COSTS AND CHARGES FOR BULK MILK ASSEMBLY
IN THE OKLAHOMA CITY MILK SHED

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Submitted to the Faculty of the Graduate School of
the Oklahoma State University
in partial fulfillment of the requirements
for the degree of
DOCTOR OF PHILOSOPHY
May, 1959

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ACKNOWLEDGMENT

The author wishes to express his sincere appreciation to the Department of Agricultural Economics, Oklahoma State University, Stillwater, Oklahoma, for making this study possible.

Special recognition is given to Professor Leo V. Blakley for his unselfish use of time spent in assisting and supervising this problem, and for his timely encouragements throughout the graduate program.

Appreciation is extended to Professors Leonard F. Miller, Adlowe L. Larson, Julian Bradsher, and Franklin A. Graybill for their helpful suggestions, guidance, and constructive criticisms in developing the graduate program and assisting with this study. Also, appreciation is given to Professor Nellis A. Briscoe for the time spent in reading and commenting upon the manuscript.

Acknowledgment is made of the assistance given by the secretarial and statistical staff of the Department of Agricultural Economics, and to Mrs. Gwendol Martin for her patient cooperation in typing the final manuscript.

Special recognition is given to the author's wife, Mariana, who provided encouragement and a happy home environment during the course of graduate studies and to the author's mother, Mrs. Lena Rogers, who provided much valuable assistance.

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INTRODUCTION

Bulk milk assembly is one of the more important changes in the dairy industry since 1940. It is increasing in importance in Oklahoma as well as in other areas of the United States and the rate of adoption of this new technique has been very rapid. It has been estimated that in 1958, bulk milk shipments will exceed can shipments in all U.S. Federal Order markets.

In Oklahoma, the bulk milk tank truck is rapidly displacing the conventional can milk truck. The first farm bulk tank truck was used in 1954. By 1957 bulk tank trucks were picking up milk from some producers in each major Oklahoma milkshed.

The transportation of bulk milk grew from the conventional can type transportation. Consequently, methods which were familiar in conventional can type transportation were utilized in the hauling of bulk milk. This created many new problems. One of the major problems is an equitable pricing system. A second major problem concerns the efficiency with which the milk is hauled from the producer to the processing plant. Other problem areas include sanitation, quality, and economic relationships.[1]

This study is concerned primarily with the cost and pricing problems of bulk milk transportation which face the producers and cooperative

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[1] Sydney Ishee, The Impact of Bulk Handling on the Market Milk Industry, Pennsylvania University Agricultural Experiment Station Paper No. 2053 Journal Series (University Park, Pennsylvania, May, 1956) p. 20.

officials of the Central Oklahoma Milk Producers Association. Cost and pricing information obtained from this study may be useful in indicating the means whereby efficiencies may be made in the bulk milk transportation service for producers and firms in Oklahoma. The specific areas under consideration are:

1. The costs incurred in the transportation of milk under varying conditions;
2. Alternative and equitable pricing systems for the service of bulk milk transportation.

BULK MILK ASSEMBLY

Development of Bulk Milk Assembly

United States

The use of enclosed tanks for bulk milk pickup at the farm is one of the major changes which the dairy industry has undergone during the past century. This method of milk assembly was introduced in California in 1939. The change has occurred during an era of improved breeding of cattle, better methods of herd management, more emphasis on quality control and improvement in the distribution and marketing of milk. The bulk milk industry has become important not only to producers, but to handlers and haulers of milk, bulk tank manufacturers and dealers, processing plants and trucking industries in all parts of the United States.

Conservative estimates show that there has been a major increase in bulk milk shipping during the past few years. A mail survey by Cowden covering the entire United States, except California and Florida, indicated that the milk producers and milk receiving plants were continuing to convert to bulk tank operations at a rapid rate.[1] The estimated number of bulk milk shippers was 17,720 in March, 1955 as compared with 6,150 in May, 1953. This indicates that there was an increase of approximately 188 percent in the number of bulk tank shippers in less than two years.

[1] Joseph M. Cowden, Bulk Milk Handling in 1955, United States Department of Agriculture Farmer Cooperative Service General Report 22 (April, 1956), pp. 1-4 and 27.

The survey indicated that the average bulk milk shipper sent 846 pounds of market milk daily to the market. The average can shipper sent 459 pounds of milk daily. This would indicate that there was a direct relationship between the size of operation and use of bulk tanks. Approximately the same relationship held for ungraded milk where the average bulk tank producer shipped 505 pounds of milk daily and the can producer shipped 249 pounds of milk daily. Bulk producers constituted 19.1 percent of the total number of producers and shipped 30.4 percent of the milk. Can producers totaled 80.9 percent of all producers but shipped only 69.6 percent of the milk.

The majority of the bulk milk was hauled in bulk trucks owned either by contract haulers or by the dairy plants receiving the milk. Some milk was hauled by trucks owned by cooperative bargaining associations. There were 231 firms which reported a total of 600 trucks operating in bulk milk hauling. The alternate or every-other-day pickup was the dominant practice in the Pacific Northwest, West North Central, and New England states. The East North Central states, in the vicinity of Chicago, were on a daily route basis because of the regulations imposed by the Chicago market area.

Each bulk tank truck hauled an average of 1.36 loads of milk per day. This meant that about one-third of the trucks were hauling more than a load per day since some trucks were on an alternate day basis.

Producers delivering bulk milk to the reporting firms were paying substantially lower average hauling rates than producers shipping in cans. In addition, bulk milk producers generally received premiums for the bulk milk over the comparable grade in cans. The major reason for the lower hauling rates was that the producers using bulk services were large, low-hauling-cost producers. The practice of charging producers a flat rate for hauling was more common for bulk than for cans.

Oklahoma

Bulk tank usage has increased tremendously in Oklahoma since the date of the first installation on June 5, 1954. At the close of 1956, there was a total of 402 milk producers shipping bulk tank milk. These producers shipped bulk milk to three centers within the state.

The first firm to initiate bulk milk operations was Bolton's Dairy at Chickasha. The first bulk tank in this milkshed was installed June 5, 1954, and producers were encouraged to change to the bulk tank. The market was small and producers made the change very quickly. During the month of June, 1954, 68,590 pounds of milk were shipped. Within four months the Bolton's Dairy received milk from bulk milk producers only. By December, 1956 a total of 435,165 pounds of bulk milk was received. The total bulk milk receipts for 1956 amounted to 4,724,556 pounds (Appendix Table I).

The Central Oklahoma Milk Producers Association began bulk milk pickup operations in the Oklahoma City milkshed on May 7, 1955. The trend toward increased use of bulk tanks was sharply upward and as of December 31, 1956 about 263 producers owned bulk tanks. During the month of December, 1956, 19.37 percent of all producers shipped 32.49 percent of all milk handled in the Oklahoma City milk marketing area. This represented 5,911,337 pounds of bulk milk out of a total of 18,195,269 pounds of milk. The annual totals indicated that bulk milk represented 12.32 percent or 46,732,376 pounds out of a total of 201,824,343 pounds (Appendix Table II).

Data obtained from the Pure Milk Producers Association of Eastern Oklahoma indicated that as of December 31, 1956 about 105 producers owned bulk milk tanks. This represented 8.31 percent of all the producers within the milkshed and 17.44 percent of the milk. Only seven months earlier, producers delivered 1,258,763 pounds of bulk milk, or 6.27 percent of all milk delivered in the milkshed. Eight month totals indicated that 17,068,709 pounds or 11.8 percent of all milk was bulk milk (Appendix Table III).

The consolidated data for the three markets indicate that the bulk tank industry has made a tremendous growth in approximately two and one-half years. During December, 1956, 402 producers were shipping 9,650,276 pounds of bulk milk. This was 25.70 percent of all milk marketed. As an average for the period June 5, 1954 to December 31, 1956, about 17.67 percent of all the milk marketed in the combined markets of Chickasha, Oklahoma City and Tulsa was bulk milk (Appendix Table IV).

All of the bulk milk shipped in these markets was hauled in trucks owned by the Associations and the dairy. The every-other-day pickup was the common practice although there were certain times when it was necessary that more than one route per day or every-day pickup be done. This was the exception rather than the rule.

Producers served by the Central Oklahoma Milk Producers Association were paying a flat rate of 25 cents per hundredweight for the period May, 1955 to April 1, 1956. This rate was used regardless of the distance from the processing plants or from the Association headquarters. However, after April 1, 1956 zone pricing has been used in the establishment of transportation rates for milk from grade A producers.

Cooperative Bulk Milk Assembly in Oklahoma

The Central Oklahoma Milk Producers Association consists of many producers banded together to form a "bargaining cooperative." The primary function of this Association is to obtain "acceptable prices" for the fluid milk through bargaining with the individual processing plants. However, the Association also performs a limited number of marketing functions characteristic of a marketing and purchasing cooperative.

One function that the Association may perform for a producer is to increase marketing efficiency. Efficiency may be defined as any act which will increase services rendered at the same cost or decrease the costs for the same services rendered. Larson states:

> Society is interested in having the total of marketing and other production costs at a minimum within some limits. Before society can get these low costs, however, it is necessary that individual marketing firms operate effectively. There is, therefore, a continual effort on the part of marketing as well as other business firms to reduce costs of providing present services, by such means as increasing volume so as to get the benefits of decreasing per unit costs, and bringing about a better combination of factors of production used. The firms practicing these measures tend to locate in areas that permit them to operate at the lowest costs, for if they did not, other firms might do so and thereby gain competitive advantage. The individual firm, considering all these costs, tends to operate at a point where marginal costs are equal to marginal revenue - where the extra total cost of doing an extra unit of business is equal to the extra total revenue received.
>
> Costs of marketing firms are reflected to consumers or society in varying degrees. Under highly competitive conditions, consumers will get goods near the cost level. Under monopolistic conditions, however, this will probably not be true, because of monopolistic profits, failure to adopt efficient practices, and failure to provide goods and services most wanted. Even a monopolist, however, reflects part of the cost savings he makes to society in his effort to maximize his profits.[2]

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[2]Adlowe L. Larson, Agricultural Marketing, New York: Prentice-Hall, Inc., 1951, pp. 391-392.

The technological development of bulk tanks has permitted the Association to expand the area in which operations may result in increased efficiency. Apparently efficiency in transportation has been increased and savings to producers have been realized. One of the primary incentives for adoption of the bulk tank system on farms in Oklahoma has been the reduction in the cost of transportation.

Many Oklahoma milk producers marketed their grade A milk in cans prior to the bulk tank innovation. The cans were loaded at the farm and hauled to the processing plant by private haulers in 10-gallon cans. The principal difference in the bulk tank and can methods is that of frequency of delivery. Milk in cans must be picked up daily while bulk milk may be picked up every-other-day. Under the can system the drivers unload previous days empty cans at the farm and load the full cans. A study by the Oklahoma State University Dairy Department indicates that the time required for loading cans makes the total time of pickup longer than for the bulk system.[3] Comparable average times at the dairy farm indicate 28.0 minutes for bulk and 137.0 minutes for cans.

There is also the possibility of a reduction in the loss to the farmer of milk which sticks to the cans. The Oklahoma study indicates that the butterfat loss for cans in delivering 100 pounds of milk per day averaged 0.320 pounds. Average losses to the farmer based on 1954 prices would be $50 to $60 per year. The Delaware Experiment Station reported

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[3] P. E. Johnson, H. C. Olsen, and R. L. Von Gunten, A Comparison of the Bulk and Can Systems for Handling Milk on Farms, Oklahoma State University Agricultural Experiment Station Bulletin No. B-456 (Stillwater, Oklahoma, August, 1954), p. 10.

a loss of 0.478 pounds per 100 pounds shipped.[4] This would result in larger annual losses to the farmer.

The Central Oklahoma Milk Producers Association has a great potential for increasing marketing efficiency through bulk milk assembly. In most cases the individual farmer represents only a small segment of the industry. He contracts with a private milk hauler to transport his milk to the distributor's plant. Economies of scale may be such that farmers acting cooperatively can approach the optimum scale for the hauling enterprise.[5] If a group of farmers through a cooperative could purchase the required equipment to transport milk for several individuals, then one segment of the cost schedules might be altered and transportation costs reduced. This would be particularly true if the cooperative action could attain added flexibility of being able to switch producers from one route to another.

Theoretically, with added flexibility and increased efficiency, costs would be lower for the cooperative bulk milk handling method than for the private can type method. The equilibrium conditions for this comparison are illustrated in Figure 1. For the can method of daily pickup, AC_1 and

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[4] T. A. Baker, W. E. McDaniel and B. L. Bondurant, Milk Handling - Can or Bulk Tank? Delaware University Agricultural Experiment Station Circular No. 29 (Newark, Delaware, May, 1954), pp. 4-5.

[5] Optimum scale of plant. An optimum scale of plant is one in which the short-run average cost curve forms the minimum point of the long-run average cost curve. It can also be thought of as the scale of plant with a short-run average cost equal to the long-run average cost at the minimum point of both curves. See Richard H. Leftwich, The Price System and Resource Allocation, Rinehart and Company, New York, 1955, p. 155.

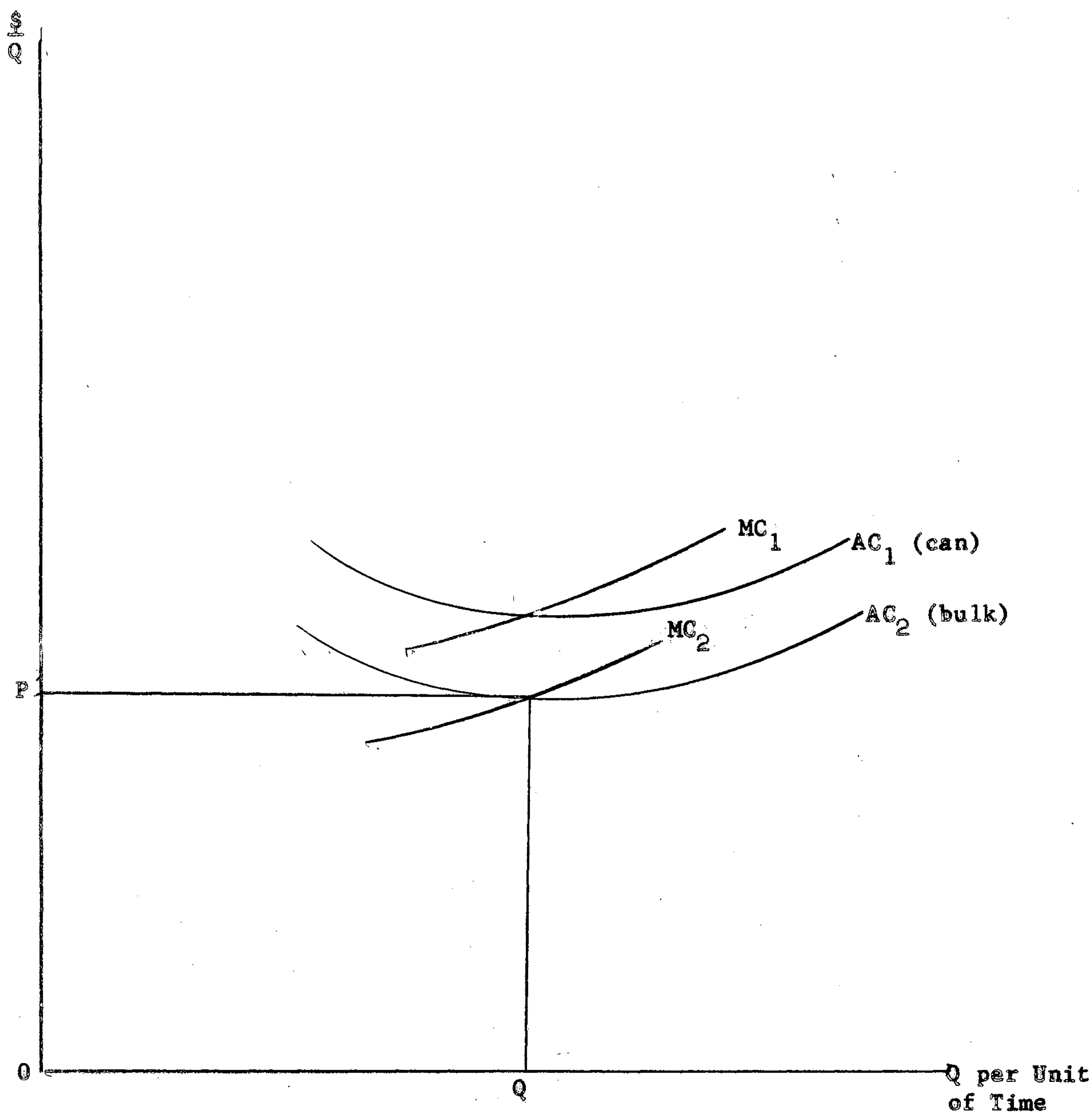

Figure 1. Hypothetical Marginal and Average Cost Curves for "Can" and "Bulk" Milk Assembly

MC_1 would represent average costs and marginal costs respectively for various levels of output under one organizational level. AC_2 and MC_2 would represent average and marginal costs respectively for various levels of output under the bulk tank method of pickup. Of course, this organizational level for the bulk tank method may or may not be the most efficient long-run organizational level. To the extent that economies of scale exist for the new method, long-run average costs could be reduced by a larger scale of operation. In this case AC_2 and MC_2 would represent only short-run average and marginal costs.

Efficiency in present bulk milk assembly methods by the Central Oklahoma Milk Producers Association might be increased by one of several ways. First, the average cost for hauling milk might be reduced with increased volume. This will establish rules for growth. The Association should be interested in producing to the point where marginal cost equals marginal revenue. Under pure competition, this operation will result in production at the point where average cost equals average revenue. A second method of increasing efficiency is by making the milk pickup operations more effective by lowering the costs on present operations. Effective operation might encompass less man minutes required for bulk milk pickup or it might include a rerouting concept. Substantial savings in time and labor may result in lower marginal costs, and in lower average costs. Third, route time may be saved through improved bulk milk pump-out facilities at the processing plants. Inefficiencies exist and additional time is required because of poor facilities, poor equipment and poor unloading arrangements. Savings would result in a more effective marketing of milk. If the average costs are reduced under any of these methods, savings may be passed to the producers in the form of patronage refunds or reduced hauling charges.

Effect of Reduced Hauling Charges

The milk price received by farmers in the Oklahoma City milkshed is determined under Federal Order according to certain formulas subject to bargaining between the Association and the distributor. This price is determined each month for the various classes of milk delivered to the plants. If, for example, a price of $5.00 per hundredweight were set on Class I milk, this would mean that the farm price should be $5.00 per hundredweight minus the cost of transportation. If the farmer pays 40¢ per hundredweight for can type transportation, his returns would be $4.60 as illustrated in Figure 2. The area (.40) Q represents the cost of hauling milk by cans which the producers must bear.

