COST OF BULK MILK ASSEMBLY IN THE WICHITA, KANSAS MILKSHED

by

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TABLE OF CONTENTS

INTRODUCTION

The "bulk" system of milk handling is one of the most important recent innovations in marketing agricultural products. This system consists of the storage and transportation of milk in bulk tanks rather than in cans. Beginning in California in the late 1930's, this system was widely adopted in that state by 1948.[1] Since then, the system spread rapidly throughout the United States. Bulk milk handling in the Wichita, Kansas, area began in the fall of 1954.[2] By January of 1957, 64 per cent of the producers in the area had bulk tanks on their farms, and they accounted for 77.8 per cent of the milk delivered in the area.[3]

As a result, producers and other agencies in the market need specific information on hauling costs under the bulk system. This study was conducted to provide certain basic cost functions of transporting bulk milk.

THE PROBLEM

The situation[4] relative to hauling of bulk milk in the Wichita area evolved from the development of can milk routes. As new can producers came into the market, they contracted with independent haulers to transport their milk from the farm to the milk plant. If a route was established in his area,

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[1]The Dairy Situation, United States Department of Agriculture, June 1957, p. 20.

[2]The Dairy Bulletin, Wichita Milk Producers Association, November, 1954, Vol. 8, No. 11, p. 1.

[3]The Dairy Situation, United States Department of Agriculture, June 1957, Table 10, p. 25.

[4]Prior to June 15, 1956 when Harvey County Milk Haulers Association was formed.

the producer would contract with the hauler on the route. In some cases, haulers were instrumental in bringing new producers into the market, a practice known as "building up" a route. Once established, there was an element of restriction of entry of other haulers on a route. By tacit agreement, the right to haul a producer's milk belonged to a particular hauler. A route, therefore, took on aspects of a monopoly. Under a monopoly, a hauler would theoretically set the hauling rate according to the demand for his service and cost curves of his operation. This condition is illustrated in Fig. 1. In this model, OP is the rate set for hauling OQ quantity. Since normal profits are included in the average cost curve, the area PABC represents monopoly profits. It is improbable that any hauling firm has attained such a position in the Wichita market. In comparison, Fig. 2 shows that a lower rate would exist and a greater quantity hauled under conditions of pure competition, assuming the same cost curves of Fig. 1. Cooperative milk hauling associations which operate at cost would set a rate OP as in Fig. 2 for OQ quantity. This would be the minimum rate in the market with these costs.

In most cases, the economic situation with respect to haulers and producers in the Wichita area was other than monopoly or pure competition. An absolute restriction of entry among haulers did not exist, nor were producers entirely unable to influence hauling charges. Thus conditions existed for a degree of competition between haulers, a situation known as monopolistic competition. Under monopolistic competition, as shown in Fig. 3, the rate would be less than under monopoly but greater than for pure competition. It will be near the pure competition rate or milk producer associations may begin milk hauling operations. The maximum and minimum rates are set by

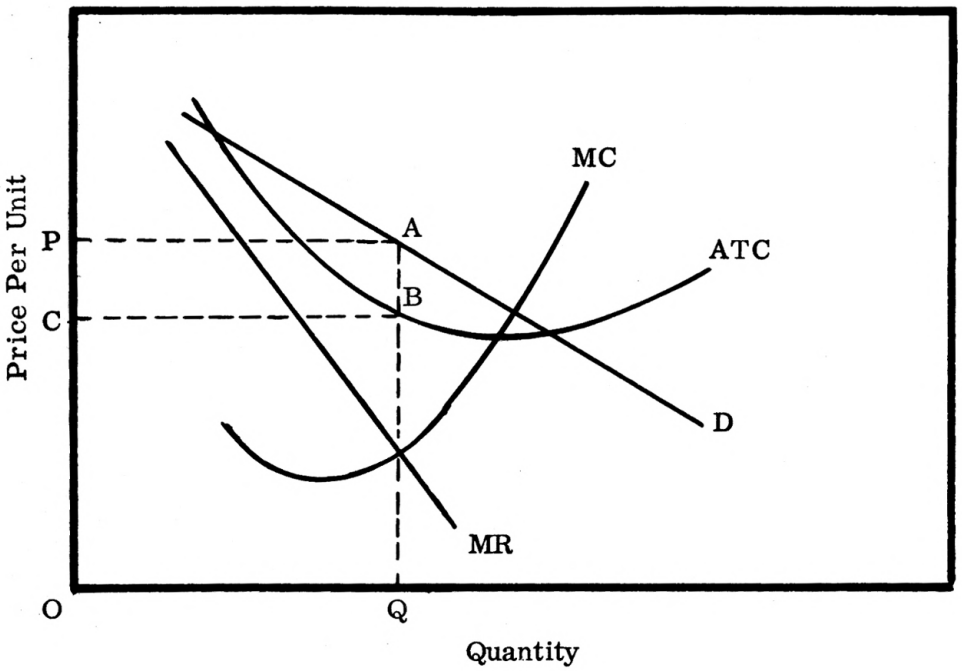

Fig. 1. Price established under monopoly conditions.

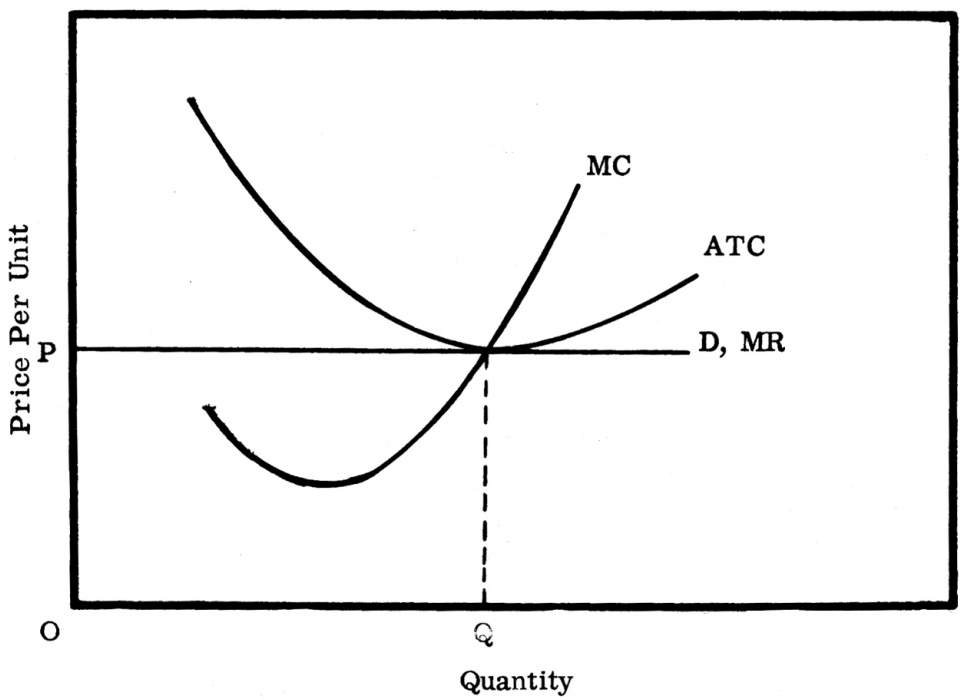

Fig. 2. Price established under conditions of pure competition.

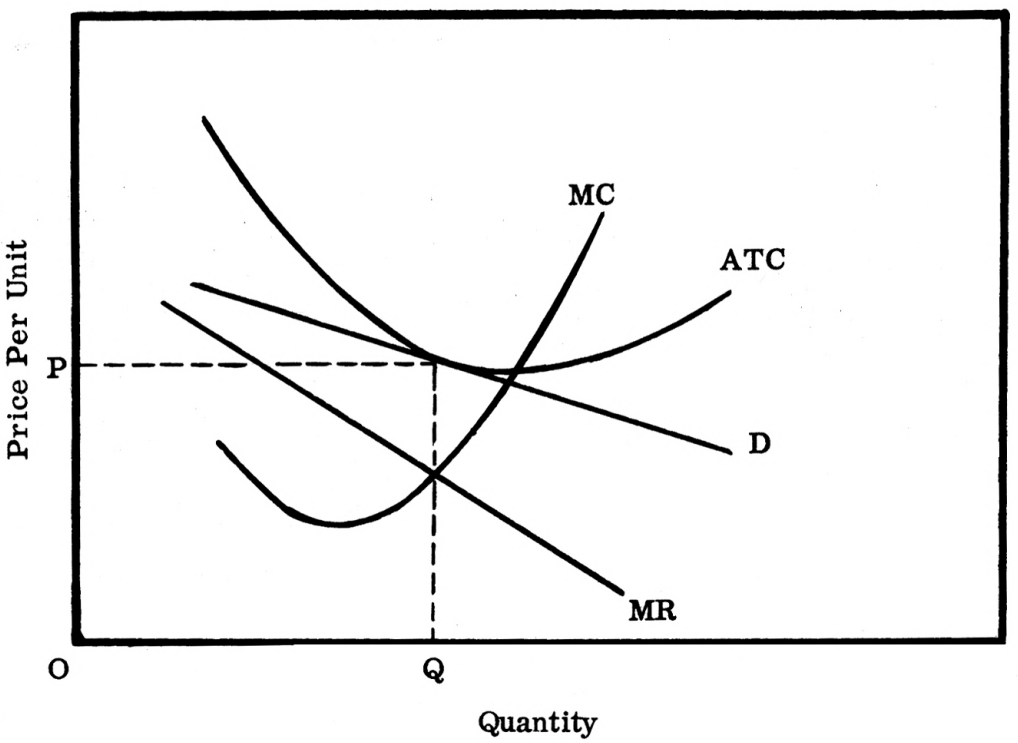

Fig. 3. Price established under conditions of monopolistic competition.

monopoly and pure competition respectively. The rate under monopolistic competition will depend upon the position of the producer association and the degree of competition in the market.

The organization and development of bulk milk routes in the area was a transition from can to bulk hauling. But the same economic structure still existed. A need developed in the market for hauling cost information under the bulk system. This lack of knowledge caused uncertainty to exist among producers and haulers about hauling charges. In one instance, producers formed a hauling cooperative when the independent hauler failed to meet their request for lower hauling charges.[1] The Wichita Milk Producers Association expressed interest in hauling cost information to improve the producers' position with respect to hauling rates.

Short-run and long-run cost information is needed in the Wichita, as well as other milk marketing areas. The latter is known as economies of scale. Short-run average total cost is the basis for establishing the hauling rate in the market. As seen in Fig. 2, hauling cooperatives tend to set the rate equal to the lowest point on the average total cost curve. A possibility of Milk Producer Associations operating hauling units exists in the market if independent hauler rates exceed this level. As a result, independent hauler rates tend to nearly equal the rate set by cooperatives. Hauling cost information was needed in the market to establish the minimum rate equal to the lowest average total cost.

Total costs are needed before average costs can be known. The relationship between total and average costs is shown in Figs. 4 and 5. In Fig. 4,

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[1]The Harvey County Milk Haulers Association was formed June 15, 1956.

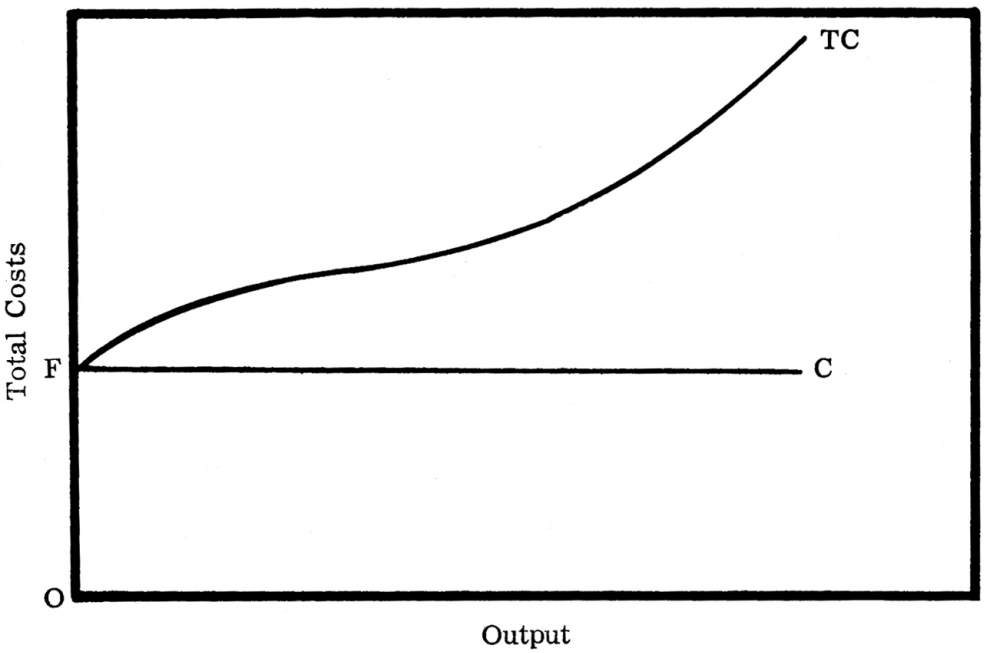

Fig. 4. Relationship of total fixed, total variable, and total costs.

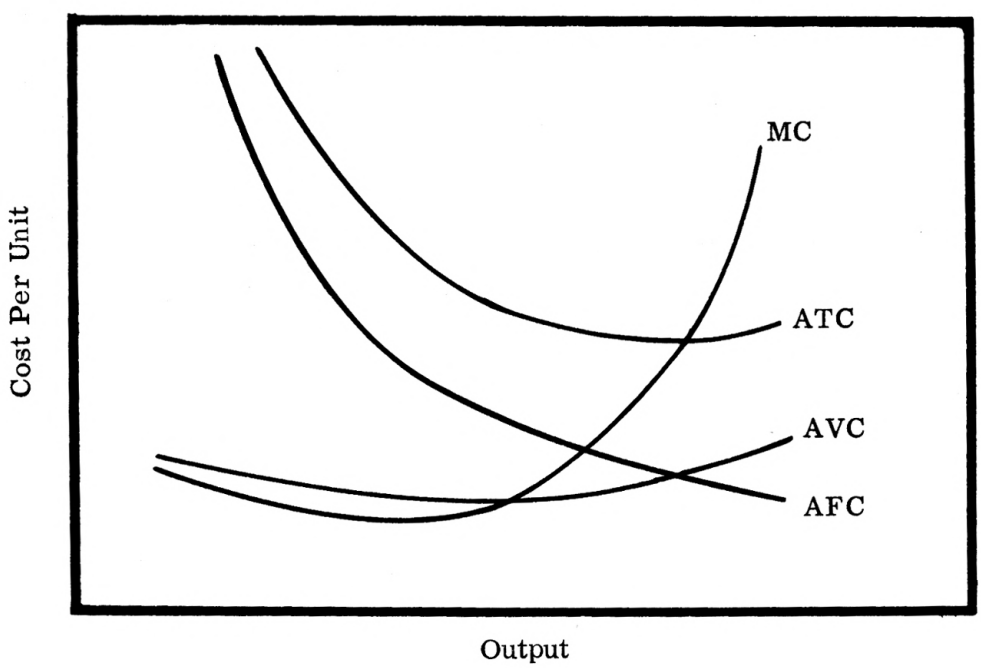

Fig. 5. Relationship of average and marginal cost curves.

OF is total fixed costs. Total variable cost is the area beneath the total cost curve and above line FC. In Fig. 5, AFC is average fixed costs, AVC average variable costs, ATC average total costs, and MC marginal cost. Because of load capacity limits, the average total cost curve for milk hauling units is shaped as shown in Fig. 7. In this study, functions were developed to determine total annual costs. Average total costs were obtained from the total costs.

Long-run costs provide information on the efficiency of different size hauling units. This information is useful when purchasing new units or replacing old units. Fig. 6 shows the relationship between short-run average total cost and economy-of-scale cost curves. Bridge load limits and farmstead maneuverability act as restraints to size of unit for hauling milk, as indicated by line QR. Unit C would be the maximum size unit which could operate under these restraints. Although long-run cost information was needed in the market, this study was limited to short-run average total costs of a specified unit without attempting to determine the position of this unit on the economy-of-scale-cost curve.

OBJECTIVES

A major objective of this study was to determine the cost of hauling milk by the bulk system under the existing organization of routes for a specific technology and time period. To achieve this objective, it was necessary to (1) develop a truck cost function for a specific technology, (2) to develop a route labor time function, and (3) to describe existing bulk milk route organization in the area.

Another objective was to determine possible improvements in the present bulk assembly process of the market.

