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AN ANALYSIS OF BULK MILK ALLOCATION AMONG SELECTED PROCESSING FACILITIES

by

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SECTION I

INTRODUCTION

A persistent problem in agricultural marketing is that of transportation, getting the raw goods produced by the farmer to each successive step in the marketing chain. The difference in price from the point of production to the final consumer is the farm-retail spread. This is the gross margin received by marketing firms for assembling, processing, transporting and distributing a market basket of food.[1]

Transportation contributes to the farm-retail spread throughout all segments of the marketing system. In 1974, intercity rail and truck transportation made up seven percent of the component bill for marketing farm foods[2] in the United States. This did not include other transportation costs, such as house or farm delivery, that may have occurred. The estimated cost of shipping farm food products by truck and rail in the United States in 1974 was $7.2 billion, an increase of 18 percent over the level of $6.1 billion in 1972 and 1973. This large increase in the cost of shipping farm food products was primarily a result of higher transportation rates rather than increased quantities of commodities marketed.

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[1] Agricultural Outlook, U.S.D.A., Economic Research Service (June, 1975), p. 5.

[2] Ibid.

The Problem

In Ontario, milk producers ship approximately five billion pounds of milk annually. The cost of hauling this milk from some 16,500 producers to processing plants is close to $20 million annually.[3] Bulk milk, which comprises 75 percent of the total, is picked up by over 600 tank trucks while those who ship their milk in cans are served by about 300 trucks.

Table 1 illustrates the rising cost of milk transportation in Ontario. Transportation costs rose from $14.7 million in 1970 to $20.1 million in 1974 or an average slightly over $1 million per year. Even with this large increase, transportation cost as a percentage of the sales value of milk has gone down.

Table 1. Total Costs of Milk Transportation Related to Sales

Fiscal Year Ended, October 31	Annual Transportation Costs	Annual Value of Sales of Milk	Transportation Costs as a % of Sales
	millions of dollars		%
1974	20.1	391.5	5.1
1973	17.6	308.3	5.7
1972	17.7	292.8	6.0
1971	15.8	261.1	6.1
1970	14.7	242.7	6.1

Source: What Milk Transportation is About, Ontario Milk Marketing Board, Undated.

From March, 1968, until January of 1973, the pool charge per cwt. to producers rose only 10.5 percent, whereas from January, 1974, to January,

[3]"How Ontario Producers Pay for Bulk Milk Haulage," Ontario Milk Marketing Board, p. 1 (Undated). Reference copy obtained May 1975.

1975, there was an increase in 18.4 percent in one year. This is shown in Table 2.

Table 2. Southern Ontario Group 1 Pool Average or Pooled Charges to Producers

Effective Date	Per Cwt. Charge
March, 1968 (average)	34.4c
June, 1969 (average)	33.4c
July, 1970 (average)	33.7c
February, 1971 (average)	35.0c
January, 1972 (average)	36.0c
January, 1973 (pooled)	36.0c
January, 1974 (pooled)	38.0c
July, 1974 (pooled)	44.0c
January, 1975 (pooled)	45.0c

Source: What Milk Transportation Is All About, Ontario Milk Marketing Board, Undated

Due to the rising marketing bill, farmers would benefit if the share of some of the factors, such as labor, transportation, or administration could be held down. Recent studies in the food distribution system indicate that improvements can be made in the movement of commodities from production to the retail shelf.[4]

Objective of the Study

The objective of this study was to determine the feasibility of applying a linear programming model for the allocation of milk to the various processing plants in the central milk marketing region of the province of Ontario.

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[4] For example, see H. M. Thornton, Transportation and the Changing South, p. 136.

SECTION II

THE IMPACT OF CHANGES IN TRANSPORTATION COSTS ON MARKET PRICE

Market Price Relationships at Various Market Stages

A change in the cost of transporting goods can affect the competitive position among producers or among processors and manufacturers. Changes in costs may alter existing relationships among producers. The comparative advantage of production relative to other producing areas in a region may be negated or strengthened by changes in transportation costs.