If cooperative action in transportation of milk could lower transportation costs, the milk producer would receive a higher net price for milk. Thus, increased marketing efficiency could be passed directly to the farmer. For example, if the cooperative were able to effectively lower the average hauling cost to 25¢ per hundredweight, then the price received by producers would increase to $4.75 per hundredweight.

In the long run, producers will not continue to supply the same quantity of milk. Therefore, they will not obtain the full benefits of the reduction in the cost of the transportation services. To illustrate, assume that the demand for milk at the processor level is D_p in Figure 3 and that transportation services have a horizontal supply curve at T_1 cents per 100 pounds. Initially, quantity Q_1 is supplied by producers at price P_1 and they receive price P_2 ($P_1 - T_1$). The equilibrium position

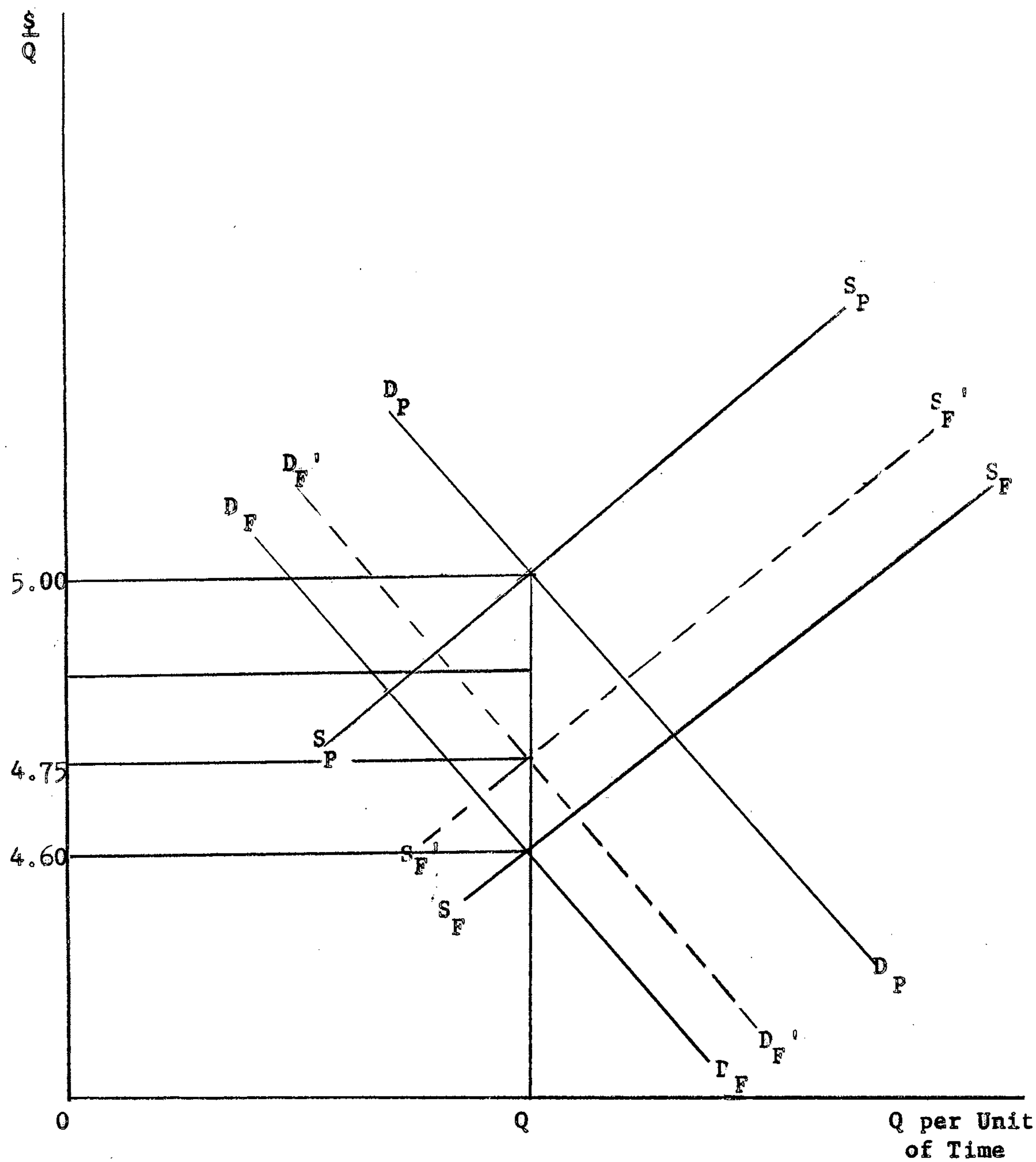

Figure 2. Hypothetical Short-Run Effects of Varied Transportation Costs on the Price of Milk at the Farm

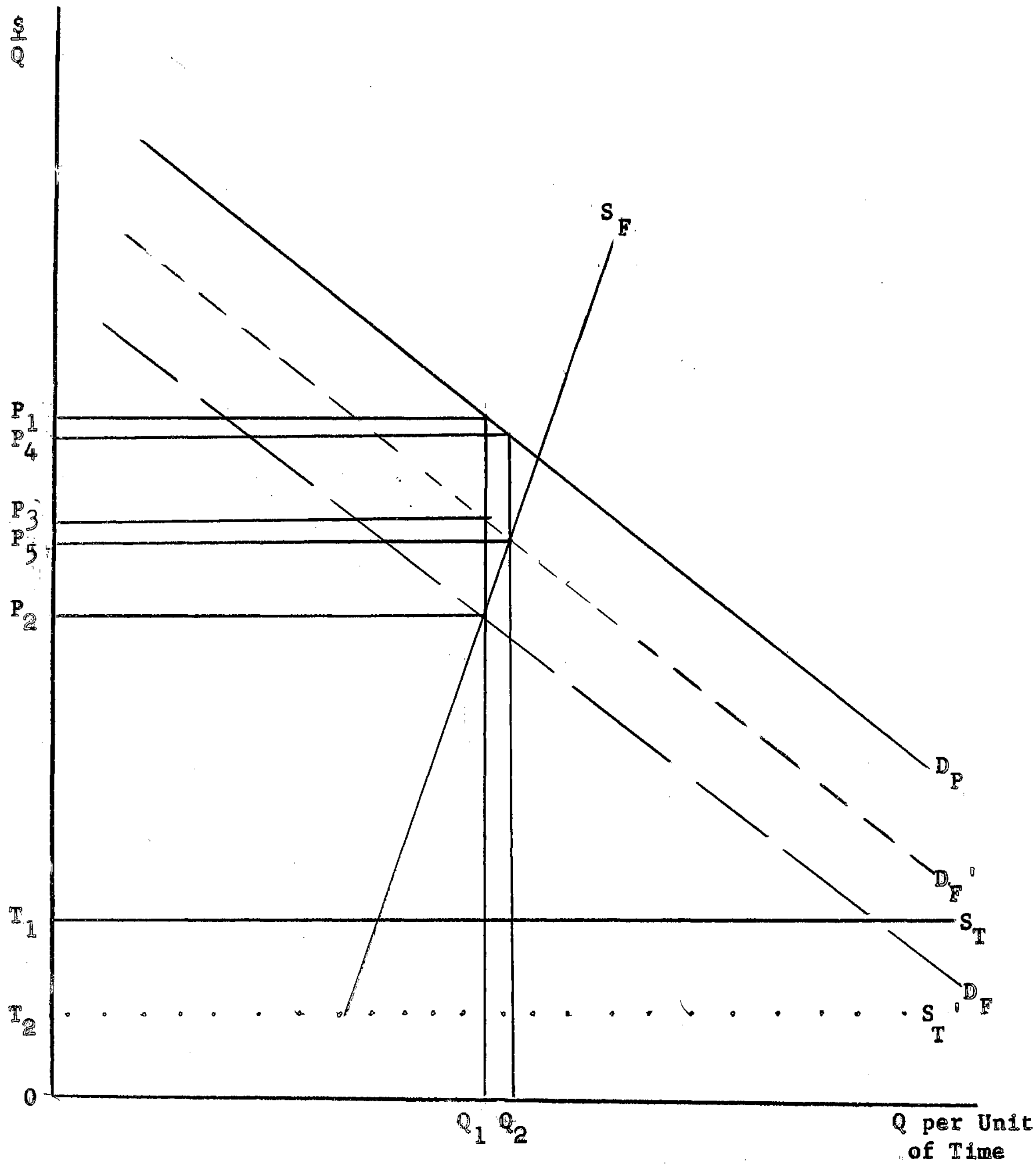

Figure 3. Hypothetical Supply and Derived Demand Relationships for Milk at the Farm

is at the intersection of S_F and D_F, the supply of milk and the demand for milk at the farm respectively.

If the cost of the transportation service is decreased to T_2, the new demand schedule for milk at the farm will be D_F' and the price of milk at the farm will increase to P_3 for quantity Q_1. This higher price will provide the incentive for expansion of production. At the new equilibrium position quantity Q_2 will be supplied by producers. For this quantity processors will pay price P_4 and producers will receive price P_5.

Under purely competitive conditions, both consumers and producers would benefit from the reduction in the cost of the transportation service. The magnitude of the share of benefits accruing to each group will depend on the elasticity of demand and the elasticity of supply. If the elasticity of demand is high relative to the elasticity of supply, then the larger share of benefits would accrue to producers.

Market Control

Bulk milk assembly by the cooperative association also has implications for market control. The Association has the power to market patron milk at the highest possible prices.

In the milk industry in the Oklahoma City area, the processors are few in number and have differentiated products. This means that each processor has some control over both the price he receives for his product and the price that he pays for the raw product. In economic terminology, each processor faces a downward sloping demand curve and marginal revenue curve. In addition, each processor faces a supply curve and a marginal resource cost curve which slope upward with increasing purchases. Marginal resource cost can be defined as the increase in a given firm's total cost which results from the purchase of an additional unit of a resource per unit of time.[6]

The producers acting cooperatively can affect the amount of profit earnings by bargaining or by control over the quantity of milk. Through joint action, the supply curve can be transformed in such a manner that at least a portion of the curve can have a horizontal segment. For example, producers could bargain through Federal Order pricing procedures for price OE in Figure 4 and supply only that quantity which could be sold at that price. This price may represent the minimum Federal Order price or the minimum Federal Order price plus a premium. The supply curve then would be EFGS. The marginal resource cost curve would be identical with the new supply curve, from point E to point G, be discontinuous at point G, and be identical with the original marginal resource cost curve for quantities greater than Q_2.

This action might necessitate the withholding of milk from distributors in an attempt to achieve the higher milk prices to producers. To this extent, the cooperative association may be able to partially offset the potential monopsony powers of distributors. Bulk milk assembly by the cooperative may contribute to increased producer control over quantity when it is the only firm transporting member patron milk and when the volume of bulk milk is large. Bulk milk may be easily moved from one market to another with only minimum extra loading time and expense.

The net result of the withholding action would be to increase the price received by farmers for milk for aggregate quantities up to Q_2. At quantity Q_1, for example, there would be an increase in the quantity of

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[6] *Ibid.*, p. 299.

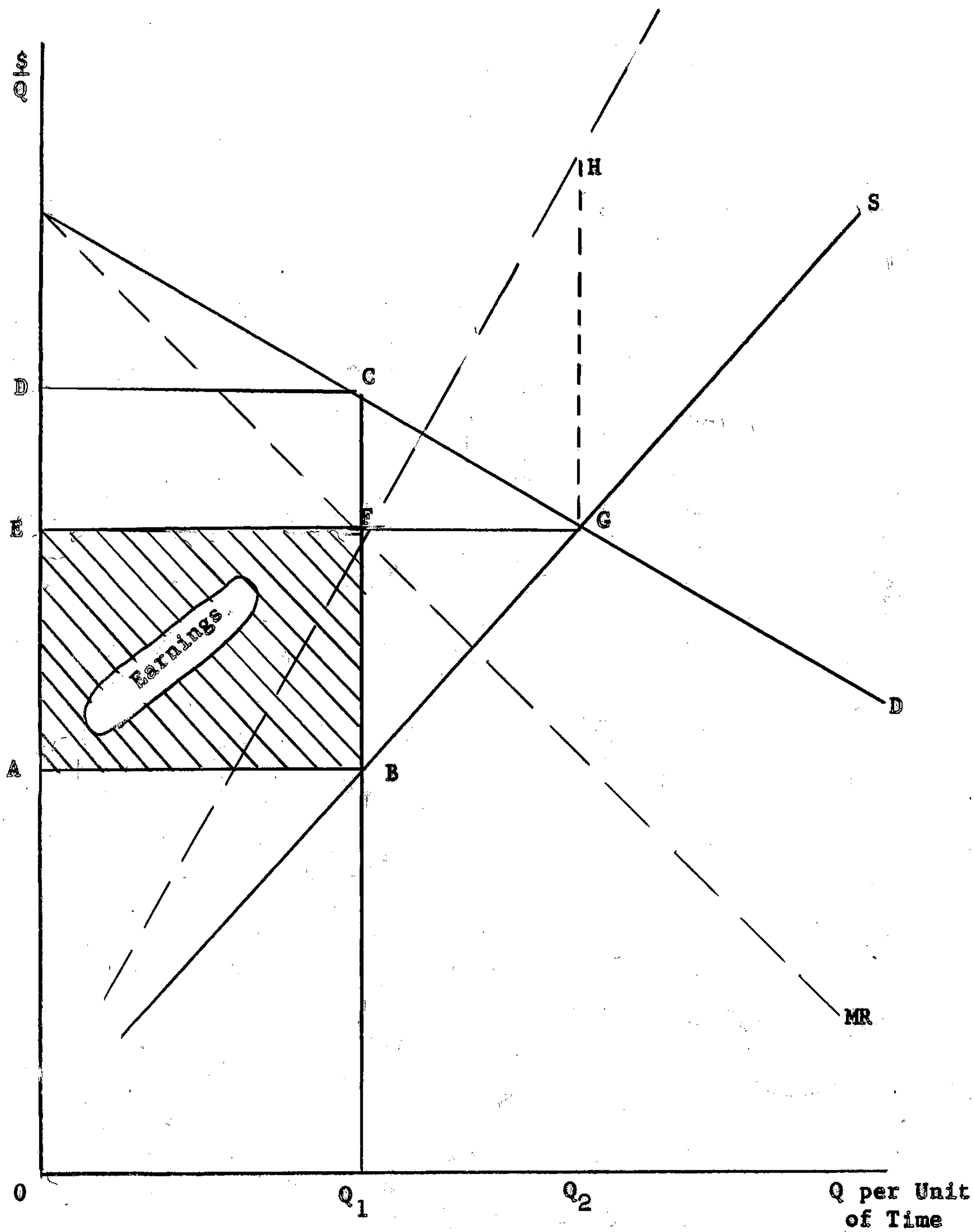

Figure 4. Hypothetical Marginal Revenue and Marginal Resource Cost Curves for a Monopolist-Monopsonist

milk supplied and a higher price paid to producers but the monopsonistic profits represented by the area ABFE would be eliminated. The quantity Q_1Q_2 would have to be diverted by the bargaining association to uses other than Class I in this market.

In Professor Leftwich's discussion on this point, the conclusion was reached that if prices were established between A and E that monopsony would be offset to some extent but not completely. The closer the fixed price approaches E the smaller the monopsony profits. Prices higher than E will result in counteraction of the monopsony profits but a quantity smaller than Q_1 would be sold as Class I. The quantity of milk produced will be greater than the quantity purchased by milk processors under these conditions.

Review of Selected Studies on Bulk Milk Assembly

Most early studies of the costs associated with bulk tank transportation of milk have been devoted to a comparison of the costs of transportation by bulk tank trucks with can type trucks. One of the first studies on the comparative costs of bulk versus can transportation of milk was completed by Clarke in 1947.[7] This study indicated that collection costs were reduced by bulk tank transportation of milk. Clarke also pointed out developments which appeared to bring about further reductions in the cost of milk distribution through the bulk tank method of milk assembly.

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[7]D. A. Clarke, Jr., A Comparative Analysis of the Costs of Operation of Milk Collection by Can and by Tank in California, Giannini Foundation of Agricultural Economics Mimeographed Report No. 91 (Berkeley, California, October, 1947), p. 1.

A comparative analysis of can and bulk tank assembly of milk was conducted in the state of Washington by Baum and Pauls. This study indicated that total truck operating costs, on a route-mile basis, were similar for the 1,500 gallon tank trucks and the 2 1/2-ton van type can pickup trucks.[8] Also it cost approximately 5 cents more per route-mile to operate a 2,500 gallon tank truck than a 1,200 gallon can truck. The analysis of operational costs under various route conditions indicated lower per hundredweight costs when all milk was collected on alternate days by tank trucks relative to the daily procurement of milk in conventional 10-gallon cans.

In 1954 the Farmer Cooperative Service of the United States Department of Agriculture published a report of bulk milk handling.[9] This study indicated that price premiums and hauling savings through bulk milk shipping brought average direct monetary benefits of slightly over 12 cents per hundredweight of milk to producers at 72 reporting plants. Also, payments by plants to producers of a price premium or "bonus" for farm tank milk not specifically related to quality was found to be a common practice. About 45 percent of all plants reported such price premiums in effect. An additional, or in some cases an alternative, monetary incentive of reduced hauling charges was offered producers by dual-receiving plants.

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[8] E. L. Baum and D. E. Pauls, A Comparative Analysis of Costs of Farm Collection of Milk by Can and Tank in Western Washington, 1952, Washington State University Agricultural Experiment Station Technical Bulletin No. 10 (Pullman, Washington, May, 1953).

[9] Noel Stocker, Progress in Farm to Plant Bulk Milk Handling, Farmer Cooperative Service, United States Department of Agriculture Circular 8 (November, 1954).

About 75 percent of reporting plants indicated that this was a common practice.

In July of 1957, Donald B. Agnew of the United States Department of Agriculture reported that with the introduction of bulk tanks, the customary tasks and their accompanying costs are redistributed among milk dealers, haulers and farmers.[10] This study indicated that bulk milk assembly results in generally lower hauling costs. The savings on a typical tank milk collection route result from larger load capacity, hauling more than one load daily, picking up larger loads of milk per farm, or picking up the milk every other day. In addition, he estimated that overall savings in milk assembly costs for the United States would be approximately $5 to $12 million annually when the development of bulk assembly farm-to-plant reaches its peak and levels off.

In October of 1955, a study of farm-to-plant bulk handling of milk by Miller of the University of Wisconsin was published.[11] He reported that bulk handling offered many plants the opportunity to reduce the cost of assembling milk from their patrons, especially when alternate day pick-up was possible. Under conditions then current, he found that route costs would be increased by bulk handling in most sections of Wisconsin under daily pickup. He felt that it was necessary that a premium be paid for

[10]Donald B. Agnew, How Bulk Assembly Changes Milk Marketing Costs, United States Department of Agriculture Market Research Report No. 190 (July, 1957), pp. iii-iv.

[11]Arthur H. Miller, Bulk Handling Wisconsin Milk - Farm to Plant, Wisconsin University Agricultural Experiment Station Bulletin No. 192 (Madison, Wisconsin, February, 1956).

bulk milk above the can milk price unless the producers and the haulers were willing to accept lower incomes in return for lighter work.

