AN ECONOMIC ANALYSIS OF DELIVERY OF MANUFACTURED FEED BY TRUCK

by

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INTRODUCTION

The formula feed industry is playing a vital part in the role of food production for our country by manufacturing many different kinds of feeds for the farmer to feed to his livestock. The industry is among the top fifteen manufacturing industries in the United States, and it is the largest industry serving the farmers.

The challenge before the feed manufacturer is to formulate, manufacture and distribute the feed to the farmer at the lowest possible cost. Feed accounts for 50 to 75 percent of the total production costs of meat, milk, and eggs. Moreover, the industry operates in a competitive system of free enterprise where narrow profit margins are known to exist. The search for methods of reducing the costs of production and distribution of feed provides the foundation for this thesis.

Feed delivery has kept pace with the changes in agriculture. As early as 1894, Ralston Purina, our largest feed manufacturer today, was finding it profitable to deliver horse and mule feed to plantations along the Mississippi River and to logging camps in the South.[1] Feed was moved from the manufacturing plant to the farm by wagon, train, and river boat.

Truck delivery of feed was started in the "late 1920's and early 1930's."[2] It was slow to get started because of two factors: (1) the capital investment required, (2) the poor roads. The feed plants were

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[1] Robert W. Schoeff, "The Formula Feed Industry," Feed Production Handbook, (Kansas City, Mo.: Feed Production School, Inc., 1960) p. 7.

[2] Ibid., p. 11.

located primarily at terminal markets and the feed was shipped out mostly by rail to retail dealers. Trucks were used to deliver feed to points relatively close to the plant and they were utilized by a few retail dealers.

However, during the past fifteen years there has been a move toward decentralization of the feed industry. Smaller plants have been built closer to the consumer for three reasons: (1) the growth of demand in certain areas, (2) the demand for service and the increase of service competition, and (3) the shift from rail to truck distribution.[3] The convenience, timeliness, and flexibility of trucks has reduced distances and, consequently, sped up the movement of both the ingredients and finished product. Improved secondary roads and more dependable trucks have permitted movement of feed at costs comparable with rail rates. Truck delivery also permits feed to be delivered to many points not served by railroads.

The present market structure of the formula feed industry, illustrated by Figure 1, shows the number of opportunities available for the use of trucks. Feed grains grown in the area near the feed mill, premixes, and many other feed additives are transported to the feed plant by truck. The feed manufacturer in turn uses trucks to deliver the processed feed to company owned warehouses, to retail dealers, or directly to the farmer. Recently, the increasing number of commercial feed lots is serving as an additional outlet for feed. The increased amount of on-the-farm mixing is providing sellers of special feed ingredients with a direct market for

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[3] V. John Brensike, "Changing Structure of Markets for Commercial Feeds," Journal of Farm Economics XI, No. 5 (December, 1958), p. 1205.

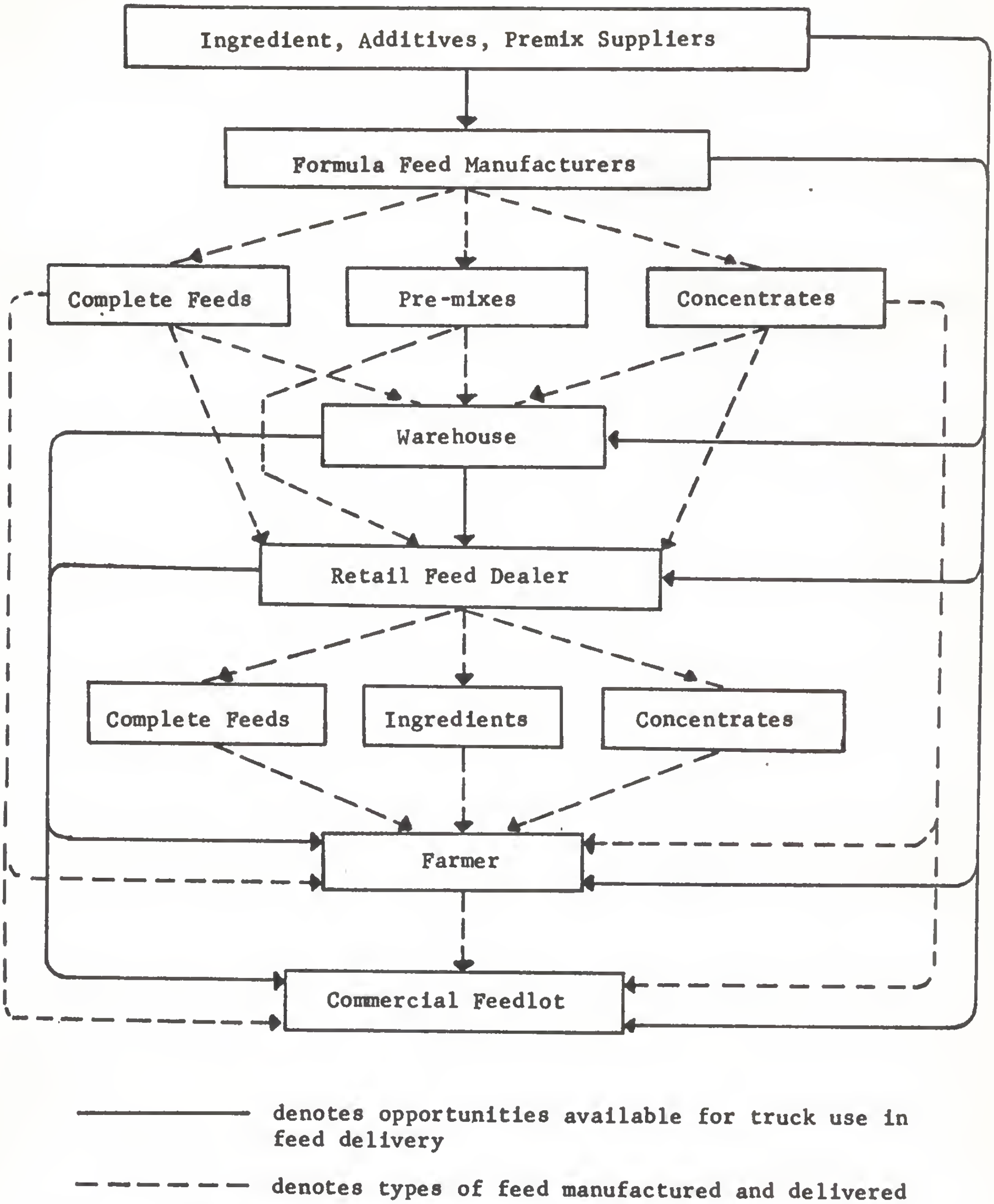

Fig. 1.--Market structure of the commercial feed industry.

their product. Thus, the use of trucks has permitted the feed industry to expand its operations to serve all parts of the nation.

Bulk handling equipment was developed in the early 1950's for use in the delivery of feed. Figure 2 shows the increase in the tonnage of feed sold in bulk from 1957 to 1963. Livestock and poultry producers have been quick to convert their feeding equipment to handle bulk feed. The mechanized equipment has reduced the handling costs and furthermore, the expense for the feed bags is eliminated. Thus, the advent of bulk feed has made it necessary for the feed manufacturer to purchase trucks specially equipped to handle bulk feed in addition to trucks for bag delivery. The increasing importance of trucks in the delivery of feed substantiates the need for research to inform business men of the feed industry about the most efficient methods of truck utilization for feed delivery.

A survey contacting thirty-two of the leading feed manufacturers in Kansas revealed that twenty-eight of the thirty-two delivered feed to farmers, retail dealers, or to other company owned facilities. A total of 130 trucks was used by these companies for feed delivery. Of these trucks, 24 were equipped to handle only bulk feed, 33 handled only bagged feed, and 73 were equipped to handle both bulk and bagged feed. The survey served to indicate that feed delivery by truck is an important part of the feed manufacturer's business.

An economies of scale study of feed mills by Brensike and Askew revealed that plants with a volume of 30,000 tons of feed per year operated

