.33	.96	.91
Miscellaneous	.47	.35	.23	.24
Total fixed costs	4.34	2.90	2.14	1.82
Total costs	8.50	5.69	3.91	3.27

[a]Computed by the writer from Tables 5--9 and from assumptions made by the writer (see text).

Table 15. Summary of feed manufacturing costs for operating four feed mills producing beef cattle feed operating at 70 percent of capacity[a]

Item	A	B	C	D
Tons manufactured annually	5,824	13,104	25,480	43,680
	Dollars per ton			
Labor:				
Production	2.18	1.35	.73	.46
Maintenance	.36	.32	.17	.15
Utilities	.97	.65	.48	.43
Equipment repairs	.45	.25	.19	.12
Mill supplies	.12	.10	.08	.10
Inventory costs	.11	.10	.07	.09
Shrink	.22	.19	.15	.18
Total variable costs	4.41	2.96	1.87	1.41
Ownership costs	2.25	1.40	1.09	.77
Administrative & supervisory	2.16	1.51	1.10	1.03
Miscellaneous	.53	.40	.27	.28
Total fixed costs	4.94	3.31	2.46	2.08
Total costs	9.35	6.27	4.33	3.49

[a]Computed by the writer from Tables 5--9, and from assumptions made by the writer (see text).

Table 16. Summary of feed manufacturing costs for operating four feed mills producing beef cattle feed operating at 50 percent of capacity[a]

Item	A	B	C	D
Tons manufactured annually	4.160	9,369	18,200	31,200
		Dollars per ton		
Labor:				
Production	2.68	1.67	.90	.57
Maintenance	.45	.40	.20	.18
Utilities	1.20	.80	.60	.53
Equipment repairs	.46	.26	.19	.13
Mill supplies	.12	.10	.08	.10
Inventory costs	.11	.10	.07	.09
Shrink	.22	.19	.15	.18
Total variable costs	5.24	3.52	2.19	1.78
Ownership costs	3.15	1.96	1.52	1.07
Administrative & supervisory	3.02	2.12	1.53	1.45
Miscellaneous	.74	.56	.38	.39
Total fixed cost	6.91	4.64	3.43	2.91
Total cost	12.15	8.16	5.62	4.69

[a]Computed by the writer from Tables 5--9, and from assumptions made by the writer (see text).

Optimum Size Plant

The data from Tables 10--16 are plotted in Figure 1. The points on the short run average total cost curves represent the operation of each mill at the different proportions of total capacity. The long run average total cost curve is negatively sloped, but begins to level off. This indicates a decreasing cost industry which may be approaching a constant cost situation or may even be approaching an increasing cost.

Where the fixed demand intersects the long run average total cost curve indicates the size of mill that should be built for lowest unit costs. This mill would produce 35,100 tons of feed per year at a cost of \$3.35 per ton, operating 12 hours per day.[7]

By working backwards it is possible to impute all of the costs associated with a mill of the capacity necessary to produce the 35,100 tons of feed per year. We know that it is between mills B and C in size. Since the composition of its product will be the same, then the equipment required and the other inputs will fall somewhere between

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[7]The writer will assume that this is the low point in the short run average total cost curve. To operate at more than 12 hours per day (150 percent of capacity) would cause per unit costs to begin to increase. In actuality, the short run average total cost curves for these four mills were still decreasing when operating at 12 hours per day. However, it is certain that they cannot continue to decrease. At some point in time, more production labor will have to be hired. A shift of supervisory labor would have to be hired, which will increase fixed cost. As equipment is used 16 and 20 hours a day, maintenance costs will go up quite steeply. In sum, the effect of these changes will cause the cost per ton of feed produced to begin to increase. This, however, will not change the analysis. The low point on the short run average total cost curve will still be a part of the long run average total cost curve. And the intersection of the assumed demand with the long run average total cost curve will still indicate the size of mill to be built for least cost production per unit.

mills B and C. Hence, we can impute the costs associated with this mill from the costs associated with mills B and C.

In order to make the above analysis, the writer has picked a series of four mills varying in size from 32 tons per day to 240 tons per day. The long run average total cost curve associated with these four mills was constructed. As noted, this curve was still decreasing slightly at the low point of mill D. The question should be raised as to what might happen if a larger fixed demand were required that was produced by mill D at the low point on the short run curve. If a short run average total cost curve were constructed for a mill E (with greater capacity than mill D) we could expect at some point the long run average total cost curve to turn up. If fixed demand fell in this area it would then be logical to build two feed mills with lower per unit costs. The main thing is to know what the long run average total cost curve looks like over the range which is being considered.