This concept can be illustrated by a hypothetical case of a single market which is served by two producing points. In the single market A, the price of the commodity is $2.00. The two producing points, Y and X, have transportation costs of $1.00 and $0.75, respectively, for each unit of product moved. This results in an F.O.B. price of $1.00 at plant Y and $1.25 at plant X, as shown in Figure 1.

The derived raw product price at each plant is shown in Figure 2. Unequal processing costs could tend to equalize or move raw product prices at the plants farther apart. However, processing costs are assumed to be the same for each plant.

The cost of moving goods from farm to plant is a determining factor of the farmer's price. The derived net farm price shown in Figure 3 assumes that the costs of transportation from farms Y and X to their respective plants are equal. If the cost of transportation from farm X to plant X was raised to $0.45, the derived net farm price would be equal for both farms.

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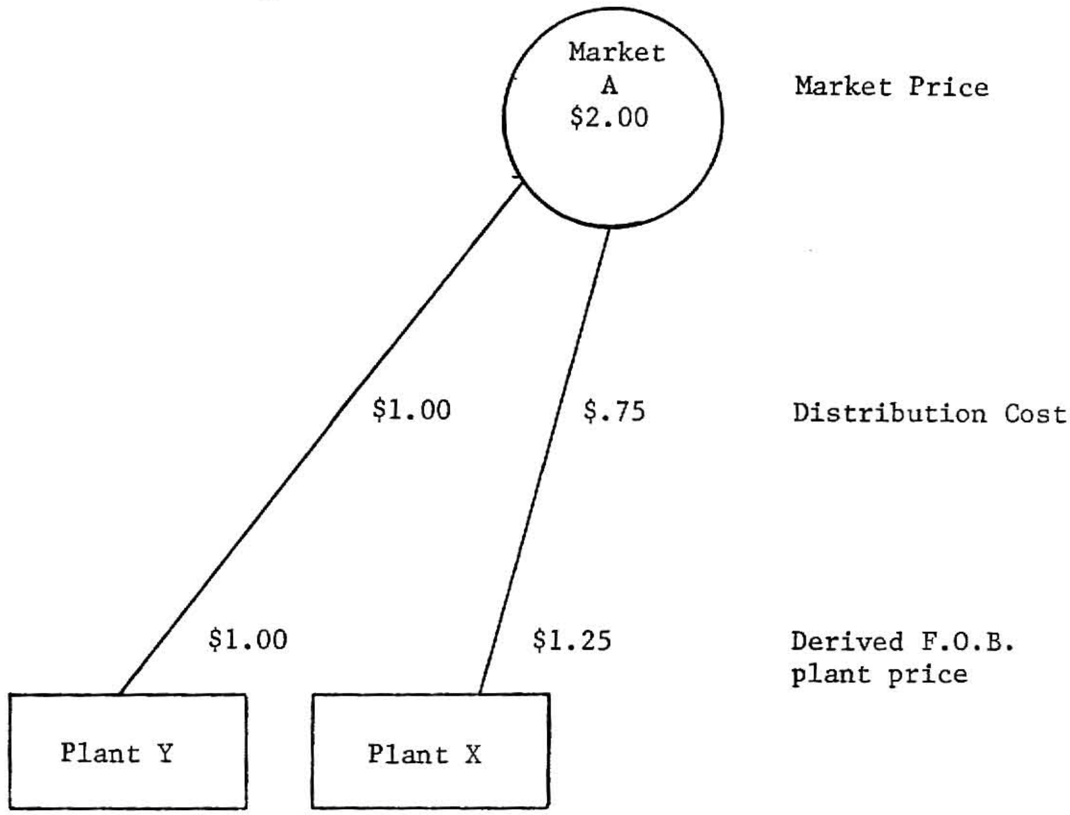

Figure 1. The Effect of Transportation Costs on Plant Price.

Source: Thornton, Transportation and the Changing South, Edited by J. E. Nichols, Jr., A.P.I. Series 25 (Raleigh: University of North Carolina, 1967), p. 78.