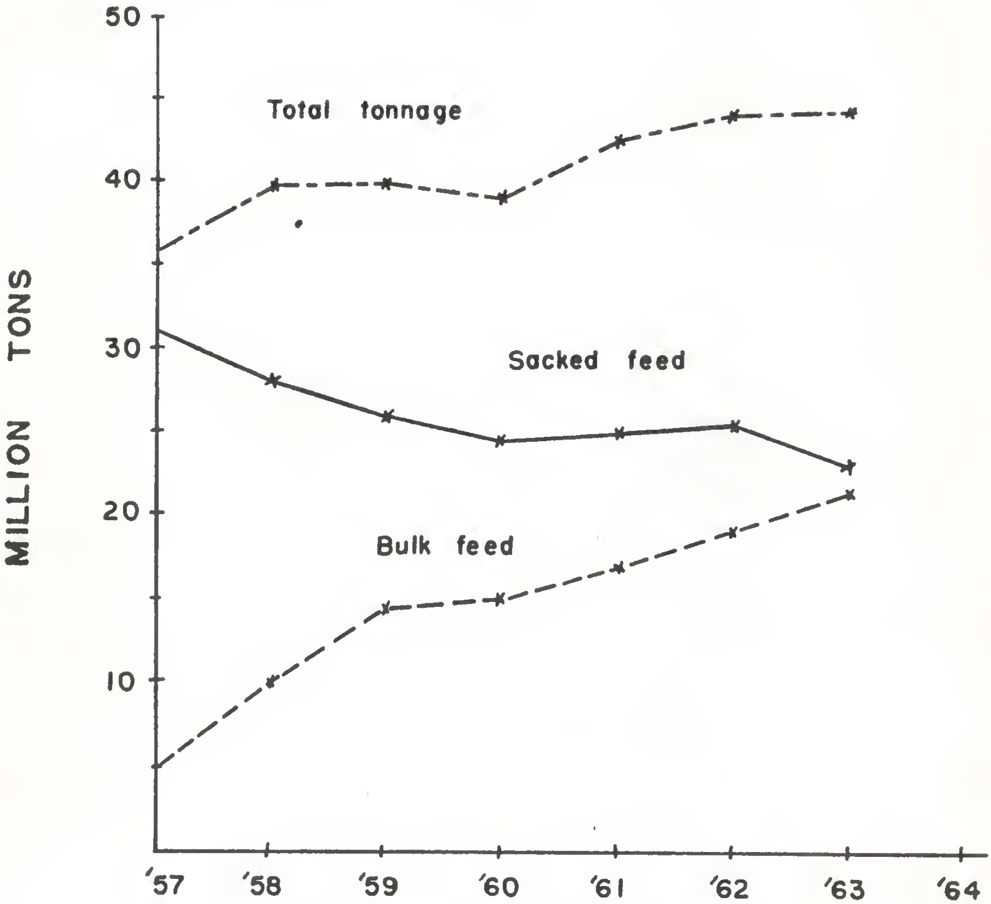

Fig. 2.--Feed tonnage sold in bulk and sacks[a]

[a]Jerry Karstens, "Feed Trends - Bulk vs. Bagged," Feed Age, XIII, No. 4 (April, 1963), p. 48. The 1963 data were obtained from the American Feed Manufacturers Association Tonnage Reporting Service, Table no. 127-R3, February, 1964.

at costs of 50 percent less than plants manufacturing 2,000 tons per year.[4] Figure 3 illustrates the economy of scale curve obtained from this study. By offering delivery service, feed manufacturers are able to increase their production volume and benefit from the lower costs of production which accompanies the expanded production volumes.

The same study also examined the percentage of total feed sales delivered by truck. Table 1 gives the findings from a sample of 121 plants.

Table 1. Portion of feed sales delivered by truck.[a]

Mill Volume	Percent of Sales Delivered by Feed Plant Trucks
Under 5,000 tons	65.5
5,000 - 14,999	61.2
15,000 - 24,999	63.4
25,000 - 34,999	43.5
35,000 - 44,999	46.6
45,000 and over	31.2

[a]V. J. Brensike and W. R. Askew, Costs of Operating Selected Feed Mills, U. S. Department of Agriculture, Marketing Research Report No. 79 (Washington: U. S. Government Printing Office, February, 1955), p. 23.

The smaller plants deliver a greater portion of their feed by truck than do the larger plants. Efficient truck delivery becomes even more important to the smaller feed manufacturer, because his production costs

[4]V. J. Brensike and W. R. Askew, Costs of Operating Selected Feed Mills, U. S. Department of Agriculture, Marketing Research Report No. 79 (Washington: U. S. Government Printing Office, February, 1955), p. 23.

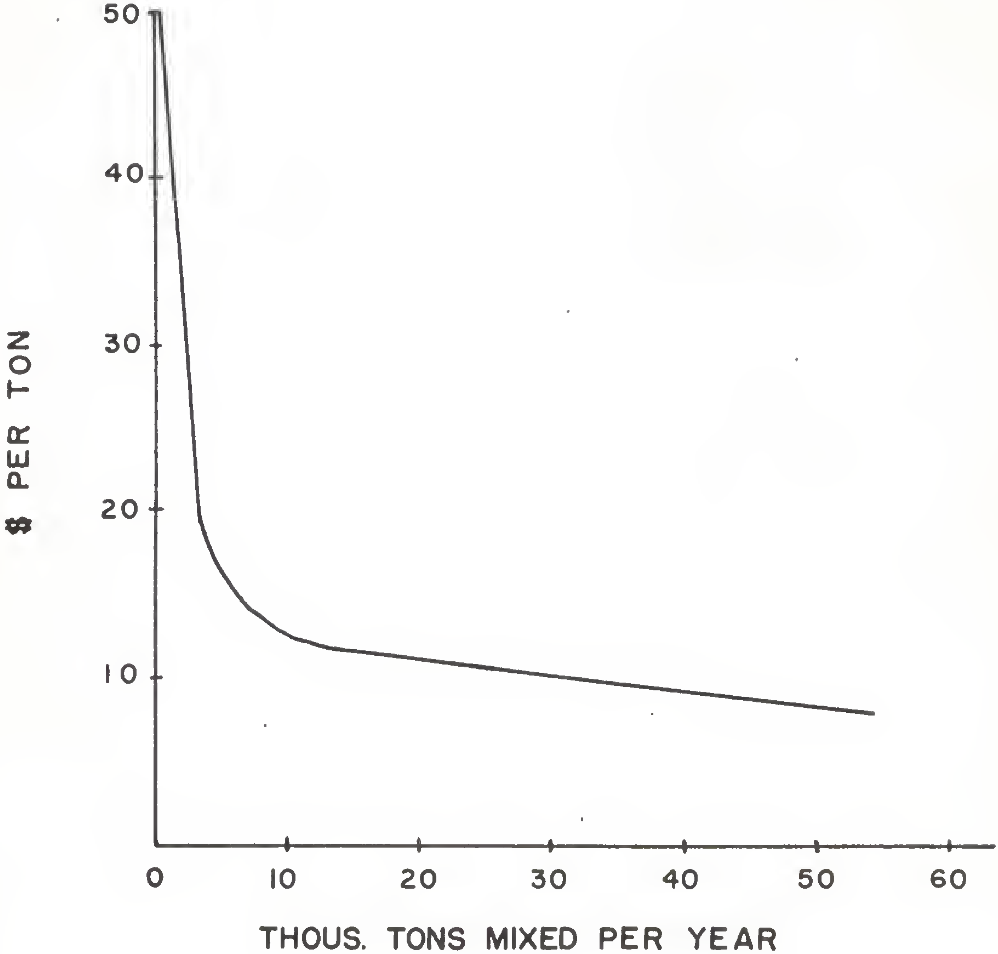

Fig. 3.--Economies-of-scale curve for 98 feed mills[a]

[a]V. J. Brensike and W. R. Askew, Costs of Operating Selected Feed Mills, U. S. Department of Agriculture, Marketing Research Report No. 79 (Washington: U. S. Government Printing Office, February, 1955), p. 23.

per unit are higher than those of the larger plants. By reducing the delivery costs, more service may be offered by the feed manufacturer. It enables him to increase his volume of production, to meet his competition, and to increase his profits from the feed sold.

The Problem

Truck delivery of feed is composed of those activities which begin when the truck is loaded with feed at the feed mill or warehouse ready for delivery to the farmers, retail dealers or other company owned facilities. All activities consisting of driving between the delivery points, unloading the feed and placing it in the desired location, making collections, and picking up backhauls are all a part of the truck delivery operation. The activity ends when the truck returns to the starting point.

The problem analyzed by this study was the variations in the cost of delivering feed as related to delivery truck utilization. Every day the feed mill receives from farmers and retail dealers orders that must be filled within a certain amount of time. Most feed mills require that feed orders be placed in advance of the expected delivery date. Among feed companies, the time period varies from one to five days. This is necessary so that production schedules can be set up in the mill. Orders for a given kind of feed must be combined in order that change-over time from one formula to another will be minimized during a day's operation of the mill. To prevent any interruption of the total feed mill operation, therefore, there must be coordination between the feed mill production schedule and the delivery schedules for efficient truck use.

Each feed mill has a number of trucks of a certain size and fixed capacity. The trucks may be specialized for hauling either bulk feed or bagged feed or both. Full use of the truck's capacity is a necessity if efficiency in the delivery operation is to be maintained. It is unprofitable to send a truck out only half loaded with feed. The problem then becomes evident when it can be seen that for optimum truck utilization, the delivery points should be arranged so that the full capacity of the truck can be utilized.

A second part of the capacity problem is the selection of trucks with a capacity sufficient to meet the delivery requirements. For example, a feed mill with three small trucks may be able to purchase one large truck, with twice the capacity, to replace two of the smaller ones. Because the larger truck can deliver the same amount of feed, the operating and fixed costs are reduced. Delivery time may be reduced for partial loads because one truck with two deliveries going in one direction will require less time for the complete trip than will one truck making two trips.

The truck capacity situation is only half of the problem, however. The delivery points should ideally be grouped close enough together so that the total mileage traveled by the truck making the deliveries will be a minimum. The importance of the advance time period for the customer to place his order can be seen here, because the more orders that a feed mill has to fill, the greater are the chances of the delivery points being closer together.

The role of the service offered by the feed company must not be forgotten. A lengthy time period required for advance notice of orders or minimum sized orders that are too large may cause customers to look for another company offering a service to fit his needs. Consequently, the feed mill manager is faced with rising delivery costs on one side and maintaining adequate delivery services on the other side to fulfill the customer's demands.

Allowance must be made also for emergencies. For instance, a customer for some unforeseen reason might call in an order for immediate delivery. The feed company that can fill such orders, even if it means running a truck only half loaded out to the customer, may make many satisfied customers. Customer satisfaction is necessary for any company selling a product and offering service if it wishes to remain in business. It is of extreme importance in the feed industry where competition is keen.