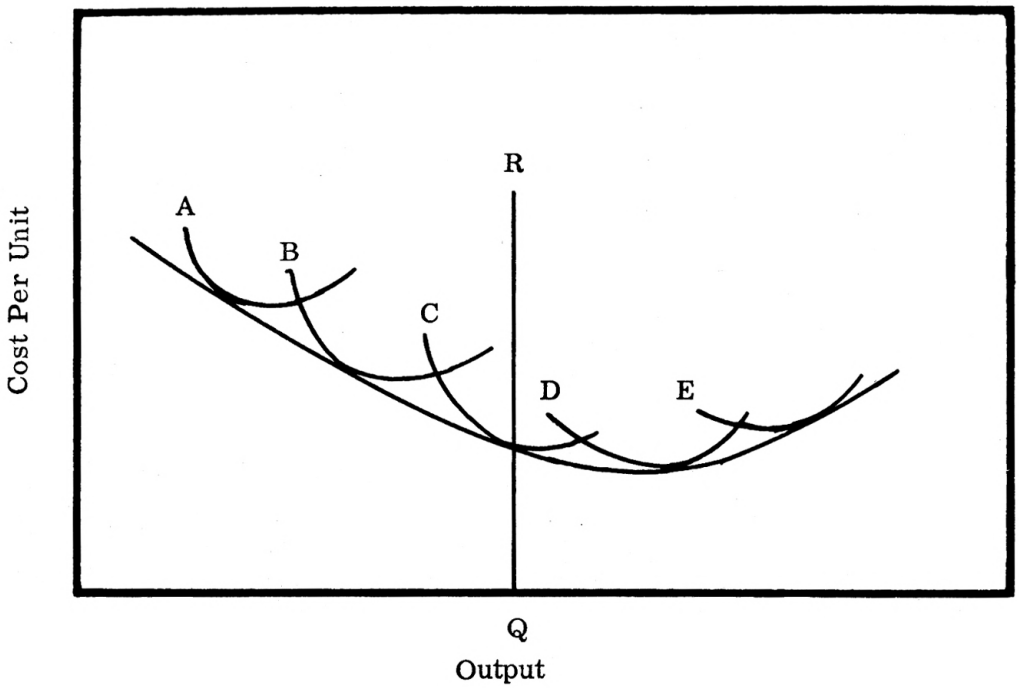

Fig. 6. Relationship between short-run and economy-of-scale cost curves.

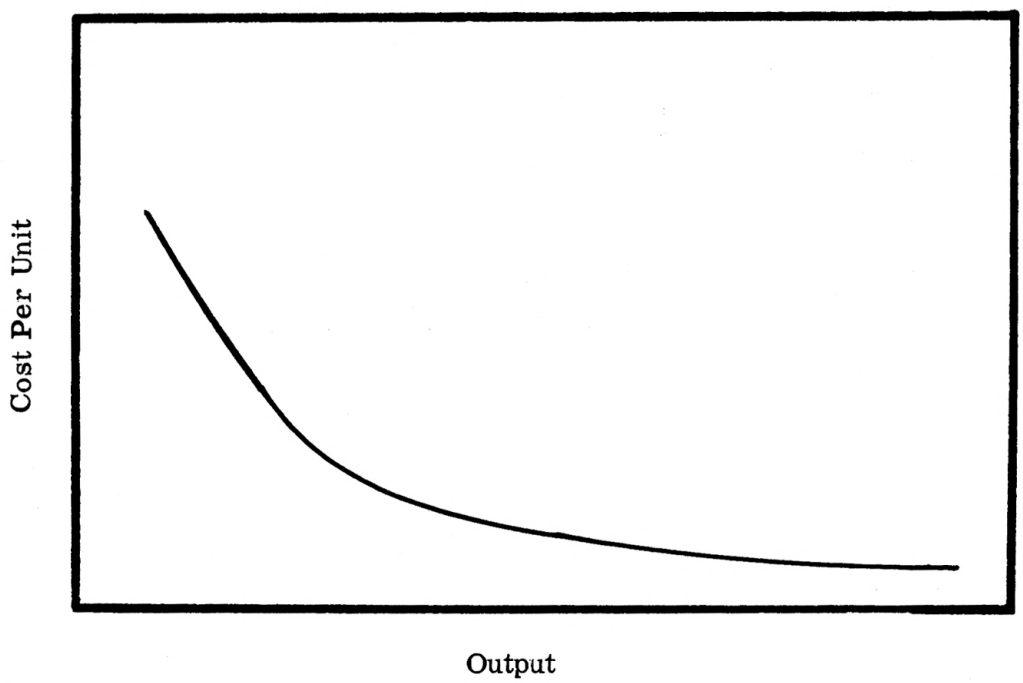

Fig. 7. Short-run average total cost curve.

ANALYTICAL MODEL

The cost of hauling milk involves inputs of physical resources and the prices of these resources. In this study, physical inputs were classified into truck chassis, tires, tank, operating, overhead, and labor inputs. Appropriate prices were applied to each of these inputs. Truck chassis and tires costs together with operating and overhead costs were combined into a truck cost function. A separate cost function was derived for the tank.

Labor inputs were divided into labor route time and plant time. Time functions were derived for each of these activities. Appropriate wage rates were applied to the labor requirements to obtain labor costs.

Truck and tank costs together with route labor costs gives total route costs. Cost per route mile was obtained by dividing total route costs by route miles. The estimated hauling cost for a hundredweight of milk was obtained by dividing the total route costs by the volume of milk in hundredweights hauled on a route.

Truck Cost Function

Truck costs for a specified time period, technology, and use may be estimated by a function of the following general form:

$$T_r = f(C_d, C_t, C_i, C_{it}, C_r, T_d, T_t, T_i, T_{it}, T_r, T_o, G, O, L)$$

where T_r = annual truck cost

C_d = annual chassis depreciation cost

C_t = annual chassis property tax cost

C_i = annual insurance cost

C_{it} = annual cost of interest on chassis investment

C_r = annual chassis repair cost

T_d = annual tire depreciation cost

T_t = annual tire property tax

T_i = annual tire insurance cost

T_{it} = annual cost of interest on tire investment

T_r = annual tire repair cost

T_o = annual truck overhead costs[1]

G = annual gasoline cost

O = annual oil cost

L = annual lubricating cost

Tank Cost Function

Tank costs may be estimated by a function of the following general form:

$$T_a = f(K_d, K_t, K_i, K_{it}, K_r)$$

where T_a = annual tank costs

K_d = annual tank depreciation cost

K_t = annual tank property tax

K_i = annual tank insurance cost

K_{it} = annual cost of interest on tank investment

K_r = annual cost of tank repairs

Route Labor Time Function

Route labor time requirements may be estimated by a function of the following general form:

$$T_m = \frac{M_1}{S_{p_1}} + \frac{M_2}{S_{p_2}} + \frac{M_3}{S_{p_3}} + \frac{M_4}{S_{p_4}} + S(F_{st}) + T\sum_{i=1}^{S} P_i$$

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[1]Annual Truck Overhead Costs includes licenses and permits, tags, and accounting service.

where T_m = minutes of route labor time

M_1 = miles from city limits to first bulk stop

S_{p_1} = speed of travel for M_1 distance

M_2 = miles of travel from first to last bulk stop

S_{p_2} = speed of travel for M_2 distance

M_3 = miles of travel from last bulk stop to city limits

S_{p_3} = speed of travel for M_3 distance

M_4 = miles of city travel (entering and leaving city)

S_{p_4} = speed of travel for M_4 distance

S = number of farm bulk stops

F_{st} = fixed farm stop time (including fixed pumping time)

T = pumping time per pound of milk

P_i = pounds of milk pumped at i^{th} farm on route

Plant Labor Time Function

Plant labor time requirements may be estimated by a function of the following general form:

$$P_m = P_f + P_p$$

where P_m = minutes of plant labor time

P_f = plant fixed time

P_p = plant pumping time

ANALYSIS

Existing Technology

Seventeen of the 18 trucks used in the Wichita area on which information was obtained in July of 1956 were single axle trucks varying in size from two

to three tons. The other truck was a tandem axle truck. Five major brands of trucks were used by the haulers indicating that no particular brand of truck was preferred by haulers. Seventeen-hundred gallon bulk tanks were mounted on 15 of the trucks and 1800 gallon tanks on the other three trucks. Seventeen of the bulk tanks were of stainless steel interior construction. The predominate exterior finish for these tanks was painted mild steel. The other tank was of fiber glass construction. Pump capacities ranged from 35 to 65 gallons per minute with the majority in excess of 50 gallons per minute. Three major brands of tanks were included in the sample.

Specified Technology

For the purposes of this study a truck and tank of a definite size and description was selected.

In selecting the size of unit to be used in this analysis, consideration was given to certain limitations on size. These limitations consist of bridge load limits, legal load limits, maneuverability on roads and in farmsteads, manufacturers specifications and volume of milk per route. It is recognized that routes could be re-organized to supply a larger volume of milk per route, but route re-organization is outside the scope of this study. Rather it is the purpose of this study to fit the most economical hauling unit to existing route conditions.

Since a 1700 gallon tank was used by a majority of the haulers and is well suited to the volume of milk on most of the routes, this size tank was selected for this study and will be called type A tank. Detailed specifications of a type A tank can be found in Appendix Table 21.

A two and one-half ton type A truck was selected for the 1700 gallon tank. Engineering data from truck and tank manufacturers were used in

fitting this size truck to the tank and load weight. Detailed specifications for this type A truck are given in Appendix Table 22.

Truck and Tank Life

The useful life of a fixed asset is determined by physical and economic factors. Miles of travel per year, miles of use before major repairs, cost of repairs, trade-in value, improved technology of newer models, and capital available influence the period of use of a truck. No definite period of use of trucks used for bulk hauling had been established in the Wichita area. The estimated period of use by owners varied from one and one half to four years with a modal period of two years. A number of operators actually purchased new trucks every two years. It was assumed that the truck used in this study would be used for two years and then traded in on a new truck.

At the present time the period of use of bulk hauling tanks is difficult to estimate. Haulers generally assumed a 10 year useful life for these tanks and this period of life will be assumed in this analysis.

Equipment Prices

Separate F.O.B. central Kansas price quotations were obtained for the two and one-half ton type A truck and tires. These prices are listed in Appendix Table 22 and include excise and sales tax. Total cost of the chassis was $4,073.26. Tires were valued at $1,281.81 giving a combined cost of $5,360.07. Many operators reported paying less than the above amount but two paid approximately the prices listed.

F.O.B. central Kansas price for the 1700 gallon type A tank are given in Appendix Table 23. The total cost of this tank, including excise and sales

tax was $7,081.20. Most haulers reported costs somewhat less than the above price but two owners paid more.

Truck Costs

Truck costs in this analysis are separated into chassis, tire, tank, operating, and overhead costs. The chassis, tires, and tank costs are considered separately rather than as a unit because different methods of depreciation are applied to each of these pieces of equipment.

Chassis Depreciation. One of the major costs of a fixed asset is depreciation. The common procedure in determining depreciation costs is to assume a useful life of the asset and then select a method of calculating the cost. The useful life of an asset is determined by use and obsolescence. Generally, the straight line, declining balance, or sum of the digits method is used in calculating depreciation costs.

In actual practice each manager has his own subjective estimate of the appropriate rate of depreciation. This estimate is influenced by his notions of the physical and economic life of the asset being considered. Other factors such as tax considerations may influence his method of depreciating a fixed asset.

The method of chassis depreciation used in this analysis is based on an "average" market or trade-in value. This method assumes that the truck would be an average truck and that truck prices and technology would remain constant for the time period relevant to this analysis. Depreciation rates for the truck chassis were derived from figures found in the National Automobile Dealers Used Car Guide and are given in Table 1.

Table 1. Annual depreciation rates as a per cent of new price assumed for two and one-half ton type A truck chassis without tires, central Kansas, 1956.[a]

Type of Depreciation	Years of use			
	1	2	3	4
	Per cent of new price			
Annual depreciation	32.988	15.308	12.580	8.736
Cumulated depreciation	32.988	48.296	60.876	69.612

[a]Rates computed from data reported in National Automobile Dealers Association Used Car Guide, April, 1956.

When these rates are applied to the truck chassis value presented in Appendix Table 22, annual depreciation costs are obtained. These costs are shown in Table 2. Some error is introduced by this method due to the fact that the trade-in values used in computing chassis depreciation rates included the value of the tires. However, this error was considered negligible.

Table 2. Estimated annual and cumulated depreciation costs for two and one-half ton truck type A without tires, central Kansas, 1956.

Item	Years of use				
	0	1	2	3	4
Annual depreciation	-	$1,345.34	$ 624.30	$ 513.04	$ 356.28
Cumulated depreciation	-	1,345.34	1,969.64	2,482.68	2,838.96
Net value of chassis	$4,078.26	2,732.92	2,108.62	1,595.58	1,239.30

This method of depreciation seems realistic since the used car guide represents the average market value for the asset. In actual practice, a particular truck may be worth more or less than the average due to the owner's bargaining ability and the condition of the truck. It was assumed in this study that the truck will have an average market value.

Chassis Property Taxes. The State Commissioner of Revenue and Taxation has authority over motor carriers having either a certificate of convenience or necessity or an Interstate License. The Commission is also authorized to assess only over-the-road motor vehicles and rolling equipment, exclusive of vehicles used solely or mainly for local transportation in a particular community or area, or for local pick up and delivery.[1]

Since the hauling operations of this study were assumed to meet the test of a local area operation, assessment procedures in the Wichita area were followed.

Assessed valuations for the two and one-half ton type A truck for 1955 and 1956 were obtained from the Kansas Personal Property Assessment Schedule.[2] Estimated assessed values for the tires were deducted to determine an estimated value of the chassis. The 1955 levy for the city of Wichita of 79.4 mills[3] was applied to the average assessed value of $1,140.16 for the first two years of life to obtain annual property tax of $90.53 for the truck chassis. Assessed values are given in Table 3.

Hauling firms qualifying for assessment at the state level would be taxed at a lower rate than the levy assumed in this study since the average state levy for motor vehicle property was $49.88 per $1,000 of assessed value.[4]

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[1]F. A. Palmer, Chief, Ad Valorem Division, State Commission of Revenue and Taxation, Topeka, Kansas, letter to Dr. Paul L. Kelley, Department of Economics and Sociology, Kansas State College, November 20, 1956.

[2]Compiled by the County Clerks Association of the State of Kansas.

[3]Kansas Government Journal, League of Kansas Municipalities, January, 1956, Table 3, p. 27.

[4]F. A. Palmer, Chief, Ad Valorem Division, State Commission of Revenue and Taxation, Topeka, Kansas, letter to Dr. Paul L. Kelley, Department of Economics and Sociology, Kansas State College, November 20, 1956.

Table 3. Estimated assessed valuation of two and one-half ton type A truck without tires, central Kansas, 1955 and 1956.

Item	Dollars	Dollars
Assessed valuation of two and one-half ton type A truck in 1956[a]	1,660.00	
Less assessed valuation of tires in 1956[b]	503.13	
Estimated 1956 assessed value of truck less tires		1,156.87
Assessed valuation of two and one-half ton type A truck in 1955[a]	1,375.00	
Less assessed valuation of tires in 1955	251.56	
Estimated 1956 assessed value of truck less tires		1,123.44
Average annual assessed value of truck excluding tires for first two years of use		1,140.16
Average annual assessed value of tires for first two years of use		377.35

[a]Kansas Personal Property Assessment Schedule, 1956, p. 62.

[b]Computed by using the ratio of market price to assessment value of new tube tires and tubes and using this ratio for tubeless tires used in this study. See Table 8.

Chassis Insurance. Trucks operated under the jurisdiction of the Kansas Corporation Commission are required to carry a minimum liability insurance in amounts of $10,000 per person for bodily injury, $20,000 per accident for bodily injury, and $5,000 per accident for property damage. The amounts of $50,000, $100,000, and $10,000 were used in this study. Premium quotations were obtained from several major insurance companies and the lowest rate was used in this study. Premium quotations were given for the chassis, tank, and tires as a unit. For the purposes of this analysis, the annual insurance charge was allocated to each of these items on the basis of the relative values of the purchase price as shown in Table 4. These allocated charges are given in Table 5.

Table 4. Percentages of totally equipped truck cost for purposes of prorating insurance costs on two and one-half ton type A truck and bulk tank, central Kansas, 1956.