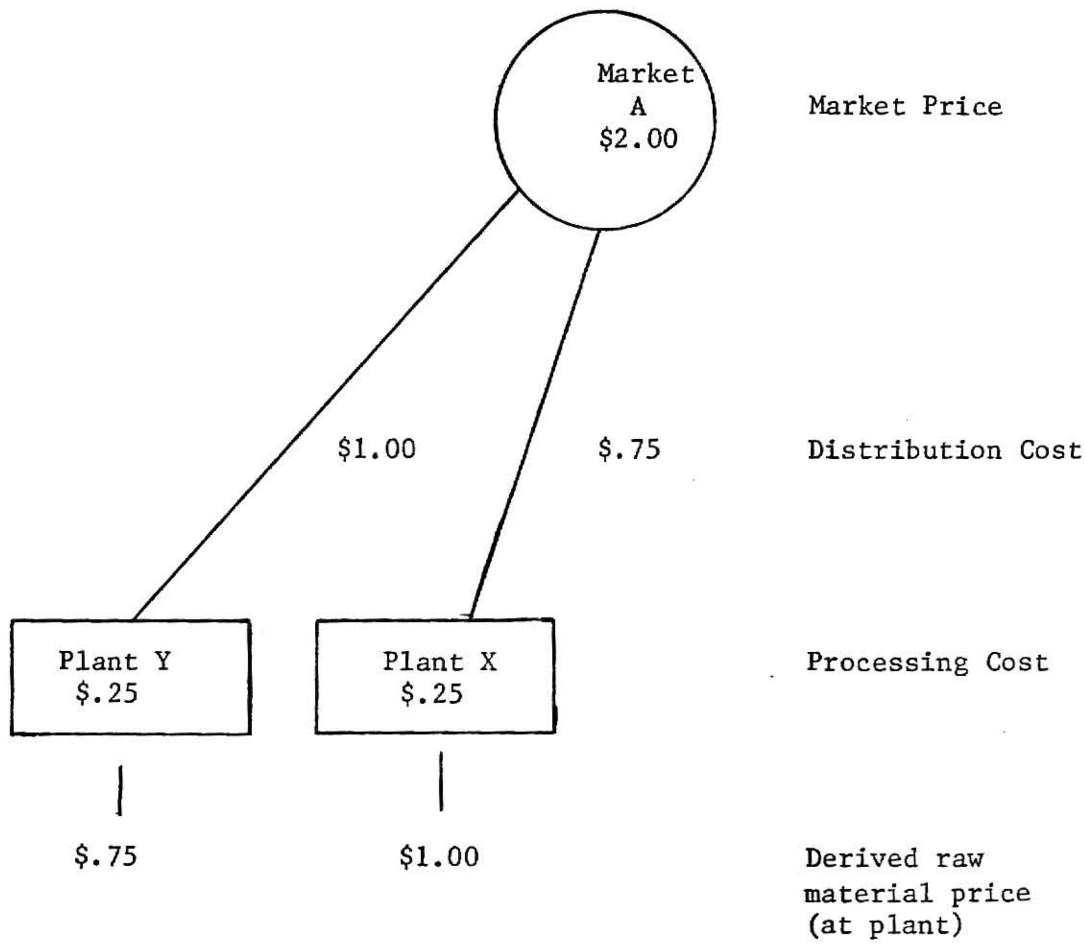

Figure 2. The Effect of Transportation Cost on the Derived Raw Product Price (at plant).

Source: Thornton, Transportation and the Changing South, p. 79.