The increasing tonnage of bulk feed sold annually further complicates the problem of feed distribution. Sacked feed can be manufactured and stored in a warehouse until it is needed to fill an order. However, for bulk feed to be stored, individual bins must be constructed for each different formula. The storage cost for even small amounts of bulk feed would be prohibitive, because any one feed mill may manufacture over 100 different formulas. Therefore, bulk feed orders must be delivered shortly after they are manufactured so that storage space will not be tied up for any length of time. Having trucks available to deliver the bulk feed soon after it is prepared is a part of the utilization problem.

Trucks that are used for delivery must be maintained in good mechanical condition so that the deliveries can be made with the least amount of difficulty. Emergencies will arise, however. Suppose, for instance, that a truck stalls out on the road with a full or partial load of feed. Another truck has to be sent out to deliver the feed. Repairs which may require time to complete will take a truck out of service for a period of time. Scheduling deliveries with one less truck may at times be an added part of the problem.

Efficient management of a fleet of trucks for feed delivery, therefore, requires a competent manager who can handle the various problems as they arise and coordinate the delivery schedules with the feed mill production schedule. Record keeping for both cost accounting and maintenance purposes is a necessary function because it serves as a guide for management decisions. It is hoped that this thesis will point out the importance of feed delivery costs to those responsible for truck delivery of feed and provide a guide to the analysis of efficient truck utilization.

Objectives of the Study and the Source of Data

The first objective of this study was to point out the variations in the costs of delivering feed to the outlets available to feed manufacturers and to indicate some of the reasons for the variations. Data obtained from a truck delivery study conducted by Leonard W. Schruben at Kansas State University along with some observations made while visiting a feed mill in Kansas will be used for this purpose.

The second objective will be to illustrate the importance of efficient truck utilization by reviewing the trucks' capacity and time utilization records. Two case studies made on the data collected by Kansas State University will be used to show the significance of truck utilization in reducing delivery costs.

REVIEW OF LITERATURE

Economic studies on feed delivery by truck have been concerned only with the cost of delivering feed. Very little work has been done on the efficiency of truck delivery operations. The following review consists largely of cost studies on feed delivery.

Phillips did a case study of four different types of feed manufacturing and distributing systems.[5] The systems analyzed were (1) premix operation with mixing done by the dealers, (2) concentrate operation with grain added by dealers, (3) centralized complete feed operation through dealers without mixing facilities, and (4) independent manufacturer-retailer operation. He found considerable variation in the types of transportation facilities used by the different organizations. Furthermore he found that transportation costs were difficult to compare because of the differences in the way trucking records were kept. In some cases, costs of hauling ingredients to the feed mill were not separated from the costs of hauling the mixed feed away from the mill. Expenses of salemen's automobiles were oftentimes included in the truck costs. Phillips set up a relationship between feed delivery cost and the length of haul and derived the equation, $Y = 1.6055 + 0.0241X$, where (Y) is the cost per ton and (X) is the range in miles from the manufacturing plant.[6]

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[5]Richard Phillips, _Costs of Procuring, Manufacturing, and Distributing Mixed Feeds in the Midwest_, U. S. Department of Agriculture Marketing Research Report No. 388, (Washington: U. S. Government Printing Office, April, 1960), p. 1.

[6]_Ibid._, p. 56.

McEllhiney, in a cost study conducted for the Northwest Feed Mill Production School, grouped all trucks delivering bag feed into one category and all trucks delivering bulk feed into a second category.[7] Records were obtained from eleven firms over a six month period. All firms participating were located on the West Coast. Cost per ton figures averaged $3.12 and $2.14 for the bag trucks and bulk trucks, respectively.

R. J. Mutti, Professor of Agricultural Marketing at the University of Illinois directed a study of feed delivery operations on firms in Illinois.[8] He analyzed the effects of expanding the total tonnage delivered by an individual firm from 2,500 tons to 5,000 tons annually. A savings of $0.33 per ton was realized from the increased tonnage. Records of daily deliveries of a typical feed dealer showed wide variation in miles traveled, number of delivery stops, and tons hauled per mile of travel. Mutti concluded that one of the key problems facing the feed dealer in management of his delivery operations is to devise ways to reduce these variations.

Rogers and Woodworth analyzed the efficiency of distributing feed in a study carried out at the University of New Hampshire.[9] The firms in New Hampshire delivered four-fifths of their feed on established delivery routes. Rogers and Woodworth surveyed the routes for the length, number

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[7] Roger Berglund, "Production, Delivery Cost Data Told", Feedstuffs, XXXV, No. 9, (February 23, 1963), p. 91.

[8] R. J. Mutti, "Know Bulk Delivery Costs," Bulk Feed and Grain, VI (March, 1964), p. 23.

[9] G. B. Rogers and H. C. Woodworth, Distributing and Handling Grain Feeds in New Hampshire (Bulletin 426, Durham, N. H.: New Hampshire Agricultural Experiment Station, July, 1956), p. 1.

of stops on each route, and the amount of feed delivered at each stop. The conditions of the route roads, and the availibility of unloading facilities on the farm were also noted. All of these factors contributed to the total amount of time a truck spent on the route. By using road maps and information for each customer on the routes, the authors rearranged and combined routes so that the amount carried per load could be increased and to reduce the total time spent on delivery. Some of the routes were changed from weekly to bi-weekly routes, further cutting down on operating and labor costs. The authors observed that the main problem arising out of the use of delivery routes was that trucks were not going out fully loaded on each delivery trip.

Only one article was found which dealt with the problem of dispatching trucks from a terminal point. Dantzig and Ramser developed a linear programming model for dispatching gasoline trucks from a bulk station.[10] The gasoline distribution problem was similar to the distribution problem in the feed industry in that each bulk plant had a number of trucks with a fixed capacity to deliver their customers' gasoline orders. The basic principle used in dispatching the trucks was to group those delivery points together whose combined demand requirements for gasoline did not exceed the truck's capacity. Because the total mileage driven was being minimized, the delivery points assigned to one truck were those with the least inter-pair distances. The article was not complete in its explanation so that the same model could not be used for solving the truck scheduling problem in the feed industry.

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[10]G. B. Dantzig and J. H. Ramser, "The Truck Dispatching Problem," Management Science, VI, No. 1 (October, 1959), p. 80.

FEED DELIVERY COSTS AND VARIATIONS

The term "cost" generally refers to the outlay of funds for productive services. In economics and accounting, costs are divided into two categories: (1) variable costs, and (2) fixed costs. Variable costs refer to those costs that are a function of production. As production output changes, the variable costs, such as wages, materials, and power costs, also changes. These costs are directly used up by the production process.

Fixed costs are those costs which are not altered as the number of units produced changes. These costs are incurred irrespective of the amount produced. Taxes, rent, and insurance are three examples of these fixed costs.

Feed delivery costs fall into the same two categories above. The delivery costs are a function of (1) labor costs, (2) operating costs, (3) repair costs, and (4) fixed costs. The first three are variable costs and generally increase as the amount of feed delivered increases and vice versa.

The labor cost includes the driver's wages from the time he leaves the mill with a load of feed until he returns. During this interim, the driver drives the truck between the delivery points, unloads the feed from the truck, and places the feed in the designated location. The driver also issues receipts for the feed delivered and may make collections from those paying for the feed upon delivery. Some delivery trips require the driver and truck to be out overnight. The lodging expenses and meals are included in the total labor cost. Workmen's compensation, group insurance, or any other benefits paid by the company are included in labor costs.

Operating expenses include those costs brought about by the operation of the truck. Fuel costs, oil, grease, anti-freeze, new tires, tire repairs, painting, and washing are all a part of operating costs. In addition, highway use and special taxes, bridge and road tolls complete the list of operating costs.

Repair costs are comprised of all repairs made on the delivery vehicle whether made by the feed mill or outside shops. Both parts and labor used in performing the repairs are included.

For the truck delivery cost study reported herein, the fixed cost was composed of depreciation on the delivery vehicle, interest on the investment, insurance, property taxes, and license fees. If the truck was rented, the basic rental fee was an added part of fixed cost. Garage rental is also a fixed cost.

The truck delivery cost study was conducted by the grain and feed marketing research project at Kansas State University in cooperation with the Midwest Feed Manufacturers Association. Feed companies from the Corn Belt to the Southwest sent to Kansas State University their cost data on standard forms prepared for this project. Cost records were received for the period May, 1963 through May, 1964. The costs collected in this study did not include administrative expenses such as costs for dispatching, accounting, supervision, and overhead or economic costs such as land or building space.

The trucks for this study were classified into two size groups based on rated capacity: (1) under ten tons, and (2) ten tons and over. This was done to separate the larger trucks from the smaller because generally larger trucks travel greater distances in delivering feed. The trucks of the different size categories were then broken down as to the type of feed hauled. These were: (1) bag, (2) bulk, and (3) both bulk and bag. For clarity purposes throughout the remainder of this thesis, trucks hauling bag feed and rated under ten tons will be classified as Type I trucks; trucks hauling bag feed with a ten tons and over rating will be referred to as Type IA trucks. Likewise, those hauling bulk feed and rated under ten tons will be described as Type II trucks; trucks rated at ten tons and over and hauling bulk feed will be called Type IIA trucks. Similarly, trucks hauling both bulk and bag feeds and grouped into the under ten ton category will be known as Type III trucks; trucks with a ten tons and over rating hauling both bulk and bag feeds will be identified as Type IIIA trucks.