Also, it should be pointed out that there are very averted economies of scale associated with the larger beef feed mills (mills C and D). In other words, costs per unit of output decrease quite rapidly with an increase in the size of plant. (The long run average total cost curve falls quite steeply at the low points of mills A and B and then levels off for mills C and D.) What has caused this rapid decline in the long run average total cost curve? To answer this question, the writer will go back to assumptions that he has made. Much of the cost data for this section came from the Broiler Feed Mill Study. In Table 7 all the data was taken directly from the Broiler Feed Mill Study. Table 7 shows a rapid decline in the cost per ton of equipment repairs and services for mills A and B. Also, production and maintenance labor costs decline rapidly for mills A and B on a per unit basis (Table 5). The empirical data from the Broiler Feed Mill Study indicates that the total cost of operating equipment do not increase as rapidly as the production costs. Also, labor costs do not increase proportionately with the plant size. This is in part due to one assumption by the writer that overtime rates are not in effect when operating a longer than 8-hour shift due to a split shift arrangement which would be possible in the Salt Lake City area.

The economies of scale noted in mills C and D are due to two things. First, the empirical data from the Broiler Feed Mill Study indicates that the actual mills observed had economies of scale in the larger mills. Secondly, the writer has made certain assumptions which tend to accentuate this empirical data. Hence, the hypothetical beef feed mills in this section show accented economies of scale.

Conclusions

This then provides a model framework which can be used by firm X to determine the size of mill they should build. Costs must be gathered from engineering firms for the kind of mill wanted by firm X for several mills of varying capacities. Then the variable costs and fixed costs per unit of output must be calculated. From this data a series of short run cost curves can be constructed along with the long run average total cost curve. Assuming a given level of demand (sales) the intersection of the long run average total cost curve with the demand will indicate the size of plant to be built and approximately the cost per unit of output.

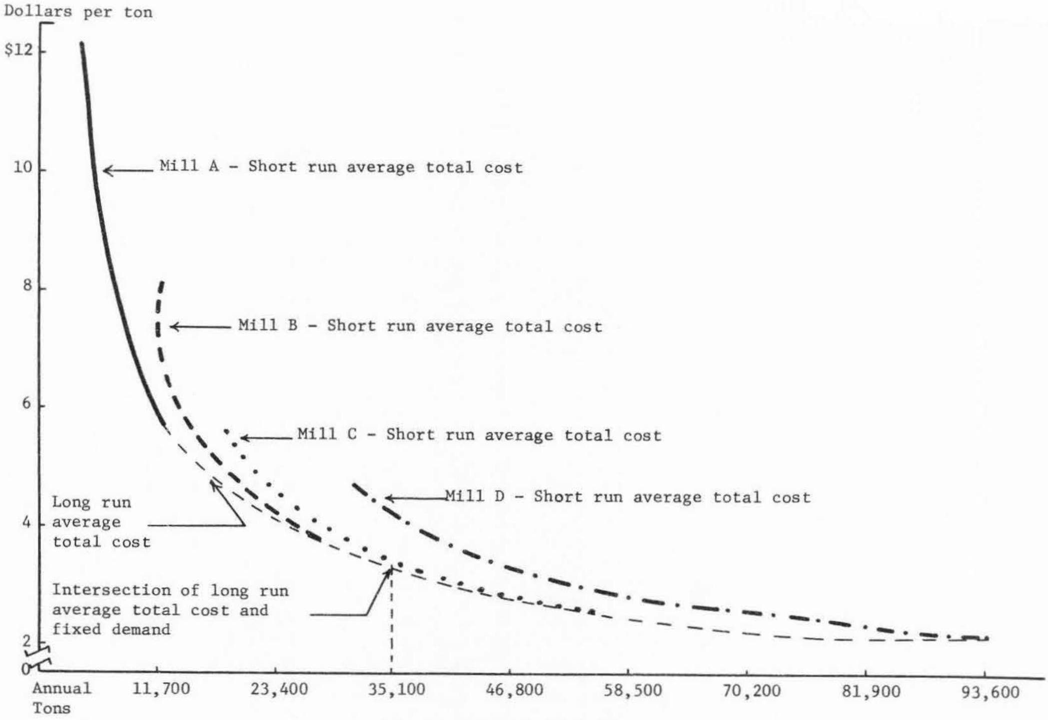

Figure 1. Average total cost curves for mills A, B, C, and D.