In 1950, an analysis of hauling charges, route returns, and route costs on 364 milk assembly routes was made by Walter P. Cotton. Assembly routes were duplicated by different trucks hauling to different companies and by individual producers hauling their own milk to market.[12] Hauling rates for both winter and summer tended to be constant. One of the recommendations made was that the supply territory should be reallocated so that milk not needed for fluid milk purposes in the flush season will not be transported unnecessary distances.

T. Burress, manager of the Tank Division of the Heil Company was the author of an article published in 1953, dealing with the entire bulk pick-up system of marketing milk. He concluded that one of the criticisms of the bulk milk industry was the method of determining the amount of milk in a farm holding tank.[13] He maintained that the reading from the calibration stick might vary depending upon the milk temperature and the milk solids content. Another criticism leveled against the bulk milk industry was the unsanitary nature of the use of the calibration sticks, the ladles, and the plastic hoses. He also discussed factors which should be considered in the selection of a farm cooling tank and a bulk pickup tank.

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[12] Walter P. Cotton, Milk Hauling Rates and Problems in North Carolina, North Carolina State University Agricultural Experiment Station AE Information Series 28 (Raleigh, North Carolina, December, 1950), pp. 8-9.

[13] Tom Burress, The Bulk Farm Pick-Up System of Marketing Milk, The Heil Company (Milwaukee, Wisconsin, 1953), p. 27.

Cowden of the Farmer Cooperative Service of the United States Department of Agriculture found that the substitution of the bulk milk procurement method for can type hauling offers opportunities for substantially reduced farm-to-plant milk transportation costs in many fluid milk markets.[14] The study indicated that savings probably will be realized only when bulk tank trucks serve each farmer every other day since time required per stop is greater under the bulk system. The average farm stop time on two bulk routes was 6 to 8 minutes per loading stop plus 0.35 minute per hundredweight of milk loaded while can type pickup was 1.45 minutes per loading stop plus 0.46 minute per can loaded. Thus the time requirements were greater for bulk milk pickup unless the every-other-day pickup is used.

In addition, Cowden found that bulk handling costs compared with can hauling costs were lower on long routes than on short routes. Potential savings were greatest when relatively large producers were served by bulk routes. Substantial savings were possible, however, when the average daily production per farm ranged from 300 to 500 pounds, a level typical of fluid milk markets in 1956. He estimated that with volumes averaging 600 pounds or more a day on alternate day bulk routes, the estimated savings in hauling over a 15-year period would more than repay producers for the added costs resulting from conversion to bulk tanks.

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[14] Joseph M. Cowden, Comparing Bulk and Can Milk Hauling Costs, Farmer Cooperative Service, United States Department of Agriculture, Circular 14 (June, 1956), p. v.

Ishee and Barr of Pennsylvania State University recently completed a study which was primarily an analysis of bulk tank costs to farmers.[15] An attempt was made to determine the size of herd necessary to pay for conversion to a bulk tank. They found that added costs of changing from customary can cooling to bulk handling of milk were greater than added returns for most farmers in the Pennsylvania area. Their study was based on the assumptions of no premium for bulk milk and no additional returns to the producer because of reduced hauling costs for bulk milk.

Those individuals in the Pennsylvania area who adopted the bulk tank, despite added costs, did so because the decrease in revenue was a smaller reduction than going out of the dairy business. Other individuals did not adopt the bulk tank because their net incomes would be reduced less by shifting resources out of dairy into other farm enterprises or non-farm occupations.

The study indicated that no time was saved in the dairy chores. However, bulk handling may allow women and children to manage a dairy enterprise since it eliminates lifting heavy weights associated with milk in cans.

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[15] Sydney Ishee and W. L. Barr, Economics of Bulk Milk Handling, Pennsylvania University Agricultural Experiment Station Bulletin No. 631 (University Park, Pennsylvania, March, 1958).

METHOD OF ANALYSIS

Both accounting data and time and motion data were used in an attempt to determine the costs of bulk milk transportation in the Oklahoma City milkshed. Generally, the time and motion data obtained during the sample period were used as a basis for allocating the annual cost data to specific functions performed.

The accounting data were obtained from the 1956 audit report and the individual monthly reports as published by the Central Oklahoma Milk Producers Association. These data included total mileage, total pounds, total cost, and gross income figures.

The time and motion data were obtained by surveyors who rode with 11 drivers on 14 different milk routes on 44 route days during the summer of 1956. Each operation performed by the driver was timed on each of the survey routes. The times for the various operations were grouped according to the following functions: (1) check-in, (2) driving, (3) farm stops, (4) unloading and testing milk, (5) clean-up and check-out, and (6) miscellaneous functions.

Specific analyses were made of the time used in performing each of these functions.

Basic Model

Check-in Time

The normal procedure for the check-in operation was to check the oil and water in the truck and start the motor. After the motor was warm, the truck was driven to the driveway adjacent to the Association headquarters. The inside of the tank was then sterilized by a spray of disinfecting solution. The next operation concerned the pump. The pump was assembled and sterilized by pumping a chlorine solution through the pump into the tank and then back from the tank.

The next operations performed in check-in were to get ice for the milk sample box, check the supply racks for potential delivery of supplies and obtain sample bottles.

The nature of the operations performed under this function suggests that check-in time may be a function of the fixed operations plus waiting time as follows:

$$T_1 = f(I_1, W_1) \quad (3.1)$$

where

I_1 = average time for performing the fixed operations,

W_1 = waiting time.

Driving Time

Total driving time will vary with many travel conditions. However, in this study driving time was assumed to vary as follows:

$$T_2 = f(D, G, R, C, V) \quad (3.2)$$

where

D = distance traveled,

G = geographical area,

R = road classification,

C = road condition, and

V = relative size of load.

The analysis of driving time involved many subjective evaluations. The actual procedure was to stratify the roads according to geographical location, type, and condition.

With respect to geographical location, an attempt was made to test the hypothesis that there was a difference in the roads between the eastern and western half of the Oklahoma milkshed. A line due north and south was drawn through Oklahoma City upon a map. All the roads which fell on the eastern side of this line were classed as eastern and all roads on the western side of the line were classed as western roads.

Within each geographical location the roads were classified according to the following types: highway, gravel, and dirt. A highway was defined as a hard surfaced road consisting of an asphalt or concrete base. A gravel road was defined as one with some form of special rock or other material placed on the surface to make it an all weather road. A dirt road was defined as a road of any other type and usually could not be considered as an all weather road.

Each different road type was then classified according to condition. The classifications were good, fair, and poor. Each classification of road condition was made by the enumerator in consultation with the driver as the road was traversed. The classifications attempted to cover the roughness of the road and the ability of the driver to maintain a desired speed consistent with proper care of the equipment.

Farm Stop Time

Within the farm milk parlor each driver performed a number of basic operations. The first duty performed was to remove the plastic milk hose from the truck and connect it to the bulk tank. Concurrent with this operation the driver generally unreeled the electric cord from the rear of the truck and placed the plug in near the electric receptacle provided by the farmer in the milk storage parlor.

Normally the second operation performed was to weigh the milk.[1] This was done with the use of a special calibrated stick and a special capacity chart for each individual bulk tank. The calibration stick indicated the height of the milk in inches with measurements as fine as 1/16 or 1/32 of an inch. The reading of height was converted to pounds by finding equivalent values expressed in the chart.

The third step was to turn the agitator on and allow the milk to become thoroughly mixed. Agitation of at least one minute usually was necessary. The fourth step was to sample the milk. The sample was obtained by dipping the ladle into the milk. Two ladles of milk were obtained from two separate parts of the tank and placed in a sample bottle marked with the producer's can number. Later the sample was placed in the iced sample box located in the rear of the truck.

The fifth step was to pump the milk from the farm tank into the tank truck. The sixth step was to write the ticket. This step was performed concurrently with the pumping of the milk if the number of pounds were large enough. If not, the writing of the ticket usually occurred before the milk was pumped out.

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[1]The normal sequence was as follows: hook up the hose and cord, weigh the milk, agitate the milk, sample the milk, write the ticket, and pump the milk into the truck tank. An abnormal occurrence often altered the normal sequence, for example, if the agitator were on the sequence might become: sample the milk, hook up the hose and cord, allow the milk to settle, weigh the milk, write the ticket and pump out the milk.

The seventh step was to unhook the hose and electric cord and replace them in the tank truck. The final step was to rinse the farmer's tank with lukewarm water. This operation was performed to prevent milk solids from drying on the tank and to aid in the prevention of milk stone.

The procedures followed by the drivers in performing the various operations were standardized but time used in each operation varied from driver to driver. Differences between drivers in the performance of these operations will be discussed in the following chapter.

The total time at farm stops per route, averaged for all drivers, was defined as follows:

$$T_3 = f(n, X, S) \tag{3.3}$$

where

n = number of farm stops per route,

X = volume of milk pumped per stop, and

S = number of items of farm supplies delivered per stop.

Unloading and Testing Time

The driver performed a number of basic operations at the processing plant.[2] The first duty performed was to hook up the stainless steel pipes from the processing plant storage tank to the tank truck. The milk was transferred into the normal marketing channel inside the processing plants.

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[2]The actual sequence was often changed because other trucks were unloading.

The second operation performed was the testing for butterfat contained in each sample.[3] The milk was tested as follows: First, milk was placed in test bottles and warmed to a normal temperature; second, acid was added and the entire solution was centrifuged for three minutes; third, distilled water was added and this solution was centrifuged one minute; fourth additional distilled water was added and this solution was centrifuged for a minute, and the final step was to read the percentage of butterfat contained in the milk.

The third operation performed was to record the appropriate butterfat on each of the producer's ticket. The fourth step was to wash and clean the equipment used in testing the milk.

The second, third, and fourth operations were performed while the milk was being removed from the tank truck and the time used was assumed to be the same as pump-out time. However, actual time used in testing may have been greater than time used in pump out. The actual time of pump out varied between processing plants and with the volume of milk hauled.

The fifth operation performed was to unhook the stainless steel pipes and return them to the processing plant. The final step was to rinse the tank truck to prohibit the drying of milk solids within the tank and to aid in the prevention of milk stone.

The time spent in unloading and testing was defined as a function of volume of milk pumped and of waiting as follows:

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[3]This test is commonly called the Babcock Test.

$$(3.4) \qquad T_4 = f(V, W_2)$$

where

V = volume of milk pumped per stop, and

W_2 = waiting time.

Clean-Up and Check-Out Time

The normal procedure upon return to the Association headquarters was the driving of the truck to the clean-up area. The driver then thoroughly cleansed the rear compartments, the pump, and the ice box of the tank truck. He dismantled the pump and scrubbed the pump parts, rear compartment, and ice box with soap and water. The entire compartment area was then rinsed with scalding water. The driver then reassembled the pump and the truck was moved to the parking area, and left for the next day's route.

The time used in clean-up and check-out was treated about the same as time used in check-in. Clean-up and check-out time was defined as:

$$(3.5) \qquad T_5 = (I_2, W_3)$$

where

I_2 = average time for performing the fixed operations, and

W_3 = waiting time.

Miscellaneous Function Time

Some receiving plants required truck weights on the milk received. This necessitated extra driving time and two stops at the scales (to obtain gross and tare weights). Also, some drivers stopped for meals and coffee breaks. Although the times for performing these functions varied, they were considered as a constant for each route. Thus, the time was defined as:

$$(3.6) \qquad T_6 = a_1$$

where a_1 = the average time per route spent in performing miscellaneous functions.

Total Time

The total time for each route can be represented as the summation of the time associated with the performance of each of the basic functions. Symbolically this is represented as:

$$(3.7) \qquad T_t = T_1 + T_2 + T_3 + T_4 + T_5 + T_6$$

where

T_t = total time per route,

T_1 = time used at Central Oklahoma Milk Producers Association from check-in to driving,

T_2 = time used in driving,

T_3 = time used at farm stops,

T_4 = time used in unloading and testing,

T_5 = time used in clean-up and check-out, and

T_6 = time used at lunch, weighing, and other miscellaneous functions.

ANALYSIS OF TIME

Check-in Time

The average time spent by drivers preparatory to running the bulk milk routes was 34.90 minutes per route. This included checking instructions, checking the truck, assembling the pump, sterilizing the tank and pump, securing sample bottles, supplies and ice, and waiting. The detailed time involved for each of these operations is listed in Table I.

In the basic model, check-in time was defined as a function of the fixed operations performed by the driver and waiting time. Differences between drivers in performing these operations were not statistically significant. Waiting time, while important in individual cases, accounted for only a small proportion of the total check-in time. Consequently, the average waiting time was included with the fixed operations for subsequent analysis as follows:

$$T_1 = \bar{I}_1 + \bar{W}_1 = 34.90 \text{ minutes per route.} \quad (4.1)$$

Driving Time

Observations were obtained for 4,789.3 miles of driving on bulk milk routes during the sample period. An average of 1.84 minutes was required to travel each mile. This was equivalent to an average speed of almost 33 miles per hour for driving on all classes and conditions of roads.

Driving time per mile varied with the class and condition of roads traveled. In the Oklahoma City milkshed about 68 percent of all roads

TABLE I

AVERAGE TIMES FOR OPERATIONS PERFORMED BY DRIVERS DURING THE CHECK-IN PERIOD, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

Operation	Average Time (minutes)
Check instructions	3.13
Check truck	1.83
Drive to building (includes warm-up time)	2.85
Sterilize tank	5.61
Assemble pump	4.52
Sterilize pump	3.70
Obtain ice	2.95
Obtain producer supplies	2.66
Obtain sample bottles	2.56
Waiting	2.54
Other	2.55
Total Time	34.90

traveled was classified as highway (Table II). Almost half of this was on good highway and almost half was on fair highway. Only a small proportion was classified as poor highway. About 23 percent of the roads was classified as gravel and this was distributed fairly equally as between fair and poor conditions. Significantly, about 9 percent of the roads was classified as dirt. The proportion of poor dirt roads was slightly greater than the proportion of fair dirt roads. Few dirt roads were classified as good.

Less time was required for traveling on highway than on gravel or dirt roads (Table II). Generally, less time was required for traveling on gravel roads than on dirt roads.

Within each road classification, speed varied inversely with the condition of the road. Minutes per mile were lowest for good conditions and highest for poor conditions for each road classification. Also for the same road condition, dirt roads required more time per mile than gravel and gravel required more time than highway. The single exception was less time for traveling on good gravel roads as compared with good dirt roads. However, this may not be an accurate representation of time since less than one-half of one percent of the roads was classified as good dirt.

With respect to geographical area, a larger percentage of the sample roads traversed was on the eastern side of Oklahoma City (Appendix Tables V, VI, and VII). Generally, the roads on the eastern side of Oklahoma have a clay type soil base, and the terrain varies from flat to quite hilly. On the other hand, roads on the western side generally have a sandy soil base and the terrain is less rolling than in the eastern areas.

TABLE II

TOTAL MILES AND MINUTES PER MILE FROM A SAMPLE OF ROADS TRAVELED ON CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION BULK MILK ROUTES: CLASSIFIED BY GEOGRAPHICAL LOCATION, TYPE OF ROAD, AND CONDITION OF ROAD; 1956

	Miles				Minutes Per Mile		
	East	West	Total		East	West	Total
	(number)	(number)	(number)	(percentage)	(number)	(number)	(number
All Roads	2,735.1	2,054.2	4,789.3	100.000	1.87	1.80	1.84
Highway	1,970.2	1,304.6	3,274.8	68.377	1.69	1.58	1.65
Good	921.0	688.0	1,609.0	33.596	1.60	1.54	1.58
Fair	928.5	575.5	1,504.0	31.403	1.73	1.61	1.68
Poor	120.7	41.1	161.8	3.378	2.10	1.79	2.02
Gravel	704.7	377.0	1,081.7	22.586	2.32	2.05	2.23
Good	41.5	15.9	57.4	1.199	1.91	*/	2.10
Fair	348.8	209.1	557.9	11.649	2.32	2.01	2.20
Poor	314.4	152.0	466.4	9.738	2.38	2.04	2.27
Dirt	60.2	372.6	432.8	9.037	2.45	2.33	2.35
Good	1.7	22.2	23.9	0.499	*/	*/	1.92*/
Fair	22.7	147.6	170.3	3.556	*/	2.17	2.22
Poor	35.8	202.8	238.6	4.982	2.37	2.50	2.48

*/Observations based on less than 25 miles for each road classification or condition were considered unreliable for reporting.

Of course, individual roads on either side are exceptions to this generalization.

On the basis of simple average time per mile, roads on the western side of Oklahoma City were slightly better than on the eastern side. There were two exceptions. Good gravel roads and the poor dirt roads on the eastern side were somewhat better than the comparable road type and condition on the western side. These exceptions, however, may be attributed in part to the limited number of observations. There were only about 16 miles of gravel roads classed as good on the western side and only 42 miles classed as good on the eastern side. Both sets of observations represented only small proportions of the roads traveled. For the poor dirt roads, there were 203 miles on the western side but only 36 miles on the eastern side.

The differences in time per mile on the eastern side as compared with the western side were quite small. In most cases, the actual time required per mile averaged from 0.02 minutes per mile to 1.02 minutes per mile. Expressed in speed, the differences averaged about one-half mile per hour for the good highway classification to about 11 miles per hour for good dirt classification.

The results obtained from statistical tests indicated that no significant difference existed between any single road type or road condition on the eastern side and the comparable road type or road condition on the western side. In addition, no significant differences between the eastern roads and the western roads were obtained when the individual road types of all conditions were tested.

The results of these analyses indicate that any apparent differences between the roads on the eastern side and the western side of Oklahoma

City were not statistically significant. Apparently the geographic location of a route was not in itself an important factor influencing the time of bulk milk pickup. Hence, the evidence was that costs of bulk milk pickup were not significantly influenced by geographical location within the Oklahoma City milkshed for routes with the same distribution of road types and road conditions. However, in 1956 there was a higher percentage of dirt roads on the western side of Oklahoma City. About 9 percent of all roads were classified as dirt and most of this was west of Oklahoma City. This fact indicates that more travel difficulties, and greater costs, may be associated with the western routes.

There was no way to estimate the net effect of relative size of load on driving time. Heavy traffic conditions were directly correlated with relative size of load. The trucks were empty or had small loads in the early morning hours at the beginning of the route and had relatively large loads on return to the processing plants during the afternoon and evening hours. Consequently, only a gross effect was obtained.

An average of 1.54 minutes per mile was required for driving from the Association headquarters to the first farm stop. This compares with 1.72 minutes per mile required for driving from the last farm stop to the scales or point of unloading. The gross effect of relative size of load plus traffic conditions increased the time of travel by about 11.7 percent. This is equivalent to a reduction in speed of about 4 miles per hour when the truck is returning with a load as compared with the empty truck early morning travel.