There were differences in the costs of hauling the different types of feed as will be shown below. The average total cost per ton of feed delivered, along with the different costs included in the total cost is shown in Table 2 for the different sizes and types of trucks.

Table 2 indicates that both Type II and Type IIA trucks have a lower average total cost per ton of feed for delivery than do the other types of trucks. Type I trucks had the highest average total cost per ton of $8.48. Labor costs accounted for the highest percentage of the total costs in the six different categories. However, the labor costs were the smallest for the bulk trucks which is to be expected because

Table 2. Average costs per ton for different sizes and types of feed delivery trucks for period May, 1963 through May, 1964.

Cost Items	Under Ten Ton					
	89 Bag Trucks (Type I)		86 Bulk Trucks (Type II)		23 Bulk & Bag Trucks (Type III)	
	Cost/Ton	Percent of Total	Cost/Ton	Percent of Total	Cost/Ton	Percent of Total
Labor Cost	$4.82	56.8	$0.83	40.3	$1.41	50.5
Operating Cost	1.70	20.1	0.44	21.4	0.54	19.4
Repair Cost	0.30	3.5	0.26	12.6	0.14	5.0
Fixed Cost	1.66	19.6	0.53	25.7	0.70	25.1
Total Cost	$8.48	100.0	$2.06	100.0	$2.79	100.0
Backhaul Credit	0.39		0.01		0.06	
Net Total Cost	$8.09		$2.05		$2.73	
	Ten Ton and Over					
	77 Bag Trucks (Type IA)		138 Bulk Trucks (Type IIA)		205 Bulk & Bag Trucks (Type IIIA)	
Labor Cost	$2.31	44.8	$0.81	40.5	$2.77	43.2
Operating Cost	1.27	24.6	0.44	22.0	1.40	21.9
Repair Cost	0.27	5.2	0.23	11.5	0.81	12.6
Fixed Cost	1.31	25.4	0.52	26.0	1.43	22.3
Total Cost	$5.16	100.0	$2.00	100.0	$6.41	100.0
Backhaul Credit	1.69		0.01		0.86	
Net Total Cost	$3.47		$1.99		$5.55	

bulk trucks have mechanical unloading facilities which move the feed at a faster rate than manual labor can move it.

Fixed costs were the second most important item in determining total cost. They accounted for approximately 25 percent of this total. Operating costs were third in order and repair costs were fourth in contributing to the average total cost.

The backhaul credit item listed in Table 2 is the average credit given to each ton of feed delivered for the number of tons that was backhauled. When a truck goes out on a delivery trip, it may be utilized after the feed is delivered to haul feed ingredients back to the feed mill. When this is done, some credit must be given to the cost of delivering the feed because the total cost was not all attributed to feed delivery. In the cost study, roughly one half of the average total cost per ton was the amount of credit given for each ton of feed backhauled. When this credit is subtracted from the total cost, the net total cost is left. The Type IA trucks had an average backhaul credit of $1.69 for every ton of feed delivered. This reduces the total cost for delivering a ton of bag feed to $3.47 which is a considerable reduction. Bulk trucks have the least backhaul credit because the truck is specialized for hauling feed. Thus, the backhauling of feed ingredients is an important means of reducing delivery costs.

Table 3 will serve to indicate some of the reasons for the cost variation on the different types of trucks. The figures in the tons delivered row of Table 3 show the average number of tons of feed delivered by the respective trucks each month. The second row of the table indicates the average number of miles that a ton of feed was hauled by the trucks.

Table 3. Average truck utilization data for different sizes and types of feed delivery trucks, May, 1963 through May, 1964.

	Bag		Bulk		Bulk & Bag	
	Under Ten Ton (Type I)	Ten Ton & Over (Type IA)	Under Ten Ton (Type II)	Ten Ton & Over (Type IIA)	Under Ten Ton (Type III)	Ten Ton & Over (Type IIIA)
Tons Delivered Per Month	49.85	212.54	235.65	508.87	174.28	219.62
Miles Per Ton	42.36	21.05	7.05	7.32	7.68	20.92
Miles Per Trip	115.4[a]	279.5	46.8	67.7	33.3	301.43
Tons Per Trip	2.92	14.13	6.64	9.24	4.33	14.41
Trips Per Month	17.10	15.04	35.1	55.07	40.26	15.24

[a]The averages for the miles per trip, tons per trip, and trips per month in the under ten ton category are based on records for 12 months.

This figure was calculated by taking the total number of miles traveled by the trucks and dividing it by the total number of tons delivered. Comparing miles per ton with the average cost per ton for delivery, one notices that the greater distance a ton of feed is carried, the higher the cost. The bag trucks in the under ten ton category traveled 42.36 miles per ton giving a cost of $8.48 per ton. The bulk truck in the ten ton and over class had an average cost of $2.00 per ton and traveled 7.32 miles per ton. This is reasonable because it costs more to operate a truck over a longer distance.

The contrast in the costs may also be explained by the difference in the types of operation conducted by the feed companies. Some of the firms having Type I trucks manufactured and marketed a premix formula feed.

The premix feed is highly concentrated feed with minerals, vitamins, and antibiotics and is usually mixed with other feed ingredients by a retail dealer. Because the formula feed is concentrated, only a small amount of the feed is needed by each customer. A truck sent out on a delivery trip with this type of feed may travel a greater distance and make more delivery stops. On the other hand, the bulk feed truck serves a smaller market area and hauls a type of feed that is not so concentrated. Table 3 supports this by showing that the average trip length for Type I trucks was 115.4 miles and the average trip length for the Type IIA trucks was 67.7 miles. Furthermore, the average number of stops per trip for the Type I trucks was 6.70. For Type IIA trucks, the average was 2.17 stops per trip.

The smaller radius of the marketing territory served by the bulk trucks permits them to make more delivery trips per month; therefore, they can deliver more tons each month. Bulk trucks in both size categories delivered more feed and made more trips per month than any of the other trucks. Type IA and Type IIIA trucks carried feed a greater distance from the feed mill. Some delivery trips take the trucks out over night; consequently, they reduce the number of trips and tons of feed that can be delivered each month. Table 3 confirms this explanation because Type IA and Type IIIA trucks made approximately fifteen trips per month and delivered an average of 212.54 and 219.62 tons of feed, respectively. At the same time, the Type IIA trucks made 55 trips per month and delivered an average of 508.87 tons of feed. Because the bulk trucks are able to deliver more tons of feed with each truck, the fixed cost per ton is less than it is for the other types of trucks.

Statistical Analysis

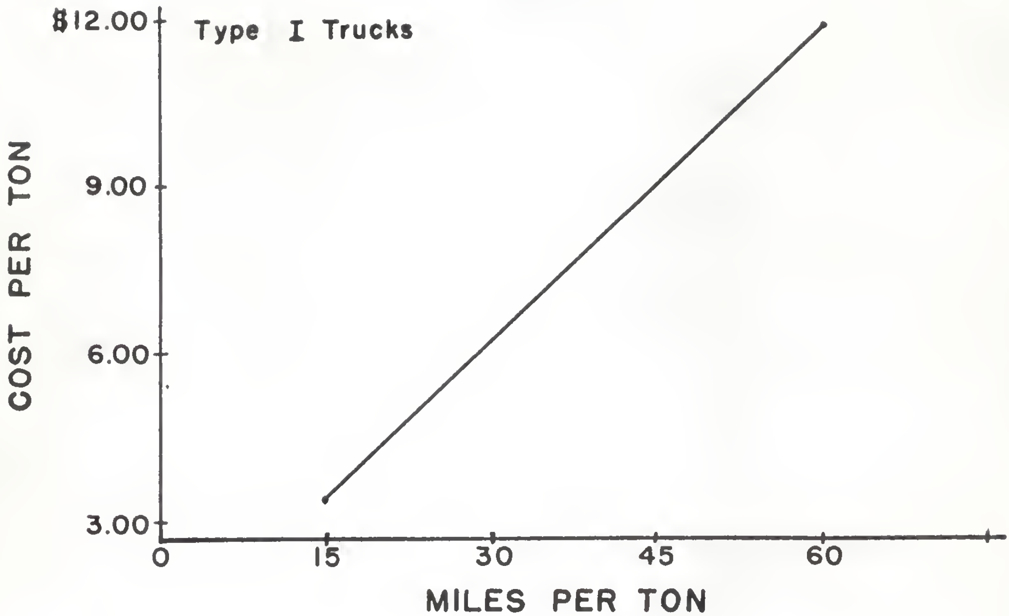
A linear regression was used to analyze the relationship between the independent variable, miles per ton, and the dependent variable, cost per ton. A regression analysis was run on each of the types and sizes of trucks. The regression statistics are shown in Table 4. The regression lines are

Table 4. Linear regression statistics for the different types and sizes of trucks. Cost per ton (Y) related to miles per ton (X). Records for period, May, 1963 through May, 1964.

Truck Identity	Regression Coefficient		Correlation Coefficient		Constant
	b	P	r	P	a
Bag Under Ten Ton (Type I)	.19	$<.05$	.91	$<.05$	0.55
Bag Ten Ton & Over (Type IA)	.26	$<.05$	.85	$<.05$	-0.24
Bulk Under Ten Ton (Type II)	.29	$<.05$	.96	$<.05$	0.04
Bulk Ten Ton & Over (Type IIA)	.31	$<.05$	.90	$<.05$	-0.28
Bulk & Bag Under Ten Ton (Type III)	.21	$<.05$	.91	$<.05$	1.19
Bulk & Bag Ten Ton & Over (Type IIIA)	.20	$<.05$	.72	$<.05$	2.36

shown in Figures 4 through 6. The null hypothesis that the regression coefficients and correlation coefficients did not equal zero was accepted with a probability of less than .05. There was a significant relationship between cost per ton and the total miles traveled in all cases studied.[11]

[11]George W. Snedecor, Statistical Methods, 5th edition,(Ames: Iowa State University Press, 1956),pp.173-174.