Item		Cost of tank	Cost of tires	Cost of chassis	Total cost equipped
Base price amount	$6,465.00	$6,465.00	$1,205.50	$3,998.29	$11,668.79
free of excise tax	1,596.00				
Taxable-excise	4,869.00				
Federal excise tax 10 per cent		486.90			486.90
Poundage			52.20		52.20
Sales tax		129.30	24.11	79.97	233.38
Total		7,081.20	1,281.81	4,078.26	12,441.27
Per cent of total		56.92%	10.30%	32.78%	100%

Table 5. Annual insurance premiums for first two years of coverage for type A bulk tank, tires, and two and one-half ton Type A truck chassis, central Kansas, 1956.[a]

Item	Chassis	Tires	Tank	Total
Liability:				
Maximum coverage: $50,000 per person bodily injury $100,000 per accident bodily injury $10,000 per accident property damage	$14.69	$ 4.61	$25.50	$44.80
Medical: including extended medical of $1,000 per person	2.62	0.83	4.55	8.00
Comprehensive:	10.49	3.30	18.21	32.00
Collision:	23.99	7.54	41.67	73.20
Total:	51.79	16.28	89.93	158.00

[a]Rates are based on the assumption that trucks are either farmer owned or co-op owned to be used in picking up milk in rural areas and taking it to some particular delivery point either in Wichita or elsewhere.

Interest on Chassis Investment. Annual chassis investment for the two year period of use was obtained by calculating the average investment over the period and applying a five per cent interest rate to the average investment. These calculations gave an annual investment cost of $145.66. The procedure used in determining the average investment is given in Table 6. Beginning and ending values were obtained from Table 2.

Table 6. Method of computing investment value for first two years of life of two and one-half ton type A truck, central Kansas, 1956.

Items	Dollars	
Value beginning of first year	4,078.26	
Value end of first year	2,732.93	
Average value first year		3,405.59
Value beginning of second year	2,732.93	
Value end of second year	2,108.62	
Average value second year		2,420.78
Average value first two years		2,913.18

Chassis Repairs and Maintenance. Truck repairs are difficult to define as an expense category. Prudent business practice does not allow setting up as capital additions the various components of a major overhaul job if these components are added over a period of weeks. Realistic accounting suggests that it is difficult if not impractical to distinguish in practice between so-called repair and capital addition in the operation of milk hauling trucks. Since managerial decisions are made on the basis of charging most of the overhaul costs to repairs, there is substantial basis for using data compiled in this manner to estimate repair and maintenance costs for the truck chassis. Such data were obtained from the operations of 15 can-hauling trucks in the

Wichita area for the year 1955, (Appendix Table 25).

These data were used for estimating repair costs in this study since the can trucks were of similar size and age and operated under essentially the same road conditions as bulk trucks. A simple linear regression equation fitted to these data is as follows:

$$C_r = -47.6529 + .0213\ M_a$$

where C_r = annual truck repair costs in dollars

M_a = annual miles of travel

Tire Depreciation. Tire depreciation was assumed to be due primarily to use although some depreciation will take place without travel. Survey data of Wichita bulk milk haulers for February 1956 showed that eight truck operators recapped and seven operators did not recap truck tires (Appendix Tables 26 and 27). Average estimated miles of use for tires which were not recapped was 62,857 miles for front tires and 60,714 miles for rear tires. Average estimated miles of use before recapping tires was 47,500 miles for front tires and 43,125 miles for rear tires. Average estimated miles of use after recapping was 30,714 miles for front tires and 29,285 miles for rear tires. In this study it was assumed that tires would be recapped, and that miles of use for both front and rear tires would be 50,000 miles before recapping, and 30,000 miles after recapping.

Interviews with dealers who recap tires indicate that a charge of $25.00 per tire could reasonably be assumed for recapping. At the start of each recap period each tire was valued at recap charge plus $15.00 carcass value. The value of tires when new can be found in Appendix Table 22. The method of computing tire depreciation costs in this analysis is illustrated in Table 7.

Table 7. Method used for computing tire depreciation cost for tires used on two and one-half ton type A bulk milk truck, central Kansas, 1956.[a]

Item	Dollars	
First period		
Value of tires new	1,281.81	
Value at 50,000 miles of use	90.00	
Depreciation cost for first period		1,191.81
Second period		
Value of tires beginning of 1st recap period	240.00	
Value at 80,000 miles of use	90.00	
Depreciation cost for second period		150.00
Third period		
Value of tires beginning of 2nd recap period	240.00	
Value at 100,000 miles of use	140.00	
Depreciation cost for third period		100.00
Total depreciation cost		1,441.81
Average annual depreciation cost		720.90

[a]This example assumed 100,000 miles of use.

This method of computing tire depreciation costs was applied to the estimated annual mileages of 18 bulk trucks operating in the Wichita market during the summer of 1956 (Appendix Table 30). These budget estimates of tire depreciation yielded the following linear regression equation:

$$T_d = 432.32 + .005\ M_a$$

where T_d = estimated annual dollars of tire depreciation

M_a = annual miles of travel

Tire Property Tax. The average annual assessed value of the tires for the two year period was computed in the same manner as previously reported for the truck chassis and is reported in Tables 3 and 8. This value was

multiplied by the 79.4 mill levy which resulted in an annual cost of $29.96.

Tire Insurance. Insurance costs of tires were determined by pro-rating the tire value to the total insurance cost for the complete trucking unit. The annual tire insurance cost of $16.25 is reported in Table 5.

Interest on Investment in Tires. The average value of an asset can be computed by the straight-line depreciation method if no substantial capital additions are assumed during the life of the asset. In this analysis, capital additions to tires in the form of recap value were assumed at 50,000 miles and each additional 30,000 miles of use. The method of computing average annual tire value over the two year period for each of the 18 bulk trucks operating in the Wichita market during July of 1956 is outlined in Table 9. The miles of travel during the two year period were estimated from route mileage obtained on these trucks during July of 1956. A five per cent rate of interest was applied to the average annual value to obtain average annual cost of interest on tire investment. Appendix Table 30 gives the estimated miles of annual use, average annual tire value, and the annual interest on tire investment for the 18 bulk trucks.

A simple linear regression equation fitted to these costs and mileages is as follows:

$$T_i = 43.521 - .0004\ M_a$$

where T_i = average annual interest cost on tire investment

M_a = annual miles of travel

Table 8. Estimated assessed values of front and rear tires for two and one-half type A truck, Wichita, Kansas, area.

Item	New price per tire plus all taxes	Assessed value new tires	Assessment ratio new tires	Est. assessed value per set of new tires	Est. assessed value per set 1 yr. old	Est. avg. annual assessment 1st 2 years
Front Tires:[b]						
10-22.5 (10 ply)	$182.32	$70.47[d]	38.65	$140.93	$70.46	$105.70
9-20 (10 ply)[a]	181.11	70.00[c]	38.65			
Rear Tires:[b]						
11-22.5 (12 ply)	229.29	90.55[d]	39.49	362.20	181.10	271.65
10-20 (12 ply)[e]	227.90	90.00[c]	39.49			
Total				$503.13	$251.56	$377.35

[a]Equivalent to 10-22.5 tubeless tire.

[b]Two front tires and four rear tires used.

[c]Obtained from Kansas Personal Property Assessment Schedule 1956.

[d]Computed by multiplying estimated assessment ratio times new tire price.

[e]Equivalent of 11-22.5 tubeless tire.

Table 9. Procedure for estimating annual tire investment for 18 bulk trucks in Wichita, Kansas, Milkshed in July of 1956.

Item			Dollars	
Miles of use per year	50,000			
Miles of use per month	4,167			
Months of new tire use		12.0		
Months of use - 1st recap period		7.2		
Months of use - 2nd recap period		4.8		
Tire value new			1,281.81	
Tire value at 50,000 miles			90.00	
Average value - first period				685.90
Tire value beginning of 1st recap period			240.00	
Tire value at 80,000 miles			90.00	
Average value - second period				165.00
Tire value, beginning of 2nd recap period			240.00	
Tire value at 100,000 miles			140.00	
Average value - third period				190.00
685.90 x 12.0 =	8,230.80			
165.00 x 7.2 =	1,188.00			
190.00 x 4.8 =	912.00			
	24.0	10,330.80		
Average annual tire value for 2 year period 10,330.80 ÷ 24 =				430.45

Tire Repairs. Tire repair cost per mile of travel was estimated from cost data of 15 can trucks operating in the Wichita area (Appendix Table 25). Tire sizes and operating conditions of these can trucks were assumed to be approximately the same as for the two and one-half ton type A truck used in this analysis. A simple linear regression equation fitted to the data for the can trucks is as follows:

$$T_r = -31.3313 + .0014\ M_a$$

where T_r = annual tire repairs in dollars

M_a = annual miles of travel

Tank Costs

Tank Depreciation. The use of the bulk system is too new to have established a definite pattern of useful life for bulk tanks. The modal years of bulk tank life estimated by tank owners in the Wichita area was 10 years. It was assumed in this study that the bulk tank would be kept for the period of its useful life. The original cost of the tank was estimated at $7,081.20 (Appendix Table 23). Assuming a 10 year useful life and a $500.00 salvage value results in an average annual depreciation cost of $658.12 by the straight line depreciation method.

Property Tax on Tanks. The suggested method[1] used in determining property tax on bulk tanks in Wichita is given in Table 10.

Table 10. Assessed values and annual property tax for bulk tanks in Wichita, Kansas, 1956.

Item	Dollars	
First year		
Value of tank	7,081.20	
Assessed value of tank[a]	4,248.72	
Second year		
Value of tank[b]	5,664.96	
Assed value of tank[a]	3,398.98	
Average assessed value of tank for two year period		3,823.85
Annual property tax for two year period[c]		303.61

[a]60 per cent of value
[b]20 per cent depreciation is allowed second year
[c]1956 levy of 79.4 mills in Wichita

[1]E. M. Bell, Office of County Assessor, Wichita, Kansas, letter to Dr. Paul L. Kelley, Department of Economics and Sociology, Kansas State College, December 17, 1956.

Tank Insurance. Liability, medical, comprehensive, and collision insurance costs allocated to tank costs are reported in Table 4. In addition, the Kansas Corporation Commission requires that operations classified as intrastate common carriers have cargo insurance in the amount of $1,000 for each piece of equipment.[1] Cargo insurance comes under the heading of Marine Coverages, and policies for the units considered in this analysis can be obtained for $15 per year for $1,000 of insurance. Loss coverage includes fire, wind, hail, explosion, falling aircraft, collision, upset or overturn. This coverage applies when the cargo is loaded and remains in effect until the cargo is unloaded. In general, cargo insurance policies carry a 100 per cent co-insurance which means the insured agrees to carry cargo insurance on at least 100 per cent of his insurable value. In case the co-insurance agreement is not met, then the insured becomes a co-insurer by the amount of his deficiency in the insurance to the amount of risk.

For the truck operations considered in this analysis, the maximum load that could be carried in a 1700 gallon tank, disregarding load limits, is 14,600 pounds of milk. At a value of $5 per hundredweight, the maximum value of the risk is $730. Therefore, a $1,000 policy would be sufficient.

Interest on Tank Investment. Since a straight line depreciation rate was assumed on the bulk tank, the value at the end of the first year was used as the average tank value for this analysis. This value was $6,423.08. Using an assumed interest rate of 5 per cent resulted in an average cost of $321.15 for interest on tank investment. For certain accounting purposes the average

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[1]R. W. McKinley, Chief Clerk, Motor Carrier Division, State Corporation Commission, Topeka, Kansas, letter to Dr. Paul L. Kelley, Department of Economics and Sociology, Kansas State College, December 5, 1956.

investment value over the life of the tank may be more appropriate than the average value over the first two years of life.

Tank Repairs. Gaskets were estimated to cost approximately $30 per year. From estimates of drivers, repair costs on the pump and motor would be about $15 per year. Sixteen feet of plastic hose was assumed to last three years with an estimated replacement cost of $68. Annual cost of these three items was assumed to be $67.67. Sampling equipment was assumed to be furnished by the plant receiving the milk.

Operating Costs

Gasoline Costs. Although some gasoline is used for starting the engine and during engine idling periods, gasoline consumption is assumed to be primarily related to distance traveled for bulk milk hauling trucks in this analysis. Based on estimates of bulk milk truck operators, these trucks averaged 7.219 miles per gallon of gasoline in the Wichita area. The average reported price was 22.71 cents per gallon. These data are similar to those reported for 15 can milk trucks operating in the Wichita area in 1955. Since the can truck data were considered applicable to bulk operation, a gasoline cost function was derived from these data. This equation is as follows:

$$G = -55.81 + .02938\ M_a$$

where G = annual cost of gasoline in dollars

M_a = annual miles of travel

Oil Costs. The quantity of oil per oil change, the quantity of oil used between oil changes, and the frequency of oil changes together with the price of oil determine oil costs. The quantity of oil per change is determined by

the size of the engine, and the quantity used between oil changes is determined by the mechanical condition of the engine and the frequency of oil changes. The frequency of oil changes is subject to the notions of the operator and is generally based on a certain distance in miles.

The average distance between oil changes reported by the Wichita haulers in February of 1956 was 1980 miles. An average of 7.43 quarts of oil were used per oil change with 2.13 quarts added between oil changes. The average cost of oil reported by the haulers was 32 cents per quart. Using this information, the average cost of oil per mile for this analysis was computed to be .1545 cents. This cost was somewhat higher than a cost per mile of .1373 cents computed for 16 can hauling trucks in the Wichita area for 1955.

Lubrication Cost. February of 1956 survey reports of Wichita haulers indicated that the average number of miles between grease jobs was 1,067 miles and the average cost of a grease job was $1.68. This resulted in a cost of .1574 cents per mile. Again this cost was substantially higher than the cost of .1195 cents per mile for the 16 can trucks operating in the area during 1955.

Overhead Costs

Principal items of overhead cost considered in the analysis were tag fees, Kansas Corporation Commission fees, milk tester's license and permit, chauffeur's license and bookkeeping costs.

Tag or truck registration fees of $125 are charged for trucks having a gross vehicle weight of 20,001 to 24,000 pounds, if the tag is purchased between January and March each year.

No costs were assumed for KCC permits in this study. However, there are

hauling operations in which such costs must be considered. Such costs can be determined as follows:

> The transportation of milk from the producer to the dairy or to sell has been considered an exempt operation by the Commission. If the operator is transporting milk from one dairy to another dairy, this, of course, would be either a contract or a common carrier. If he is operating for hire or if he is buying the milk from one dairy and reselling it to a dairy, it will be a private carrier operation.
>
> On the contract and private carrier operation there is a filing fee of $10 for each power unit registered under the authority. Under the common carrier or public carrier, the filing fee is $25. The regulatory fee, of course is $10, the same as on the contract and private carrier.[1]

Bulk milk haulers must obtain a milk tester's license from the State Dairy Commissioner. In addition, they are required to have a chauffeur's license and a city truck permit in the Wichita area. The annual cost of these permits was estimated at $9.50. Bookkeeping costs were estimated from the survey reports at $300 per year. Combined overhead costs totaled $434.50 per year.

Transportation Cost

A three per cent transportation tax must be paid under certain specified conditions but is not included in the cost calculations of this study. Where applicable, this tax is payable to the U. S. Treasury Department. The person who makes payment of transportation charges is liable for the tax payment and this liability cannot be shifted by contract. Certain exemptions, however, are provided:

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[1] R. W. McKinley, Chief Clerk, Motor Carrier Division, State Corporation Commission, Topeka, Kansas, letter to Dr. Paul L. Kelley, Department of Economics and Sociology, Kansas State College, December 5, 1956.

A Cooperative or Mutual Association organized and operated for the purpose of marketing the produce of its members is not engaged in the business of transporting property for hire to the extent of the trucking services furnished by it to its members with its own trucks. However, in the event trucking services are furnished to the members which are not performed in connection with the marketing of their produce, the cooperative is engaged in transporting property for hire, according to IRS.

A mutual cartage company or association organized and operated for the purpose of furnishing a trucking service to its members in the operation of their separate business is held by the IRS to be engaged in the business of transporting property for hire even though the charges to the members cover only the actual cost of operating the trucks.[1]

Route Time

Route time is determined by the number of stops, time spent at each stop, distance between stops, total distance, and speed of travel. Estimate of the time required for various route operations were derived by a time and motion analysis of bulk milk hauling operations in the Wichita area during the summer of 1955.

Total Farm Stop Time. For the purposes of the time and motion study, a bulk tank stop was defined to be the total elapsed time from the point of leaving the main road and entering the farm lane to the time the truck again entered the main road. The various elements originally defined in total stop time were (1) enter farmstead and position truck, (2) measure weight of milk, (3) read and record temperature of milk, (4) record weight of milk, (5) agitate milk, (6) attach hose to farm tank, (7) obtain milk samples, (8) pump milk, (9) disconnect and reassemble hose in truck, (10) rinse farm tank,

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[1]Harry W. Lash, Acting Chief, Review Staff, Internal Revenue Service, Treasury Department, Wichita, Kansas, letter to Dr. Paul L. Kelley, Department of Economics and Sociology, Kansas State College, March 21, 1957.

(11) conversation time, (12) travel from milk house to road. Since certain of the bulk stop operations could be performed on various independent and joint sequences, stop elements were combined into four major categories as follows: (a) fixed stop time, (b) pumping time, (c) lane time and (d) waste time.