CHAPTER IV. SUMMARY AND CONCLUSIONS

Location Problem

It has been shown that Draper is the best location for firm X to build a new feed mill (considering transportation costs to be the only variable cost in gathering the inputs and assuming a fixed demand at each location). Even without the factor of costs for outputs being much higher in the northern locations, Draper is still the best location for the transportation costs for inputs are higher in the northern part of the state than they are in Draper. In other words, the advantage gained by moving closer to the supply of feed grains is offset by having to move feed ingredients from the Midwest further north. And so unless firm X were to suddenly change the proportion of their mix more heavily to the feed grains found in the northern part of the state, then there is no advantage in moving to the north.

Size Problem

A model, or analytical framework has been provided whereby firm X can determine what size of a plant it should build. Cost data was provided for four different sizes of beef feed mills. Then fixed and variable costs were computed for operating these mills at various proportions of total capacity. From these cost data, short run average total cost curves were drawn along with the long run average total cost curves (from the low points of the short run curve). The intersection of this long run average total cost curve with a fixed amount of sales indicated the size of plant to be built by a firm (as long as the intersection was where the long run average total cost curve was negative in slope or zero in slope). If the intersection of the fixed sales (demand) and the long run average total cost happened where long run average total cost was increasing (had a positive slope) then a firm should build two smaller size plants with lower unit costs than those associated with the larger plant.

Hence, firm X can follow the model provided in Chapter III in answering the question of optimum size.

Other Considerations

Specialized U.S. General Purpose Mills

The Broiler Feed Mill Study points up an interesting fact. Namely, specialized feed mills have lower unit costs than general purpose feed mills. Firm X should carefully consider this as they examine the breakdown of their sales.

Should firm X consider the possibility of building two specialized feed mills? One located in Draper could produce laying mash and other poultry feed; and the other could be located in the north and produce dairy and beef rations. Hence, the northern plant would realize savings for the ingredients it would use which are found in excess in the northern Utah-southern Idaho area. Also, dairying and beef cattle feeding are the principal livestock operations in that area.

While it is beyond the scope of this work to provide concrete answers to these questions, the writer feels that it should be pointed out.

Changes in Demand

Also, beyond the scope of this work are changes in demand. It is very important for firm X to anticipate the changes that they will have in demand. In what direction will there be change? What class of customer should they be prepared to serve in 5 or 10 years? How is the best (least cost) way to gain access to the market? What livestock will comprise the market in 5 or 10 years? What will be the impact of technology on the manufacturing process in 5 or 10 years? How will technology affect consumption patterns? There are a host of questions and areas that need to be under surveilance by firm X. Once again, these questions are beyond the scope of this work but need to be pointed out.

Finally, the writer would like to emphasize to firm X that there are several analytical techniques which can be of great value to firm X. One of these is linear programming which can tell the least cost combination for some specific ration or can predict the least cost method of transporting factors of production or finished product. However, all of these tools of the economist of necessity rely on good data. And the only good data is that that is recorded. And so it would be to the advantage of firm X to update its system of keeping records so as to have the best information available at all times for decision making purposes.

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Pillsbury Mills. Personal interview with Traffic Manager, February 9, 1966, Ogden, Utah.

Feed manufacturers in Cache, Box Elder, Franklin and Oneida counties.
Personal interviews during December, 1965 and January, 1966.

APPENDIXES

Appendix A--Letters

UTAH STATE UNIVERSITY

EXTENSION SERVICES

January 12, 1966

Dr. Robert Schoeff
Marketing Specialist
Formula Feed Extension
Milling Industries Building
Manhattan, Kansas 66504

Dear Dr. Schoeff:

We are working on a feed study of the northern Utah and southern Idaho area trying to determine the feasibility of locating more modern mills in this area which is closer to the feed grain supply center of southern Idaho and Montana. In analyzing this problem, we intend to use a linear programming technique and in order to do so, we need some cost data on different sizes of feed mills. We understand that you have such information available and would appreciate being able to receive copies of it.

Could you also please send us any information which you have relating to the feed manufacturing industry which you feel might be helpful or of interest to us in pursuing this problem. We need to have this information by February 1. Would it be possible for you to help us on this matter? Any suggestions which you have would be appreciated.

Thank you very much for your help.

Sincerely,

Morris D. Whitaker
Statistical Analyst

MDW/klr

COOPERATIVE EXTENSION SERVICE

OF KANSAS STATE UNIVERSITY

January 24, 1966

Mr. Morris D. Whitaker
Statistical Analyst
Extension Service
Utah State University
Logan, Utah 84321

Dear Mr. Whitaker:

Sorry for the delay in answering your letter of January 12, but have been out of my office during the past ten days.