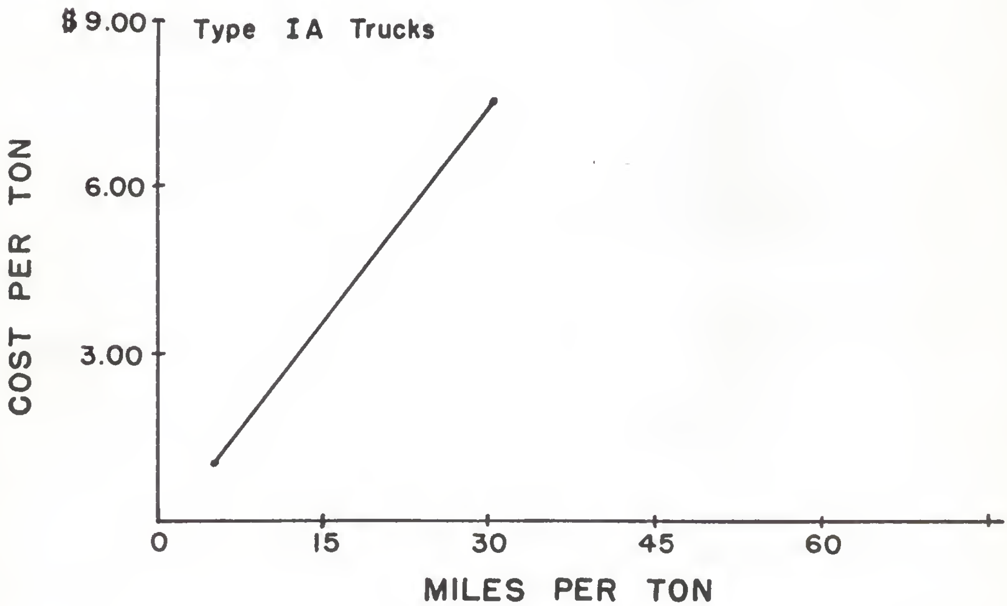


Fig. 4.--Relation of cost per ton (Y) to miles per ton (X) for Type I and Type IA trucks.

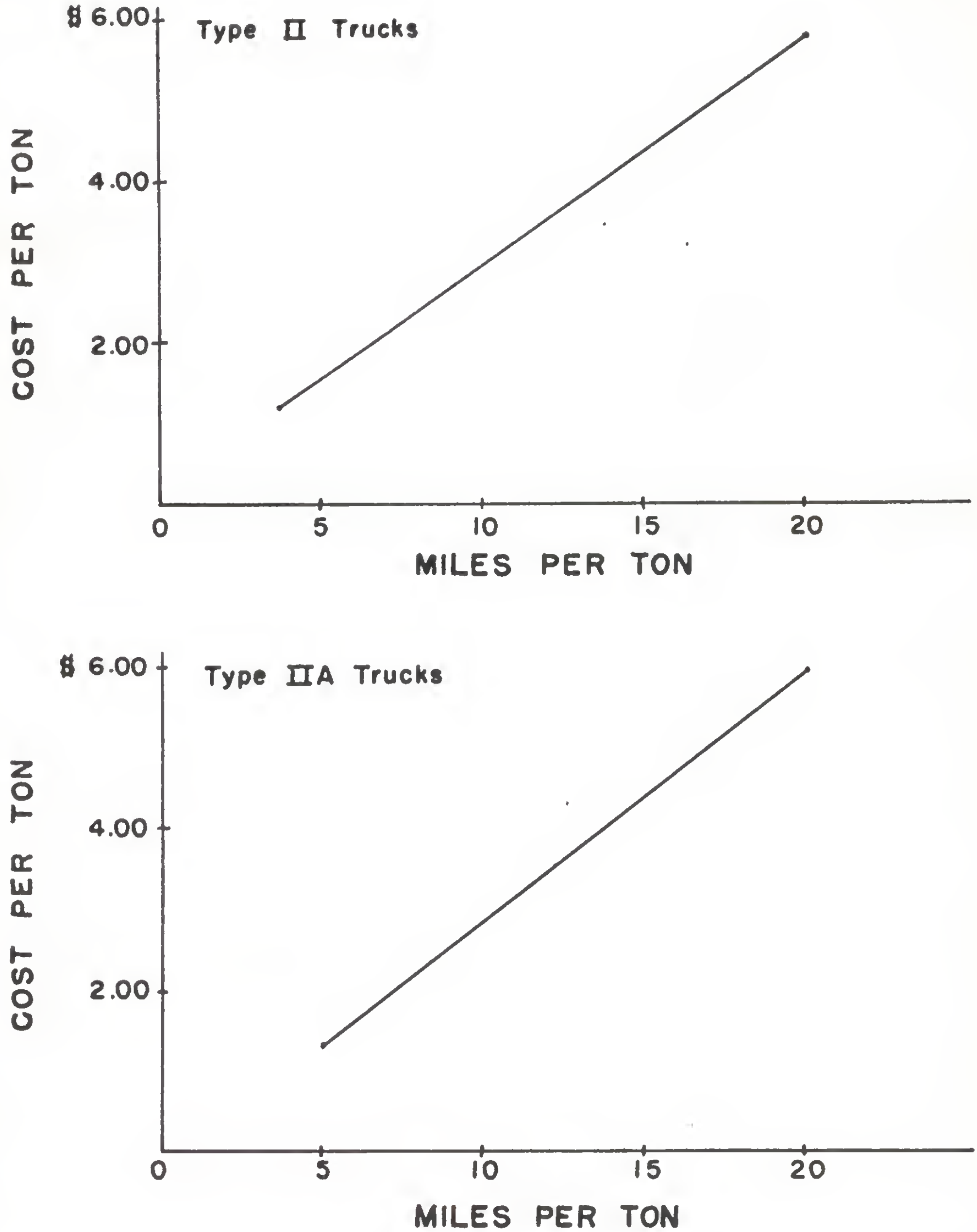
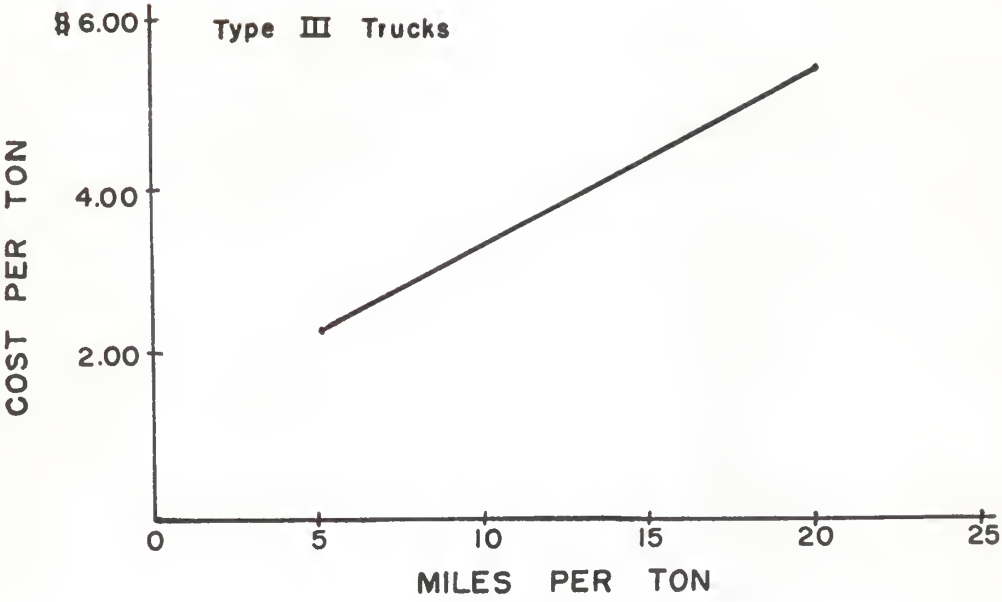


Fig. 5.--Relation of cost per ton (Y) to miles per ton (X) for Type II and Type IIA trucks.