Total stop time varied from 8.83 to 34.56 minutes with an average of 15.57 minutes. The above maximum and minimum figures are given for general information and were not used in the route time function.

Fixed Farm Stop Time. Fixed farm stop time was defined to be total stop time less all lane pumping and waste time. It includes elements 2, 3, 4, 5, 6, 7, 9, and 10 of the items originally defined in stop time. Fixed stop time ranged from 4.65 to 18.92 minutes per stop with an average of 9.01 minutes for all stops. Average fixed time per stop per route ranged from 5.64 to 12.33 minutes with an average of 8.98 minutes. Average fixed time per farm stop per driver varied from 6.63 to 12.33 minutes with an average of 8.87 minutes. In this analysis, the fixed time per farm stop was assumed to be 8.98 minutes.

Pumping Time at Farm Stop. Pumping time is the chief variable time element in a bulk pick-up stop. Pumping time was defined as the actual time spent in pumping from the time the motor was started until it was turned off. Pumping time and volume information was obtained for 113 farm stops. As noted earlier pump capacities varied from 35 to 65 gallons per minute. A simple linear regression fitted to these data yielded the following equation:

$$T_1 = .8498 + .0023\ P$$

where T_1 = pumping time in minutes and

P = number of pounds of milk

Lane Time. Lane time is the travel time required for entering and leaving the farmstead. This time ranged from 0.83 to 6.65 minutes with an average of 2.23 minutes per farm. Lane time figures are not used in this analysis because this time is included in the route travel time from the first to last stop.

Waste Farm Stop Time. Waste farm stop time includes the conversation and other personal time that actually slows down the pick-up process. This time ranged from 0 to 7 minutes with an average of 0.46 minutes per farm stop. Waste time is not included in route time in this analysis.

Travel Time, City Limits to First Stop. Route mileages from the city limits to the first farm stop which used in this analysis are calculated mileages. Therefore, measured time data were not available for this type of route distance. However, in the 1955 time and motion survey, speeds were recorded at random for the various trucks when traveling from their point of origin to the first stop. A simple average of these speeds was 45 miles per hour. This figure was used in the analysis.

Travel Time, First to Last Bulk Stop. Mileage was recorded during the 1955 survey only as the truck left the main road to enter the farm lane. As a result, the distance between farm stops in this analysis is defined as the miles of travel from the point of leaving the main road at the first stop to the same point on the next successive farm stop. In this manner the distance includes lane, farmstead and main road travel. Miscellaneous stops to pick up milk in cans or to leave feed were excluded. Also rest stops were excluded since they did not occur on all routes and did not appear to occur in any predictable fashion. The time between each farm stop as defined above

was also recorded. Since this time included farm fixed stop, pumping, and waste time, these were deducted from the recorded time to obtain actual travel time.

Eighty-five observations were obtained in this manner for 17 routes during the summer of 1955. These data yielded essentially a linear relationship for miles of travel between stops and minutes of travel time as follows:

$$T_2 = 3.9109 + 1.3826\ M$$

where T_2 = estimated minutes of driving time and

M = miles of travel from point of entering a farm lane to the same point on the next bulk stop.

Most of the distance between stops were from 1 to 8 miles. The longest distance reported was about 25 miles. From the estimating function it is possible to estimate the average speed per hour for various distances between stops within the range of distances reported in this study.

For certain purposes lane speed would be desirable. However, the distance between farm stops as defined in this study is of value in estimating travel time requirements in route reorganization since lane distances are usually not available for this purpose. As a practical matter distances between farms could be measured on a highway map ignoring lane distances.

Travel Time, Last Stop to City Limits. Complete data were available for 9 bulk milk routes in the Wichita area for the sample period in the summer of 1955 to estimate the speed of travel from the last stop to the city limits. A simple linear regression equation fitted to these data is as follows:

$$T_3 = 11.5976 + 1.1785\ M$$

where T_3 = travel time in minutes from entering the last stop to city limits and

M = distance in miles

City Travel Time. City travel time and distance data were available on 8 bulk milk routes in the Wichita Milkshed for a sample period in the summer of 1955. An average of this speed was 15.07 miles per hour or 3.9814 minutes per mile.

Plant Time

The time spent at the plant consisted of fixed plant time, pumping time, and waste time. Typical operations involving time at the plant were (1) enter plant area and position truck, (2) hook up to plant intake, (3) pumping, (4) unhook from plant intake, (5) clean tank and pump, and (6) leave the plant area. Time on these operations was obtained for 15 bulk routes in the summer of 1955. All of these operations were performed by the driver, except for assistance by a plant helper in cleaning tank and pump. Milk samples and weight tickets were delivered to the plant during the pumping time.

Total Plant Time. Total plant time includes fixed time, pumping time, and waste time. This time varied from 34 to 168 minutes per route with an average of 68.72 minutes.

Plant Fixed Time. Plant fixed time was considered to consist of all plant time exclusive of pumping and waste time. When more than one load of milk was hauled by a truck per day, the tank, pump, and hose were cleaned only after the last load. Therefore, it was necessary to determine plant fixed time including and excluding washing and cleaning operations.

Table 11 shows that an average of 34.62 minutes of fixed time was

required at the plant when one load of milk was hauled per day. Since the data give time information on only one truck which hauled more than one load per day, plant fixed time excluding washing and cleaning operations was estimated from other information. This estimated time is given in Table 12. The time required to enter the plant area and position the truck, and to hook up the plant intake was taken from the survey data. An assumption was made that the same amount of time would be required to unhook from the plant intake as to hook up. One minute was assumed as the time required to leave the plant area.

The difference of 27.31 minutes between the average fixed time of 34.62 minutes which included washing and cleaning operations, and the estimated 7.31 minutes where these operations were excluded, indicates that a substantial reduction in the average fixed plant time per route could be achieved if several loads of milk were hauled by one truck in a day.

Plant Pumping Time. The time required to pump milk from the truck to the plant depends upon the volume of milk, the capacity of the pump, and technical organization within the plant.

Pumping time on 15 unloadings during the summer of 1956 together with the volume of milk unloaded is reported in Table 11. As previously reported, the capacity of pumps used in the Wichita area varied from 35 to 65 gallons per minute. Some delays in pumping time due to technical difficulties with the plant were observed at the time of the survey.

A simple linear regression fitted to the data in Table 11 is as follows:

$$Y = -4.1 + .003413\ X$$

where Y = minutes of pumping time, and

X = pounds of milk unloaded at the plant

Table 11. Minutes of time for unloading bulk tanks at plants for 15 routes, Wichita, Kansas, summer 1955.

Route no.	Date 1955	Lbs. of milk unloaded	Total time	Pumping time	Waste time	Fixed time per day: One load	Fixed time per day: First load*	Fixed time per day: Second load**
			(Minutes and hundreds of minutes)					
a	6/14	7,428	43.25	18.63	2.35	22.27	--	
b	6/15	7,657	67.27	18.83	16.25	32.19	--	
c	6/23	9,776	148.17	44.67	68.00	35.50	--	
d	6/24	11,119	78.00	36.17	0.08	41.75	--	
e	6/28	11,616	66.00	46.25	5.07	14.68	--	
f	6/30	4,952	36.62	11.50	0.00	25.12	--	
g	7/1	12,445	88.50	26.88	10.50	51.12	--	
h	7/12	7,819	40.67	27.00	0.83	--	12.84	
i	7/12	10,449	80.50	36.00	2.33	--	--	42.17
j	7/14	6,281	69.33	19.17	0.00	50.16	--	
k	7/15	9,102	78.00	30.25	0.00	47.75	--	
l	6/16	4,871	40.67	13.83	5.42	21.42	--	
m	6/21	6,417	34.25	9.67	0.00	24.58	--	
n	6/22	12,388	98.00	26.13	30.92	40.95	--	
o	6/17	7,429	61.50	14.58	4.33	42.59	--	
Average		8,648	68.72	25.30	9.74	34.62	12.84	42.17

* Washing and cleaning operations omitted.
**Washing and cleaning operations included.

Table 12. Estimated fixed unloading time at plant where washing of tank and pump is omitted, Wichita, Kansas, summer 1955.

Operation	Avg. time in minutes
1. Enter plant and position truck	2.23
2. Hook up to plant intake	2.04
3. Unhook from plant intake[a]	2.04
4. Leave plant area[a]	1.00
Total fixed time	7.31

[a]Assumed values from judgment of observers.

Pumping time in the Wichita area was somewhat greater than reported in California and Wisconsin studies.[1] Reasons which may explain this difference are differences in capacity of pumps used, delays due to technical difficulties within the plant, and a general lack of experience with this system of milk hauling in the Wichita area. Therefore, pumping times observed during the survey period were not considered to be typical of what might be expected after a routine was developed for this operation. In fact, the rate of unloading was actually less than the rate of loading observed on the survey routes.

For these reasons, the coefficient for pumping time used in the analysis was adapted from Clark.[2]

Plant Waste Time. All unproductive avoidable delays that extended the total unloading time were classified as waste time. Variation in plant waste time between routes was from 0 to 60 minutes with an average of 9.74 minutes. These figures are given in Table 11. At the time of the survey, some drivers spent a considerable amount of time waiting to unload that could have been prevented by more adequate intake facilities and proper scheduling of trucks. Waste time is not included in determining route time in this study.

Labor Rates

Many of the bulk milk routes in the Wichita market were operated by the

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[1]Arthur H. Miller, Bulk Handling of Wisconsin Milk, Farm to Plant, Research Bulletin 192, University of Wisconsin, February 1956, p. 18 and 19.

[2]Ibid., footnote 12 p. 18. Clark reported a tank unloading time as "25.3 plus 0.0167 G minutes."

owners of the tank and truck. Some of these owners operated can milk trucks in addition to their bulk operations and hired extra drivers who were used on both bulk and can operations. In actual practice, truck owners will attempt to keep their labor force fully employed for at least an eight hour day or pay a flat amount to a driver for a particular day's run. There may be instances, however, in which an owner must guarantee an eight hour day when the driver works less than this amount. In these cases, labor costs can not be computed at a flat rate per hour for the hours of work required on a particular route. These complications in labor utilization are recognized but are beyond the scope of this study. In order to simplify the analysis and to make comparisons of costs between routes, the assumption was made that labor could be fully employed when not otherwise used for route operations. Charges for management were also excluded in this analysis. Two basic wage rates were computed and applied to the route time requirements in the final phase of the analysis. The first wage rate assumes a $300 per month basic salary. The second rate assumes levels currently being paid union truck drivers in the Wichita area.

Calculations using the basic salary of $300 per month are shown in Table 13. Haulers are assumed to meet the requirements of the minimum wage provisions but not overtime wage requirements of the Fair Labor Standards Act. From the data of Table 13 an average labor cost of $1.60 per hour was derived.

The second estimate of labor cost was obtained by using union wage rates for truck operators in the Wichita area. These rates varied from $2.00 to $2.10 per hour during the period of the analysis.[1]

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[1]Letter of May 7, 1956, from Martin Grantham, Chief of Research and Statistics, Employment Security Division, State of Kansas Labor Department, Topeka

Table 13. Procedure for determining estimated labor costs per hour per driver on bulk milk routes, Wichita, Kansas, summer 1956.

	Annual costs	
Basic wage ($300 per month)	$3,600.00	
Unemployment compensation (3% on first $3,000)	90.00	
Workmen's compensation ($1.53 per $100)[a]	55.08	
Social Security Taxes (2%)	72.00	
Health insurance ($8.60 per month)	103.20	
Total annual cost of regular driver		$3,920.28
Annual hours worked by regular driver (51 weeks at 48 hours per week = 2,448)		
Base rate of pay per hour ($3,600 ÷ 2,448 = $1.47 per hour)		
Costs of relief driver		
Salary: 1 day per week for 52 weeks plus six days during vacation of regular driver at 8 hours per day = 464 hours per year.		
464 hours at $1.47 per hour	682.08	
Unemployment compensation (3%)	20.46	
Workmen's compensation ($1.53 per $100)	10.44	
Social Security Taxes (2%)	13.64	
Health insurance (464/2448 x $103.20)	19.56	
Total annual cost of relief driver		746.18
Total annual labor cost per driver		4,666.46
Total hours (464 ÷ 2448 = 2,912) Average labor cost per hour ($4,666.46 ÷ 2,912) =		1.60

[a] $14 annual constant charge for writing policy omitted in cost calculations.

Summary of Functions

Truck Cost Function. The specific costs of the truck cost function discussed in this analysis are summarized in Table 14. Since these costs are assumed to be additive, they can be summarized in a truck cost function as follows:

$$T_r = 1,753.54 + [341.0468 + .059799\ M_a]$$

where T_r = annual truck costs in dollars, and

M_a = annual miles of travel

Tank Cost Function. The specific tank costs discussed in this analysis are given in Table 14. Since all tank costs were classified as fixed in this analysis, the tank cost function is as follows:

$$T_a = 1,455.48$$

where T_a = annual tank costs in dollars

Time Functions. Since more than one wage rate is used in this study, the labor cost function is presented as a route time function and a plant time function. Wage rates may then be applied to these time functions to determine labor costs. A summary of the time elements used in this study are given in Table 15.

(1) Route time function

$$T = 1.3333\ M_1 + [S-1\ (5.9109) + 1.5826\ M_2] + [11.3976 + 1.7850\ M_3] + 3.9814\ M_4 + [S\ (9.8298) + .0023\ P]$$

where T = route time in minutes

M_1 = miles of route travel from city limits to first stop

M_2 = miles of route travel from first to last bulk milk stop

M_3 = miles of route travel from last bulk milk stop to city limits

Table 14. Estimated annual costs of operating a two and one-half ton type A truck and type A bulk tank in Wichita, Kansas Milkshed, 1956.[a]

Item	Average annual fixed cost	Fixed for annual miles of use	Variable per annual miles of use
Truck: (Without tires or tank)			
Depreciation	$ 984.82		
Property taxes	90.53		
Liability insurance	14.69		
Collision insurance	23.99		
Comprehensive insurance	10.49		
Medical insurance	2.62		
Interest on investment	145.66		
Repairs and maintenance		($-47.6529	.0213)
	$1,272.80	/$-47.6529	.0213/
Tires:			
Depreciation		($432.3200	.0050)
Property taxes	$29.96		
Liability insurance	4.61		
Collision insurance	7.54		
Comprehensive insurance	3.30		
Medical	.83		
Interest on investment		(43.5210	-.0004)
Repairs and maintenance		(-31.3313	.0014)
	$46.24	/$444.5097	.0060/
Tank:			
Depreciation	$658.12		
Property taxes	303.61		
Liability insurance	25.50		
Collision insurance	41.67		
Comprehensive insurance	18.21		
Medical insurance	4.55		
Cargo insurance	15.00		
Interest on investment	321.15		
Repairs and maintenance	67.67		
	$1,455.48		
Overhead:			
City licenses and permits	$9.50		
Tag	125.00		
Accounting service	300.00		
	$434.50		
Gasoline:		-55.81	.02938
Oil:			.001545
Lubrication:			.001574
Total:	3,209.02	341.0468	.059799

[a]Costs apply only to first two years of life of truck and tank.

M_4 = miles of route travel in city

S = number of bulk stop on route

P = total pounds of bulk milk picked up on route

(2) Plant time function

(a) one load per day

$$T_1 = 34.6 + .001941\ P$$

where T_1 = minutes of unloading time

P = pounds of milk unloaded

(b) each load per day except last load

$$T_2 = 7.31 + .001941\ P$$

where T_2 = minutes of unloading time

P = pounds of milk unloaded

Table 15. Summary of estimated route and plant time in Wichita, Kansas Milkshed, summer, 1955.

Item	Fixed time in minutes	Variable time in minutes
Route time		
Farm stop time		
Fixed	8.9800	---
Pumping	0.8498	.0023 P[a]
Travel time		
City limits to first bulk stop	---	1.3333 M[b]
First to last bulk stop	3.9109	1.3826 M
Last bulk stop to city limits	11.3976	1.7850 M
Within city limits	---	3.9814 M
Plant time		
Fixed per load		
With cleaning operations	34.6000	
Without cleaning operations	7.3100	
Pumping		0.001941 P

[a] P = pounds of milk

[b] M = miles of travel

APPLICATION OF FUNCTIONS TO SAMPLE ROUTES

In the following sections, a description of a sample of route organizations, mileages, and loads is presented. This was a judgment sample including 81 per cent of the producers selling by the bulk method in July 1956. Essentially the same technology, that is, 1700 or 1800 gallon tanks, was used on these routes. A 2500 gallon tank was in use but was excluded from this analysis. The cost functions derived in this study were applied to the sample routes to determine variations in costs among routes. This information should provide a basis for determining if more efficient route organizations could be developed. In addition such cost data provide a bench mark for comparing the relative economic efficiency of the use of different technologies in the hauling process.