Was glad to learn of your plans to do a plant feasibility study for northern Utah. We have some information on feed mill costs as gleaned from trade papers and personal visits to new mills in Kansas and other areas across the United States. I do not have this data compiled in any orderly fashion, according to size or type of mill (custom or full line). Very few feed mills are built alike due to different capabilities needed, geographic considerations and owner preferences. Costs today range from $50,000 depending on size and complexity.

I don't like to disappoint you, but there has been no studies made to my knowledge that would provide all the information I believe you want. Keep hoping to be relieved of some of my extension responsibilities in order to do some economic research to provide the kind of information you have requested.

Mr. Carl Stevens, formerly of our Formula Feed Extension staff, worked up some estimated cost figures for feed mills to be used by commercial feedlots in Kansas. These were investment figures only--not operating costs. A set of this data is enclosed for your information.

I have gone through our reference files and pulled copies of materials that may be of interest and value to you. There is one USDA publication of which our supply is exhausted that may help you. The data is 10 years old but it is the only study of its kind. Marketing Research Report No. 388, "Costs of Procuring Manufacturing and Distributing Mixed Feeds in the Midwest", USDA, Washington, D.C.

The 1961 Feed Production Handbook contains rather complete data on mill layout and costs for our feed mills of different capacities: 30, 100, 200 and 400 tons per eight hour day. A copy should be in your University Library under catelog number 61-17116. Dr. Lorin Harris may have a copy in his personal library.

Let me know if I can be of further help.

Sincerely,

Robert W. Schoeff
Marketing Specialist
Formula Feeds

RWS:bam

Enclosures

UTAH STATE UNIVERSITY

EXTENSION SERVICES

February 1, 1966

Mr. Carl J. Vosloh, Jr.
Agricultural Economist
Marketing Economics Division
Economic Research Service
U.S.D.A.
Washington, D.C.

Dear Mr. Vosloh:

I am currently engaged in doing a feasibility study in the feed mixing industry. In particular, I have been asked to determine the feasibility of re-locating a feed mill with better access to feed grains as a prime consideration.

I have been reading Marketing Research Report No. 564, "Labor and Capital for Mixing Formula Feeds", published by the U.S.D.A. under your name. In the summary you state that the models were developed from records on feed manufacturers in 34 states. You also indicated that all of these manufacturers supplying data use comparable record keeping techniques.

I need total cost information for feed mills of varying sizes from the smallest (30 tons or so) and then 40, 60, 80, 100, 150, 200, 300, and 400 tons per 8-hour day. Would it be possible for you to send me total costs for feed mills of these sizes or any other sizes from 30 tons to 400 tons on a similar breakdown to that in Table 6 on page 13 of the above mentioned report? I need this information to develop a criterian function to determine an optimum size for this feed mill.

Would you please indicate to me at your earliest convenience whether or not this information is available and if it is not, could you please indicate to me where I could obtain this information.

Thank you very much for your consideration. I am hoping to hear from you soon.

Sincerely,

Morris D. Whitaker
Statistical Analyst

MDW/jm

UNITED STATES DEPARTMENT OF AGRICULTURE

ECONOMIC RESEARCH SERVICE

WASHINGTON, D.C. 20250

February 8, 1966

AIRMAIL

Mr. Morris D. Whitaker
Utah State University
Extension Service
Logan, Utah 84321

Dear Mr. Whitaker:

Thank you for your letter of February 1. Your feasibility study sounds most interesting and I would appreciate receiving any information released concerning this work.

The records referred to in Marketing Research Report No. 564 are for production input and output data only. These records do not cover the total cost for the firm. The Feed Production School emphasizes record keeping by the production supervisor or manager. I did obtain several cost of production records in my survey, but believe these would be of little value to you.

Enclosed is a copy of a report by Clark Burbee, a member of our field staff in St. Paul, Minnesota. His address is MED, ERS, 212 Haecker Hall, Institute of Agriculture, St. Paul, Minnesota 55101. You may want to contact him since his study covers the same basic size plants mentioned in your letter. At the present time he is reworking some of these data using cost data and assumptions for the North Central region.

I am sorry I cannot provide more information. Please feel free to write if you have any further questions.

Sincerely yours,

Carl J. Vosloh, Jr.
Agricultural Economist
Marketing Economics Division

Enclosure

UTAH STATE UNIVERSITY

EXTENSION SERVICES

February 10, 1966

Mr. Clark Burbee
MED, ERS
212 Haecker Hall
Institute of Agriculture
St. Paul, Minnesota 55101

Dear Mr. Burbee:

I wrote to Mr. Carl J. Vosloh, Jr., Agricultural Economist in ERS, requesting information on total cost of operating feed mills of varying sizes from the smallest (30 ton or so), 40, 60, 80, 100, 200, 300, and 400 tons per 8-hour day. He indicated to me that he did not have this information and enclosed a copy of a report under your name which explores in part the cost structure of eight different sizes of broiler feed mills. I was very interested to see your short run average total cost and long run average total cost analysis on page 30 in relation to economies of size.