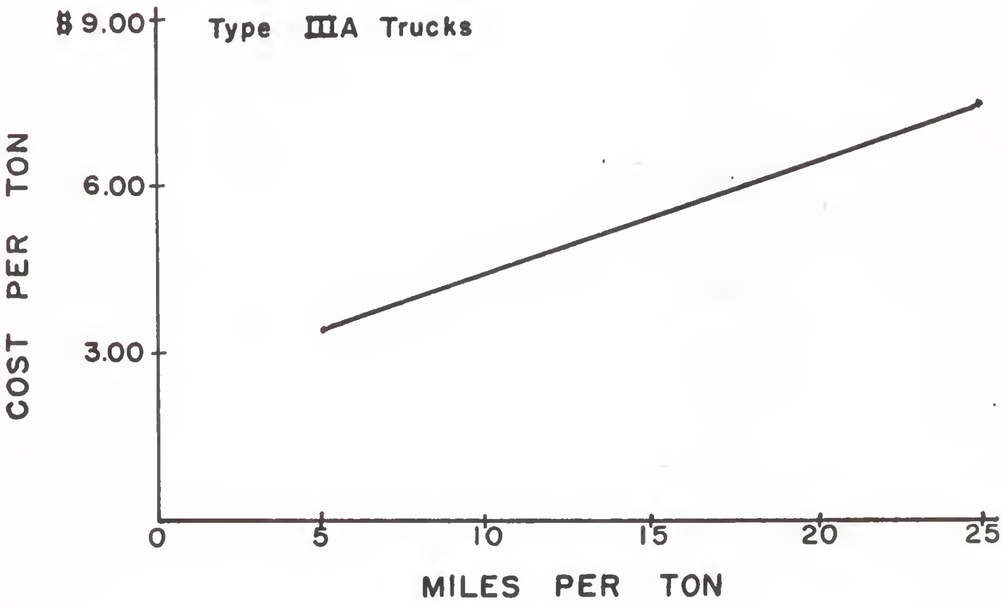


Fig. 6.--Relation of cost per ton (Y) to miles per ton (X) for Type III and Type IIIA trucks.

The correlation coefficient, r, illustrates that a linear relationship exists between the independent variable, miles per ton and the dependent variable, cost per ton for the different types of trucks. Examination of the regression coefficients for each type of truck indicates that the cost per ton variable does rise as the miles per ton variable increases. Thus, with more efficient means of scheduling trucks to reduce the miles per ton variable, the cost per ton figure should be lowered.

Monthly Cost Variations

The importance of scheduling for efficient truck delivery operations can be emphasized by examining the monthly cost variations of individual trucks. Theoretically a ton of feed should cost no more to deliver one month than any other month. However, when comparing monthly records one finds considerable differences in the cost per ton of feed delivered. Narrow-profit margins which characterize the feed industry make it possible for costs such as those charged to truck delivery to make the difference between a profit and a loss. Because a profit must be made for an enterprise to remain solvent, the cost variations must be taken into consideration when looking for ways to increase profits.

Records of a Kansas feed mill were examined for monthly variations in delivery costs. The firm has three trucks classified as Type IA, two Type IIIA trucks, one Type I truck, and one Type IIA truck. The trucks in the Type IA and Type IIIA classifications are tractor-trailer units. Nine trailers, three of which are equipped to handle both bulk and bag feed, are used by the firm with the idea in mind that while a tractor and trailer unit is out on a delivery trip, an empty trailer at the feed plant can be loaded with feed. Consequently, there need not be any time delay due to loading. As soon as a tractor returns from a delivery trip with an empty trailer, it can be exchanged for the loaded trailer and be ready for another delivery trip.

Records over the thirteen month period May, 1963, to May, 1964, were examined for monthly variations. Repair costs for each truck were considerably higher in some months than in others. As a result, the cost per ton figures were out of proportion. Therefore, an average repair cost was calculated for the thirteen months for each truck and this figure was used to adjust each month's total cost per ton figure. The labor and operating costs were not altered in any way. The monthly cost per ton figures for each truck are shown in Table 5 along with the average, range, and standard deviation for each truck. There were variations between each of the months for each truck. Truck D with a deviation of $1.20 was the largest deviation from the mean of $4.70; furthermore, it has the largest range of $4.21. Trucks E and G have the smallest standard deviation of $0.49 and a range of $1.47 and $1.38 respectively. The remaining trucks A, B, C, and F have deviations that are significantly important when considering variations in monthly costs. The costs for the different trucks during the same month show variations too, even in the same size category. Two of the Type IA trucks, B and C are rated at eighteen tons while truck D is rated at twenty-two and one half tons. It is not possible for all trucks even of the same size to have exactly the same costs of operation because each truck will inherently have some different operating characteristics. However, when there is almost one dollar per ton difference in average delivery cost as there is between B and C, some other factor besides operating costs must be contributing to the cost variance.

Table 5. Monthly cost per ton figures, average costs, range in costs, and standard deviations for trucks of a Kansas feed mill, May, 1963 through May, 1964.

Month	Bag Under Ten Ton (Type I)	Bag Ten Ton & Over (Type IA)			Bulk & Bag Ten Ton & Over (Type IIIA)		Bulk Ten Ton & Over (Type IIA)
	A	B	C	D	E	F	G
May 1963	$3.75	$4.95	$3.45	$3.60	$4.73	$4.70	$5.07
Jun	3.93	5.74	4.78	7.75	5.75	6.43	5.31
Jul	3.26	3.96	4.11	3.84	4.50	5.05	5.15
Aug	4.56	4.64	4.75	3.54	5.97	5.00	4.46
Sept	5.13	5.52	5.73	4.91	4.76	5.48	4.40
Oct	2.89	6.78	5.84	4.92	4.96	5.81	3.93
Nov	4.74	5.15	5.59	4.01	5.86	6.41	3.97
Dec	5.74	5.84	4.62	4.81	5.19	5.69	4.11
Jan 1964	5.44	5.88	4.12	4.35	4.71	5.60	3.99
Feb	4.68	6.36	5.00	4.31	4.97	5.05	4.18
Mar	3.70	6.19	4.63	4.59	5.45	4.48	4.23
Apr	3.30	6.04	4.35	5.68	5.24	4.93	3.99
May	3.28	6.25	4.05	4.76	4.68	6.28	4.77
Average	4.18	5.66	4.69	4.70	5.14	5.45	4.43
Range	2.85	2.82	2.39	4.21	1.47	1.95	1.38
Standard deviation	.92	.78	.71	1.10	.49	.65	.49

A comparison was made with the monthly cost per ton figures and the miles per ton. A simple linear regression was run on each truck and the results are shown in Table 6. The r values were all significant at the 5 percent level.

Table 6. Correlation coefficient values for individual trucks of a Kansas feed mill showing relationship between cost per ton (Y) and miles per ton (X), records for period May, 1963 through May, 1964.

	Truck Identity						
	(Type I)	(Type IA)			(Type IIIA)		(Type IIA)
	A	B	C	D	E	F	G
Correlation Coefficient	.84	.93	.90	.92	.72	.83	.77

The cost variations were then due in part to differences each month in the miles per ton figure established by each truck. One would not expect great differences in the miles per ton number for trucks delivering primarily in the same marketing territory each month. But examination of Table 7 shows that the miles per ton figure does vary substantially from month to month just as the cost per ton data. Once again, the trucks with the largest variation in cost per ton have the greatest variance in miles per ton. In May, 1963, truck D traveled 17.0 miles per ton and during the next month, it traveled 30.5 miles per ton, a difference of 13.5 miles. For efficient low cost truck delivery operations, such a variation is not desirable. During May, 1963, truck D carried 18.3 tons per trip but in June, 1963, it only hauled 10.4 tons per trip. The truck traveled nearly the same number of miles per trip during the two months, 316.3 in May and

Table 7. Monthly miles per ton figures for individual trucks of a Kansas feed mill, May, 1963 through May, 1964.

Month	Bag Under Ten Ton	Bag Ten Ton & Over			Bulk & Bag Ten Ton & Over		Bulk Ten Ton & Over
	(Type I)	(Type IA)			(Type IIIA)		(Type IIA)
	A	B	C	D	E	F	G
May 1963	21.0	23.0	16.0	17.0	22.0	21.0	19.0
Jun	20.4	22.4	19.9	30.5	23.2	27.3	19.5
Jul	11.5	16.8	20.8	20.2	18.7	23.9	19.1
Aug	25.0	19.3	19.8	18.6	25.7	22.5	16.7
Sept	23.2	24.5	26.2	22.8	20.1	24.2	13.9
Oct	14.7	30.1	27.9	25.4	23.9	26.2	16.4
Nov	21.5	22.8	23.7	18.9	22.7	26.5	16.1
Dec	23.6	26.8	22.1	23.1	23.6	21.1	16.5
Jan 1964	31.5	25.3	19.8	22.4	22.7	24.4	15.5
Feb	23.1	25.7	22.6	20.1	22.2	21.1	16.5
Mar	19.8	25.1	21.9	21.6	23.6	20.6	17.0
Apr	18.1	27.7	19.1	25.6	22.8	20.4	15.7
May	16.0	25.8	20.1	19.2	19.7	24.6	16.5

317.0 in June, but it was not being utilized as efficiently during June as it could have been. This example serves to illustrate the need for an efficient method of scheduling feed delivery by truck. Because the firm has six trucks in addition to D, it seems that the loads could have been evenly distributed so that one truck would not have been under-utilized during one month. A study of truck utilization will be presented in the next section.

Truck Efficiency in Feed Delivery

There are two factors which must be considered in an efficient truck delivery operation. These are: (1) capacity utilization, and (2) time utilization. These are equally important if low delivery costs are to be maintained. Capacity utilization refers to the amount of the truck's capacity that is used each time it is sent out on delivery. For efficient truck use, it is desirable that a truck be loaded as near to full capacity as possible. The operating and labor costs will be approximately the same whether or not a truck is fully loaded. If there are more tons over which these costs must be spread, the total cost per ton will be lower. An example of this is truck D of the Kansas feed mill studied in the previous section. During May, 1963, when the average load per trip was 18.3 tons, the labor and operating costs were $1.76 and $1.12 per ton, respectively. However, during June, 1963, the labor and operating costs were $3.32 and $1.78 per ton. This serves to illustrate the importance of full capacity utilization when scheduling deliveries.

Time utilization, the second factor, is the amount of time that a truck is being used during a specified period of time for feed delivery.