Characteristics of Routes

The organization of 40 bulk milk routes was obtained in the summer of 1956. These data are summarized in Table 16.

Most bulk milk routes do not originate in practice at city milk plants. Drivers may begin the route at home, plant, or some other convenient point. This practice could result in excessive distance from point of origin to first farm stop, which would affect total route costs. For this reason actual route mileages were adjusted.

Adjusted Route Miles

A route in this analysis was defined to include the distance from the city limits to the first bulk stop, first bulk stop to last bulk stop, last bulk stop to city limits, city limits to plant, and plant to city limits.

Table 16. Miles of travel, pounds of milk hauled, and number of producers by specific routes and days for bulk milk routes in the Wichita, Kansas Milkshed, July, 1956.[a]

Truck code no.	Route code no.	Date July 1956	No. of producers	Lbs. per route	Lbs. milk per stop			Miles per route				
					Avg.	High	Low	City limits to first stop	First to last stop	Last stop to city limits	Total city travel	Total route travel[b]
1	a	18 a.m.	11	13,218	1,202	2,605	242	19.25	45.90	1.35	6.00	72.50
	b	18 p.m.	6	7,599	1,266	2,039	927	2.00	38.00	13.00	6.00	59.00
2	c	18	11	13,329	1,212	2,479	606	55.00	55.00	25.00	7.00	142.00
	d	19	14	13,983	999	1,993	374	50.00	38.00	48.00	7.00	143.00
3	e	18 a.m.	8	12,144	1,518	2,813	707	30.00	43.70	37.30	7.80	118.80
	f	18 p.m.	7	12,314	1,759	3,567	872	29.00	16.20	25.30	7.80	78.30
	g	19 a.m.	7	9,231	1,319	2,825	448	30.00	29.50	26.50	8.80	94.80
	h	19 p.m.	6	9,522	1,587	2,327	553	28.00	13.50	25.50	8.80	75.80
4	i	18	14	12,138	867	2,712	458	42.00	36.00	51.00	6.80	135.80
	j	19	14	6,303	450	1,346	225	42.00	36.00	51.00	6.80	135.80
5	k	18	8	13,127	1,641	2,711	540	65.50	26.90	62.50	6.40	161.30
	l	19 a.m.	7	13,259	1,894	5,345	867	46.00	12.00	37.00	6.40	101.40
	m	19 p.m.	7	5,520	789	1,788	212	42.50	47.85	50.00	6.40	146.75
6	n	18	15	9,593	640	2,781	185	52.50	71.60	26.40	6.00	156.50
	o	19	9	10,801	1,200	2,315	330	33.00	41.70	33.30	6.00	114.00
7	p	18	12	10,760	897	2,904	152	46.00	16.00	38.00	8.80	108.80
	q	19	11	11,501	1,046	2,012	454	54.00	40.50	51.50	8.80	154.80
8	r	18	11	14,958	1,360	6,111	434	46.00	39.35	29.65	6.80	121.80
	s	19	14	15,947	1,139	1,801	599	47.00	61.25	45.75	6.80	160.80
9	t	24	9	15,721	1,747	4,258	858	7.00	53.50	5.50	8.00	74.00
	u	25	10	13,577	1,358	2,325	781	13.00	46.20	12.30	9.20	80.70
10	v	25	11	13,625	1,239	2,104	322	65.00	68.00	31.00	6.40	170.40
	w	26	12	13,887	1,157	1,788	371	64.00	35.25	57.50	6.00	162.75

Table 16 (Concl.).

Truck code no.	Route code no.	Date July 1956	No. of producers	Lbs. per route	Lbs. milk per stop			Miles per route				
					Avg.	High	Low	City limits to first stop	First to last stop	Last stop to city limits	Total city travel	Total route travel[b]
11	x	25 a.m.	7	11,724	1,675	3,172	823	13.50	21.00	6.50	9.00	50.00
	y	25 p.m.	1	4,018	4,018	4,018	4,018	6.00	—	6.00	9.20	21.20
	z	26 a.m.	7	10,945	1,564	2,935	965	9.50	64.50	22.50	6.90	103.40
	a_1	26 p.m.	6	8,862	1,477	1,890	1,152	13.00	25.50	5.50	6.80	50.80
12	b_1	26	8	9,381	1,173	1,619	765	20.00	31.00	16.00	7.70	74.70
	c_1	27	4	4,560	1,140	1,424	829	10.50	18.00	6.00	8.40	42.90
13	d_1	26	6	10,018	1,670	2,365	1,008	68.75	30.00	54.00	6.80	159.55
	e_1	27	11	12,308	1,119	2,163	456	62.50	78.25	63.75	6.80	211.30
14	f_1	26	2	5,124	2,562	2,742	2,382	25.00	7.50	17.50	6.80	56.80
	g_1	27	11	11,338	1,031	2,336	431	54.50	27.00	63.00	6.80	151.30
15	h_1	26	4	5,391	1,348	2,211	841	43.50	17.75	56.00	12.80	130.05
	i_1	27	7	10,042	1,435	2,172	850	72.00	30.00	71.75	12.80	186.55
16	j_1	26	10	14,926	1,493	2,688	780	18.00	30.50	14.50	9.00	72.00
	k_1	27	9	10,474	1,164	1,959	446	29.50	25.00	15.50	8.10	78.10
	l_1	27	7	7,539	1,077	1,436	697	18.00	26.40	12.10	7.70	64.20
17	m_1	27	12	13,276	1,106	1,898	708	36.50	62.75	29.25	6.80	135.30
18	n_1	27	9	11,544	1,283	1,886	703	12.50	52.50	28.50	6.80	100.30

[a]Routes surveyed included 81 per cent of the producers selling in bulk at the time of the study. The sample was a judgment sample selected to be representative of bulk operations in the summer of 1956.
[b]This is a computed mileage.

The adjustment procedure consisted of discarding the distance from point of origin to first bulk stop and substituting the shortest distance over all-weather roads from the city limits to the first bulk stop. The route miles reported in Table 16 and 17 are adjusted route miles.

Time Requirements

The time functions developed in this analysis were applied to the sample routes to compute route time, plant time, and total time required for each of the routes. These times are given in Tables 18 and 19.

Route Costs

Truck Costs. The truck cost function and tank cost function developed in the analysis were combined to compute truck costs per route. These costs are given in Table 20.

Average annual fixed costs were allocated to routes on the basis of days of operation and routes traveled per day. Fixed costs for annual miles of use were allocated to routes on the basis of route miles. Annual miles of travel was assumed to be 365 times daily route mileage.

Truck costs per route were computed with the following functions:

(1) Trucks operated daily

$$T_r = \frac{3209.02}{365 \times N} + \frac{(341.0468 + .059799\, M_a)\, R_m}{M_a}$$

(2) Trucks operated every other day

$$T_r = \frac{3209.02}{182.5 \times N} + \frac{(341.0468 + .059799\, M_a)\, R_m}{M_a}$$

where T_r = route truck costs in dollars

N = number of routes traveled per day

Table 17. Miles of travel, pounds of milk hauled, and number of producers by specific days for bulk milk routes in Wichita, Kansas Milkshed, July 1956.

Truck code no.	Date: July 1956	No. of producers	Lbs. per route	Miles per day: City limits to first stop[a]	First to last stop	Last stop to city limits	Total city travel	Total travel	Ave. daily miles
1	18	17	20,817	21.25	83.90	14.35	12.00	131.50	65.75
2	18	11	13,329	55.00	55.00	25.00	7.00	142.00	142.50
	19	14	13,983	50.00	38.00	48.00	7.00	143.00	
3	18	15	24,458	59.00	59.90	62.60	15.60	197.10	183.85
	19	13	18,753	58.00	43.00	52.00	17.60	170.60	
4	18	14	12,138	42.00	36.00	51.00	6.80	135.80	135.80
	19	14	6,303	42.00	36.00	51.00	6.80	135.80	
5	18	8	13,127	65.50	26.90	62.50	6.40	161.30	204.72
	19	14	18,779	88.50	59.85	87.00	12.80	248.15	
6	18	15	9,593	52.50	71.60	26.40	6.00	156.50	135.25
	19	9	10,801	33.00	41.70	33.30	6.00	114.00	
7	18	12	10,760	46.00	16.00	38.00	8.80	108.80	131.80
	19	11	11,501	54.00	40.50	51.50	8.80	154.80	
8	18	11	14,958	46.00	39.35	29.65	6.80	121.80	141.30
	19	14	15,947	47.00	61.25	45.75	6.80	160.80	
9	24	9	15,721	7.00	53.50	5.50	8.00	74.00	77.35
	25	10	13,577	13.00	46.20	12.30	9.20	80.70	
10	25	11	13,625	65.00	68.00	31.00	6.40	170.40	166.58
	26	12	13,887	64.00	35.25	57.50	6.00	162.75	
11	25	8	15,742	19.50	21.00	12.50	18.20	71.20	112.70
	26	13	19,807	22.50	90.00	28.00	13.70	154.20	
12	26	8	9,381	20.00	31.00	16.00	7.70	74.70	58.80
	27	4	4,560	10.50	18.00	6.00	8.40	42.90	

Table 17 (Concl.).

Truck code no.	Date: July 1956	No. of producers	Lbs. per route	Miles per day: City limits to first stop[a]	First to last stop	Last stop to city limits	Total city travel	Total travel	Ave. daily miles
13	26	6	10,018	68.75	30.00	54.00	6.80	159.55	185.42
	27	11	12,308	62.50	78.25	63.75	6.80	211.30	
14	26	2	5,124	25.00	7.50	17.50	6.80	56.80	104.05
	27	11	11,338	54.50	27.00	63.00	6.80	151.30	
15	26	4	5,391	43.50	17.75	56.00	12.80	130.05	158.30
	27	7	10,042	72.00	30.00	71.75	12.80	186.55	
16	26	10	14,926	18.00	30.50	14.50	9.00	72.00	107.15
	27	16	18,013	47.50	51.40	27.60	15.80	142.30	
17	27	12	13,276	36.50	62.75	29.25	6.80	135.30	67.65
18	27	9	11,544	12.50	52.50	28.50	6.80	100.30	50.15

[a]This is a computed mileage.

Table 18. Travel time requirements for 40 bulk milk routes in the Wichita, Kansas Milkshed, July 1956.

Route no.	City limits to first stop	First to last stop	Last stop to city limits	City travel	Total travel
			(minutes)		
a	25.60	102.57	12.99	24.00	165.16
b	2.66	72.09	26.72	24.00	125.47
c	73.15	115.15	40.86	28.00	257.16
d	66.50	103.38	67.97	28.00	265.85
e	39.90	87.80	55.36	31.20	214.26
f	38.57	45.86	41.21	31.20	156.84
g	39.90	64.25	42.63	35.20	181.98
h	37.24	38.22	41.45	35.20	152.11
i	55.86	100.62	71.50	27.20	255.18
j	55.86	100.62	71.50	27.20	255.18
k	87.12	64.57	85.05	25.60	262.34
l	61.18	40.06	55.00	25.60	181.84
m	56.52	89.62	70.32	25.60	242.06
n	69.82	153.75	42.51	24.00	290.08
o	43.89	88.94	50.64	24.00	207.47
p	61.18	65.14	56.18	35.20	217.70
q	71.82	95.10	72.09	35.20	274.21
r	61.18	93.51	46.34	27.20	228.23
s	62.51	135.52	65.31	27.20	290.54
t	9.31	105.26	17.88	32.00	164.45
u	17.29	99.07	25.89	36.80	179.05
v	86.45	133.13	47.93	25.60	293.11
w	85.12	91.76	79.16	24.00	280.04

Table 18 (Concl.).

Route no.	City limits to first stop	First to last stop	Last stop to city limits	City travel	Total travel
			(minutes)		
x	17.96	52.50	19.06	36.00	125.52
y	7.98	--	18.47	36.80	63.25
z	12.64	112.64	37.91	27.60	190.79
a_1	17.29	54.81	17.88	27.20	117.18
b_1	26.60	70.24	30.25	30.80	157.89
c_1	13.96	36.62	18.47	33.60	102.65
d_1	91.44	61.03	75.04	27.20	254.71
e_1	83.12	147.30	86.53	27.20	344.15
f_1	33.25	14.28	32.02	27.20	106.75
g_1	72.48	76.44	85.64	27.20	261.76
h_1	57.86	36.27	77.39	51.20	222.72
i_1	95.76	64.94	95.96	51.20	307.86
j_1	23.94	77.37	28.49	36.00	165.80
k_1	39.24	65.85	29.66	32.40	167.15
l_1	23.94	59.97	25.66	30.80	140.37
m_1	48.54	129.78	45.87	27.20	251.39
n_1	16.62	103.87	44.98	27.20	192.67

Table 19. Total route time requirements for 40 bulk milk routes in the Wichita, Kansas Milkshed, July 1956.

Route no.	Total travel time	Farm pumping time	Total fixed time for farm stops	Total route time	Plant fixed time[a]	Plant pumping time	Total time
			(minutes)				
a	165.16	39.75	98.78	303.69	7.31	25.64	336.64
b	125.47	22.58	53.88	201.93	34.62	14.74	251.29
c	257.16	40.00	98.78	395.94	34.62	25.86	456.42
d	265.85	44.06	125.72	435.63	34.62	27.13	497.38
e	214.26	34.73	71.84	320.83	7.31	23.56	351.70
f	156.84	34.27	62.86	253.97	34.62	23.89	312.48
g	181.98	27.18	62.86	272.02	7.31	17.91	297.24
h	152.11	27.00	53.88	232.99	34.62	18.47	286.08
i	255.18	39.81	125.72	420.71	34.62	23.55	478.88
j	255.18	26.39	125.72	407.29	34.62	12.23	454.14
k	262.34	36.99	71.84	371.17	34.62	25.47	431.26
l	181.84	36.44	62.86	281.14	7.31	25.72	314.17
m	242.06	18.64	62.86	323.56	34.62	10.71	368.89
n	290.08	34.81	134.70	459.59	34.62	18.61	512.82
o	207.47	32.49	80.82	320.78	34.62	20.95	376.35
p	217.70	34.95	107.76	360.41	34.62	20.87	415.90
q	274.21	35.80	98.78	408.79	34.62	22.31	465.72
r	228.23	43.75	98.78	370.76	34.62	29.02	434.40
s	290.54	48.58	125.72	464.84	34.62	30.94	530.40
t	164.45	43.81	80.82	289.08	34.62	30.50	354.20
u	179.05	39.73	89.80	308.58	34.62	26.34	369.54
v	293.11	40.69	98.78	432.58	34.62	26.43	493.63
w	280.04	42.14	107.76	429.94	34.62	26.94	491.50
x	125.52	32.91	62.86	221.29	7.31	22.74	251.34
y	63.25	10.09	8.98	82.32	34.62	7.79	124.73
z	190.79	31.12	62.86	284.77	7.31	21.23	313.31
a_1	117.18	25.48	53.88	196.54	34.62	17.19	248.35
b_1	157.89	28.37	71.84	258.10	34.62	18.20	310.92
c_1	102.65	13.89	35.92	152.46	34.62	8.85	195.93
d_1	254.71	28.14	53.88	336.73	34.62	19.43	390.78
e_1	344.15	37.66	98.78	480.59	34.62	23.88	539.09
f_1	106.75	13.48	17.96	138.19	34.62	9.94	182.75
g_1	261.76	35.43	98.78	395.97	34.62	22.00	452.59
h_1	222.72	15.80	35.92	274.44	34.62	10.46	319.52
i_1	307.86	29.05	62.86	399.77	34.62	19.48	453.87
j_1	165.80	42.83	89.80	298.43	34.62	28.96	362.01
k_1	167.15	31.74	80.82	279.71	7.31	20.32	307.34
l_1	140.37	23.29	62.86	226.52	34.62	14.63	275.77
m_1	251.39	40.73	107.76	399.88	34.62	25.76	460.26
n_1	192.67	34.20	80.82	307.69	34.62	22.40	364.71

[a] 7.31 is for first of 2 loads per day, 34.62 is for one load per day.

Table 20. Estimated route costs using two labor wage rates for 40 bulk milk routes in the Wichita, Kansas Milkshed, July 1956.