The lack of statistical significance for geographical location of routes and the lack of data for the net effect of relative size of loads necessitated a revision in the equation for driving time. The equation, based on average times in Table II and omitting geographical location and size of load, is as follows:

$$(4.2) \quad T_2 = D\left[1.58\ R_1C_1 + 1.68\ R_1C_2 + 2.02\ R_1C_3 + 2.10\ R_2C_1 + 2.20\ R_2C_2 + 2.27\ R_2C_3 + 1.92\ R_3C_1 + 2.22\ R_3C_2 + 2.48\ R_3C_3\right]$$

In this formula,

D = total number of miles,

R_1C_1 = percentage of roads classed as highway - good;

R_1C_2 = percentage of roads classed as highway - fair;

R_1C_3 = percentage of roads classed as highway - poor;

R_2C_1 = percentage of roads classed as gravel - good;

R_2C_2 = percentage of roads classed as gravel - fair;

R_2C_3 = percentage of roads classed as gravel - poor;

R_3C_1 = percentage of roads classed as dirt - good;

R_3C_2 = percentage of roads classed as dirt - fair;

R_3C_3 = percentage of roads classed as dirt - poor.

An example may be useful in interpreting this formula. If a route existed which required travel on good highway only, then the driving time would be 1.58 minutes times the number of miles. However, if 70 percent of the route consisted of good highway roads and 30 percent consisted of good gravel roads, then the driving time would be computed in the following manner. With 70 percent of all roads traveled classified as good highway, a net of approximately 1.106 minutes would be required to travel the good highway portion of an average mile [1.58 (.70) = 1.106]. A similar computation for the gravel portion of this mile would give 0.630

minutes [2.10 (.30) = .630]. The driving time for an average mile on this route is obtained by adding the minutes from these computations and is 1.736 minutes per mile (1.106 + 0.630 = 1.736). This is a weighted average number of minutes per mile. If the route is 100 miles in length then the driving time per route is 173.6 minutes or slightly less than three hours. The same procedure can be followed for determining the driving time on routes with other road types and conditions.

Farm Stop Time

The procedures followed by drivers in performing the various operations of bulk milk pickup at the farm were standardized but actual times varied from driver to driver. A detailed analysis was made of the times and of the differences between drivers in performing each operation.

Hook-up

The driver's first action upon arrival at a milk storage parlor was to hook the milk pipeline plastic hose to the bulk tank. A 15-foot hose was unwound from within the back compartment of the truck and fitted upon the coupling at the front of the bulk tank. Immediately thereafter, the driver unreeled the electric cord from within a second back compartment and placed the plug-in near the electric socket.

The eleven drivers were compared on the basis of the mean time required in the performance of these functions. The average time required varied from 1.17 minutes to 2.04. The spread in time as required by the different drivers was 52 seconds. The "F" test was used to determine if there were statistically significant differences. In this test the hypothesis was that there was no differences between the means of the individual drivers. The criteria for accepting or rejecting the hypothesis were based on the comparison of the computed "F" value to the table value of "F". The table value of "F" was 2.37 based on M_1 = 10 and M_2 = 482 degrees of freedom. The computed value, "F" = 4.45, was greater than the table value, therefore, the hypothesis that the means were equal was rejected (Appendix Table VIII). This test indicated that there were significant differences between drivers but it did not indicate which drivers were significantly different from the others. The New Multiple Range Test was utilized to indicate the differences between drivers which existed.[1] The results are presented in Table III.

This test was conducted in order that those drivers or groups of drivers who were significantly different from the other drivers in terms of hooking up the hose and electric cord could be determined. If a driver were significantly different from the other drivers, then this driver would be isolated from the line under the other drivers. In other words, there would be no overlapping of the lines as in Table III.

There is an indication, at different levels of the test, that some drivers were significantly different in performing this function, however, when all stages of the test and all drivers were examined there was no driver whose mean time was significantly different from that of all other drivers considered.

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[1]David B. Duncan,"Multiple Range and Multiple F Tests," Biometrics, March, 1955, pp. 1-42.

TABLE III

NEW MULTIPLE RANGE TEST FOR DIFFERENCES BETWEEN DRIVERS IN HOOK-UP OPERATION, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

	Driver										
	D	A	B	C	E	G	F	J	H	I	K
	(99 percent probability level)										
Mean Time	1.169	1.382	1.403	1.440	1.507	1.515	1.588	1.720	1.779	1.905	2.036

The results of the test are as follows:

1. The test indicated that the mean time for driver K was significantly different from mean times of drivers D, A, B, C, E, and G and not significantly different from drivers F, J, H and I.

2. The test further indicated that the mean time for driver I was significantly different from D, A, B, C, E and G and was not significantly different from F, J and H.

3. Driver H was significantly different from D and not significantly different from A, B, C, E, G, F and J.

4. Driver F was not significantly different from drivers D, A, B, C, E and G.

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer, 1956.

Milk Weights

The second step with normal operation was to weigh the milk by using a calibrated rod. This rod was inserted into the bulk tank and a measurement of height of milk was determined. The driver compared this measurement with a poundage scale. This comparison gave the total pounds of milk in the bulk tank. Agitating the milk and pouring in other milk were occurrences which altered the normal sequence. When this occurred, the driver deviated from his set routine and allowed the undulation to cease.

The eleven drivers were compared on the basis of the mean time required by each driver to weigh the milk. The average time required varied from .40 to 1.318 minutes or from 24 to 79 seconds. This was a difference of 55 seconds. There was a significant difference between drivers since the "F" observed, 9.38, was greater than the table value (Appendix Table VIII).

The New Multiple Range Test was used to indicate the difference between drivers. Since there was overlapping of lines, there was no driver who was significantly different from the other drivers in the operation of weighing the milk. The results are presented in Table IV.

Milk Samples

The third step which was performed by the majority of the drivers consisted of sampling the milk. However, this sequence could be easily altered. If the agitator were on when the driver arrived, then the sampling of milk became the first step. The usual procedure followed was: (1) after agitation, the ladle was dipped into the milk and two separate samples were drawn, (2) the milk was checked for odor and

TABLE IV

NEW MULTIPLE RANGE TEST FOR DIFFERENCES BETWEEN DRIVERS IN WEIGHT OF MILK OPERATION, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

	Driver										
	C	A	D	K	E	I	G	B	J	H	F
	(99 percent probability level)										
Mean time in minutes	.400	.680	.651	.678	.968	.977	1.049	1.129	1.195	1.221	1.318

The results of the test are as follows:

1. The test indicated that the mean time for driver F was significantly different from the mean times of drivers C, A, D and K and was not significantly different from E, I, G, B, J, H and F.

3. Driver I was significantly different from drivers C, G, B, J, H and F and was not significantly different from drivers A, D, K, E, and I.

3. Driver K was significantly different from drivers E, I, G, B, J, H and F and was not significantly different from drivers C, A and D.

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer, 1956.

rancidity by either tasting or smelling, (3) the sample bottle was marked with the producer's number, and (4) the ladle and the sample bottle were placed in the proper place in the truck.

The eleven drivers were compared on the basis of the mean time required by each driver to sample the milk. The range varied from .254 to .845 minutes or 15 to 51 seconds. The "F" test indicated a significant difference between drivers since "F" observed, 2.50, was greater than the table value (Appendix Table VIII). However, the New Multiple Range Test did not indicate any one driver to be significantly different from all other drivers (Table V).

Ticket

Writing the ticket was the most flexible of all the duties performed in the milk storage parlor. This act did not specifically fit into any certain phase of the sequence. It might be done at the beginning, at the end, or at any time between. The major reason causing this variation was the difference in actual time spent in the milk parlor based on quantity of milk picked up. If the quantity picked up was large, then the ticket usually was written as time permitted between duties in the normal sequence. Small quantities required the performance of the normal sequence and the writing of the ticket usually occurred at the end of the pump-out period. The writing of the ticket often fell at the beginning, especially when an agitator was on and the driver had to wait to let the milk settle.

The eleven drivers were compared on the basis of the mean time required to write the ticket. The range of time required varied from .08

TABLE V

NEW MULTIPLE RANGE TEST FOR DIFFERENCES BETWEEN DRIVERS IN MILK SAMPLE OPERATION, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

	Driver										
	I	C	K	B	A	E	D	J	H	F	G
	(99 percent probability level)										
Mean time in minutes	.254	.410	.530	.550	.590	.602	.638	.739	.779	.844	.845

The results of the test are as follows:

1. The test indicated that the mean time for driver G was significantly different from the mean times of drivers I and C and was not significantly different from drivers K, B, A, E, D, J, H and F.

2. Driver J was significantly different from drivers H, F and G and was not significantly different from drivers I, C, K, B, A, E, and D.

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer, 1956.

to 1.241 minutes or 5 to 74 seconds.

The "F" test indicated a significant difference between drivers since "F" observed, 14.52, was greater than the table value (Appendix Table VIII). The New Multiple Range Test did not indicate that one driver was significantly different from the other drivers in the ticket writing operation (Table VI).

Unhook

The final step of the driver was to replace the pipeline hose and the electric cord in the rear of the truck. This was done by unplugging the electric cord and allowing the cord to reel in. The milk hose was unhooked from the bulk tank, wound, and stored in the rear compartment.

The eleven drivers were compared on the basis of the mean time required to unhook. The range varied from 1.112 to 1.77 minutes. This was a variation of 73 to 106 seconds. The "F" test indicated a significant difference between drivers (Appendix Table VIII). However, the New Multiple Range Test did not substantiate differences in one driver as compared with the other drivers (Table VII).

Other Services

Delivery. The drivers often made deliveries of certain small items such as milk strainers, soaps, disinfectants, and feeds to farms on their routes. Deliveries were made to 2.6 percent or 13 of the 492 producers on the 44 routes. The time required to perform this service was compared with a time obtained at the same farm when deliveries were not made. If this time were impossible to obtain, then the nearest comparable stop on the same route by the same driver was selected.

TABLE VI

NEW MULTIPLE RANGE TEST FOR DIFFERENCES BETWEEN DRIVERS IN TICKET WRITING OPERATION, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

	Driver										
	A	B	C	I	K	H	J	D	E	F	G
	(99 percent probability level)										
Mean time in minutes	.080	.241	.310	.600	.614	.788	.889	.976	.990	1.222	1.241

The results of the test are as follows:

1. The test indicated that driver G was significantly different from drivers A, B, C, I and K and was not significantly different from drivers H, J, D, E and F.

2. Driver E was significantly different from drivers A, B, C, F, and G and was not significantly different from drivers I, K, H, J and D.

3. Driver K was significantly different from drivers H, J, D, E, F, G, A and B and was not significantly different from drivers C and I.

4. Driver C was significantly different from drivers I, K, H, J, D, E, F and G and was not significantly different from drivers A and B.

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer, 1956.

TABLE VII

NEW MULTIPLE RANGE TEST FOR DIFFERENCES BETWEEN DRIVERS IN THE UNHOOK OPERATION, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

	Driver										
	F	A	G	C	D	B	I	E	H	K	J
	(99 percent probability level)										
Mean time in minutes	1.112	1.218	1.260	1.290	1.311	1.397	1.445	1.487	1.608	1.668	1.770

The results of the test are as follows:

1. The test indicated that the mean time for driver J was significantly different from mean times of drivers F, A and G and was not significantly different from drivers C, D, B, I, E, H and K.

2. Driver K was significantly different from F and J and was not significantly different from drivers A, G, C, D, B, I, E and H.

3. Driver H was significantly different from drivers K and J and was not significantly different from drivers F, A, G, C, D, B, I and E.

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer, 1956.

The average time required when a delivery was made was 1.0 minute more per stop than when no delivery service was performed. The "t" test indicated that this difference was not significantly different at the 99 percent probability level (Appendix Table IX).

Agitator on. Actual time of waiting was obtained when drivers were forced to wait for the bulk tank milk agitator to stop turning or for the milk to settle. The agitator was turning at 27 of the 492 stops. This constituted 5.5 percent of all stops. For analysis, this time was compared with a time obtained at the same farm with the agitator off and the milk calm. If this time were impossible to obtain, then the nearest comparable time on the same route by the same driver was selected and the comparison made.

A net addition of 3.9 minutes per stop was required if the agitator was on when the driver reached the farm milk parlor. This addition was significantly different at the 99 percent probability level (Appendix Table IX).

Producer at the farm milk parlor. Drivers were often detained by producers talking to them or interrupting the driver schedule in some other manner. The producer was at the farm and interrupted the driver's routine in 15 of the 492 stops. This was 3.1 percent of all stops. The amount of time at each of these stops was compared when possible with the amount of time obtained at the same farm when the producer was not present. If this was impossible to obtain, then the time required for a comparable layout and volume on the same route by the same driver was used.

An addition of 4.9 minutes was required for the pickup operation when producers were at the parlor as compared with producers away from the parlor. This addition, or difference was statistically significant at the 99 percent probability level (Appendix Table IX). Generally, this time represented a public relations function for the Association and may have been quite valuable to the Association.

Wait for milking. The drivers often had to wait or re-route while producers completed their milking. To test, observations were taken when drivers were forced to wait for the producers to complete milking. The drivers had to wait for the producers to complete milking on 7 of the 492 stops. This constituted 1.4 percent of all stops. This time was compared with the time at the same farm on a different day when possible. If this were impossible, then the nearest comparable time on the same route by the same driver was selected.

The results obtained from the comparison indicate that 8.2 minutes would be added each time a driver had to wait for the producer to finish his milking. The difference was statistically significant at the 99 percent probability level but the frequency of such occurrences was small. Generally, the routes were organized to avoid the necessity of waiting to complete milking except in unusual weather or routing conditions.

Summary of Driver Differences in Farm Stop Operations

Statistical tests indicated that the mean time for performing each of the operations by some drivers was greater than for other drivers. Consequently, the drivers were ranked in the performance of each of the five major operations. The driver with the lowest time in each operation was assigned a number of 1. The next lowest received a number of 2. This method was continued until the last man received a number of 11. The figures were summed and the driver with the lowest total score was ranked as the most efficient. That is, this driver required the least time to perform the milk parlor duties. The eleven drivers were compared on the basis of the rank in total time required to perform five milk storage parlor duties (Table VIII). The "F" test indicated that there was no significant difference between drivers as the "F" observed 1.48, was smaller than the table value (Appendix Table VIII).

There were several variables which affected the time required by the various drivers in performing the farm stop operation. Some of these variables depended on the characteristics of the drivers. Others depended on additional services performed.

For the individual characteristics of the drivers, the drivers with the greatest length of service tended to use less time or rank higher in Table VIII than the newer drivers. Apparently, the more experienced drivers used "shortcuts," which increased their efficiency in the operations.

A second variable was the amount of education. The drivers who had the higher levels of education tended to be slightly more efficient. These drivers may have been able to recognize and adopt time-saving ways to do the job.

A third variable was the age of the driver. The younger drivers appeared to rank higher than the older drivers. The drive and the ambitions manifested by the younger men may have accounted for their ability to perform their duties in a minimum amount of time.

The similarity of estimates of the time required to perform the five major operations at a milk storage parlor for the various drivers indicated

TABLE VIII

RANK OF DRIVERS IN PERFORMING THE FARM STOP OPERATIONS, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

Operation	Driver										
	A	B	C	D	E	F	G	H	I	J	K
Hook up	2	3	4	1	5	7	6	9	10	8	11
Weigh	2	8	1	3	5	11	7	10	6	9	4
Sample	5	4	2	7	6	10	11	9	1	8	3
Write ticket	1	2	3	8	9	10	11	6	4	7	5
Unhook	2	6	4	5	8	1	3	9	7	11	10
Total	12	23	14	24	33	39	38	43	28	43	33
Rank in Efficiency	1	3	2	4	6 (tie)	8	7	9 (tie)	5	9 (tie)	6 (tie)

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer, 1956.

that a constant linear relationship could be used for the farm stop operations of bulk milk pickup. Consequently the data for all drivers were pooled and a least squares regression computed. This regression provided the basis for the following formula for farm stop time:

$$T_3 = N\ (7.5) + .214X \qquad (4.3)$$

where

N = number of stops per route

X = hundredweight of milk picked up on each route.

In general terms, the fixed time required for each stop was 7.5 minutes (Figure 5). Fixed time was defined as the amount of time required at any milk parlor with zero pounds of milk picked up. This consisted of the time required in hooking up, sampling, weighing, writing the ticket and unhooking.

Each additional one hundred pounds of milk required .214 minutes additional time for pumping out the milk. For example, if a producer had 1500 pounds of milk, then Figure 5 indicates that a total of approximately 10.7 minutes would be required at this farm. This is 7.5 minutes fixed and approximately 3.2 minutes variable time.

Studies of these operations in one other milkshed indicate a somewhat different time structure. Cowden of the Farmer Cooperative Service obtained estimates of 6.8 minutes for the fixed operations and 0.35 minute per 100 pounds of milk pumped, based on observations from two routes. For the 1500 pound pickup, these estimates indicate a total time at the farm of about 12 minutes which is somewhat higher for the same volume than in the Oklahoma City milkshed.