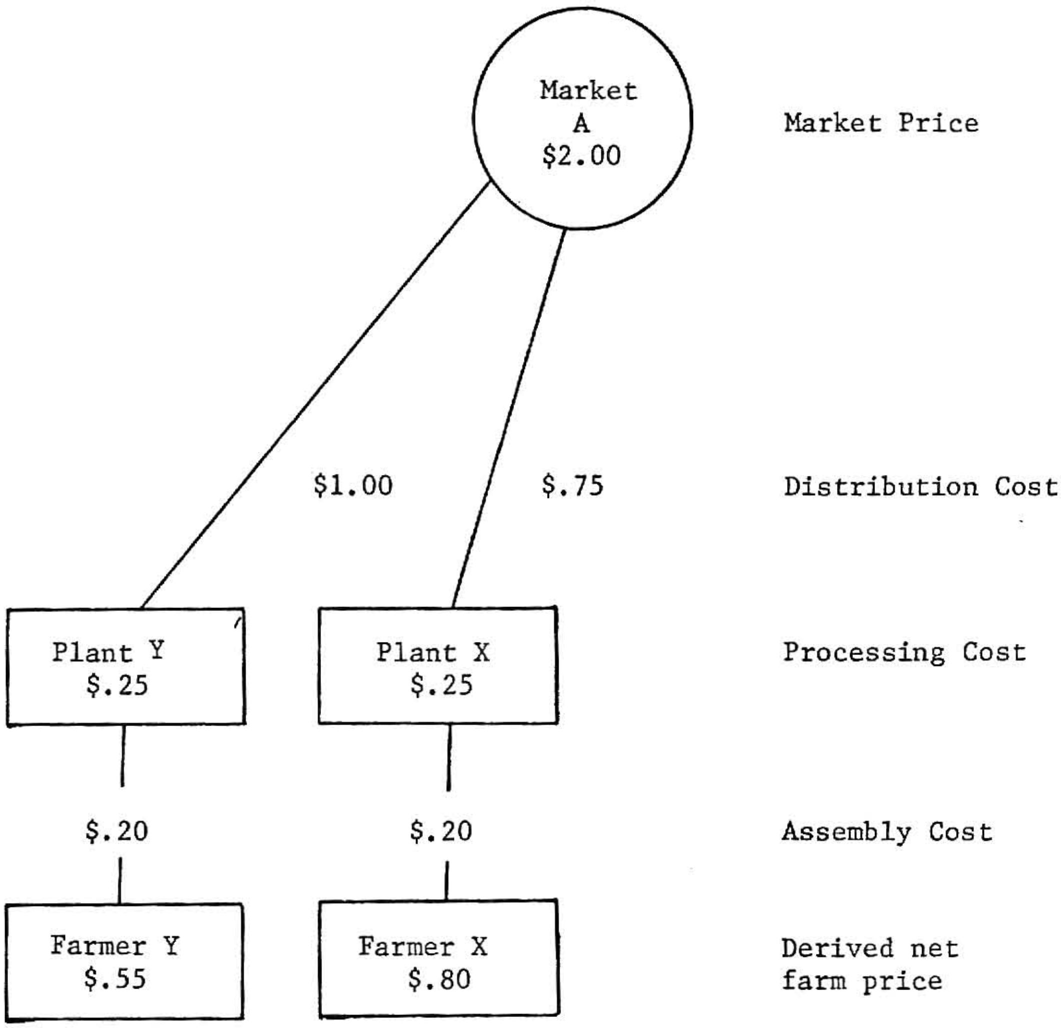

Figure 3. The Effect of Assembly Costs on the Farm Price.

. Source: Thornton, Transportation and the Changing South, p. 80.

The Effect of Elasticity of Demand

Transportation costs enter into the market price of a good. However, a change in the cost of transportation will not always alter the market price by the exact amount of the change in cost. The relative elasticities of supply and demand in conditions of competition, determines the share of the change in cost that would be absorbed by either the consumer or seller.

The less elastic the demand for a good, the greater tendency there will be for an increase in transportation costs to be paid by the consumer.[5] A change in the price of a good tends to curtail or increase consumption which causes production to readjust to the altered demand situation and a new supply-demand equilibrium must be established. The demand curve DD in Figure 4 is relatively inelastic. The supply curve SS represents the cost of producing various units of the supply, including the cost of transportation. An equilibrium supply and demand is established and the price is represented by the distance OP, and the quantity produced