I am currently trying to gather cost data on various sizes of feed mills in order to predict an optimum size plant in relation to per unit costs of output. This mill would be a general type of feed mill manufacturing poultry (laying hen) mash, dairy rations and beef rations. I am at a loss as to know where I can get cost information that might be useful to me, and I was wondering if you might have something on this, or, if not, could recommend a source.

I am working under a deadline and would appreciate hearing from you as soon as possible. Thank you very much for your help in this matter.

Sincerely,

Morris D. Whitaker
Statistical Analyst

MDW/klr

P.S. I really enjoyed your bulletin 484 which was sent to me by Mr. Vosloh.

UNITED STATES DEPARTMENT OF AGRICULTURE

ECONOMIC RESEARCH SERVICE

February 15, 1966

Mr. Morris D. Whitaker
Statistical Analyst
Extension Services
Utah State University
Logan, Utah 84321

Dear Mr. Whitaker:

In regards to your letter of February 10th, I do not have information that would be very useful to your study. The type of mills you are considering in your analysis have a somewhat unique mix, one that we haven't considered. All our research in process or contemplated consists of economic analysis of specialized poultry feed mills for either the Northeast or Midwest. The type of mill in your analysis would differ in terms of technology, operating efficiency, and ingredient storage requirements because of the product mix and their location.

I do not know of any source of information to assist you in your study. At present, there is very little research in this area. I can keep you informed of progress in our studies regarding manufacture of poultry mash feeds and turkey mash and pelleted feeds if you wish. However, interpretation and application of the results to Utah conditions should be made with a note of caution.

Sincerely yours,

Clark R. Burbee
Agricultural Economist

sjh

UTAH STATE UNIVERSITY

EXTENSION SERVICES

February 17, 1966

BUTLER MANUFACTURING COMPANY
7400 East 13th Street
Kansas City, Missouri 64108

Dear Sir:

I am currently trying to gather cost data on various sizes of feed mills in order to predict an optimum size plant in relation to per unit cost of output. This mill would be a general type of feed mill, manufacturing poultry, dairy and beef rations.

I need total cost information for feed mills of varying sizes from the smallest (30 tons a day or so), 40, 60, 80, 100, 150, 200, 300 and 400 tons per 8-hour day. I need this cost broken down on the basis of direct fixed costs and variable costs in relation to labor, utilities, equipment repairs, mill supplies, inventory shrink, ownership, administrative and supervisory and miscellaneous. I need these costs for each of the sizes of mills mentioned above, operating at 100 percent of capacity, 80 percent of capacity, 60 percent of capacity, 40 percent of capacity and 20 percent of capacity.

Do you have any information such as this or, if not, could you suggest where it might be available?

Any help you could give me would be very much appreciated. I am working on a deadline and would appreciate hearing from you one way or another on this matter as soon as possible.

Thank you very much for your help.

Sincerely,

Morris D. Whitaker
Statistical Analyst
and Researcher

Identical letters also sent to MEC Company and Halverson Corrugating Works Company

MDW/klr

M-E-C COMPANY

NEODESHA, KANSAS 66757

March 3, 1966

Mr. Morris D. Whitaker
Utah State University
Extension Services
Logan, Utah 84321

Dear Mr. Whitaker:

In response to your letter of February 17, we are not in a position to assist you with your request for operating costs on various size feed mills operating at various levels of capacity. The M-E-C Company engages in the design, fabrication and erection of feed manufacturing plants all over the United States.

It is my suggestion that you write to Mr. Jerry Karstens, American Feed Manufacturers Association, 53 West Jackson Boulevard, Chicago, Illinois. This organization should have various research reports done in the general area about which you are inquiring.

Yours truly,

Dave Parker
President

DMP/js

Enclosure

L. J. HALVERSON CORRUGATING WORKS

SALT LAKE CITY, UTAH 84101

March 5, 1966

Morris D. Whitaker
Utah State University
Extension Services
Logan, Utah 84321

Dear Morris:

Please accept our apologies for not answering sooner, and that this reply will be of little value to you.

Unfortunately, we do not have any meaningful data on operational statistics, this is rarely of primary concern to our customers. May I suggest you contact Feedstuffs Magazine at P.O. Box 67 of Minneapolis, Minnesota, and Feeds Illustrated at 15 West Huron Street, Chicago, Illinois.