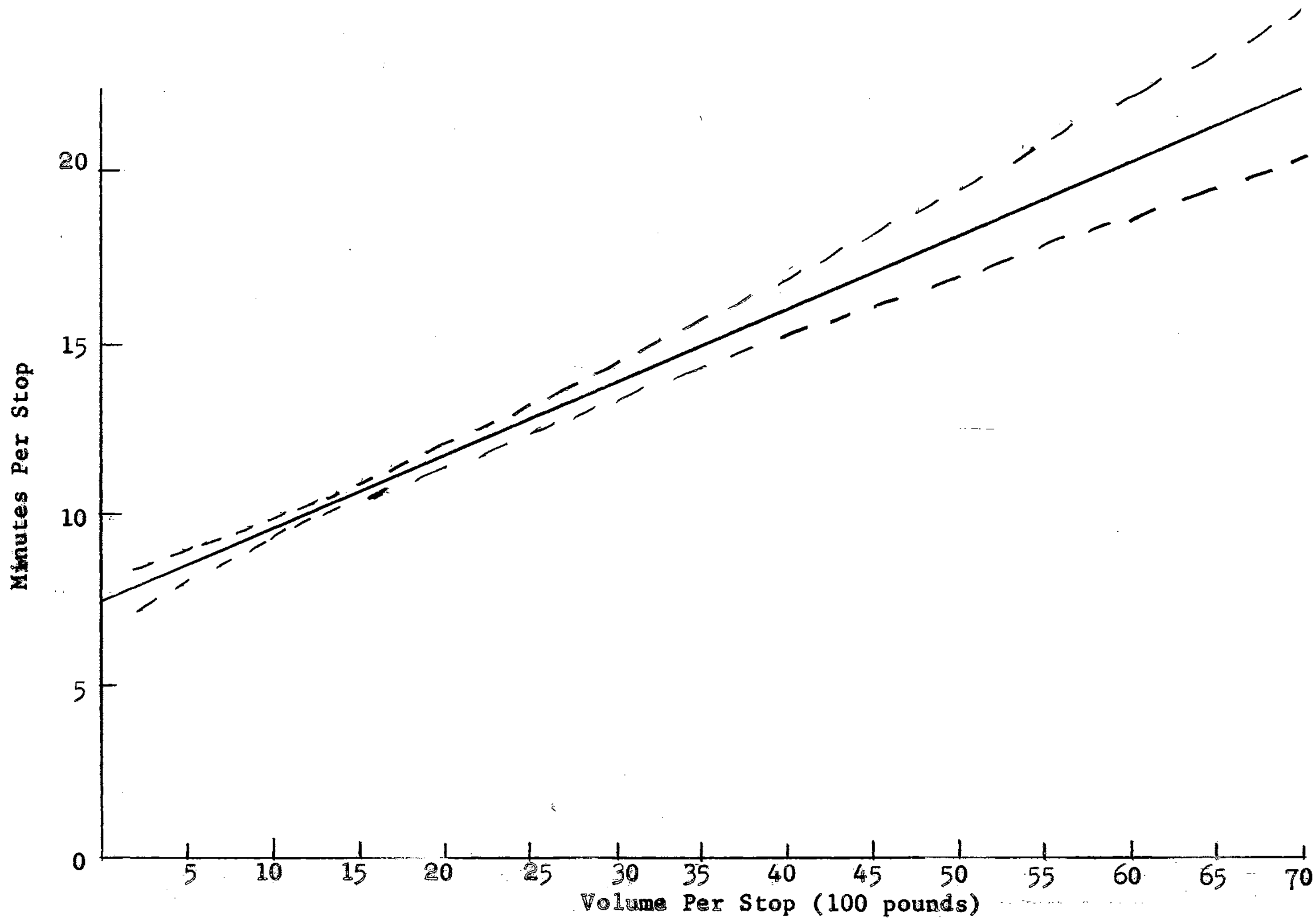

Figure 5. Estimated Aggregate Time Required Per Farm Stop Based on Volume Pumped, Central Oklahoma Milk Producers Association, 1956

Unloading and Testing

At the time of the survey, the unloading operation was performed simultaneously with the testing of producers milk for butterfat content. The actual time of unloading (T_4) then depended on both the facilities of the receiving plant and the time required by the driver for testing the milk. Generally, the testing required more time than the unloading and this may have resulted in the allotment of more time to the unloading operation than was actually consumed. Certainly the relationship between unloading time and volume was obscured. Waiting time appeared to be only a small proportion of the total unloading and testing time. Thus separate estimates were not obtained. The average unloading and testing (including waiting) time was 52.89 minutes. Thus:

$$T_4 = \bar{V} + \bar{W}_2 = 52.89 \text{ minutes} \qquad (4.4)$$

where

V = the longer of the times for either unloading or testing

W_2 = the waiting time.

Clean-up and Check-out

On most routes the driver was required to dismantle and clean the pump and hoses and perform other cleaning operations. However, he was not required to wash the tank. The average time required for check-out was 36.23 minutes of which 29.05 minutes were required for the clean-up operations. Waiting time was rare in the clean-up and check-out operations and was included with the fixed operations. Thus:

$$T_5 = \bar{I}_2 + \bar{W}_3 = 36.23 \text{ minutes.}$$

Miscellaneous Functions

Some receiving plants required truck weights on the milk received. When these weights were obtained, the time for the route was increased. An average of 6.5 minutes was spent at the scales plus any extra time involved in driving. However, since not all the routes required truck weights, the total time was distributed over all routes. An average of 4.61 minutes for each route was used at the scales for weighing.

Some drivers stopped for coffee or meals, usually at mid-morning or lunch time. As an average for all routes, approximately 26.77 minutes per route were used for these purposes.

The total of scales time plus coffee or lunch time was 31.38 minutes per route. Thus:

$$T_6 = a_1 = 31.38 \text{ minutes.}$$

Summary

The average time was obtained for each of the various functions performed in bulk milk assembly. The first function, check-in, used 34.90 minutes per route. The second function, driving time, varied with distance traveled, road classification, and road condition. The average time was obtained for each road classification and condition. Farm stop time, the third function, required an average of about 10 minutes per farm but the actual time varied directly with the volume of milk pumped. The average time for each of the remaining functions was as follows: 52.89 minutes per route for unloading and testing; 36.23 minutes per route for clean-up and check-out; and 31.38 minutes per route for miscellaneous functions.

The efficiency of the eleven drivers was compared for each of the operations performed at the farm stops. The statistical "F" test for each operation indicated that performance was significantly different among drivers. However, this test did not indicate which drivers were different from other drivers. The New Multiple Range Test was used to determine such differences. There was an indication at different levels of the latter statistical test that some drivers were significantly different in performing each of the farm stop operations; however, when all stages of the test and all drivers were considered, there was no driver whose mean time was significantly different from that of the other drivers.

Generally drivers with the greatest length of experience tended to use less time and to be more efficient at the farm stop than did the newer drivers. In addition, drivers who had higher levels of education seemed to be more efficient than those with less education. Younger aged drivers took less time than did older drivers to perform the farm stop operations, probably because of extra "drive" and ambition.

Service functions and unexpected delays added various amounts of time to the normal total route time. The frequency of occurrence of these functions and delays was small; however, their appearance should be expected. One delay encountered by the driver at the farm was to wait for the milk to settle because the agitator was on at the time of arrival. This occurred at approximately 5 percent of all stops and the net addition to time was 3.9 minutes per stop. A second major addition to time was the result of interruption by farmers talking to drivers or by disrupting drivers in some other manner. The drivers were detained by farmers at approximately

3 percent of all farm stops which resulted in an addition of 4.9 minutes for the farm stop function. Generally, the latter time represented a public relations function for the Association and may have been valuable to the Association.

Some inefficiencies existed in performing the unloading and testing function. The time required for unloading and testing might be lowered somewhat if better facilities and more efficient service were provided at additional processing plants.

ANALYSIS OF COSTS

Three major cost items in the bulk milk pickup operations were labor costs, truck and tank costs, and other costs such as equipment and overhead costs. Some of these costs varied directly with respect to total use and were defined as variable costs. Some did not vary with use and were defined as fixed costs.

Labor costs consisted of such items as haulers salaries, payroll taxes, clothing, laundry, supplies, group insurance, training, and overhead items. For the purpose of this analysis, haulers salaries and payroll taxes were defined as variable costs and totaled $53,250.58 for 1956 (Appendix Table XII). All other labor items were defined as fixed labor costs and totaled $8,793.60 for 1956.

Truck and tank costs were the major equipment costs and were divided into two groups. The first group included costs which varied with road type and road condition and were defined as variable truck costs. This included gasoline, oil, tires, sanitation supplies, truck rentals and truck and tank depreciation. Actual variable truck costs under this formulation totaled $61,500.80 for 1956 (Appendix Table XI).

Depreciation costs generally are not classified as variable costs in economic analyses. However, for purposes of longer range planning, it was felt that such costs did vary with use - particularly as related to roads - and should be included in any decisions relating to expansion of routes. The depreciation rates in 1956 were based on a three year expected life for trucks and a 10-year expected life for tanks. In view of subsequent experience, depreciation costs in this analysis were based on a two-year expected life for trucks and a seven-year expected life for tanks. This higher depreciation rate resulted in an increase in variable truck costs of $4,252.27 for 1956 or about one cent per mile. In addition, the equipment which replaced that in use during 1956 was larger and the gasoline requirements were greater than in 1956. Thus an addition of $4,351.29 was made to variable truck costs for the greater gasoline consumption. With the extra depreciation and gasoline costs included, variable truck costs totaled $70,104.36.

The second group of truck and tank costs included costs which did not vary with road type and condition. These costs were combined with other fixed costs of the Association, including overhead, which were associated with the bulk milk hauling operation. These costs totaled $24,483.22 in 1956 (Appendix Table X).

The Typical Route

An attempt was made to use the time and motion data in Chapter IV to allocate the 1956 annual or adjusted annual costs to the various functions performed in bulk milk assembly. Consequently, it was necessary to construct an average or typical route. This typical route will be used as a basis for determining the number of routes traveled in 1956 and the use of labor and truck time.

Some of the functions performed on the routes tended to require about the same amount of time per route. These functions included T_1 (check-in), T_4 (unloading), T_5 (check-out), and T_6 (miscellaneous functions). The total time for these functions was 155.40 minutes for the Association average route during the sample period.

The average route during the sample period was 145.2 miles in length. This consisted of driving 38.8 miles from the Association headquarters to the first stop, driving 77.8 miles between producer stops, and driving 28.6 miles from the last producer stop to the unloading dock where the pump-off occurred then to the Association headquarters. The 1956 average route is illustrated in Figure 6.

The distances traveled from the Association to the first producer and from the last producer to the Association were combined to represent a fixed mileage of 67.4 miles per route. The total time required to travel this distance was 111.92 minutes and the average time required was 1.66 minutes per mile. This average time reflected the relatively heavy concentration of highway driving in the fixed or overhead portion of route driving time.

The travel between producer stops generally included more gravel and dirt roads; consequently speeds were lower. It required 155.25 minutes to travel 77.8 miles which was an average of 2.00 minutes per mile.

The total route driving time was 267.17 minutes. This was obtained by adding the time of travel on the fixed portion of the route and the time of travel between producers. It could be obtained by the use of formula 4.2 as follows:

$$(5.1) \quad T_2 = 145.2 \left[1.58\ (33.596) + 1.68\ (31.403) + 2.02\ (3.378) + 2.10\ (1.199) + 2.20\ (11.649) + 2.27\ (9.738) + 1.92\ (0.499) + 2.22\ (3.556) + 2.48\ (4.982) \right]$$

$$T_2 = 267.17 \text{ minutes.}$$

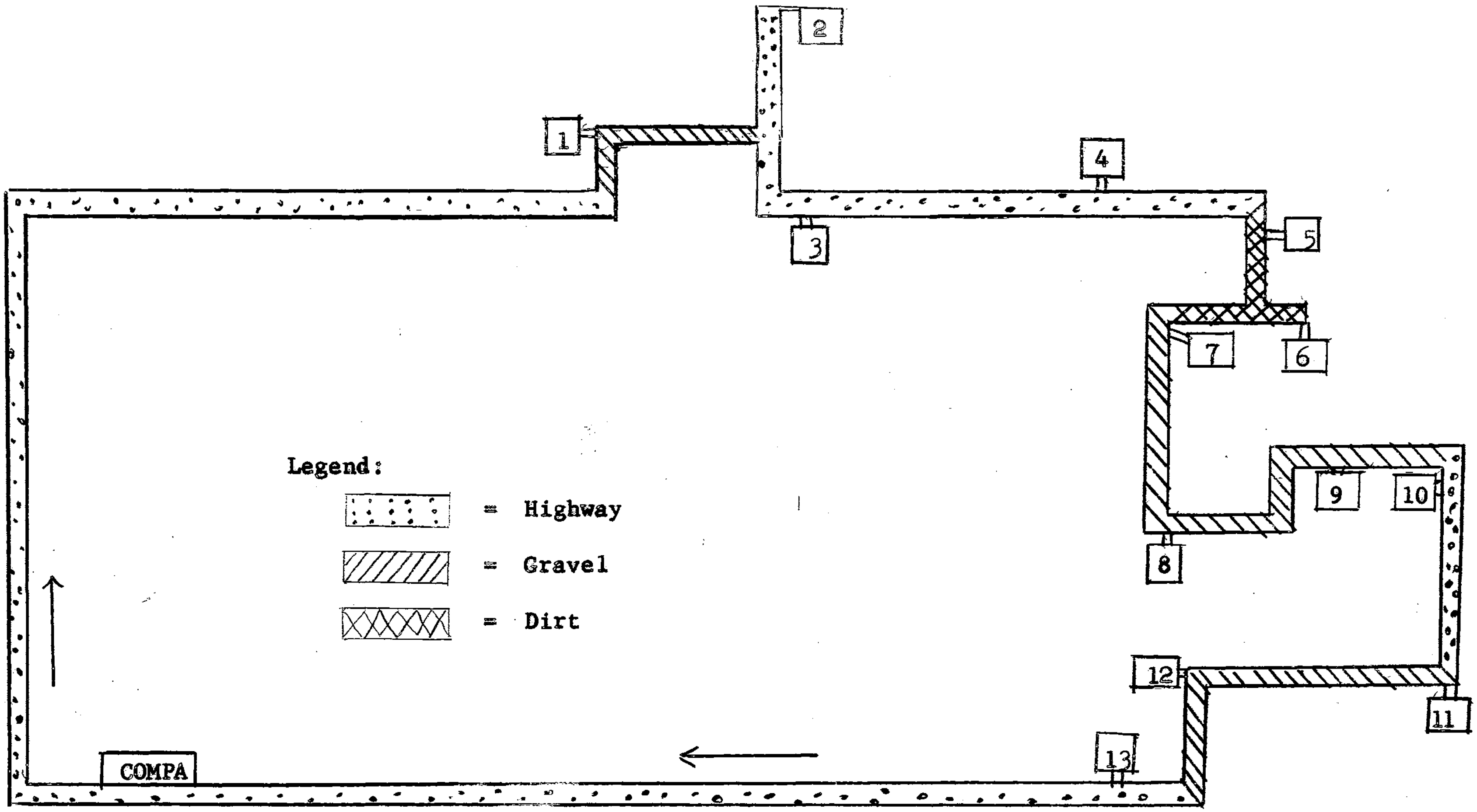

Figure 6. A typical Bulk Milk Route, Central Oklahoma Milk Producers Association, 1956

The average route during the sample period included 13 farm stops and the volume of milk picked up at each stop varied considerably. In order to reflect variable volumes per stop, an average volume was determined for the first stop on each route. The same procedure was followed for the second stop and for each of the remaining stops. The volumes are presented in Table IX.

It is recognized that this procedure may minimize the extent of variation on individual routes but it appeared that some variation in volume was desirable for the typical route formulation. The volumes in Table IX were used with formula 4.3 to obtain the total time at farm stops for the typical route as follows:

$$T_3 = n\,(7.5) + \sum_{i=1}^{n} X_i = 134.30 \text{ minutes.}$$

The times for performing all functions are summarized in Table X. The total time was 556.87 minutes or about 9.28 hours. Approximately one-half of the driver's time was used in actual driving, about one-fourth was used at the farm stops and the remainder was used in the various fixed functions.

Labor Costs

During the 1956 calendar year, 435,129 miles were traveled on Association routes. With an average route length of 145.2 miles, approximately 2,997 routes were traveled. At 9.28 hours per route, approximately 27,812 hours of driver labor would have been used in 1956.

A cost of driver labor per minute was computed from this estimate and from the record of salaries spent by the Association for labor. Variable labor costs totaled $53,250.58 in 1956. Based on 27,812 hours of labor,

TABLE IX

POUNDS OF MILK PUMPED AND TIME REQUIRED PER STOP FOR A TYPICAL ROUTE, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

Stop Number	Volume of Milk Picked Up	Fixed Time	Pump-Out Time	Total Time
	(pounds)	(minutes)	(minutes)	(minutes)
1	1185.6	7.5	2.5	9.0
2	1412.6	7.5	3.0	10.5
3	1562.5	7.5	3.6	11.1
4	1274.0	7.5	2.7	10.2
5	1214.8	7.5	2.6	10.1
6	1343.4	7.5	2.9	10.4
7	1412.5	7.5	3.0	10.5
8	1523.6	7.5	3.3	10.8
9	1123.4	7.5	2.4	9.9
10	1361.4	7.5	2.9	10.4
11	1431.2	7.5	3.1	10.6
12	1312.6	7.5	2.8	10.3
13	1385.0	7.5	3.0	10.5
Total	17542.6			134.3

TABLE X

SUMMARY OF THE TOTAL TIME REQUIRED FOR A TYPICAL ROUTE, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

	Minutes	Percentage of Total Time
Fixed Functions		
T_1 (check-in)	34.90	6.27
T_4 (unloading and testing)	52.89	9.50
T_5 (clean-up and check-out)	36.23	6.51
T_6 (miscellaneous functions)	31.38	5.63
Total Fixed Function	155.40	27.91
Variable Function		
T_2 (driving)	267.17	47.98
T_3 (farm stop)	134.30	24.11
Total Variable Functions	401.47	72.09
Total of All Functions	556.87 (9.28 hours)	100.00

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer, 1956.

this would be equivalent to a variable labor charge of 3.19 cents per minute.

Fixed labor costs associated with bulk milk assembly in the Oklahoma City milkshed were $8,793.60. This was equivalent to about 0.53 cents per minute. If these costs were spread uniformly over the functions performed in 1956, fixed labor costs would have been $2,454.29 for fixed functions, $4,219.17 for driving, and $2,120.14 for farm stops.

Labor Costs for Fixed Functions

Variable cost of driver labor for the fixed functions of the bulk milk route totaled $14,862.24 for 1956. This was an average of $4.96 per route. The variable labor cost for these functions could have been obtained either from labor costs and the percentage of time for fixed functions or from the average time per route (155.40 minutes) and the average variable labor cost per minute (3.19 cents).

The fixed cost of driver labor for the fixed functions totaled $2,454.29 in 1956. The share of the fixed costs per route totaled $0.82. Thus, the average driver labor cost (including fixed and variable shares) was $5.78 per route.

Labor Cost for Driving Time

Labor costs in 1956 were allocated to total driving time on the basis of a fixed and a variable element. Fixed labor charges were based on the proportion of driving time to total time and were assumed to be $4,219.17. Variable labor charges were assumed to be 3.19 cents per minute. If the variable costs per minute are combined with the minutes per mile in formula 4.2, the following variable cost schedule results:

$$(5.2) \quad VLC_D + D\left[5.040\ R_1C_1 + 5.359\ R_1C_2 + 6.444\ R_1C_3 + 6.699\ R_2C_1 + 7.018\ R_2C_2 + 7.241\ R_2C_3 + 6.125\ R_3C_1 + 7.082\ R_3C_2 + 7.911\ R_3C_3\right]$$

The variable labor cost is given directly in this formula for roads in any given classification. For example, if all roads were good highway, the variable labor cost would be 5.04 cents per mile and for 500,000 miles of travel during a given year, the total variable labor cost would be $25,200.00. (500,000 [5.040¢] = $25,200.00). For combinations of road types and conditions, the variable labor cost of driving would reflect a weighted average of the actual time involved.

Total labor costs of driving would reflect both the fixed and variable elements. Thus, total labor costs of driving per year would be:

$$(5.3) \quad LC_D = 4{,}219.17 + D\left[5.040\ R_1C_1 + 5.359\ R_1C_2 + 6.444\ R_1C_3 + 6.699\ R_2C_1 + 7.018\ R_2C_2 + 7.241\ R_2C_3 + 6.125\ R_3C_1 + 7.082\ R_3C_2 + 7.911\ R_3C_3\right]$$

Labor Cost for Farm Stops

The variable labor cost per farm stop depended on the volume of milk picked up. The physical relationship for time used at these stops indicated that 7.5 minutes were used for fixed operations and that 0.214 minutes were used for each hundredweight of milk pumped (Formula 4.3 in Chapter 4). If the variable or marginal cost is 3.19 cents per minute then the variable labor cost in cents for each farm stop would be:

$$(5.4) \qquad VLC_F = 23.9 + .68\ X$$

To illustrate the use of this formula, assume that a stop is made and that 1400 pounds of milk are picked up. The substitution of X = 14 in formula 5.4 results in a variable labor cost of 33.4 cents (23.9 + .68 [14]) for this volume of milk.