Truck no.	Route no.	Route miles	Route volume cwt.	Total truck cost	Costs using labor rate of $1.60 per hour: Route labor	Total route	Per mile (cents)	Per 100 lbs. (cents)	Costs using labor rate of $2.10 per hour: Route labor	Total route	Per mile (cents)	Per 100 lbs. (cents)
1	a	72.50	132.18	$14.15	$ 8.98	$23.13	31.90	17.50	$11.78	$25.93	35.77	19.62
	b	59.00	75.99	13.16	6.70	19.86	33.66	26.14	8.80	21.96	37.22	28.90
2	c	142.00	133.29	18.22	12.18	30.40	21.41	22.81	15.98	34.20	24.08	25.66
	d	143.00	139.83	18.28	13.26	31.54	22.06	22.56	17.41	35.69	24.96	25.52
3	e	118.80	121.44	12.10	9.38	21.48	18.08	17.69	12.31	24.41	20.55	20.10
	f	78.30	123.14	9.48	8.34	17.82	22.76	14.47	10.94	20.42	26.08	16.58
	g	94.80	92.31	10.55	7.92	18.47	19.48	20.01	10.40	20.95	22.10	22.70
	h	75.80	95.22	9.31	7.63	16.94	22.35	17.79	10.02	19.33	25.50	20.30
4	i	135.80	121.38	17.85	12.77	30.62	22.55	25.23	16.76	34.61	25.49	28.51
	j	135.80	63.03	17.85	12.11	29.96	22.06	47.53	15.90	33.75	24.85	53.55
5	k	161.30	131.27	19.17	11.50	30.67	19.01	23.36	15.10	34.27	21.25	26.11
	l	101.40	132.59	10.92	8.38	19.30	19.03	14.56	11.00	21.92	21.62	16.53
	m	146.75	55.20	13.84	9.84	23.68	16.14	42.90	12.92	26.76	18.24	48.48
6	n	156.50	95.93	19.23	13.68	32.91	21.03	34.31	17.96	37.19	23.76	38.77
	o	114.00	108.01	16.40	10.03	26.43	23.18	24.47	13.17	29.57	25.94	27.38
7	p	108.80	107.60	16.07	11.09	27.16	24.96	25.24	14.55	30.62	28.14	28.46
	q	154.80	115.01	19.15	12.42	31.57	20.39	27.45	16.30	35.45	22.90	30.82
8	r	121.80	149.58	16.88	11.58	28.46	23.37	19.03	15.20	32.08	26.34	21.45
	s	160.80	159.47	19.45	14.14	33.59	20.89	21.06	18.56	38.01	23.64	23.84
9	t	74.00	157.21	14.11	9.44	23.55	31.82	14.98	12.39	26.50	35.81	16.86
	u	80.70	135.77	14.59	9.86	24.45	30.30	18.01	12.94	27.53	34.11	20.28

Table 20 (Concl.).

Truck no.	Route no.	Route miles	Route volume cwt.	Total truck cost	Costs using labor rate of $1.60 per hour: Route labor	Total route	Per mile (cents)	Per 100 lbs. (cents)	Costs using labor rate of $2.10 per hour: Route labor	Total route	Per mile (cents)	Per 100 lbs. (cents)
10	v	170.40	136.25	$19.94	$13.17	$33.11	19.43	24.30	$17.28	$37.22	21.84	27.32
	w	162.75	138.87	19.44	13.10	32.54	19.99	23.43	17.20	36.64	22.51	26.38
11	x	50.00	117.24	7.80	6.70	14.50	29.00	12.37	8.80	16.60	33.20	14.16
	y	21.20	40.18	5.84	3.33	9.17	43.25	22.82	4.37	10.21	48.16	25.41
	z	103.40	109.45	11.46	8.35	19.81	19.16	18.10	10.96	22.42	21.68	20.48
	a_1	50.80	88.62	7.87	6.62	14.49	28.52	16.35	8.69	16.56	32.60	18.69
12	b_1	74.70	93.81	14.45	8.29	22.74	30.44	24.24	10.88	25.33	33.91	27.00
	c_1	42.90	45.60	12.04	5.23	17.27	40.26	37.87	6.87	18.91	44.08	41.47
13	d_1	159.55	100.18	19.14	10.42	29.56	18.53	29.51	13.67	32.81	20.56	32.75
	e_1	211.30	123.08	22.49	14.37	36.86	17.44	29.95	18.86	41.35	19.57	33.60
14	f_1	56.80	51.24	12.70	4.88	17.58	30.95	34.31	6.41	19.11	33.64	37.30
	g_1	151.30	113.38	19.20	12.06	31.26	20.66	27.57	15.83	35.03	23.15	30.90
15	h_1	130.05	53.91	17.34	8.53	25.87	19.89	47.99	11.19	28.53	21.94	52.92
	i_1	186.55	100.42	21.05	12.10	33.15	17.77	33.01	15.88	36.93	19.80	36.78
16	j_1	72.00	149.26	13.72	9.65	23.37	32.46	15.66	12.66	26.38	36.64	17.67
	k_1	78.10	104.74	9.75	8.19	17.94	22.97	17.13	10.75	20.50	26.25	19.57
	l_1	64.20	75.39	8.79	7.36	16.15	25.16	21.42	9.66	18.45	28.74	24.47
17	m_1	135.30	132.76	27.54	12.27	39.81	29.42	29.99	16.11	43.65	32.26	32.88
18	n_1	100.30	115.44	25.48	9.73	35.21	35.10	30.50	12.77	38.25	38.14	33.13

M_a = annual miles of travel

R_m = miles per route

Labor Cost. Labor cost on the sample routes was computed by converting the total time requirement in minutes to hours, and multiplying by the appropriate wage rate. Labor costs using both the $1.60 and $2.10 per hour wage rates are given in Table 20.

Total Route Cost. Total route cost was obtained by combining truck cost and labor cost.

Average Total Cost per Route Mile. Average total cost per route mile was obtained by dividing total route cost by miles of route travel. This cost varied from 16.14 to 43.25 cents per mile for the $1.60 wage rate and from 18.24 to 48.16 cents for the $2.10 wage rate. Figs. 8 and 9 give the relationship of average cost per mile to miles of route travel.

Average Cost per Hundredweight of Milk per Route. Estimated hauling cost per hundredweight of milk on the sample route was obtained by dividing total route cost by the volume of milk in hundredweight hauled on the route. This cost varied from 12.37 to 47.99 cents for the $1.60 wage rate and from 14.16 to 53.55 cents for the $2.10 wage rate. The relationship of average cost per hundredweight of milk to volume of milk hauled is given in Figs. 10 and 11.

Cost per hundredweight of milk is of greater interest to most haulers and producers, since this is the basis of contracting hauling services. It should be emphasized that these calculations do not include management charges or an allowance for normal profits in the hauling industry. Waste time and other delays encountered in actual practice would increase these cost estimates.

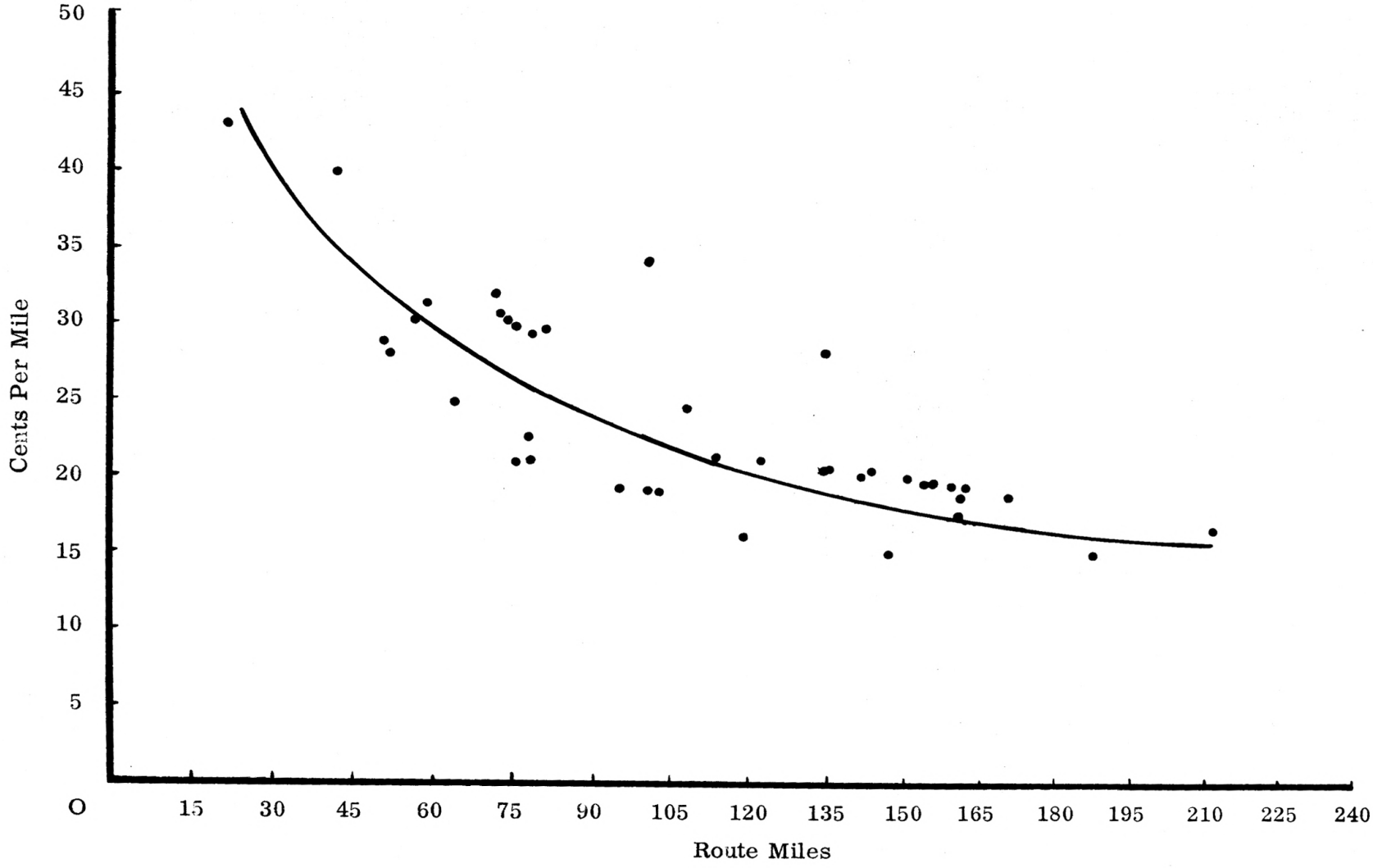

Fig. 8. Freehand curve showing the relationship between miles per route and cost per mile with wage rate of $1.60 per hour for 40 bulk milk routes in Wichita, Kansas, Milkshed, July 1956.

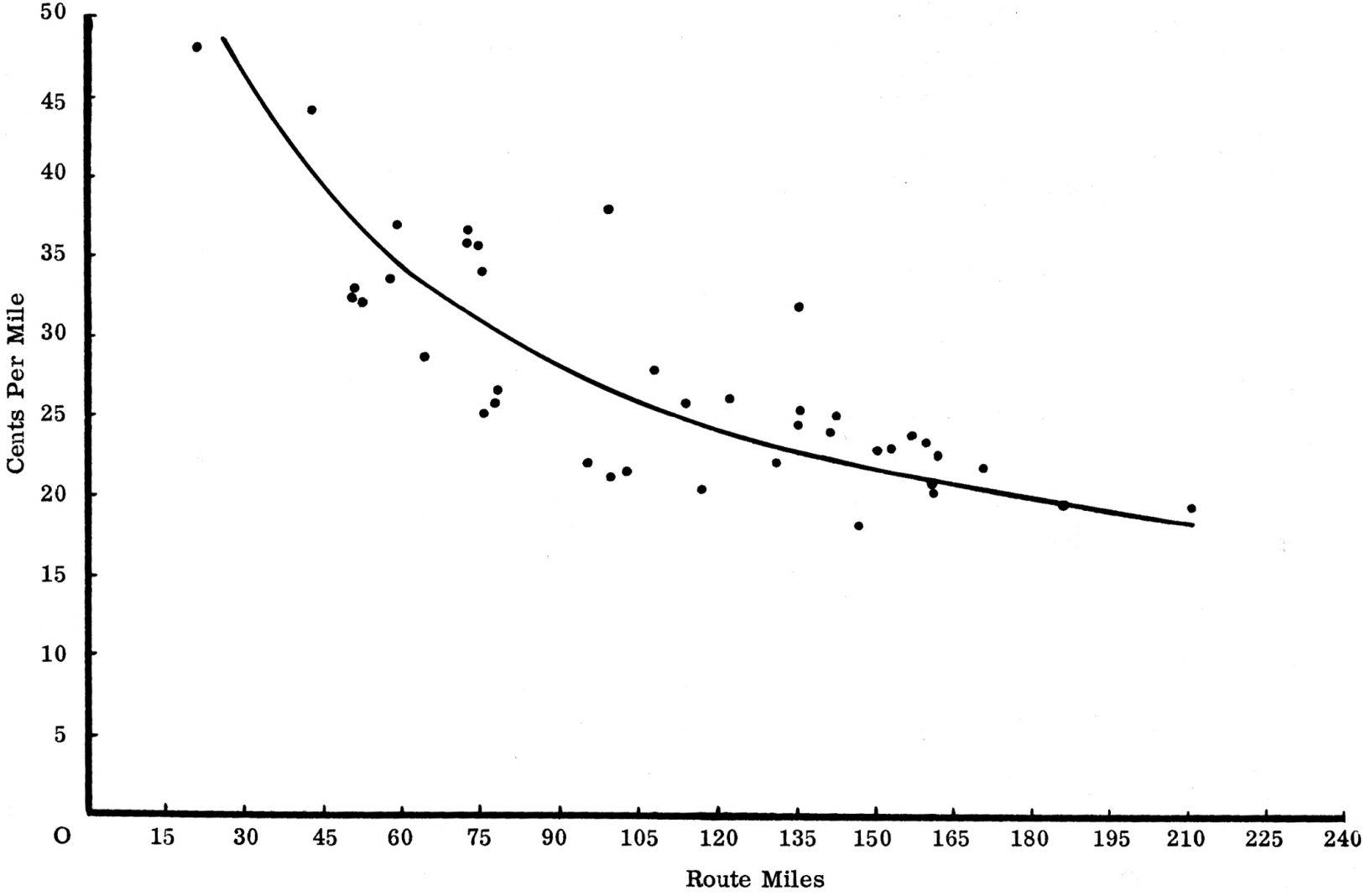

Fig. 9. Freehand curve showing the relationship between miles per route and cost per mile with wage rate of $2.10 per hour for 40 bulk milk routes in Wichita, Kansas, Milkshed, July 1956.

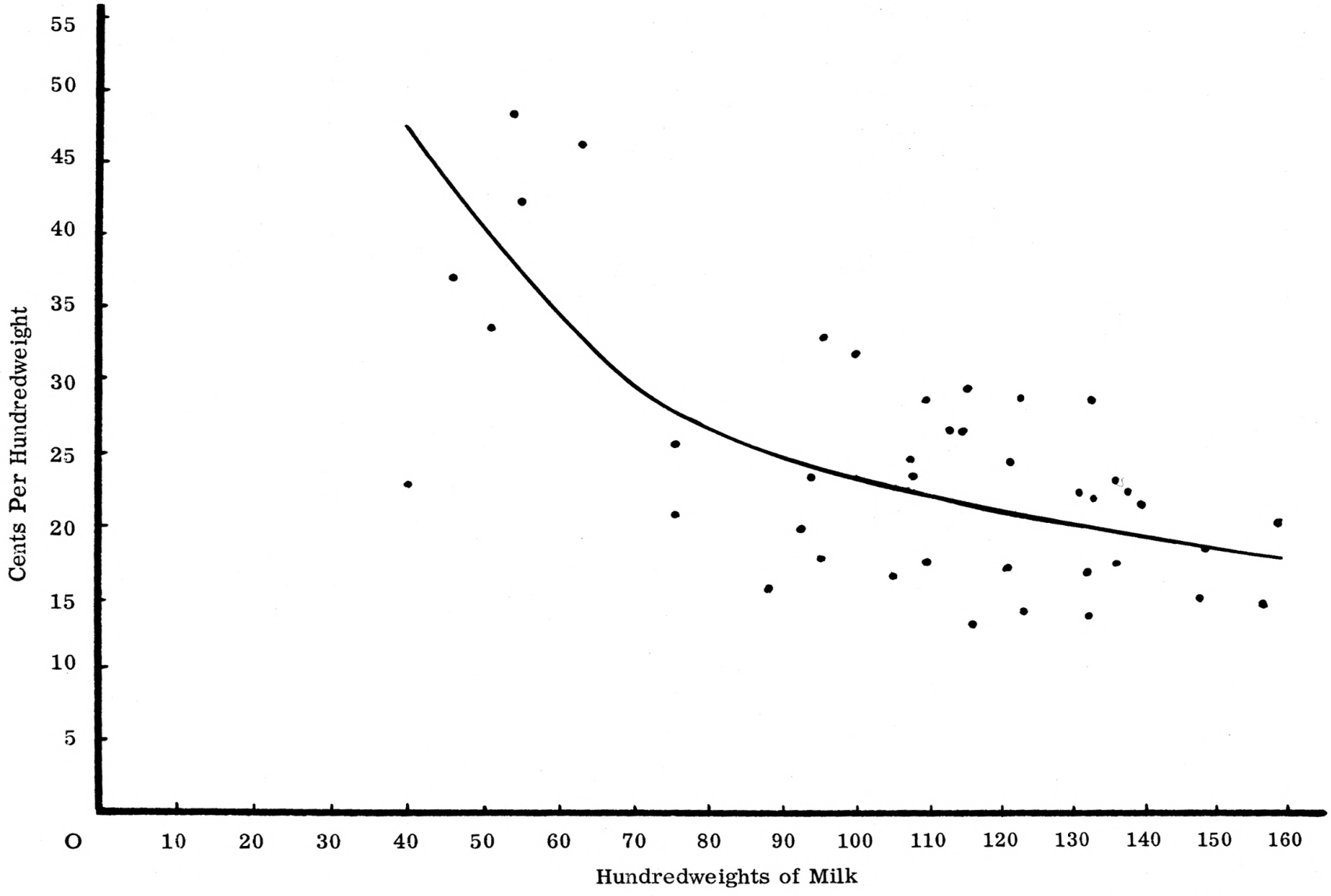

Fig. 10. Freehand curve showing relationship between hundredweights of milk hauled per route and cost per hundredweight with wage rate of $1.60 per hour for 40 bulk milk routes in Wichita, Kansas, Milkshed, July 1956.