Before you put these questions to these people may I offer a few suggestions. The questions you ask are too ambiguous to be answered. First of all, what type of feed plant are you talking about? There are roller mills, pellet mills, hammermills, etc. Cost of installation and operation vary widely.

Secondly, what is required besides the basic mill? Conveyors, mixers, elevators, boilers, storage, buildings, electrical, and a host of other considerations must be accounted for.

Furthermore, you state you are interested in 30 to 400 ton per eight hour day units. A 400 ton per day unit would be equal to about twenty five percent of the output of the entire state of Utah, and could cost five to ten million dollars or more. Anyone looking for a unit like this in this area is after a tax write off.

One final thought. You cannot expect great detail no matter how well expressed your questions are. Presently we are working on a 100 ton plant in Phoenix. Most of their physical plant is already there. The engineering on this fully automated and most modern plant in the West will be about $15,000.00. This should give you an idea of the complications involved.

Yours truly,

L. J. HALVERSON CORRUGATING WORKS

Richard Halverson

RPH/m

BUTLER MANUFACTURING COMPANY

KANSAS CITY, MISSOURI 64126

March 8, 1966

Utah State University
Extension Service
Logan, Utah 84321

Mr. Morris D. Whitaker
Statistical Analyst & Researcher

Dear Mr. Whitaker:

When I returned from out of the city, I received your letter in regards to cost data and various sizes of feed mills for your research work.

I am sorry to say that we do not have the cost information for feed mills varying in sizes from 30 tons a day up to 400 tons. We do sell our component parts, buildings, tanks and Stor-O-Matics in feed mills but we find each one of them being of different mill plans and end use. Therefore, it is impossible for us to actually pick from memory a cost breakdown. We, as of this time, do not put this information into our computer to produce the information you need in your study.

By a copy of this letter, I am asking our territory manager, Frank Eggleson of Walnut Creek, California to see if he knows of any such breakdown available in his area through the contractors with whom he works. If he can find any information, I will have him forward it to you immediately.

We are indeed sorry we cannot be of too much help to you at this time on your present project but look forward to helping you in whatever way possible in the future. Thank you for your consideration.

Cordially yours,

Robert S. Noller
Agri-Products Division
Field Manager, Southwest Zone

RSN:MG

C Frank Eggleson

Appendix B--Cost Data

Table 17. Total investment in equipment, buildings, and other facilities for four feed mills producing beef cattle feed[a]

Item	A	B	C	D
	8,320	18,720	36,400	62,400
	Dollars			
Equipment	57,660	70,900	103,850	116,050
Mill building	4,200	6,700	9,500	10,000
Office	2,100	4,500	4,500	4,500
Storage (input & output)	6,100	16,150	32,300	53,000
Construction	15,880	28,500	43,500	56,200
Total	85,940	126,750	193,650	239,750
Investment per ton of annual capacity	10.32	6.77	5.32	3.84

[a]Computed from data supplied by Carl J. Vosloh, Jr., Flour and Feed Milling Department, Kansas State University, June 28, 1964 (see pages 58--63).

List of equipment, building
and construction costs
for mill A

1.	Scales	
	a. Truck scales (10'x30') with dial	$ 4,800
	b. Livestock scales (8'x14')	810
2.	Receiving	
	a. Grain hopper (200 cu.ft.)	200
	b. Silage hopper (concrete)	150
3.	10" portable drag conveyor from silage hopper to mixer tank	800
4.	10" drag conveyor (15' long) from grain hopper to elevator leg	650
5.	One bucket elevator	
	1 - 800 BPH - 60' long	1,600
6.	Two turnheads	
	a. 2 - 4-5 way	900
7.	Rollermill	
	a. 1 - 12x18", 2.5 ton/hour	2,200
	b. Rollermill blower and collector	1,000
	c. Steamer	550
	d. Boiler	2,500
8.	Hay grinding equipment	
	a. Bale breaker, hay grinder, hay conveyor	5,200
	b. Building for hay storage (40'x20')	2,000
9.	Ingredient bins	
	a. 10 bins for grain and supplement	6,500
	2 @ 3-5 ton each Approx.	
	6 @ 8-10 ton each 5,000	
	2 @ 15 ton each cu.ft.	
	b. Screw conveyors to mixer truck from 8 bins	1,000
	2 - 10' conveyors	
	5 - 15' conveyors	
	1 - 8' conveyor (live bottom)	
10.	Control panel	1,200
11.	Self mixing, self unloading truck (5 ton capacity)	16,000
12.	25' elevator leg, 2 bins at 25 cu.ft. each, with screw conveyors to truck to be used with concentrates or pre-mixes	1,550