The share of fixed labor costs attributable to the farm stops totaled $2,120.14 in 1956. This is an average of $0.71 per route or 5.5 cents per producer.

The average labor cost in cents per producer, based on 1956 conditions would be the sum of the variable and fixed elements as follows:

$$(5.5) \qquad ALC_F = 29.4 + .68\ X.$$

This formulation of average labor cost is not usual in that the fixed element is expressed as an average rather than a total. It is also different from that obtained by applying average labor costs per minute to the physical relationship expressed in formula 4.2. The first formulation was preferred for this analysis, in spite of its shortcomings, because it appeared to be more useful in subsequent analysis of a potential farm stop charge.

Truck Costs

Variable truck and tank costs totaled $70,104.36, including $22,260.04 for depreciation of trucks and tanks. The actual time of travel for trucks, 13,366.62 hours, was the same as the driving time for drivers.

If the variable truck and tank costs are related directly to the time on the road, then the variable truck cost would be 8.75 cents per minute. Multiplying this rate by actual time involved in travel would give one estimate of cost by road type and condition. These costs would be as follows:

$$(5.6)\quad VTC_1 = D\Big[13.825\ R_1C_1 + 14.700\ R_1C_2 + 17.675\ R_1C_3 + 18.375\ R_2C_1 + 19.250\ R_2C_2 + 19.862\ R_2C_3 + 16.800\ R_3C_1 + 19.425\ R_3C_2 + 21.700\ R_3C_3\Big]$$

However, costs based on actual times overstated the costs of travel on highways and understated the costs of travel on gravel and dirt roads. The times were obtained on dry roads during the summer months of 1956. This was a relatively dry period in Oklahoma and very little difficulty was encountered because of wet roads. When roads are wet and muddy, equipment will not stand up as long and occasionally additional time is required as compared with dry road conditions. It not only takes extra time, extra fuel, and an occasional assist from a farm tractor or commercial winch truck, but it also means that the equipment may sustain internal damage which shows up later in motor overhauls and increased maintenance.

In an attempt to approximate actual costs on the various roads for average conditions over an entire year, the following assumptions were made:

1. Each minute of actual time of travel on highway roads would constitute 1.0 unit of cost.
2. Each minute of actual time traveled on gravel roads would constitute 1.5 units of cost.
3. Each minute of actual time traveled on dirt roads would constitute 2.0 units of cost.

On the basis of these assumptions, a total of 1,002,780.89 units of cost were involved in travel in 1956. This would be a unit cost of 6.99 cents for the variable truck cost category. The formula for variable truck costs by road types under this formulation would be:

$$(5.7) \quad VTC_2 = D\left[11.044\ R_1C_1 + 11.743\ R_1C_2 + 14.120\ R_1C_3 + 22.019\ R_2C_1 + 23.067\ R_2C_2 + 23.801\ R_2C_3 + 26.842\ R_3C_1 + 31.036\ R_3C_2 + 34.670\ R_3C_3\right]$$

Fixed costs, including other equipment and overhead were $24,483.22. If these costs were distributed uniformly over the miles driven, they would have been equivalent to 5.627 cents per mile.

Average truck costs per mile, based on average fixed truck costs and the second formulation of variable truck costs would be as follows:

$$(5.8) \quad ATC = 5.627 + D\left[11.044\ R_1C_1 + 11.743\ R_1C_2 + 14.120\ R_1C_3 + 22.019\ R_2C_1 + 23.067\ R_2C_2 + 23.801\ R_2C_3 + 26.842\ R_3C_1 + 31.036\ R_3C_2 + 34.670\ R_3C_3\right]$$

As was indicated in the section on labor costs, this formulation departs from the usual average cost formulas.

Total Costs Per Mile

Total costs per mile for trucks and labor are summarized in Table XI and Figure 7. These costs are based on formulas 5.3 and 5.8 and include only actual driving costs. They do not cover such costs as check-in, unloading or clean-up.

In Figure 7, the costs for the various classes of roads averaged as follows: 24.5 cents per mile for pavement, 37.0 cents per mile for gravel, and 44.5 cents per mile for dirt. It should be noted that these are costs for average conditions over an entire year. During months when dirt roads are wet and muddy, actual truck costs may rise sharply above

TABLE XI

COST OF DRIVING ON VARIOUS TYPES AND CONDITIONS OF ROADS, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956*

Road Class or Condition	Share of Fixed Costs†	Variable Cost¶			Total Fixed and Variable Cost
		Truck	Labor	Total	
		(cents per mile)			
Pavement					
Good	6.596	11.044	5.040	16.084	22.680
Fair	6.596	11.743	5.359	17.102	23.698
Poor	6.596	14.120	6.444	20.564	27.160
Gravel					
Good	6.596	22.019	6.699	28.718	35.314
Fair	6.596	23.067	7.018	30.085	36.681
Poor	6.596	23.801	7.241	31.042	37.638
Dirt					
Good	6.596	26.842	6.125	32.967	39.563
Fair	6.596	31.036	7.082	38.118	44.714
Poor	6.596	34.670	7.911	42.581	49.177

*Based on time costs for labor and unit costs for the variable component of costs for trucks. Unit costs for trucks were determined as follows: one minute on a highway road is 1.0 unit of variable cost, 1.0 minute on a gravel road is 1.5 units of variable cost; and one minute on a dirt road is 2.0 units of variable cost.

†Fixed Costs:

Truck and overhead	$24,483.22
Labor	4,220.05
	$28,703.27

¶Included in Variable Costs:
Truck and tank depreciation $22,900.04

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer, 1956.

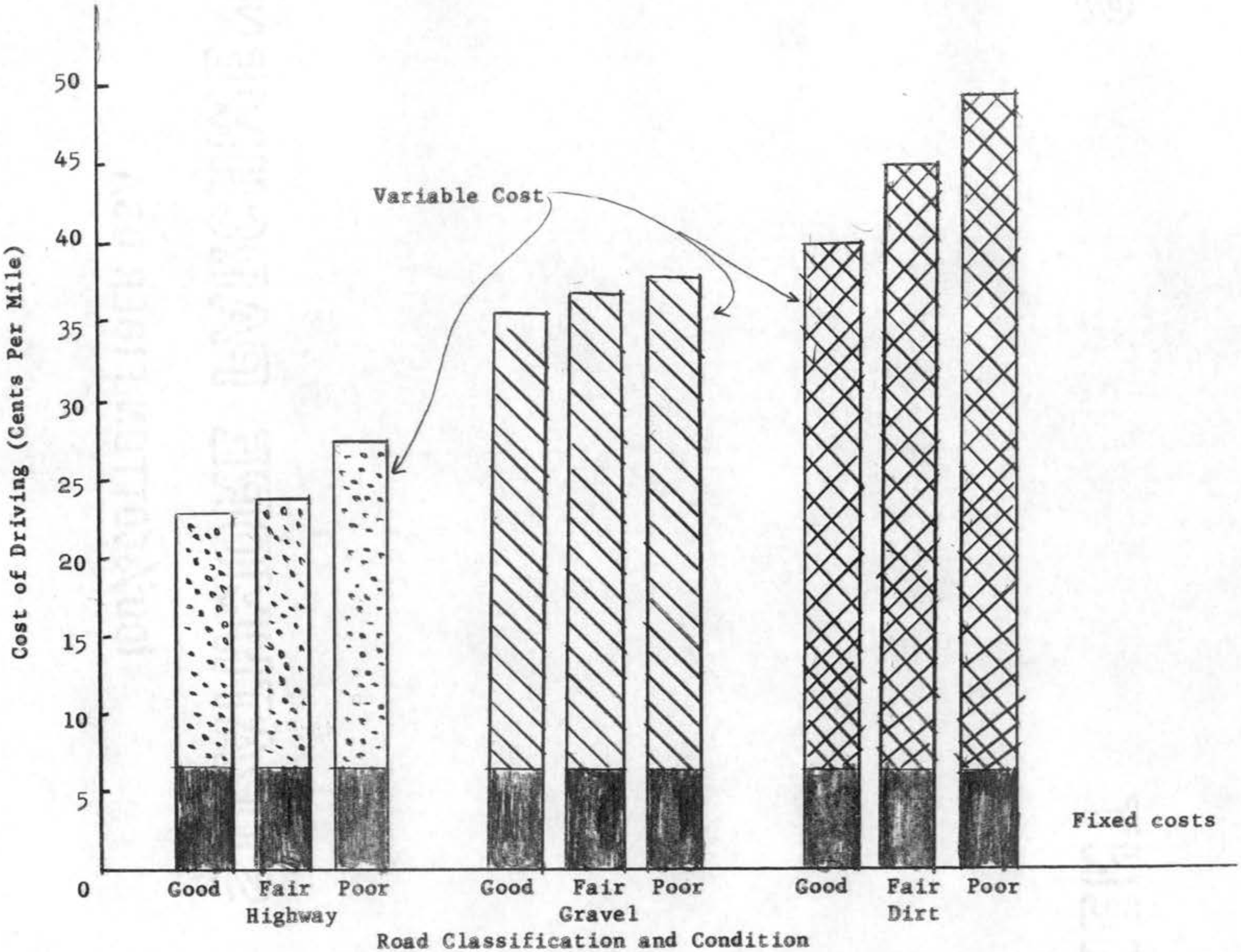

Figure 7. Cost of Driving on Different Classes and Conditions of Roads, Central Oklahoma Milk Producers Association, 1956

the costs indicated in Figure 7. Also during months when dirt roads are dry, actual truck costs may decline relative to these average costs.

Costs of Bulk Milk Assembly on the Typical Route

A summary of the time and cost associated with each function performed on the typical route of the Association is presented in Table XII. The two primary classifications used were fixed functions and variable functions.

The fixed functions included check-in, unloading, check-out, and miscellaneous functions. The variable labor cost of performing these functions totaled $4.96. This together with a share of the fixed labor cost resulted in a total cost of $5.78 per route or 44 cents per producer.

The variable function included driving and farm stops. Driving costs were further subdivided into overhead driving and driving from one producer to another. It was assumed that all overhead driving was on highway of which half was classified as good and half was classified as fair. Under this assumption the total overhead driving cost averaged $15.63 per route or about $1.20 per producer. Driving between producers averaged $25.87 per route or about $1.99 per producer. Farm stop costs averaged $4.99 per route based on average volumes per stop. This was equivalent to 38 cents per producer. The total cost for the typical route was $52.27 or $4.02 per producer.

Cost of Adding a New Producer to the Typical Route

The detailed breakdown of labor and truck costs associated with the operations involved in bulk milk assembly may be used to evaluate the net

TABLE XII

AVERAGE DAILY TIME AND COST FOR EACH MAJOR FUNCTION PERFORMED ON A TYPICAL ROUTE, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

Function	Time (minutes)	Labor Cost Variable	Labor Cost Fixed Share	Labor Cost Total	Truck Cost	Total Cost Per Route	Total Cost Per Producer
Fixed Functions							
Check-in	34.90	$1.11	.18	1.29	---	$1.29	$ .10
Unloading	52.89	1.69	.28	1.97	---	1.97	.15
Check-out	36.23	1.16	.19	1.35	---	1.35	.10
Miscellaneous	31.38	1.00	.17	1.17	---	1.17	.09
Total	155.40	4.96	.82	5.78	---	$5.78	$ .44
Variable Functions							
Driving							
Overhead 67.4 miles						15.63	1.20
Between producers 77.8 miles						25.87	1.99
Total 145.20 miles	267.17	8.52	1.42	9.94	$31.56	$41.50	$3.19
Farm Stops	134.30	4.28	.71	4.99	---	4.99	.38
Total Cost Per Route						$52.27	$4.02*

*Determined from the total cost per route and differs slightly from the sum of the costs for individual items.

effect of adding new producers to existing routes. For example, suppose there was a producer considering the installation of a bulk tank who was located northeast of producer No. 2 on the typical route. This producer is now shipping about 400 pounds per day in cans. However, if he converts to bulk, there is reason to believe that he may increase production by 25 percent. If he succeeds in increasing production, he will ship about 1,000 pounds per pickup on alternate days. For this production, he may have a herd of about 26 cows averaging 7,000 pounds per cow per year. This producer is located in Zone 3 which means that he will be charged 35 cents per 100 pounds for hauling. At this rate, the Association would gross $3.50 per pickup.

Can the Association afford to let this producer install a bulk tank? The answer depends, of course, on a number of factors. The first question obviously is "how much extra driving would be necessary?" This producer is located seven miles from producer No. 2 and in view of the road conditions it will be necessary to back track on the route. Thus, a total of 14 miles would be added to the route.

The second question is "what kind of roads must be traveled?" In this case, consider that 2 miles are good highway, 3 miles are fair gravel, 1 mile is fair dirt, and 1 mile is poor dirt. Since the road must be back tracked, total travel will be 4 miles on good highway, 6 miles on fair gravel, 2 miles on fair dirt, and 2 miles on poor dirt.

The costs to the Association can be determined from Table XI as follows:

Good Highway	4 miles at 16.084 =	0.64
Fair Gravel	6 miles at 30.085 =	1.81
Fair Dirt	2 miles at 38.118 =	.76
Poor Dirt	2 miles at 42.581 =	.85
Extra cost of driving		4.06
Extra labor cost at the farm		.31
Total of extra costs		$4.37

These extra costs include the wear and tear on trucks and tanks but they include no contribution whatsoever to other overhead costs of running the bulk tank pickup service. In addition, they do not provide for the fixed labor costs such as laundry and driver supplies. If these costs were included, the total cost of adding this producer would be $4.37 plus 92 cents for fixed costs of driving plus .07 cents for fixed costs of labor at the farm to make a total of $5.36. Even at this higher cost the producer is not sharing the route costs of check-in, driving from Central Oklahoma Milk Producers to the first producer, and other items.

With income at $3.50 per pickup and costs at $5.36 per pickup, a loss to the Association is inevitable. It is not so much the actual distance which will make this unprofitable as it is the kind of roads traveled. If the dirt roads were paved, the total extra costs would have been $3.41 which would be slightly less than income. A slight contribution would be made to the overhead. Just graveling the dirt roads would help cut costs although a loss would still exist. Total extra costs in the latter case would be $3.96 and total costs would be $4.93.

These examples were used in order that the importance of type and condition of roads on costs of bulk milk assembly might be brought into focus. They also illustrate one way of using the data to evaluate the income and cost position to the hauling agency of adding new producers to existing routes.

Summary

The time and motion data were integrated with the 1956 income and cost accounting data to obtain estimates of unit costs of performing specific functions in bulk milk assembly. Unit costs for labor were based on minutes used in performing each function. Unit costs for trucks and tanks were based on assumed relationships between time of travel on the three road types: highway, gravel, and dirt. The assumed relationships were that one minute on a gravel road represented 50 percent greater variable truck cost than one minute on a highway road and one minute on a dirt road represented 100 percent greater variable truck cost than one minute on a highway road.

Costs of performing the specific functions of bulk milk assembly represented the proportionate shares of time in minutes multiplied by the unit costs. For the fixed functions of running a route, the variable labor cost was $4.96 in 1956 and the share of fixed labor cost was $0.82. Thus the average labor cost was $5.78 per route.

Costs of driving depended on distance traveled, road classification, and road condition. Average costs of driving in 1956, including labor and truck costs, ranged from a low of 22.68 cents per mile for good highway roads to a high of 49.18 cents per mile for poor dirt roads. Based on the distribution of miles driven in 1956, average costs per mile were as follows: 24.5 cents for highway, 37.0 cents for gravel and 44.5 cents for dirt.

The average labor cost for each farm stop was expressed with a fixed and a variable portion. The fixed portion was 29.4 cents. The variable portion was 0.68 cents times the volume of milk pumped. The average labor cost for each farm stop was 38 cents.

It appears that changes may be made to increase efficiency in the bulk milk transportation department of the Association. The Association management is faced with the dilemma of adding some producers to obtain greater market control and of refusing to add some producers because of high cost transportation conditions. The relatively large proportion of dirt roads, particularly on the western side of Oklahoma City, is indicative of the direction of decisions made in the face of this delimma. Travel on these dirt roads has been costly and in many cases the individual producers located on the dirt roads have not shared the full cost of the transportation service. Much the same condition exists with respect to individual farm driveways.

The decision to add a producer who is located on a dirt road should be made with full recognition of the consequences. These consequences include direct extra costs on these roads, hidden extra costs, and delays in route pickup. It would seem desirable that the decision to add a new producer should be made by the person in charge of the transportation department. A check list to be used in this decision might be as follows:

1. Is the farm situated on an all-weather road?

2. Are all bridges adequate for loaded tanks and trucks?

3. Are the farm entrances sufficiently wide to accommodate present truck and tank equipment?

4. Is the farm driveway classified as all-weather?

5. Is the income from the volume of milk per stop sufficient to cover the cost of driving the additional mileage for this producer?

6. Is the farm bulk milk parlor layout accessible and convenient?

A negative answer to any one of these points should be sufficient to rule against adding a new producer.

In the event that the decision of this manager was unfavorable for adding a particular producer, the producer should be able to appeal to the hauling committee or some other appeal board. Then, if the manager is overruled and the producer is added, a net loss on this route might be expected.

Individual farm driveways can be as difficult, if not more difficult, than the dirt roads. Thus, it would appear that each producer should be required to have a driveway surface which can be classified as all-weather before he is added to a route. Producers on existing routes should be encouraged, and eventually required, to meet the same driveway specifications.

ANALYSIS OF ALTERNATIVE HAULING RATE SYSTEMS

There are several basic methods which might be used for determining the bulk milk transportation charges to producers. Among these basic methods are: (1) a standard flat rate per 100 pounds of milk, (2) a zone rate per 100 pounds of milk with zones related to distances from a central point in the milkshed, and (3) a flat charge per stop.

When bulk milk pickup was initiated by the Central Oklahoma Milk Producers Association, a standard flat rate of 25 cents per 100 pounds of milk was the method employed by the Association to price the transportation service to producers. This method had the advantage of simplicity in administration and in producer understanding. However, it did not reflect the costs involved in transporting milk from producer farms to plants when these farms were not equally distant from the plants. Thus, there was the problem of equity of pricing the transportation service to farmers.

The use of the standard flat rate pricing procedure resulted in higher costs to the Association than were anticipated at initiation of the bulk milk transportation service. At this time the can type pickup service which was being displaced was priced on the basis of distance traveled. Charges varied from about 25 cents per 100 pounds for producers relatively close to the plants to as much as 50 cents per 100 pounds for producers relatively far from the plants.