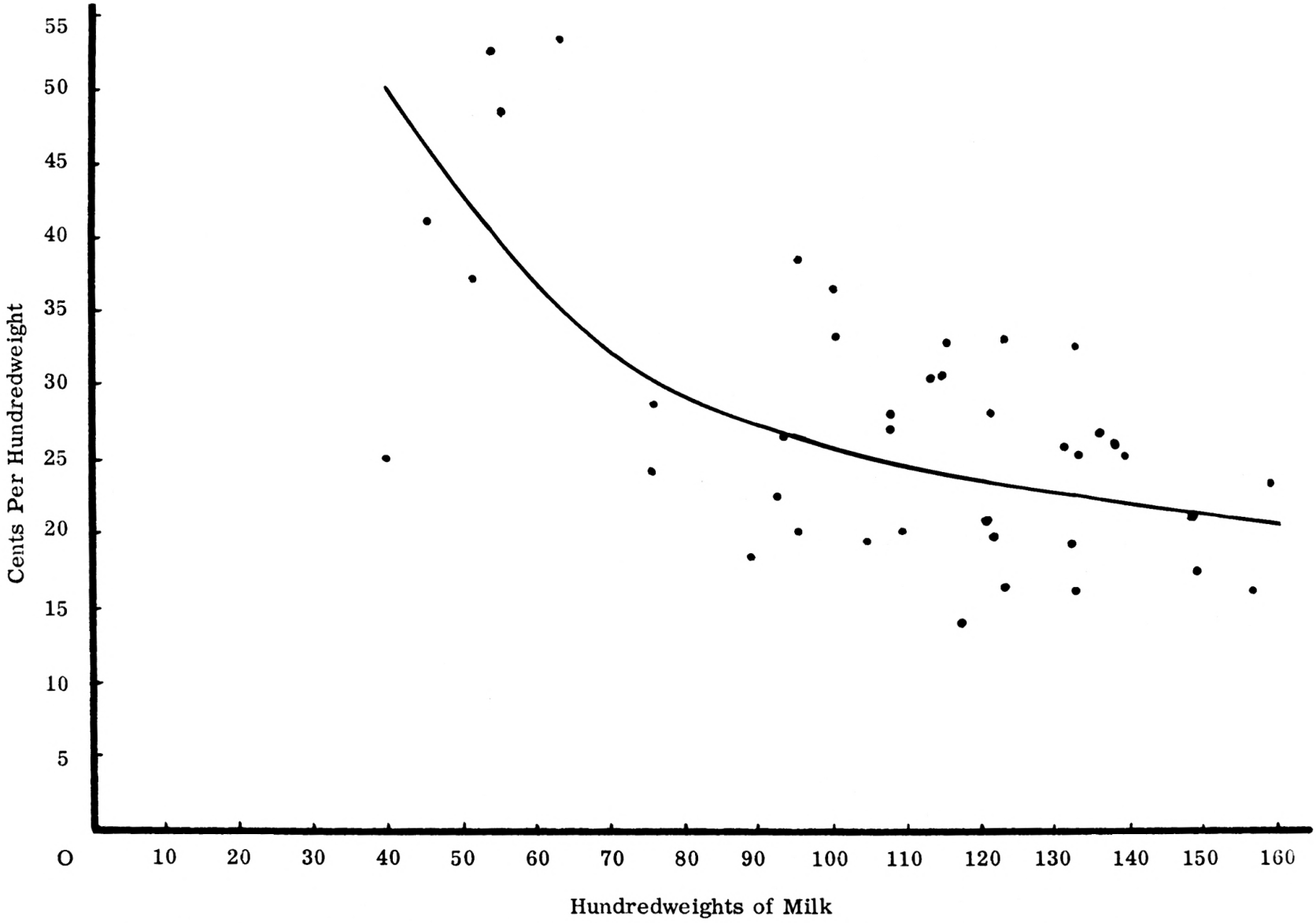

Fig. 11. Freehand curve showing relationship between hundredweights of milk hauled per route and cost per hundredweight with wage rate of $2.10 per hour for 40 bulk milk routes in Wichita, Kansas, Milkshed, July 1956.

LIMITATIONS TO ANALYSIS

Costs derived in this study are budget estimates based on certain given assumptions and average cost relationships. Therefore, the costs apply only to the technology and institutional arrangements specified. It should not be inferred that the estimates represent actual costs on any given route. An individual hauler's cost might exceed, or be less than those shown in this study, because average rates of operation and efficiency have been assumed. Also, individual firms may be able to purchase equipment more advantageously than the list prices assumed. Estimated costs on the sample routes were based on the organization of routes at a specific time.

No allowance has been made for waste or extra time due to unexpected hazards of weather or mechanical failure. Such estimates are largely of a subjective nature and must be provided by the experience or judgment of individual firms. An assumption was made that payments for labor in excess of actual route time is not required. Such an assumption implies that drivers are employed "full time" in bulk operations or other part time jobs.

Management costs and "normal profits" have been excluded from the estimates. Presumably a risk allowance for technical obsolescence and the effect of entry of new competing firms into the market would be included in "normal profits."

SUMMARY

The bulk milk system is a recent innovation in the marketing of fluid milk. This system was adopted in the Wichita, Kansas, Milkshed in 1954. Due to the economic structure of the market, information on average costs for hauling milk was needed for the adjustment of milk hauling rates. The major

objective of the study was to provide information on hauling costs in the market.

In the analysis, cost functions were developed for a two and one-half ton type A truck and 1700 gallon type A bulk tank. Time functions were developed for route and plant labor time. The synthetic method was used for the cost functions because actual cost data were unavailable. A time and motion study provided data for the time function.

The functions developed in the analysis were applied to 40 sample routes in the Wichita area. Information on these routes was obtained in July of 1956. Costs computed for each of these routes were truck costs, labor costs, total route costs, average cost per route mile, and average cost per hundredweight of milk. Basic wage rates of $1.60 and $2.10 were applied to the route time to obtain labor costs. Average cost per route mile varied from 16.44 to 43.25 cents for the $1.60 wage rate and from 18.24 to 48.16 cents for the $2.10 wage rate. Average cost per hundredweight of milk varied from 12.37 to 47.99 cents for the $1.60 wage rate and from 14.16 to 53.55 cents for the $2.10 rate. No allowance was made for management, "normal profits" in the industry, waste time or extra time due to unexpected hazards in these costs.

This analysis assumed a single technology which was applied to all routes. Two years of truck use and 10 years of tank use were assumed for this unit. Average operations were assumed on each route and the truck was considered to be an "average" truck. Therefore, the costs derived in this study are budget estimates based on certain given assumptions and average cost relationships and apply only to the technology and institutional arrangements specified.

CONCLUSIONS

Appraisals of the efficiency of a milk procurement system cannot be

considered without first specifying the institutional arrangements in the market. These arrangements are restraints. For example, the optimum route organization will be different for contract haulers than where a producers association specifies route layout. For this reason, estimates by routes under the system existing in the summer of 1956 serve primarily as a bench mark for testing alternative procurement methods.

Variations in estimated cost of hauling milk between routes are the result of differences in miles of travel, labor time, and pounds of milk hauled per route. An analysis of the relationship of these factors to hauling costs was not included in this study. The stability or adjustment of the market should be considered in such an analysis. The Wichita market was in the process of adjustment to the bulk system.

If present route organization is assumed as given, hauling costs could be reduced by operating trucks on more than one route per day. Examination of Table 16 reveals that a majority of the trucks hauled one load per day. Fixed costs per day could be spread over a greater volume by more intensive use of hauling equipment. If present organization of routes is not assumed as given, routes could be combined to give greater over-all efficiency in hauling. Such re-organization might require operating trucks more than eight hours per day. This would require adjustments in drivers' salaries and some rearrangement of receiving schedules at plants. However, these do not appear to be substantial difficulties. The present routes were developed without the over-all objective of minimizing total miles of procurement for the entire market. Minimum over-all hauling costs, as measured by least miles of route travel, are not likely to be achieved unless a coordinated approach is taken in designing route layouts.

Other alternative methods of assembling milk in the market area need to

be considered. These include the use of other types of tanks and trucks. Costs under different institutional arrangements need to be appraised since these arrangements have a major impact on the over-all organization of milk assembly. The effect of assembly costs on the diversion of milk supplies for strategic marketing reasons needs careful study. In addition, concentration or receiving points in the outer areas of the milkshed might offer substantial economies.

ACKNOWLEDGMENTS

The author wishes to express his gratitude and appreciation to Dr. Paul L. Kelley, major professor, for his guidance and interest in the preparation of this thesis. Recognition is given to the Wichita Milk Producer Association, Milk Market Administrator and others who contributed information used in this study.

The cooperation of Mrs. Lilley and other members of the clerical staff is gratefully acknowledged.

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APPENDIX

Table 21. Specifications for 1700 gallon truck bulk milk tank used in analysis.

Item	Specifications
Tank:	14 gauge, stainless steel
Shape:	Elliptical, straight bottom
Insulation:	2 1/2"
Outer jacket:	A. Mild steel - 18 gauge
Running boards:	Steel with non-slip surface
Skirting:	Steel trim skirting
Rear Cabinet:	3 compartment stainless steel lined rear cabinet to house pump, hose, motor, and sample chest.
Pump system:	Pump, 60 GPM 1 1/2" Pipe and fittings - 1 1/2" Electric motor - 1 1/2 H.P., single phase, 60 cycle 110/220 volts (wired for 220), reversing switch. Hose - 2-8' lengths, 1 1/2 I.D. x 3/8" wall tygon hose joined by S. S. nipple with clamps and with one set of hose couplings. Electric cord - 25' electric cord with a 3 straight prong plug and cord hanger and self winding cord reel.
Manhole and dust cover:	13" diameter - sanitary type with hinged stainless steel cover, 3" sanitary connection, sanitary 2-way rubber air vent and S. S. dust cover.
Top platform:	Stainless steel
Ladders:	Two alumimum ladders, one on each side.
Outlet:	2" stainless steel flanged outlet.
Outlet valve:	2" nickel alloy flanged sanitary outlet valve is standard on truck mounted tanks.
Lights:	In accordance with I.C.C. specifications, including Class A directional signals on tank only. Also triple light cluster - individually mounted. (Does not include cab control.)
Bumper:	Standard bumper.

Table 22. Truck and tire specifications and costs for type A two and one-half ton truck, F.O.B. Central Kansas, August 1956.

Item	Truck cost	Tire cost	Total truck and tires
GVW 22,000 lbs.			
156" wheelbase			
106" cab to axle			
Transmission:			
Medium duty direct-in-fifth, synchro-silent			
Cast spoke wheels			
Engine			
Displacement-302 cu. in.			
Max. brake horsepower-185 3800 RPM			
Max. torque (lbs./ft.) 290 2000-2600 RPM			
Compression ratio-7.5 to 1			
Standard cab			
Front axle-7,000 lbs. capacity	$3,585.60		
2-speed rear axle-(16,000 lbs. capacity)	303.00		
Heavy duty rear springs	19.36		
Turn signals-front and rear	24.80		
Heater	65.53		
Tires:[a]			
Front + 10-22.5 10 ply tubeless		342.90	
Rear + 11-22.5 12 ply tubeless		862.60	
Total before taxes	3,998.29	1,205.50	
Excise tax:			
Front tires		14.80	
Rear tires		37.32	52.20
Total before sales tax	3,998.29	1,257.70	
Sales tax 2%	79.97	24.11	
Total truck cost exclusive of tires	$4,078.26		
Total tire cost		$1,281.81	
Total cost-truck and tires			$5,360.07

[a] 9-22.5, 10 ply tubeless tires are standard equipment.

Table 23. Price quotations for mild steel 18 gauge 1700 gallon bulk tank type A, F.O.B. central Kansas.

Item			
Base price		$6,465.00	
Excise tax			
Base price	$6,465		
Less free of excise tax	1,596		
Net amount for excise tax	4,869		
10% tax on $4,869		486.90	
Sales tax			
2% on $6,465		129.30	
Total delivered cost			$7,081.20

Table 24. Load distribution for type A two and one-half ton truck using type A 1700 gallon tank.

	Pounds	Pounds
Front axle gross		
Tank weight	3,750	
Payload (1482.55 gal.)	12,750	
Tank and payload weight		16,500
Distribution of tank and payload on front axle		
a. Divided 16,500 lbs. by 156" wheelbase which gives 105.77		
b. Multiply 105.77 by 29.75 from mfg. bulletin = 3146.65 lbs. — weight of tank and payload on front axle.		
Tank and payload weight on front axle	3,147	
Front axle curb weight of truck chassis	3,790	
Front axle gross weight		6,937
Front axle load limit mfg. spec.		7,000
Underload on front axle		63
Rear axle gross		
Tank and payload	16,500	
Less tank and payload front axle	3,147	
		13,353
Plus rear axle weight	3,565	
Plus 2 speed rear axle	70	
		2,635
Rear axle gross weight		15,988
Rear axle load limit		16,000
Rear axle underload		22

Table 25. Annual costs for 15 can milk trucks, Wichita, Kansas Milkshed 1955.

Truck no.	Miles of travel	Truck repair costs	Tire repair costs	Gasoline cost	Oil cost	Lubrication cost
1	57,709	421.54	60.00	1,498.78	62.12	60.02
2	39,525	695.84	11.25	1,024.08	35.06	32.25
3	49,099	1,680.87	51.92	1,625.00	64.10	64.60
4	53.814	1,343.47	25.00	1,581.60	60.54	61.01
5	50,092	890.71	68.17	1,208.92	70.86	53.84
6	44,191	951.92	21.25	1,205.06	57.01	56.33
7	45,872	1,216.42	16.25	1,257.57	65.54	57.66
8	53,097	1,144.41	41.25	1,760.13	78.79	53.76
9	27,191	305.56	23.75	916.82	56.56	50.13
10	36,302	856.42	25.00	1,022.59	71.82	39.68
11	37,129	597.83	13.75	823.43	43.36	52.71
12	30,576	681.81	6.25	832.66	54.10	54.41
13	38,292	658.90	13,75	1,000.53	42.50	42.99
14	40,209	806.64	22.50	1,199.84	39.05	38.60
15	38,059	689.45	27.50	1,041.08	57.33	48.36
Total	641,157	12,941.79	427.59	17,998.09	858.74	766.35
Avg.	42,744	862.79	28.51	1,199.87	57.25	51.09

Table 26. Estimated miles life and trade-in value per tire for non-recapped tires used on bulk milk routes in Wichita, Kansas, area, Feb. 1956.[1]

Route no.	Front			Rear		
	Tire size	Estimated miles life	Trade-in value	Tire size	Estimated miles life	Trade-in value
1	8.25 x 20	40,000	$25.00	9.00 x 20	50,000	$37.50
2						
4	9.00 x 20	65,000	12.00	9.00 x 20	65,000	12.00
5	9.00 x 20	100,000	20.00	9.00 x 20	80,000	20.00
6	9.00 x 20	60,000	0	9.00 x 20	60,000	0
7	9.00 x 20	75,000	0	9.00 x 20	75,000	0
8	8.25 x 20	50,000	10.00	8.25 x 20	45,000	10.00
10						
11						
13						
14						
30	8.25 x 20	50,000	15.00	8.25 x 20	50,000	15.00
Total		440,000	82.00		425,000	94.50
Average		62,857	16.24		60,714	18.90

[1]Data are estimates for trucks in actual use rather than budget data.