A truck that is being used every working day during a month's time will ultimately have a lower fixed cost per ton than will a truck used less than full time. The fixed cost must be paid whether or not the truck is being used. Hence, the more tons of feed to which the fixed cost can be applied, the lower will be the total cost per ton because the fixed cost will be less.

An example of time utilization lowering fixed costs can be given with data obtained from another feed company participating in the Kansas State University truck study. In November, 1963, the firm delivered 368 tons of feed on nineteen delivery trips. During May, 1964, the same truck delivered 167 tons on nine trips. The fixed cost for both months was $352.64 giving a fixed cost of $0.95 and $2.11 per ton in November and May, respectively. Assuming that all other costs were equal, this would make a difference of $1.16 in the total cost per ton. Thus, time utilization is a factor that must not be neglected if variations in delivery costs are to be kept at a minimum.

By using the records of two feed companies participating in the Kansas State University cost study, the author made some comparisons between trucks within each firm for efficiencies of operation. The first group of records that will be analyzed in this section is that of the Kansas feed mill discussed in the preceding section. The second set of records that will be analyzed in this section is that from a feed mill in Texas.

Table 8 is a summary of the truck utilization and cost figures on the Kansas feed mill. Row one of the table shows the total number of tons delivered by each truck over the thirteen month period. Row two lists the average number of miles traveled on a delivery trip. Row three gives the

Table 8. Summary of thirteen months truck utilization and cost data of a Kansas feed mill, May, 1963 through May, 1964.

	Type, Size, and Identity of Trucks						
	Bag Trucks				Bulk & Bag Trucks		Bulk Trucks
	(Type I)	(Type IA)			(Type IIIA)		(Type IIA)
	8 Ton	18 Ton	18 Ton	22.5 Ton	22.5 Ton	18 Ton	12 Ton
	A	B	C	D	E	F	G
Tons Delivered	1322.15	2742.28	3391.29	3352.64	3680.38	2778.76	4411.94
Miles Per Trip	102.3	356.6	323.8	392.6	418.3	356.0	143.0
Miles Per Ton	20.0	23.9	21.1	21.3	22.3	23.2	16.4
Tons Per Trip	5.11	14.90	15.34	18.40	18.77	15.35	8.72
Percentage of Truck Capacity Utilization	63.9	82.8	85.2	81.8	83.4	85.3	72.7
Percentage of Time Utilization	31.6	76.8	86.0	83.1	96.3	77.4	84.9
Total Cost Per Ton	$3.97	$5.55	$4.53	$4.46	$5.08	$5.39	$4.35
Net Total Cost Per Ton[a]	$3.68	$4.86	$3.32	$3.66	$4.45	$4.73	$4.34

[a]Backhaul credit subtracted from total cost gives Net Total Cost Figure.

average number of miles traveled per ton of feed delivered. Row four shows the average number of tons hauled per trip. Row five indicates the average percent of the truck's capacity that was utilized in each delivery trip. This figure was calculated by dividing the truck's rated capacity into the average number of tons delivered on each trip. For example, truck A, which has a rated capacity of eight tons, delivered 5.11 tons per trip to give a 63.9 percent truck capacity utilization figure.

The percentage of time utilization figure was calculated by dividing the number of hours that the truck was actually available for delivery into the actual number of hours that the truck was on delivery. The Kansas feed mill operated on a delivery schedule of twelve hours a day, five days a week, giving a total of sixty hours per week that a truck could be on delivery. Over the thirteen month period, the total hours possible numbered 3324 per truck. Holidays were not included in the total number of hours.

Truck A was on delivery 1051.6 hours to give a 31.6 percent time utilization figure. This is somewhat misleading for this particular truck, however, because this truck had to be loaded during the time that it could be on delivery. No figures were available on the time spent loading the trucks.

The five tractor-trailer unit trucks, B, C, D, E, and F had approximately the same percentage of truck capacity utilization which was between 82 and 85 percent. The twelve ton bulk truck, G, had a 72.7 percent capacity utilization figure. Truck A had the lowest figure of 63.9 percent. This truck was used for the smaller deliveries in the marketing territory closer to the feed mill. The truck also served as an emergency vehicle for deliveries that had to be made immediately. This may be one reason for the low capacity utilization figure because it was not always scheduled with full loads.

It cost $4.35 per ton to deliver a ton of feed with the bulk truck G. This is over twice the average cost compiled by all of the bulk trucks of the same size category in the truck cost study. But this truck G traveled 16.4 miles per ton while the average for all of the bulk trucks was 7.32 miles per ton. The truck is used more for one stop delivery trips because the average number of stops per trip was 1.2. Because most of the orders delivered by this truck were less than twelve tons, the truck carried an average of 8.72 tons per trip for a 72.7 percent capacity utilization figure. The low average tons hauled per trip accounts for the high miles per ton and consequently the higher total cost per ton for delivery. Larger feed orders would help to lower the delivery cost for the bulk truck.

In order to set a delivery cost per ton standard for the Kansas feed mill to work on, the author selected the firm's truck in each size category with the lowest delivery cost per ton. Of the three trucks with an 18 ton rating, C operated at the lowest cost of $4.53 per ton. Truck F accumulated a cost of $5.39 per ton which was $0.86 per ton more than C's cost. Truck B was operated for $5.55 per ton or $1.02 per ton higher than C. Truck E in the 22.5 ton class had a total cost of $0.62 per ton less than that of truck D. The savings that could have then been made if all of the trucks had the same cost per ton figure for delivery was calculated by taking the cost per ton difference and multiplying it by the total number of tons hauled by each truck with the higher cost. The savings for each truck is shown in Table 9.

Table 9. Savings on delivery costs for trucks of a Kansas feed mill operating at the lowest truck's delivery cost figure, May, 1963 through May, 1964.

Truck Size and Identity	Cost Per Ton Savings	Total Savings Per Truck
18 Ton Trucks		
F	\$0.86	\$2,389.73
B	\$1.02	\$2,797.12
22.5 Ton Trucks		
D	\$0.62	\$2,281.84
	Total Savings	\$7,468.69

The total cost of operating the seven trucks for the thirteen month period was \$79,293.79. Therefore, the \$7,468.69 savings in delivery cost represents a 9.42 percent decrease in the total delivery cost. This is a substantial amount of savings and this author believes that the savings could be realized if closer attention was given to scheduling the trucks.

The figures given above were the total cost figures without any mention of backhaul credits. The author did not use the net total cost figures for calculating the savings because not every truck has an equal opportunity to get backhauls when returning from a delivery trip. The net total cost per ton figures presented in Table 8 shows that some trucks were able to get more backhauls than others. Backhauls are important as pointed out earlier in reducing the cost for delivery and every effort should be made to backhaul as much tonnage as possible without interfering with normal delivery operations.

A Texas feed mill sent truck cost records to Kansas State University during the period July, 1963 through May, 1964. They operated six trucks during the first five months of the study and sold one truck leaving them five trucks during the last six months of the study.

The feed mill is located in a part of Texas that was predominantly dominated by cattle feeders so that their feed sales tended to be seasonal in that the tonnage was high in the fall months when cattle are brought in off of pasture and tapered off during the spring and summer months. The cyclic nature of feed sales presents a problem for efficient truck utilization because if enough trucks are purchased to deliver feed during the high peak of the cycle, they will be idle during the slack months of the year.

Table 10 lists the monthly tonnage carried by each truck and the total tons delivered each month. The months September through December are the months when the most feed was delivered. Truck 3 was sold during the month of November and the remaining trucks were able to deliver the total tonnage of feed through the last of the peak months, December, January, and February. During the months of November and December, truck 4 was not used as much as it could have been because it only delivered 129 tons on nine trips in November and 119 tons on eight trips in December.

After the month of December, the total tonnage gradually decreases to May when the cost study ended. Because only eleven months data are available, a definite seasonal pattern cannot be established.

Table 11 shows the truck utilization, total and net total cost per ton figures for the six trucks. With the exception of truck 5, the truck's capacity utilization figures were over 80 percent. The total cost per ton figures for trucks 2, 3, 4, and 6 were higher than the average figures given earlier for trucks in the same class. The bulk truck's total cost

Table 10. Tons of feed delivered each month by each truck of a Texas feed mill, July, 1963 through May, 1964.

Month	Type, Size, and Identity of Trucks						Totals for each Month
	Bulk & Bag Trucks (Type III A)					Bulk Trucks (Type IIA)	
	22.5 Ton	22.5 Ton	18 Ton	18 Ton	18 Ton	12.5 Ton	
	1	2	3	4	5	6	
July 1963	291	250	148	20	111	273	1093
August	327	165	77	172	112	203	1056
September	315	257	269	219	206	135	1401
October	317	138	278	234	292	189	1548
November	368	347	41	129	121	349	1355
December	334	399	. .	119	264	398	1514
January 1964	363	268	. .	76	224	279	1210
February	301	208	. .	152	229	269	1159
March	271	230	. .	134	132	98	865
April	218	234	. .	150	22	133	751
May	167	217	. .	78	6	160	628
Totals for each truck	3272	2813	813	1483	1719	2486	

Table 11. Truck capacity utilization, total and net total cost per ton figures for trucks of a Texas feed mill, July, 1963 through May, 1964.