On the basis of these charges, the incentive for producers to change to the bulk system were greatest at the periphery of the milkshed and these distant producers actually were first to make the transition. This resulted in a concentration of farm stops at greater than average distances from the plants, which in turn, caused relatively high transportation costs per 100 pounds. Under these conditions, either the producers who were located relatively close to the plants were helping to defray the transportation costs of producers located further from the plants, or, if deficits to the Association occurred, all members of the Association were helping to defray these costs. Either situation appeared unacceptable for the long-run interests of the Association.

In April, 1956, the Association changed its pricing procedure from a standard flat rate to a zone rate per 100 pounds of milk. Zones were established on the basis of 20-air-mile intervals. Concentric circles with the center in Oklahoma City were drawn on township and range maps of Oklahoma as illustrated in Figure 8. Producers who were located in the interval between two circles were charged the same rate per 100 pounds of milk. The zones and charges per zone are presented in Table XIII.

This method represented a compromise between a standard flat rate per 100 pounds and a rate based on distance. As such it incorporated both advantages and disadvantages of each method. The 20-air-mile zone rate system required somewhat more effort to establish transportation charges which were applicable to individual producers but, once established, it was relatively easy to administer. In addition, it was more equitable among producers than the standard flat charge and most producers understood this pricing system. However, problems of equity among producers

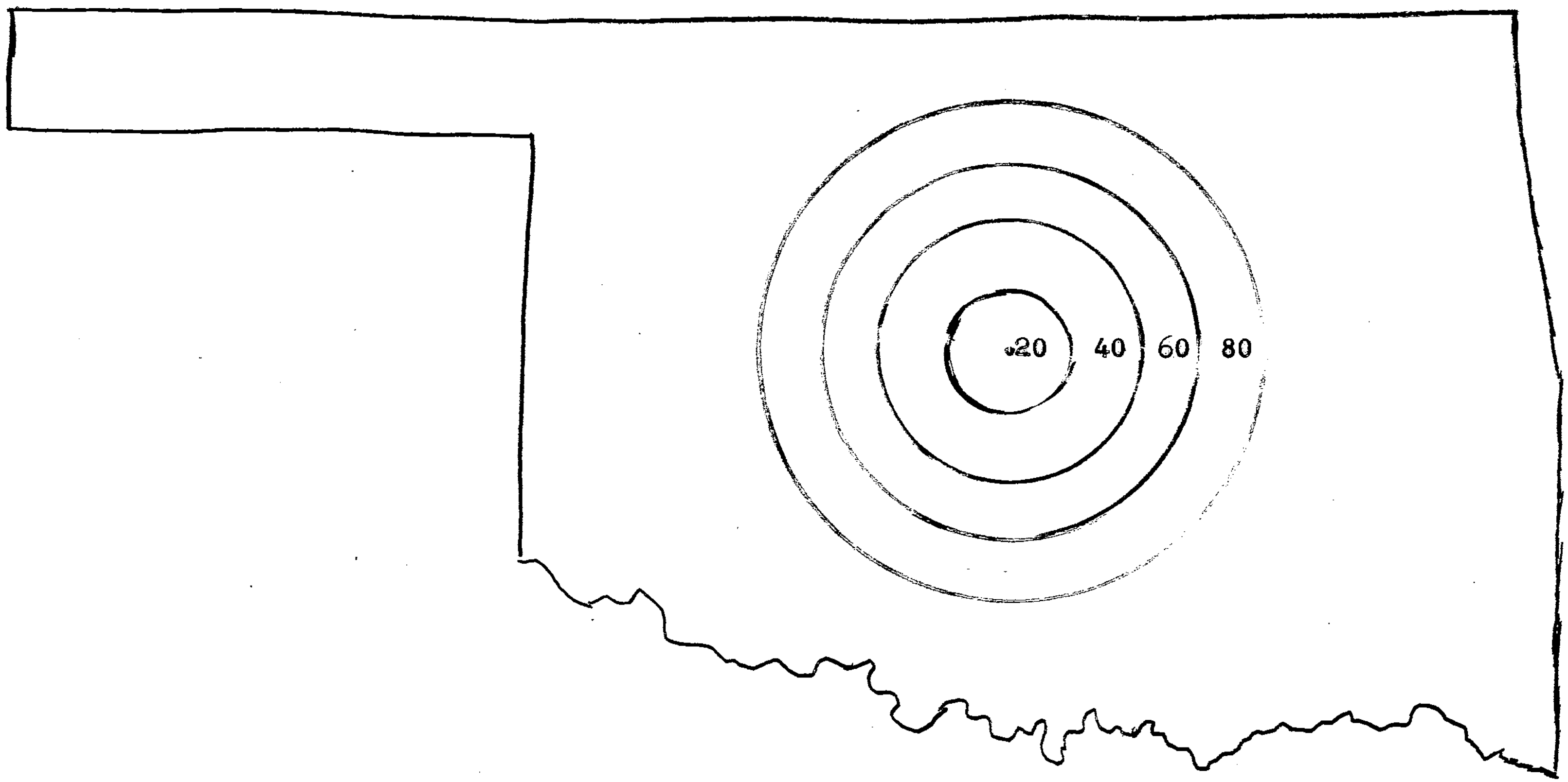

Figure 8. Illustration of 20-Air-Mile Zones, Central Oklahoma Milk Producers Association

still existed under the zone pricing system. Costs of transportation were greater for producers located at the outer fringe of the zone than for producers located at the inner fringe of the zone. Also, this zone may have resulted in different charges to neighboring producers who were located on opposite sides of the same road. There was also the question of whether air-miles or miles from the producer to a central point with travel on the most direct hard surfaced road should determine the zone rate.

TABLE XIII

SCHEDULE OF CHARGES USED BY THE CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, APRIL 1956 THROUGH JUNE 1958

Zone Number	Miles Inclusive	Charge per Hundred Weight (in cents)
1	0-20	.25
2	21-40	.30
3	41-60	.35
4	61 and over	.40

The problem of equitable charges among producers could be minimized by decreasing the size of the zones. However, administration costs would be greater for establishing and maintaining charges for the larger number of zones. In the analysis which follows, standard flat-rate, 20-air-mile zone, and 5-air-mile zone systems will be considered.

Income and Costs for the Standard Flat Rate

During the 1956 calendar year, a total of 46,732,376 pounds of bulk milk was picked up from farms by the Association. At 25 cents per 100 pounds, this would indicate a gross income of $116,830.94. The costs incurred by the Association totaled $148,028.20 in 1956 and with adjustments for larger equipment and higher depreciation rates would have totaled $156,631.76. Using the latter costs, a net loss of $39,800.82 would have occurred for the bulk milk hauling operations of the Association in 1956 under the 25 cent flat rate. This would be a loss of 8.52 cents for each 100 pounds of milk, or about $13.28 per route. This would be equivalent to about $1.02 for each producer per pickup or about $186.00 per producer per year.

These cost and income figures indicate that the flat rate charge must be at least 33.5 cents per 100 pounds for 1956 density of producers and road conditions if the bulk milk hauling operations are to break-even. At a charge less than 33.5 cents per 100 pounds, a deficit would exist which would require a transfer of funds from some other segment of the Association activities.

Even with the same producers and no reorganization of routes, it would appear that each producer would have to increase his daily average volume of production by about 400 pounds if the Association were to break-even on the hauling operations under this pricing system. This extra volume, of course, could not be handled on the present routes and would require additional routes which would incur extra costs.

A variation of the standard flat rate method is a standard charge per stop plus a flat rate per 100 pounds of milk. The usual premise for such a pricing system is that it would cost almost as much to stop for a small volume producer as for a large volume producer.

In the analysis of Chapter V, the average per stop cost was 29.4 cents plus 0.68 cents times the volume. This indicates that a cost of almost 30 cents was associated with the usual operations of picking up milk at the farm even if no pump-out time were required. Thus, a charge of 30 cents per stop might be levied against each producer. Such a charge in 1956 would have decreased the potential deficit of the standard flat rate pricing method to $28,112.52 per year or to 72 cents per pick-up.

This portion of the average cost does not allow for overhead items such as check-in, testing, lunch, time at scales, and check-out. Nor does it allow for an average quantity of milk picked up. As an average for all routes sampled, with these overhead costs and the volume of milk included, the per stop cost would amount to about 82 cents. Under the present rate structure, 82 cents per stop would substitute for five cents of the hauling rate so far as income to the Association is concerned. If this charge were levied against each producer for each stop plus the standard flat rate charge per 100 pounds of milk, the deficit would have been cut to 20 cents per 100 pounds in 1956. The hauling rate under this system would be 82 cents plus 25 cents per 100 pounds. A fixed charge of $1.00 per stop would be required to make income and costs approximately equal so long as the rate remained at 25 cents per 100 pounds.

The inclusion of an 82 cent stop charge would have the effect of increasing the effective rates for small volume producers and decreasing the effective rates for large volume producers. For a volume of 500 pounds this would be 82 cents plus $1.25 for a total charge of $2.07 per stop or about 41 cents per 100 pounds. For a volume of 8,000 pounds, this would be 82 cents plus $20.00 for a total charge of $20.82 per stop or about 26 cents per 100 pounds.

This pricing system would recognize the close relationship existing between cost and volume, but it would not reflect the costs associated with distance. Instead, the rate per 100 pounds of milk under this system must be high enough to cover costs associated with distance. Such rates generally do not result in equitable pricing of the service for producers.

Income and Costs for 20-Air-Mile Zone Rates

An attempt was made to use the sample routes to evaluate income and costs for zone pricing of the transportation service. It was assumed that generalizations derived from income and cost data applied to the sample routes would be applicable to the total operations of the Association.

Generally, the sample routes were distributed geographically in the same proportion as the total of all routes. Also, these routes were about average in volume of milk hauled per mile. Data from the 44 route sample indicated that 773,302 pounds of milk were picked up at the farm which required total travel of 7,161.4 miles. This was about 108 pounds of milk hauled per mile in the sample as compared with the Association average of 107 pounds per mile for the calendar year 1956.

Income received by the Association for milk transportation under the zone pricing method was computed from the sample routes. A zone rate based on 20-air-mile intervals was determined for the geographical location of each producer on each sample route. This rate was multiplied by the actual volume of milk on the day of the sample to obtain the gross income for each producer. These gross incomes were summed to obtain a gross income of $2,377.82 for all sample routes.

Total costs were computed from the total miles driven on the sample routes and the average cost per mile, adjusted basis, for the calendar year 1956. These costs totaled $2,577.89 for the sample routes.

The 20-air-mile zone pricing procedure would have resulted in a net deficit of $200.07 for the 44 routes or about $4.55 per route. The deficit per producer stop would be approximately 35 cents and the deficit for the calendar year would be about $13,636.00.

There is some justification for pricing the transportation service in line with the cost of providing this service on the basis of a per stop cost plus a zone rate per 100 pounds of milk pickup. Accordingly, an attempt was made to evaluate the effect of this pricing procedure. An average per stop cost of 82 cents was used as in the previous section. This average cost was defined in such a way as to include driver labor costs at the farm plus a proportionate share of the labor costs involved in the fixed functions such as check-in and unloading. If the charge of 82 cents per stop were levied against each producer, then the hauling rate in each zone could have been reduced by two cents per 100 pounds to keep income and costs approximately equal. Actually, a net return of $31.92 or 73 cents per route would have been realized on the 44 routes. This would be equivalent to almost six cents per producer or a total of $2,188.00 for the calendar year 1956.

This pricing procedure would have the effect of increasing the effective rate for small volume producers and decreasing the effective rate for large volume producers. For example, a producer with a pickup volume of 500 pounds in Zone 2 (250 pounds daily) would pay 82 cents plus $1.40 (500 pounds at 28 cents per cwt.) or a total of $2.22. This would be about 44 cents per 100 pounds as compared with 30 cents under the regular zone pricing procedure with deficit conditions. The large producer, on the other hand, would have a reduced rate relative to the regular zone pricing. A producer in Zone 2 with 8,000 pounds would pay $0.82 plus $22.40 (8,000 pounds at 28 cents per cwt.) or a total of $23.22. This would be about 29 cents per 100 pounds as compared with 30 cents under the deficit producing regular zone pricing. An average producer in Zone 2 with 1,368 pounds would pay 82 cents plus $3.82 or a total of $4.65. This would be about 34 cents per 100 pounds which is slightly higher than under the regular zone pricing procedure with deficit conditions but is about the same as under a zone pricing system which entailed no loss to the Association for the bulk milk hauling operation.

Generally, the addition of a per stop cost plus the reduced zone rate would increase the transportation charges more for small producers located relatively close to Oklahoma City than for small producers located at greater distances from Oklahoma City. This occurs because of the nature of adding a fixed element to the variable zone pricing. A fixed charge of 82 cents on a 500 pound volume would be equivalent to an effective rate of about 16 cents. In percentage terms, this would be a greater increase for a low zone rate than for a high zone rate. For example, the 500 pound volume in Zone 1 would have an effective rate (based on the per stop charge and 23 cents per 100 pounds) of about 39 cents per 100 pounds. This would be 14 cents higher than the regular zone price of 25 cents and would represent an increase of about 56 percent. The 500 pound volume in Zone 4 would have an effective rate of about 54 cents per 100 pounds ($0.82 per stop charge and 38 cents per 100 pounds) which would be 14 cents higher than the regular zone rate but an increase of only 35 percent.

Income and Costs for 5-Air-Mile Zone Rates

Zones smaller than 20-air-mile intervals would minimize the problem of unequitable charges for transportation as related to distance within zones. Consequently, an attempt was made to construct estimated income and cost data for zone pricing on 5-air-mile intervals.

Income received by the Association for milk transportation under a given zone system was calculated at $2,464.66 from the sample routes. This would represent a net loss on the hauling operation of $113.23 for 44 routes or about $2.57 per route. The schedule of charges which would cover costs was determined on the basis of producer locations and volumes on the sample routes and is presented in Table XIV. In order to keep rates in terms of cents rather than fractions of cents the possible income under this system was allowed to increase from $2,464.66 to $2,619.32 for the 44 routes. Actually about one-half cent per hundredweight would be made on bulk hauling since the charges were rounded to the nearest cent.

For the first zone, the rate would be one cent per 100 pounds more than the 20-air-mile zone rate. For distances from 20 to 25 miles, the

TABLE XIV

SCHEDULE OF HYPOTHETICAL ZONE RATES BASED ON 5-AIR-MILE INTERVALS, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION

Zone Number	Miles Inclusive	Rate per 100 Pounds	
		Without Stop Charge	With Stop Charge (82¢)
1	0-20	26	20
2	20.1-25	29	23
3	25.1-30	31	25
4	30.1-35	33	27
5	35.1-40	35	29
6	40.1-45	37	31
7	45.1-50	39	33
8	50.1-55	40	34
9	55.1-60	41	35
10	60.1-65	42	36
11	65.1-70	43	37
12	70.1-75	44	38
13	75.1-80	45	39
14	80.1-85	46	40
15	85.1-90	47	41
. . .	. . .	The rates increase one cent for each additional 5-mile zone.	

rates would be less than the 20-air-mile zone rate but for distances greater than 25 miles there would be a higher rate. These higher rates reflect the larger income necessary for a break-even position of the Association.

If a per stop charge of 82 cents per producer were combined with the 5-mile zone rate system, then each zone rate could be reduced by about 6 cents per 100 pounds of milk (Table XIV). Income from these routes would be slightly in excess of costs. Generally, the rates under the smaller zones would be more equitable among producers and the rates would be somewhat higher for distances greater than 85 miles as compared with the 20-air-mile zone system.

The inclusion of a per stop cost under the 5-air-mile zone system of pricing would increase the effective rate for hauling milk from small volume producers and decrease the effective rate for hauling milk from large volume producers. It would also result in a greater percentage increase in hauling rates for producers located relatively close to Oklahoma City than for the same size producers located at greater distances from Oklahoma City.

Summary

Estimates of income and costs were made for alternative hauling rate systems of the Central Oklahoma Milk Producers Association. Generally, these estimates indicate that hauling rates should be increased in order that the bulk milk assembly operations might be a profitable department. Rates under the now discarded flat rate system would have to be increased about 8.5 cents to 33.5 cents per 100 pounds. Rates under the current

20-air-mile zone system would have to be increased about 3.0 cents per 100 pounds.

It appears that a 5-air-mile zone rate would minimize the problem of unequitable charges for transportation as related to distance within zones. For this reason, it is recommended that the 5-air-mile zone rate system be carefully considered in the determination of rate structures for bulk milk assembly in Oklahoma.

The addition of a per stop charge to the rate structures would contribute to more equitable charges among large and small producers. The per stop charge would increase the effective rate most for the small producers located relatively close to Oklahoma City.

At present, it appears that a larger and larger proportion of producers adding bulk tanks will have relatively small volumes of milk. Thus, each producer should contribute to the direct costs involved at his farm plus some share of the fixed costs of running the route. A per stop charge plus a rate per 100 pounds would be more equitable between large and small producers. The per stop charge could be levied once each month for bookkeeping convenience. If new producers adding bulk tanks in the future are likely to have small volumes, then costs of hauling may increase enough to force an increase in rates for all producers. This could result in a continuous upward adjustment in hauling rates during the coming years which would be independent of changes in the general price level in the economy.

SUMMARY AND CONCLUSIONS

The central problem area of this study involved the bulk tank transportation of milk in the Oklahoma City milkshed. This problem was examined from the standpoint of varying cost conditions and alternative hauling rate structures for the Central Oklahoma Milk Producers Association.

The drivers were compared on the basis of efficiency in performing each of the functions. Analysis of variance indicated that there were significant differences between drivers in performing each function. The New Multiple Range Test was used to determine which drivers were significantly different from the other drivers in performing the functions. However, when the five major functions were pooled and the drivers compared, there were no significant differences between drivers.

Service functions and unexpected delays added additional time to the normal total route time. The frequencies of these functions and delays were small but they should be expected. In a limited number of cases drivers were detained by farmers interrupting the normal pickup operation. Generally, the additional time represented a public relations function for the Association and may have been valuable to the Association.

The time and motion data were integrated with income and cost accounting data for 1956 to obtain estimates of unit costs of performing specific functions. It was found that the average cost was $5.78 per route for 1956. Cost of driving depended on distance traveled, road classification, and road condition. Based on the distribution of miles driven in 1956, average costs per mile were as follows: 24.5 cents for highway, 37.0 cents for gravel, and 44.5 cents for dirt.

Careful consideration should be given to the addition of producers to the bulk tank pickup route. Travel on dirt roads and poor gravel roads is costly and in many instances where individual producers are added on these road types they do not share in the full cost of transportation services.

The decision to add a producer who is located on a dirt road should be made with full recognition of the consequences. Normally, the person in charge of the transportation department should make this decision. A check list of items to be used in this decision might be as follows:

1. Is the farm located on an all-weather road?
2. Are all bridges adequate for loaded tanks and trucks?
3. Are the farm entrances sufficiently wide to accommodate present truck and tank equipment?
4. Is the farm driveway classified as all weather?
5. Is the income from the volume of milk per stop sufficient to cover the cost of driving the additional mileage for this producer?
6. Is the farm bulk milk parlor layout accessible and convenient?