(continued from page 62)

13.	Conveyors from grain storage 40' long, 12" diameter	550	
14.	Motors and drives (approx. 175 HP)	5,300	
15.	Spouting and adapters	2,200	$57,660
16.	Storage a. Grain storage - 12,000 bu. at 50¢/bu.	6,100	6,100
17.	Construction a. Millwright and equipment installation. Approximately 30% of all equipment costs. ($20,000)	6,000	
	b. Electrical	4,900	
	c. Bin erection Approximately 30% of all storage costs excluding hay building ($12,600)	3,780	
	d. Driveway and grading	1,200	15,880
18.	Mill building - steel construction	4,200	
19.	Office	2,100	6,300
	TOTAL		$85,940

List of equipment, building, and construction costs for mill B

1. Scales	
a. Truck scales (10'x30')	$ 4,000
b. Livestock scales (8'x22')	1,500
2. Receiving	
a. Grain hopper (300 cu. ft.)	300
b. Silage hopper "stainless" (300 cu. ft.)	500
3. 10" screw conveyor (30' long) "stainless" from silage hopper to surge bin	650
4. 10" drag conveyor (20' long) from grain hopper to elevator leg	700
5. Two bucket elevators	
a. 1 - 2500 BPH - 60' long	2,000
b. 1 - 800 BPH - 60' long	1,600
6. Three turnheads	
a. 3 - 4-5 way	1,300
7. Rollermill	
a. 1 - 16x30", 150 BPH, 5 ton/hour	3,300
b. Rollermill blower and collector	1,400
c. Steamer	600
d. Boiler	3,000
8. Hay grinding equipment	
a. Bale breaker, hay grinder, hay conveyor	7,200
b. Building for hay storage (50'x20')	2,500
9. Ingredient bins	
a. 15 bins for grain and supplement 3 @ 3-5 ton each Approx. 10 @ 8-10 ton each 7,200 2 @ 15 ton each cu. ft.	9,400
b. Screw conveyors to hopper scale from 10 bins 2 - 15' conveyors 5 - 10' conveyors 3 - 8' conveyors (1 live bottom for hay)	1,100
10. Scale hopper - 1 ton capacity	1,600
11. Control panel	2,500

(continued from page 64)

12.	Mixer - 1 ton a. Horizontal drop bottom	2,900	
13.	Surge bin with drag conveyor	1,900	
14.	Pre-mixing - scales, mixer, elevator leg	2,000	
15.	Molasses mixer (9 ton/hour)	1,200	
	a. Molasses tank and heaters (10,000 gal. capacity)	3,800	
16.	Inclined screw to loadout bins 12" diameter, 35' long	950	
17.	Conveyors from grain storage 50' long, 13" diameter	600	
18.	Motors and drives (approx. 220 HP)	8,800	
19.	Spouting and adapters	3,100	$70,900
20.	Storage		
	a. 2 loadout bins - 5 tons each, 500 cu.ft.	1,150	
	b. Grain storage - 30,000 bu. at 50¢/bu.	15,000	16,150
21.	Construction		
	a. Millwright and equipment installation. Approximately 30% of all equipment costs ($39,100)	11,800	
	b. Electrical	7,000	
	c. Bin erection. Approximately 30% of total storage costs excluding hay building ($22,500)	7,700	
	d. Driveway and grading	2,000	28,500
22.	Mill building - steel construction	6,700	
23.	Office	4,500	11,200
	TOTAL		$126,750

List of equipment, building,
and construction costs
for mill C

1.	Scales	
	a. Truck scales (10'x60')	9,000
	b. Livestock scales (8'x22')	1,500
2.	Receiving	
	a. Grain hopper (300 cu.ft.)	300
	b. Silage hopper "stainless" from silage hopper to surge bin	500
3.	10" screw conveyor (30' long) "stainless" from silage hopper to surge bin	650
4.	10" drag conveyor (20' long) from grain hopper to elevator leg	800
5.	Two bucket elevators	
	a. 1 - 2500 BPH - 70' long	2,220
	b. 1 - 1500 BPH - 70' long	1,800
6.	Three turnheads	1,500
	a. 2 - 6-way	
	b. 1 - 4-way	
7.	Rollermill	
	a. 2 - 16x30", 340 BPH, 10 ton/hour	6,500
	b. Rollermill blower and collector	2,000
	c. Steamer	1,000
	d. Boiler	4,500
8.	Hay grinding equipment	
	a. Bale breaker, hay grinder, hay conveyors	10,500
	b. Building for hay storage (60'x30')	4,500
9.	Ingredient bins	
	a. 15 bins for grain and supplement	13,000
	2 @ 3-4 ton each Approx.	
	11 @ 8-10 ton each 10,000	
	2 @ 20 ton each cu.ft.	
	b. Screw conveyors to hopper scale from 10 bins	3,500
	2 - 20' conveyors	
	5 - 15' conveyors	
	3 - 10' conveyors (1 live bottom for hay)	
10.	Scale hopper - 2 ton capacity	2,500
11.	Control panel	3,500