Truck	Truck Identity					
	(Type IIIA)					(Type IIA)
	1	2	3	4	5	6
Tons Per Trip	18.6	18.36	16.54	15.03	12.03	10.97
Percent Capacity Utilization	82.6	81.6	91.9	83.5	68.3	87.8
Total Cost Per Ton	$ 5.90	$ 7.54	$ 7.39	$ 7.75	$ 5.75	$ 5.46
Net Total Cost Per Ton[a]	$ 5.38	$ 7.38	$ 7.30	$ 7.30	$ 5.31	$ 5.44

[a]Backhaul credit subtracted from total cost gives net total cost per ton.

was over two and one half times the average cost figure of $2.00 established by all bulk trucks. The truck delivered 2486 tons of bulk feed during the eleven month period. Thus the fixed cost figure of $1.47 was $0.95 a ton higher than the average of $0.52 a ton for all bulk trucks. Furthermore, the labor cost per ton of $2.27 for this bulk truck was higher when compared to the $0.81 figure for all bulk trucks. The reason for this high labor cost is not known because the hours that the truck was on delivery were not available.

With only eleven months data, no definite conclusions can be made about this firm but a few suggestions can be made. The seasonal nature indicated by the tonnage data on hand leads this author to believe that the firm could reduce its delivery costs by selling at least one more truck, leaving four trucks to deliver the feed. During the season of the year when the feed sales are high, the firm could rent a truck to facilitate the other trucks in feed delivery. The firm owns six trailers which would mean that only a tractor of the tractor-trailer unit would need to be rented. By operating a rented truck during the peak sales season, the firm would not have the investment of an additional truck and could eliminate fixed costs which would be incurred during the eight months of the year when the truck was not needed. Even with four trucks, the firm would have some excess capacity during two or three months of the year.

SUMMARY AND CONCLUSIONS

The increasing volume of feed delivered in bulk each year and the continued use of sacked concentrates points out the importance of the feed delivery operations of a feed company. Because the trend toward the use of bulk feeds is expected to continue, the feed mill managers must direct their attention to their truck delivery operations more than they have in the past.

The truck delivery cost study conducted at Kansas State University indicated that there are economies in bulk delivery operations. The bag delivery trucks and the trucks used for delivering both bulk and bag feed had costs that were higher than the bulk truck costs. A linear relationship was found to exist between the miles that a ton of feed was carried on delivery and the total cost per ton. As the miles per ton figure increases, the total cost per ton also rises.

Considerable variation was noticed from month to month between trucks and even for the same truck. Truck utilization was believed to have been a cause of these variations because the truck's capacity was not utilized in many instances. Furthermore, the trucks were not used during much of the time that they were available for delivery. Trucks not being used efficiently tended to have higher total cost per ton figures than did those that were utilized more efficiently. The case study approach of two feed companies' cost records were used to point out the necessity for efficiency in the delivery operation.

This author believes that many feed companies do not have any idea about what it is costing them to deliver feed. A survey sent out to leading feed manufacturers in Kansas showed that only six out of the twenty-seven reporting kept cost accounting records on their feed delivery operations. If this is representative of the industry as a whole, many feed companies may not be taking advantage of the savings that could be made from more effective truck delivery operations.

BIBLIOGRAPHY

Public Documents

Brensike, V. John, and Askew, William R. Costs of Operating Selected Feed Mills, U. S. Department of Agriculture, Marketing Research Report No. 79, Washington: U. S. Government Printing Office, February, 1955.

Phillips, Richard. Costs of Procuring, Manufacturing, and Distributing Mixed Feeds in the Midwest, U. S. Department of Agriculture, Marketing Research Report No. 388, Washington: U. S. Government Printing Office, April, 1960.

Books

Broehl, Wayne G., Jr. Trucks, Trouble and Triumph. New York: Prentice Hall Inc., 1954.

Conroy, Bernard Fredric. Motor Freight Workshop: Profit Control in the Motor Freight Terminal. New York: Exposition Press, 1952.

Feed Production Handbook. Kansas City, Mo.: Feed Production School Inc., 1961.

Koopmans, T. C. (ed.) Activity Analysis of Production and Allocation. New York: John Wiley and Sons, 1951.

Snedecor, George W. Statistical Methods. 5th ed. Ames: Iowa State University Press, 1956.

Periodicals

Berglund, Roger. "Production, Delivery Cost Data Told," Feedstuffs, (February 23, 1963), 91.

Brensike, V. John. "The Changing Structure of Markets for Commercial Feeds," Journal of Farm Economics, XL, No. 5, (December, 1958), 1201-1210.

Dantzig, G. B., and Ramser, J. H. "The Truck Dispatching Problem," Management Science, VI, No. 1, (October, 1959), 80-91.

Karstens, Jerry. "Feed Trends - Bulk vs. Bagged," Feed Age, XIII, No. 4, (April, 1963), 48.

Mutti, R. J. "Know Bulk Delivery Costs," Bulk Feed and Grain, (March, 1964), 22-23.

Sorenson, V. L., and Hall, C. W. "Efficiency in Distribution of Mixed Feeds. A Study of Bulk Handling Costs," Quarterly Bulletin of the Michigan Agricultural Experiment Station, XXXVIII, No. 3, (February, 1956), 460-470.

Extension Bulletins

Conner, M. C., and Giles, Edward J. Milk Delivery Practices, Alternatives and Costs. (Bulletin 515) Blacksburg, Va.: Virginia Agricultural Experiment Station, July, 1960.

Kelley, Paul L. Cost Functions for Bulk Milk Assembly in the Wichita Market. (Technical Bulletin 96) Manhattan, Kan.: Kansas State College, May, 1958.

Kelley, Paul L. Route Organization and Bulk Milk Assembly Costs in the Wichita Market. (Agricultural Economics Report No. 82) Manhattan, Kan.: Kansas State College, July, 1958).

Rogers, G. B., and Woodworth, H. C. Distributing and Handling Grain Feeds in New Hampshire. (Bulletin 426), Durham, N. H.: New Hampshire Agricultural Experiment Station, July, 1956.

________. Distributing and Handling Grain Feed in New Hampshire, (Bulletin 427), Durham, N. H.: New Hampshire Agricultural Experiment Station, July, 1956.

________. Distributing and Handling Grain Feed in New Hampshire, (Bulletin 431), Durham, N. H.: New Hampshire Agricultural Experiment Station, August, 1956.

Reports

American Feed Manufacturers Association. Annual Report. A Report Prepared by the American Feed Manufacturers Association Feed Tonnage Reporting Service. Table No. 127-R3, February, 1964.

Zusi, Charles J. Economic Factors Affecting Feed Delivery. A Report Prepared by the Research Committee of the Textile Bag Industry. Evanston, 1959.

Personal Interviews

Personal Interview with Harley Donnell, Price Analyst, Central Soya, Fort Wayne, Ind., March 25, 1964.

Personal Interview with Dean Widler, Traffic Manager, Naturich Feed Mills, Abilene, Kan., June 24, 1964.

AN ECONOMIC ANALYSIS OF DELIVERY
OF MANUFACTURED FEED BY TRUCK

by

WILLIAM LARRY JUSTICE

B. S. Kansas State University, 1963

AN ABSTRACT OF A MASTER'S THESIS

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This study had two objectives. The first objective was to point out the variations in costs of delivering feed to the outlets available to the feed manufacturer. The second objective was to illustrate the importance of truck efficiency in feed delivery and to set up guidelines for measuring efficiency of delivery trucks.

The truck delivery cost study was conducted by the grain and feed marketing project at Kansas State University in cooperation with the Midwest Feed Manufacturers Association. Feed companies from the Corn Belt to the Southwest sent to Kansas State University their cost data on forms prepared for this project.

The trucks were classified into two size groups based on rated capacity. Trucks in each size classification were then grouped according to the type of feed hauled. This gave a total of six classes which were as follows: (1) Type I trucks rated under ten tons, hauling bag feed, (2) Type IA trucks rated ten tons and over, hauling bag feed, (3) Type II trucks rated under ten tons, hauling bulk feed, (4) Type IIA trucks rated ten tons and over, hauling bulk feed, (5) Type III trucks rated under ten tons, hauling both bulk and bag feed, and (6) Type IIIA trucks rated ten tons and over, hauling both bulk and bag feed.

Bulk trucks in both size classifications had the lowest cost per ton figure for delivering feed. The Type I trucks accumulated the highest cost. The difference was attributed to the characteristics of the market area served by the trucks. The bulk trucks did not carry the feed as great a distance as did the Type I trucks.

Labor costs accounted for nearly half of the total cost per ton for feed delivery. Fixed costs contributed to approximately one-fourth of the total cost and operating and repair costs were third and fourth, respectively.

Regression analysis showed that there was a linear relationship between cost per ton (Y) and miles per ton (X). The cost per ton variable rose as the miles per ton variable increased.

Cost records of a Kansas feed mill were used to show that the cost per ton figure varied each month for the same truck. Also, delivery costs for trucks in the same classification differed from one another during the same month. The monthly variations were due in part to the changes in the miles per ton variable.

Case studies were made on the records of the Kansas feed mill mentioned above and a Texas feed mill's records to show the importance of truck efficiency in reducing delivery costs. Two factors were considered for an efficient truck delivery operation. These were: (1) capacity utilization, and (2) time utilization. Capacity utilization referred to the truck's capacity that was used each time the truck was sent out on a delivery trip. Time utilization was the amount of time that a truck was used during a specified time for feed delivery. The trucks of both firms that were utilized more efficiently had the lower feed delivery costs. The trucks with the lower costs were used as a standard to show that a savings in cost could be made if all of the trucks were operated as efficiently. Particular attention must be given to the scheduling of feed deliveries by truck if the costs are to be reduced.