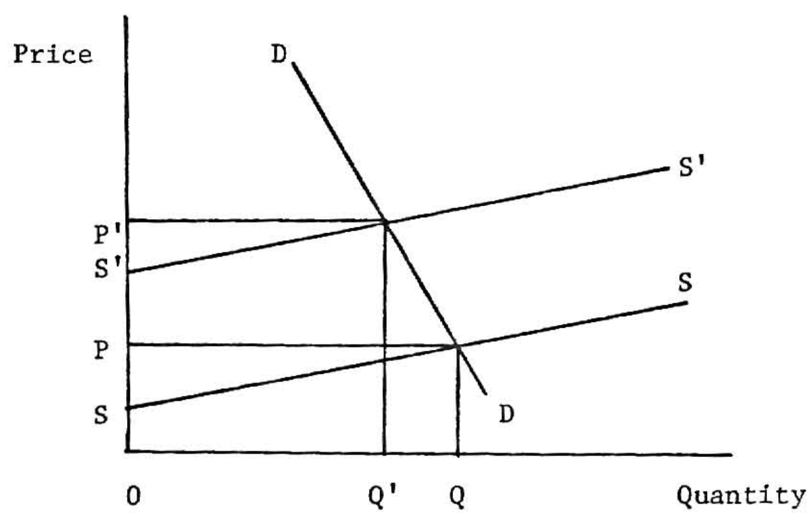

Figure 4. Inelastic Demand.

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[5] D. Philip Locklin, The Economics of Transportation, 5th ed. (Homewood, Illinois: Richard D. Irwin, Inc., 1972), p. 51.

by the distance OQ. The curve S'S' represents a new supply or cost curve created by an increase in transportation costs represented by the distance SS'. A new equilibrium of supply and demand is established and the price becomes OP' and the quantity produced OQ'. The increase in transportation costs represented by the distance SS' is only slightly greater than the increase in price represented by the distance PP'. Therefore, almost the entire amount of increased cost was absorbed by the consumer.

The more elastic the demand, the less tendency there will be for an increase in transportation costs to be paid by the consumer. The demand curve DD in Figure 5 is relatively more elastic than the demand curve illustrated in Figure 4. However, the supply curves SS and S'S'

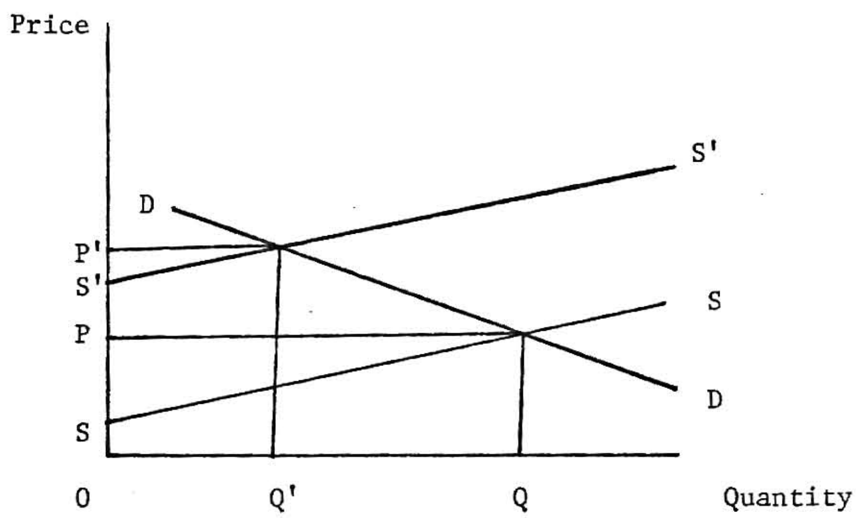

Figure 5. Elastic Demand.

are identical in both figures. An increase in transportation cost is represented by the supply curve S'S'. Once a new supply-demand equilibrium is established, the new price is represented by OP' and the quantity by OQ'. The increase in cost represented by the distance

SS' is equal for Figures 4 and 5. However, the offsetting increase in price, represented by the distance PP', is greater in the case of inelastic demand than when demand is elastic.

The Effect of Elasticity of Supply

If the supply of a good is elastic, any addition in transportation cost will be shifted to the consumer to a greater extent than if the supply is inelastic.[6]

The elasticity of demand is identical in Figures 6 and 7. However, in Figure 6, the supply curve SS is relatively more elastic than the supply curve SS in Figure 7.