(continued from page 62)

12.	Mixer - 2 ton		
	a. Horizontal drop bottom	4,500	
13.	Surge bin with drag conveyor	2,100	
14.	Pre-mixing - scales, mixer, elevator leg	3,000	
15.	Molasses mixer (20 ton/hour)	1,500	
	a. Molasses tank and heaters (20,000 gal. capacity)	5,400	
16.	Inclined screw to loadout bins		
	a. 12" diameter - 40' long	1,000	
17.	Conveyors from grain storage, 50' long, 12" diameter	600	
18.	Motors and drives (approx. 320 HP)	12,000	
19.	Spouting and adapters	4,000	103,850
20.	Storage		
	a. 4 loadout bins - 5 ton cap., 1,000 cu.ft.	2,300	
	b. Grain storage - 60,000 bu. @ 50¢/bu.	30,000	32,300
21.	Construction		
	a. Millwright and equipment installation approximately 30% of all equipment costs ($56,250)	16,900	
	b. Electrical	10,000	
	c. Bin erection. Approximately 30% of total storage costs excluding hay building ($45,300)	13,600	
	d. Driveway and grading	3,000	43,500
22.	Mill building - steel construction	9,500	
23.	Office	4,500	14,000
	TOTAL		$193,650

List of equipmement, building,
and construction costs
for mill D

1.	Scales	
	a. Truck scales (10'x60')	9,000
	b. Livestock scales (8'x22')	1,500
2.	Receiving	
	a. Grain hopper (300 cu.ft.)	300
	b. Silage hopper "stainless" (300 cu.ft.)	500
3.	10" screw conveyor (30' long) "stainless" from silage hopper to surge bin	650
4.	13" drag conveyor (20' long) from grain hopper to elevator leg	800
5.	Two bucket elevators	
	a. 1 - 3000 BPH - 75' long	2,300
	b. 1 - 2000 BPH - 75' long	1,900
6.	Three turnheads	
	a. 6-way, 8" opening	1,800
7.	Rollermill	
	a. 2 - 16x36", 500 BPH, 15 ton/hour	8,000
	b. Blower for rollermill with collector	2,500
	c. Steamer	1,000
	d. Boiler	5,000
8.	Hay grinding equipment	
	a. Bale breaker, hay grinder, hay conveyors	12,000
	b. Building for hay storage (40x60')	6,000
9.	Ingredient bins	
	a. 15 bins for grain and supplement 2 @ 3-5 ton each Approx. 11 @ 10 ton each 10,500 2 @ 20 ton each cu.ft.	13,600
	b. Screw conveyors to hopper scale from 10 bins 2 - 20' conveyors 5 - 15' conveyors 3 - 10' conveyors (1 live bottom for hay)	3,500
10.	Scale hopper - 2 ton capacity	2,500
11.	Control panel	3,500

(continued from page 68)

12.	Mixer - 2 ton		
	a. Horizontal drop bottom	4,500	
13.	Surge bin for 2-ton mixer with drag conveyor to elevator or molasses mixer	2,100	
14.	Pre-mixing - scales, mixer, elevator leg	3,000	
15.	Molasses mixer (30 ton/hour)	1,800	
	a. Molasses tank and heaters (30,000 gal. capacity)	8,000	
16.	Inclined screw to load out bins (12' x 40')	1,000	
17.	Conveyors from grain storage	800	
18.	Motors and drives (approx. 400 HP)	14,000	
19.	Spouting and adapters	4,500	$116,050
20.	Storage		
	a. 6 loadout bins - 5 ton cap., 1,500 cu. ft.	3,000	
	b. Grain storage - 100,000 bu. steel bins 50¢/bu.	50,000	53,000
21.	Construction		
	a. Millwright and installation of equipment. Approximately 30% of all equipment costs ($63,950)	19,000	
	b. Electrical	13,000	
	c. Bin erection. Approximately 30% of total storage costs, except hay building ($66,600)	20,000	
	d. Driveway and grading	4,000	56,200
22.	Mill building - steel construction	10,000	
23.	Office	4,500	14,500
	TOTAL		$239,750