A negative answer to any one of these points could be sufficient to rule against adding a new producer.

Individual driveways often cause as much trouble as poor dirt roads. Care should be exercised to insure that all producers, both old and new in terms of using bulk tank facilities, meet a minimum driveway specification.

Estimates of income and costs were made for alternative hauling rate systems of the Central Oklahoma Milk Producers Association. Under the flat rate system, hauling rates would have to be about 33.5 cents per 100 pounds. Zone systems of pricing the hauling service appeared to be more equitable than the flat rate system. Rates under the 20-air-mile zone system in use from April 1956 through June 1958 would have to be increased by about 3.0 cents per 100 pounds for the Association to cover costs. A proposed system of 5-air-mile zone rates appears to be more equitable for bulk milk assembly in Oklahoma.

The addition of a per stop charge to the rate structures would contribute to more equitable charges among large and small producers. It appears that many producers adopting the bulk tank system in Oklahoma will have small volumes of milk. If this occurs, the costs of hauling may increase enough to force an increase in the rates for all producers. A greater proportion of small volume bulk milk producers could result in a continuous upward adjustment in hauling rates which would be independent of changes in the general price level in the economy.

Additional studies should deal with density of producers and its effect on the costs of bulk milk assembly. Also, the effect of weather should be carefully examined. The extent of additional costs and depreciation rates because of variable weather conditions are not known. Specific studies under varying conditions should be arranged to determine the effect of weather on the costs of bulk milk assembly.

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APPENDIX

APPENDIX TABLE 1

BULK MILK PICKUP AT FARMS BY BOLTON'S DAIRY, CHICKASHA, OKLAHOMA, JUNE 5, 1954 TO DECEMBER 31, 1956

	1954		1955		1956	
	Number of Producers	Pounds of Milk	Number of Producers	Pounds of Milk	Number of Producers	Pounds of Milk
January			34	438,745	34	425,755
February			34	409,506	34	389,366
March			34	466,765	34	442,622
April			34	467,177	34	430,345
May			34	453,349	34	426,575
June	7	68,590	34	406,800	34	367,214
July	11	98,800	34	384,114	34	346,497
August	20	103,760	34	351,438	34	324,607
September	30	275,622	34	377,209	34	323,630
October	35	378,414	34	394,249	34	397,279
November	35	431,376	34	417,051	34	415,501
December	34	444,629	34	442,698	34	435,165
TOTALS		1,801,191		5,009,101		4,724,556

Source: Bolton's Dairy, Chickasha, Oklahoma.

APPENDIX TABLE II

BULK MILK PICKUP AT FARMS IN THE OKLAHOMA CITY, OKLAHOMA MILKSHED MAY 7, 1955 to DECEMBER 31, 1956

Month	Number of Producers	Pounds of Milk	Percentage of Total Market: Number of Producers	Percentage of Total Market: Pounds of Milk
1955 May	4	75,746	.30	.48
June	20	204,787	1.49	1.42
July	36	492,787	2.66	3.51
August	61	938,422	4.37	6.74
September	76	1,329,024	5.40	8.97
October	86	1,807,561	6.06	11.58
November	94	1,933,201	6.69	12.63
December	100	2,126,251	7.23	13.23
		8,907,779		7.43
1956 January	107	2,319,315	7.80	14.24
February	111	2,305,278	8.15	15.20
March	120	2,825,306	8.83	16.48
April	135	3,207,044	9.80	18.55
May	149	3,549,291	11.04	19.99
June	161	3,474,370	11.70	21.05
July	175	3,618,864	12.95	22.29
August	199	3,792,290	14.48	24.24
September	235	4,684,328	17.03	28.62
October	249	5,609,302	17.82	31.30
November	255	5,575,838	18.61	32.18
December	263	5,911,337	19.37	32.49
		46,872,563		23.22

Source: Milk Market Administrator, Dairy Division, Agricultural Marketing Service, United States Department of Agriculture, Oklahoma City, Oklahoma.

APPENDIX TABLE III

BULK MILK PICKUP AT FARMS IN THE TULSA, OKLAHOMA MILKSHED
MAY, 1956 TO DECEMBER 31, 1956

Month	Number of Producers	Pounds of Milk	Percentage of Total Market	
			Number of Producers	Pounds of Milk
May	29	1,258,763	2.40	6.27
June	34	1,214,397	2.82	6.95
July	45	1,318,989	3.75	7.77
August	69	1,814,595	5.52	11.02
September	79	2,223,330	6.27	12.87
October	98	2,919,326	7.68	15.53
November	100	3,015,565	7.89	16.52
December	105	3,303,774	8.31	17.44
Total		17,068,739		11.8

Source: Milk Market Administrator, Dairy Division, Agricultural Marketing Service, United States Department of Agriculture, Oklahoma City, Oklahoma.

APPENDIX TABLE IV

BULK MILK PICKUP AT FARMS IN THREE OKLAHOMA MILKSHEDS, JUNE 5, 1954 TO DECEMBER 31, 1956

Month		Number of Producers	Pounds of Bulk Milk	Percent of Total Milk
1954	June[1]	7	68,590	.22
	July	11	98,800	.35
	August	20	103,760	.37
	September	30	275,622	.97
	October	35	378,414	1.45
	November	35	431,376	1.39
	December	34	494,629	1.52
	Total		1,851,191	.88
1955	January	34	438,745	1.35
	February	34	409,506	1.37
	March	34	466,765	1.32
	April	34	467,177	1.29
	May[2]	38	529,095	1.45
	June	54	611,587	1.90
	July	100	876,901	2.85
	August	95	1,289,860	4.31
	September	110	1,706,233	5.39
	October	120	2,201,910	6.61
	November	128	2,350,252	7.26
	December	134	2,568,949	7.73
	Total		13,916,980	3.53
1956	January	141	2,745,070	8.20
	February	145	2,694,644	8.59
	March	154	3,267,928	9.11
	April	167	3,556,576	9.57
	May[3]	212	5,235,259	13.69
	June	227	4,995,977	14.36
	July	254	5,484,350	16.34
	August	302	5,931,492	18.29
	September	348	7,231,288	21.29
	October	381	8,925,907	24.05
	November	389	9,006,904	25.02
	December	402	9,650,276	25.68
	Total		68,725,671	16.30
Grand Total			84,493,842	8.24

[1] Bulk milk pickup began on the Chickasha market June 5, 1954.

[2] Bulk milk pickup began on the Oklahoma City market May 7, 1955.

[3] First date available for pounds of bulk milk on the Tulsa market.

Source: Milk Market Administrator, Dairy Division, Agricultural Marketing Service, United States Department of Agriculture, Oklahoma City and Tulsa, Oklahoma; Bolton's Dairy, Chickasha, Oklahoma.

APPENDIX TABLE V

MILES TRAVELED AND TIMES PER MILE FOR EAST AND WEST HIGHWAY ROADS, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

Route	GOOD			FAIR			POOR		
	No. of Obser-vations	No. of Miles	Elapsed Time (min.)	No. of Obser-vations	No. of Miles	Elapsed Time (min.)	No. of Obser-vations	No. of Miles	Elapsed Time (min.)
				EAST ROADS					
A	29	149.3	242.0	23	135.1	210.1	5	9.5	15.0
B	14	36.2	58.6	12	42.9	84.9	3	5.6	18.5
C	8	36.1	55.7	7	34.6	54.0	2	10.1	13.9
D	12	86.4	140.2	12	57.2	113.8	2	1.3	2.4
E	13	69.9	138.4	17	194.6	340.6	8	21.7	57.5
F	3	15.5	34.0	13	90.4	170.0	4	5.7	11.2
G	11	100.7	162.5	7	71.3	126.8	1	7.5	18.2
H	17	148.8	236.2	24	180.4	294.0	3	33.3	62.9
I	20	278.1	409.2	31	122.0	208.4	10	26.0	53.3
Total East	127	921.0	1476.8	146	928.5	1602.6	38	120.7	252.9
Ave. time per mile			1.60			1.73			2.10
				WEST ROADS					
J	10	119.2	150.2	26	228.2	374.4	1	1.1	1.7
K	57	270.2	459.4	16	34.6	73.2	4	8.0	16.3
L	6	79.8	107.3	10	60.7	92.8	-	--	--
M	6	70.0	124.1	11	82.6	137.6	2	4.9	6.8
N	29	148.8	220.1	30	169.4	246.8	7	27.1	48.6
Total West	108	688.0	1061.1	93	575.5	924.8	14	41.1	73.4
Ave. time per mile			1.54			1.61			1.79
Total East and West	235	1609.0	2537.9	239	1504.0	2527.4	52	161.8	326.3
Ave. time per mile			1.58			1.68			2.02

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer 1956.

APPENDIX TABLE VI

MILES TRAVELED AND TIMES PER MILE FOR EAST AND WEST GRAVEL ROADS, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

Route	GOOD No. of Obser-vations	GOOD No. of Miles	GOOD Elapsed Time (min.)	FAIR No. of Obser-vations	FAIR No. of Miles	FAIR Elapsed Time (min.)	POOR No. of Obser-vations	POOR No. of Miles	POOR Elapsed Time (min.)
				EAST ROADS					
A	3	5.3	11.6	27	96.1	229.2	34	139.5	322.8
B	5	9.4	23.8	18	27.3	75.1	5	6.2	29.2
C	-	--	--	12	21.6	49.5	4	5.9	15.1
D	-	--	--	26	29.5	79.7	13	27.4	70.7
E	1	6.7	9.4	17	26.6	69.6	4	2.8	9.5
F	3	7.9	13.0	5	11.7	25.3	7	25.5	64.3
G	2	1.2	2.9	9	9.7	23.1	5	12.2	34.7
H	5	11.0	18.7	31	105.4	204.7	13	25.4	50.6
I	-	--	--	26	20.9	52.4	47	69.5	151.8
Total East	19	41.5	79.4	171	348.8	808.6	132	314.4	748.7
Ave. time per mile			1.91			2.32			2.38
				WEST ROADS					
J	4	2.3	6.3	17	55.2	109.3	20	85.6	163.1
K	4	1.3	5.1	19	32.9	77.5	6	8.4	26.7
L	1	3.4	15.0	9	17.4	44.6	6	12.8	31.2
M	4	8.7	13.9	16	36.0	73.2	4	3.1	5.6
N	1	.2	.6	34	67.6	116.5	12	42.1	83.5
Total West	14	15.9	40.9	95	209.1	421.1	48	152.0	310.1
Ave. time per mile			2.57			2.01			2.04
Total East and West	33	57.4	120.3	266	557.9	1229.7	180	466.4	1058.8
Ave. time per mile			2.10			2.20			2.27

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer 1956.

APPENDIX TABLE VII

MILES TRAVELED AND TIMES PER MILE FOR EAST AND WEST DIRT ROADS, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

	GOOD			FAIR			POOR		
Route	No. of Observations	No. of Miles	Elapsed Time (min.)	No. of Observations	No. of Miles	Elapsed Time (min.)	No. of Observations	No. of Miles	Elapsed Time (min.)
				EAST ROADS					
A	-	--	--	-	--	--	1	4.1	7.6
B	-	--	--	1	.9	1.5	5	4.5	18.7
C	1	1.0	1.1	6	5.8	18.3	-	--	--
D	-	--	--	1	.7	1.7	5	9.1	17.2
E	-	--	--	3	2.6	6.0	3	9.7	18.9
F	-	--	--	1	1.9	4.5	4	7.8	20.6
G	-	--	--	-	--	--	-	--	--
H	2	.7	3.9	4	8.2	20.1	-	--	--
I	-	--	--	2	2.6	5.7	1	.6	1.8
Total East	3	1.7	5.0	18	22.7	57.8	19	35.8	84.8
Ave. time per mile			2.94			2.55			2.37
				WEST ROADS					
J	-	--	--	5	9.2	19.5	12	43.0	100.1
K	15	15.2	31.6	44	64.0	139.4	39	54.7	156.4
L	1	4.0	4.2	7	15.3	39.5	11	26.7	68.6
M	1	3.0	5.2	20	25.2	58.7	9	14.4	40.0
N	-	--	--	19	33.9	62.7	30	64.0	141.9
Total West	17	22.2	41.0	95	147.6	319.8	101	202.8	507.0
Ave. time per mile			1.85			2.17			2.50
Total East and West	20	23.9	46.0	113	170.3	377.6	120	238.6	591.8
Ave. time per mile			1.92			2.22			2.48

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer 1956.

APPENDIX TABLE VIII

"F" TEST FOR THE VARIOUS OPERATIONS PERFORMED BY DRIVERS AT FARM STOPS, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

	d.f.	S.S.	M.S.	F
		HOOKING UP		
Total	491	325.05	--	--
Group	10	27.57	2.76	4.45
Error	481	297.48	0.62	--
$F_{obs} = 4.45 >$ 2.37**				
		SAMPLING		
Total	491	310.09	--	--
Group	10	71.86	7.19	14.52
Error	481	238.23	0.495	--
$F_{obs} = 14.58 >$ 2.37**				
		WRITE TICKET		
Total	491	316.20	--	--
Group	10	20.46	2.05	3.33
Error	481	295.74	0.615	--
$F_{obs} = 3.33 >$ 2.37**				
		WEIGHING		
Total	491	194.65	--	--
Group	10	31.81	3.18	9.38
Error	481	162.84	0.339	--
$F_{obs} = 9.38 >$ 2.37**				

APPENDIX TABLE VIII (Continued)

	d.f.	S.S.	M.S.	F
		UNHOOKING		
Total	491	316.20	--	--
Group	10	20.46	2.05	3.33
Error	481	295.74	0.615	--
F_{obs} = 3.37 > 2.37**				
		TOTAL OF ABOVE		
Total	491	10848.66	--	--
Group	10	323.9175	32.3918	1.4804
Error	481	10524.7425	21.88	--
F_{obs} = 1.4804 < 2.37				

**Significant at the 99 percent probability level.

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer 1956.

APPENDIX TABLE IX

STUDENT "t" TEST FOR OTHER SERVICES, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

Comparison: Delivery Services

	Delivery	No Delivery
ΣX	134.4	121.1
ΣX^2	1455.86	1174.09
N	13	13
$\bar{X}$	10.34	9.32
s_x	2.35	1.96
$s_{\bar{x}}$	.65	.54

$s_{\bar{x}_1 - \bar{x}_2}$ = .845

t = 1.178

Comparison: Agitator On or Off

	On	Off
ΣX	345.9	267.2
ΣX^2	4823.95	2814.42
N	27	27
$\bar{X}$	12.81	9.9
s_x	3.89	2.56
$s_{\bar{x}}$	.75	.49

$s_{\bar{x}_1 - \bar{x}_2}$ = .896

t = 3.248**

Comparison: Producer at the Bulk Milk Parlor

	Yes	No
ΣX	198.3	121.7
ΣX^2	2776.39	1029.59
N	15	15
$\bar{X}$	13.2	8.1
s_x	3.33	1.74
$s_{\bar{x}}$	.86	.45

$s_{\bar{x}_1 - \bar{x}_2}$ = .97

t = 5.26**

APPENDIX TABLE IX (Continued)

Comparison: Waiting to Milk

	Wait	Non-Wait
ΣX	123.5	58.6
ΣX^2	2455.39	503.28
N	7	7
$\bar{X}$	17.6	8.4
s_x	6.79	1.46
$s_{\bar{x}}$	2.57	.55

$$s_{\bar{x}_1 - \bar{x}_2} = 2.628$$

$$t = 3.50^{**}$$

**Significant at the 99 percent probability level.

Source: Computed from survey data obtained from Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, Summer 1956.

APPENDIX TABLE X

SCHEDULE OF OVERHEAD AND TRUCK COSTS FIXED WITH ROAD CLASSIFICATION, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

Truck and Tank Insurance	$5,366.87
Compensation Insurance	418.37
Sanitation Supplies[1]	1,194.63
Federal Use Tax	587.50
License Plates	4,785.53
Utilities[1]	2,197.51
Travel Expense[1]	2,394.18
Office Supplies[1]	1,368.86
Telephone and Telegraph[1]	516.97
Freight and Hauling[1]	60.87
Receiving Plant Depreciation	951.20
Plant Repairs and Maintenance[1]	862.70
Pump House and Pump Depreciation	541.32
Butane Tank Depreciation	127.59
Boiler Depreciation	159.96
Office Building Depreciation	234.83
Postage[1]	212.76
Dues and Subscriptions[1]	127.12
Property Taxes	139.72
Interest Expense	2,232.73
Miscellaneous	2.00
Total	$24,483.22

[1]These items may be classified as variable costs for some analyses. These items totaled $8,935.60 in 1956.

Source: Audit Report, Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma, for period January 1, 1956, to December 31, 1956.

APPENDIX TABLE XI

SCHEDULE OF TRUCK COSTS VARIABLE WITH ROAD CLASSIFICATION, ADJUSTED FOR 1957 EQUIPMENT, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

1956 Actual Costs		
Truck and tank operation and maintenance	$25,904.75	
Fuel and oil	16,915.84	
Truck rental	32.44	
Total		$42,853.03
Adjustment in fuel costs for 1957 equipment		4,351.29
1956 Depreciation Costs Assumed to Vary with Road Conditions		
Trucks	12,710.37	
Tanks	5,937.40	
Total		18,647.77
Adjustment of depreciation for higher rate of use		4,252.27
		$70,104.36

APPENDIX TABLE XII

SCHEDULE OF LABOR COSTS, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

Costs Variable with Road Classification		
Haulers salaries	$52,082.68	
Payroll taxes	1,167.90	
Total		$53,250.58
Costs Fixed with Road Classification		
Coveralls and laundry	1,520.76	
Drivers supplies	102.23	
Employee training	47.41	
Group insurance	223.20	
Other salaries	6,900.00	
Total		8,793.60
Total Labor Costs		$62,044.18

APPENDIX TABLE XIII

MILES DRIVEN AND VOLUME OF MILK PICKED UP, CENTRAL OKLAHOMA MILK PRODUCERS ASSOCIATION, 1956

Month	Miles Driven	Volume
January	23,234	2,319,315
February	25,847	2,305,278
March	29,486	2,825,306
April	32,056	3,126,231
May	36,480	3,549,921
June	35,031	3,414,366
July	37,778	3,618,864
August	37,500	3,792,290
September	42,062*	4,684,328
October	45,000*	5,609,302
November	45,114	5,575,838
December	45,665	5,911,337
Total	435,129	46,732,376

*Estimated.

Source: Central Oklahoma Milk Producers Association, Oklahoma City, Oklahoma and Milk Market Administrator, Dairy Division, Agricultural Marketing Service, United States Department of Agriculture, Oklahoma City, Oklahoma.

VITA

Walter Bob Rogers
Candidate for the Degree of
Doctor of Philosophy

Thesis: COSTS AND CHARGES FOR BULK MILK ASSEMBLY IN THE OKLAHOMA CITY MILK SHED

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