Table 27. Estimated miles life and trade-in value per tire for recapped tires used on bulk milk trucks in the Wichita, Kansas, area, Feb. 1956.[1]

Route no.	Front				Rear			
	Tire size	Est. miles use before recapping	Est. miles use after recapping	Trade-in value	Tire size	Est. miles use before recapping	Est. miles use after recapping	Trade-in value
3	9.00 x 20	50,000	30,000	$10.00	9.00 x 20	45,000	25,000	$10.00
9	9.00 x 20	55,000	--	--	9.00 x 20	55,000	--	--
12	9.00 x 20	60,000	30,000	10.00	9.00 x 20	60,000	30,000	10.00
15	9.00 x 20	50,000	20,000	20.00	9.00 x 20	30,000	20,000	30.00
19	8.25 x 20	35,000	30,000	--	8.25 x 20	35,000	30,000	--
20	8.25 x 20	30,000	20,000	18.00	8.25 x 20	20,000	15,000	18.00
22	8.25 x 20	40,000	25,000	10.00	8.25 x 20	40,000	25,000	10.00
27	8.25 x 20	60,000	60,000	25.00	9.00 x 20	60,000	60,000	25.00
Total		380,000	215,000	93.00		345,000	205,000	103.00
Average		47,500	30,714	15.50		43,125	29,285	17.17

[1] Data are estimates for trucks in actual use rather than budget data.

Table 28. Total route time for 17 bulk milk routes in Wichita, Kansas Milkshed, summer 1955.

Route no.	No. farm stops	Total pounds of milk	Total fixed time (min.)	Total waste time (min.)	Total lane time (min.)	Total pumping time (min.)	Total stop time (min.)
A	5	7,428	36.42	1.58	10.31	18.19	66.50
B	4	7,657	31.37	3.33	7.37	15.52	57.59
C	8	9,776	61.44	3.58	13.71	23.99	102.72
D	11	11,120	120.36	13.08	26.21	41.43	201.08
E	5	11,616	39.10	0.67	8.56	33.08	81.41
F	4	9,179	34.22	0.08	6.81	20.94	62.05
G	3	4,932	27.23	3.05	4.09	10.98	45.35
H	8	12,443	55.03	0.00	13.75	41.70	110.48
I	6	7,819	71.34	0.00	15.91	23.13	110.38
J	4	10,449	45.23	7.00	9.80	32.75	94.78
K	11	9,477	113.77	5.26	33.41	31.07	183.51
L	9	6,281	61.75	3.09	23.29	21.75	109.88
M	10	9,102	103.45	3.67	19.84	35.56	163.52
N	6	4,871	62.75	1.83	12.92	16.75	94.25
O	6	6,417	33.84	2.10	9.93	21.14	67.01
P	8	12,388	59.14	1.12	22.15	30.94	113.35
Q	5	7,429	61.65	2.63	13.97	17.15	95.40
Total	113	148,384	1,018.09	52.07	252.03	437.07	1,759.26
Average per route		8,728	59.89	3.06	14.83	25.71	103.49
Average per stop		1,313	9.01	0.46	2.23	3.87	15.57

Table 29. Average route time per stop for 17 bulk milk routes in Wichita, Kansas Milkshed, summer 1955.

Route no.	No. farm stops	Average pounds of milk per stop	Average per stop (minutes)				
			Fixed time	Waste time	Lane time	Pumping time	Total stop time
A	5	1,486	7.28	0.32	2.06	3.64	13.30
B	4	1,914	7.84	0.83	1.84	3.88	14.40
C	8	1,222	7.68	0.45	1.71	3.00	12.84
D	11	1,011	10.94	1.19	2.38	3.77	18.28
E	5	2,323	7.82	0.13	1.71	6.62	16.28
F	4	2,295	8.56	0.02	1.70	5.24	15.51
G	3	1,644	9.08	1.02	1.36	3.66	15.12
H	8	1,555	6.88	0.00	1.72	5.21	13.81
I	6	1,303	11.69	0.00	2.65	3.86	18.40
J	4	2,612	11.31	1.75	2.45	8.19	23.70
K	11	862	10.34	0.48	3.04	2.82	16.68
L	9	698	6.86	0.34	2.59	2.42	12.21
M	10	910	10.34	0.37	1.98	3.66	16.35
N	6	812	10.46	0.30	2.15	2.79	15.71
O	6	1,070	5.64	0.35	1.66	3.52	11.17
P	8	1,548	7.39	0.14	2.77	3.87	14.17
Q	5	1,486	12.33	0.53	2.79	3.43	19.08
Average per stop		1,456	8.98	0.48	2.15	4.09	15.71

Table 30. Estimated annual costs for 18 bulk milk trucks, Wichita, Kansas, Milkshed, summer 1956.

Truck no.	Estimated annual: Miles of use	Tire depreciation cost	Tire value	Interest cost on tire investment
1	23,999	572.04	709.56	34.59
2	52,012	697.20	422.02	21.10
3	67,105	753.80	360.58	18.03
4	49,202	686.66	434.63	21.73
5	73,949	779.46	346.05	17.30
6	49,366	687.28	434.10	21.70
7	48,107	682.56	439.70	21.99
8	51,574	695.56	423.84	21.19
9	28,233	608.03	633.42	31.67
10	61,028	731.01	382.26	19.11
11	41,136	656.42	487.34	24.37
12	21,462	511.58	770.23	38.51
13	66,631	752.02	362.25	18.11
14	37,978	644.58	516.93	25.85
15	58,053	719.86	395.07	19.75
16	39,110	648.82	505.91	25.30
17	24,692	588.56	693.24	34.66
18	17,757	423.26	858.55	42.93
Total	811,394	11,838.70	9,175.88	458.79
Average	45,077	657.71	509.77	25.49

Statistical Assumptions

Statistical tests used in this study are based on the assumption of random samples from an infinite population. The assumption is made that each observation for the dependent variable is made up of a systematic part and an erratic component. These erratic components can be assumed to be errors of observation, and are a sample from a hypothetical infinite population of all possible errors of observation in the dependent variable Y. The assumption was made that these data are a single sample from the hypothetical infinite population of observations of Y upon repeated measurements of the same variables of the same trucks considered in this analysis.

Significance tests were not computed for equations 2 and 3 since the dependent variable in these equations are derived from budget data.

It will be noted that the annual miles of travel for the can trucks was less than the estimated miles of travel for the bulk trucks. Consequently, in this analysis a linear extrapolation of cost functions derived from the can milk trucks was made on the judgment that the linear functions would apply in the operating range of the bulk trucks. Recognition of this judgment extrapolation must also be made when estimating prediction intervals beyond the range of the observed data. In equation 3 an equation of the form $Y = a + b_1X_1 + b_2X_1^2$ provides a better fit than the equation used here. However the extra complications of the use of the above function did not appear justified in view of the minor importance of this cost item in the analysis.

Table 31. Regression coefficients and related statistics for specified functions.

Functions	1	2	3	4	5	6	7	8	9	10
Value of a (arithmetic form)	-47.652900	432.322800	43.521000	-31.331300	-347.845800	-55.812600	5.910900	11.597600	0.849800	-4.104800
Value of b_1	0.021300[b]	0.005000[a]	-0.000400[a]	0.001400[a]	0.143543[a]	0.029380[a]	1.382600[a]	1.178600[a]	0.002300[a]	0.003400[a]
Standard error of b_1	0.000095	---	---	0.000430	0.022460	0.004500	0.049670	0.078200	0.000102	0.000835
r	0.519400	0.942400	-0.945900	0.879700	0.863000	0.875901	0.980400	0.984900	0.907900	0.749760
$\bar{y}$	862.790000	657.710000	25.490000	28.510000	5,818.125000	1,200.000000	11.930000	48.320000	3.870000	25.300000
$\bar{X}$	42,743.800000	46,077.440000	46,077.440000	42,743.800000	42,968.437500	42,743.800000	5.800000	31.330000	1,513.130000	8,648.470000
Maximum y	1,680.870000	779.460000	42.930000	68.170000	8,380.000000	1,760.130000	38.090000	91.500000	17.330000	46.250000
Minimum y	305.560000	423.260000	17.300000	6.250000	3,921.000000	823.430000	2.840000	24.080000	0.670000	9.670000
Maximum X	57,709.000000	73,949.000000	73,949.000000	57,709.000000	57,709.000000	57,709.000000	25.000000	69.000000	8,014.000000	12,448.000000
Minimum X	27,191.000000	17,757.000000	17,757.000000	27,191.000000	27,191.000000	27,191.000000	1.000000	12.000000	276.000000	4,871.000000
n	15.000000	18.000000	18.000000	15.000000	16.000000	15.000000	85.000000	9.000000	113.000000	15.000000

[a]sig. 1% level.

[b]sig. 5% level.

[1]Regression of dollars annual truck repair costs on annual miles of travel, 15 can milk trucks, Wichita area, 1955.
[2]Regression of dollars annual tire depreciation on estimated annual miles of use, 18 tank milk trucks, Wichita, 1956.
[3]Regression of dollars of annual average interest on investment in tires on estimated annual miles of use, 18 tank milk trucks, Wichita, 1956.
[4]Regression of dollars annual tire repairs on annual miles of use, 16 can milk trucks, Wichita area, 1955.
[5]Regression of annual gallons of gas used on annual miles of travel, 16 can milk trucks, Wichita area, 1955.
[6]Regression of annual cost of gasoline on annual miles of travel, 16 can milk trucks, Wichita area, 1955.
[7]Regression of minutes travel time on miles between bulk stops, Wichita bulk milk routes, summer 1955.
[8]Regression of minutes travel time on miles from last bulk stop to Wichita city limits, Wichita bulk milk routes, summer, 1955.
[9]Regression of minutes pumping time on pounds of milk pumped at a farm stop, Wichita bulk milk routes, summer, 1955.
[10]Regression of minutes of pumping time at plants on pounds of milk pumped, Wichita bulk milk routes, summer 1955.

Hauling Rate Structure

No uniform method of charging for hauling services was used during the summer of 1956. Most haulers varied their rate from producer to producer although four haulers charged the same rate to each producer on the route. Several general systems of rate charges can be described in order of their complexity. The simplest system was a single flat rate charged all producers on a given route. A multiple flat rate system was used on other routes. Flat rates were charged each producer for the month but these rates varied from producer to producer along the route. A single flat rate plus a fixed charge per stop was used on one route. On other routes, a single schedule of rates varying with volume was used. Each producer was charged a rate varying with his volume but this schedule of volume rates was available to each of the producers on the route. Multiple schedules of rates varying with volume were also in use. For certain reasons, some producers with equal volumes were assigned to a different rate schedule. Increasing in the order of complexity were route rate structures in which part of the producers were charged a single flat rate and other producers on the same route were charged according to a single volume rate schedule. Still other routes used a multiple flat rate system plus a single volume rate schedule. Probably the most complicated route rate structures were those where a multiple flat rate system was used in conjunction with multiple volume rate schedules.

Since the over-all rate structure in the Wichita market was in a process of adjustment, no detailed analysis was made of the relation of rates charged to such factors as volume per stop, distance from market, and condition of roads. However the total revenue per route was computed by applying the individual farm rates to the volume picked up at each farm during

the sample period. These revenues and the weighted average rate per route are presented in Appendix Table 32.

Table 32. Total revenue and weighted average hauling rates for 40 bulk milk routes in sample period July 1956, Wichita, Kansas, Milkshed.

Truck no.	Route no.	No. of stops	Total route revenue	Hauling rates: Weighted average route rate	High rate on route	Low rate on route
1	a	11	$39.17	$0.296	$0.300	$0.200 2/
	b	6	22.80	0.300	0.300	0.300 2/
2	c	11	47.31	0.355	0.400	0.300 3/
	d	14	49.13	0.351	0.360	0.350 3/
3	e	8	32.29	0.266	0.341	0.236
	f	7	31.62	0.257	0.314	0.228 1/
	g	7	25.47	0.276	0.424	0.235 1/
	h	6	25.05	0.263	0.382	0.243
4	i	14	43.69	0.360	0.360	0.360 3/
	j	14	22.70	0.360	0.360	0.360 3/
5	k	8	55.13	0.420	0.420	0.420
	l	7	47.63	0.359	0.370	0.350 3/
	m	7	21.96	0.398	0.500	0.370
6	n	15	32.26	0.336	0.400	0.300
	o	9	36.05	0.334	0.350	0.300 3/
7	p	12	35.17	0.327	0.350	0.300
	q	11	42.40	0.369	0.400	0.350 3/
8	r	11	41.84	0.280	0.320	0.225
	s	14	56.32	0.353	0.400	0.320 2/
9	t	9	43.81	0.279	0.300	0.250
	u	10	35.72	0.263	0.300	0.250 3/
10	v	11	57.47	0.422	0.530	0.350 3/
	w	12	60.31	0.434	0.450	0.420 3/
11	x	7	30.18	0.257	0.300	0.250
	y	1	10.04	0.250	0.250	0.250
	z	7	35.97	0.329	0.400	0.250 3/
	a_1	6	22.15	0.250	0.250	0.250
12	b_1	8	25.95	0.277	0.300	0.250
	c_1	4	12.28	0.269	0.300	0.250 2/
13	d_1	6	41.25	0.412	0.450	0.400
	e_1	11	53.78	0.437	0.450	0.400 3/
14	f_1	2	15.38	0.300	0.300	0.300
	g_1	11	45.35	0.400	0.400	0.400 3/
15	h_1	4	24.25	0.450	0.450	0.450 3/
	i_1	7	45.18	0.450	0.450	0.450 3/
16	j_1	10	37.30	0.250	0.250	0.250
	k_1	9	26.58	0.254	0.300	0.250 3/
	l_1	7	18.85	0.250	0.250	0.250
17	m_1	12	44.50	0.335	0.350	0.300 2/
18	n_1	9	32.26	0.279	0.400	0.200 2/

1/ Effective rates for actual volume for the day used in this study.
2/ Rates charged for the month of July, 1956, based on average daily volume.
3/ Flat rate in effect during July, 1956.

COST OF BULK MILK ASSEMBLY IN THE WICHITA, KANSAS MILKSHED

by

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B. S., Iowa State College, 1951

AN ABSTRACT OF A THESIS

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The major objective of this study was to determine the cost of hauling milk by the bulk method in the Wichita, Kansas, Milkshed. To achieve this objective, truck and tank cost functions and labor time functions were developed in the analysis. Another objective was to determine possible improvements in the present bulk assembly process of the market.

A two and one-half ton type A truck with a 1700 gallon type A bulk tank was the unit of technology specified in the analysis. Annual average costs were computed for a two year period for this unit. Truck costs were divided into chassis, tires, overhead and operating costs. Separate costs were obtained on the chassis and tires because different methods were used on these items to determine depreciation and annual investment. Tank costs were computed separately from these costs. Functions were developed for route labor time and plant labor time.

The synthetic method was used in the analysis. Data were obtained from survey sheets, plant records, personal interviews, time and motion study, truck and tank manufacturers, tire dealers, and governmental and private agencies.

Functions developed in the analyses were applied to 40 bulk routes which existed in the Wichita Milkshed in July 1956. The miles of travel, number of stops, and pounds of milk were obtained for each of these routes. Wage rates of $1.60 and $2.10 per hour were applied to total labor time on each of these routes. Total costs were calculated for each route. Average annual fixed costs were allocated to routes by days. Fixed and variable costs for annual miles of travel were allocated to routes by miles. Cost per mile and per hundredweight of milk were obtained from total route costs. Average cost per route mile varied from 16.14 to 43.25 cents for the $1.60 wage rate and from 18.24 to 48.16 cents for the $2.10 wage rate. Average cost per hundredweight

of milk varied from 12.37 to 47.99 cents for the $1.60 wage rate and from 14.16 to 53.55 cents for the $2.10 wage rate. An allowance for management and normal profits was not included in the estimated costs.

Costs obtained in this study were based on certain assumptions and average cost relationships. Two years of use was assumed for the truck and was the period of time used to develop cost functions. The truck was assumed to be average. Labor was assumed to be fully employed at all times. It should not be inferred, therefore, that the cost obtained on the sample routes are actual costs. However, they do serve as bench marks for comparison with alternative methods of hauling bulk milk.

Bulk milk hauling costs with present route organization could be reduced by increasing the number of loads of milk hauled per truck per day. Routes could also be reorganized to provide greater over-all efficiency in bulk milk assembly. Institutional arrangements in the market are factors in the efficiency of a milk procurement system. Additional studies are needed for alternative methods of bulk milk assembly.