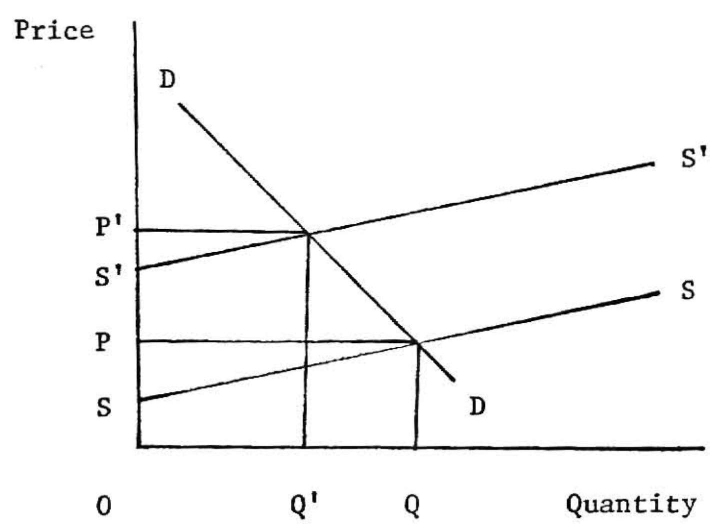

Figure 6. Elastic Supply.

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[6] Ibid., p. 52.

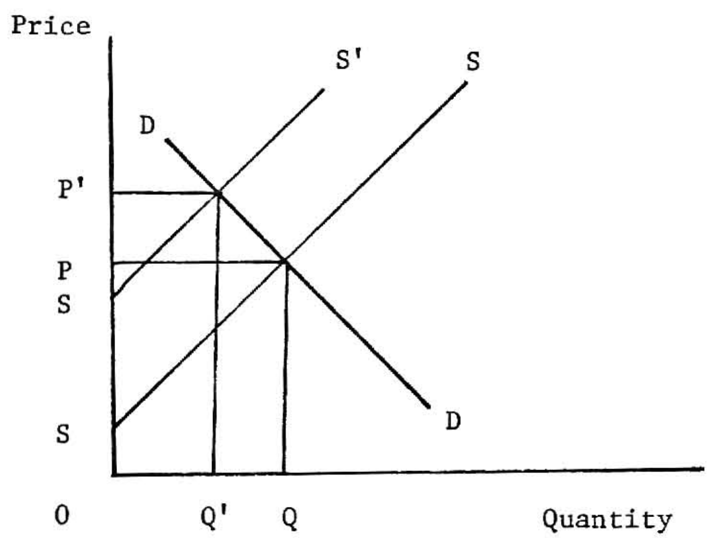

Figure 7. Inelastic Supply.

If the cost of transportation rises by an equal amount in each case, the consumer's proportion of the added cost will be greater in the elastic rather than the inelastic supply situation. The added cost of transportation is represented by the distance SS' in both figures. However, the distance PP', which represents the increase in price to the consumer, is greater in Figure 6. Thus, a greater proportion of the added cost is paid by the consumer rather than the producer. This is because production can readily be adjusted to new demand conditions when supply is elastic but cannot when supply is inelastic.

The Effect of Structural Characteristics In The Transport Industry Upon Producer Price

Previous sections have dealt with the influence of the elasticities of supply and demand upon market prices and the extent of price increases.

However, any decrease in the cost of transporting a good would lower market price by an amount less than the decrease in cost.

The proportion of the extra amount which is passed back to producers would depend upon the structural characteristics, such as cost, and rate flexibility, of the carrier involved. Rates charged by barge operators and unregulated truckers can respond quickly to fluctuations in demand brought about by changes in price. Rail rates generally are not adjusted downward because of the structural characteristics of the rail industry and because of regulation.

This paper deals with a particular market structure in which producers are represented by a marketing board whose purpose is to represent producer's interests and maximize individual producer's return. Through the board, producers have sufficient market power in dealing with carriers so that transport rates strictly reflect carrier costs. Therefore, any benefit from the reduction of carrier costs would accrue to the producers and not the carriers.

SECTION III

SYSTEM MODELS

The intraregional physical flow of a commodity involves the physical movement of milk between origins and destinations. Supply points are represented in this study as origins and demand points by destinations.

This necessity of movement is a cost which adds to the marketing margin which is the difference between what consumers pay for milk and the amount farmers receive. Therefore, efficiency of the physical flow, which is largely determined by the transportation system, should be analyzed.

The network model and transportation linear programming model are the analytical tools used in this study. They have been developed as a system, that is, in conjunction with each other. Each model provided a part of the final solution. A discussion of the network model will be presented first and followed by a description of the transportation linear programming model.

The Network Model

Network analysis has been successfully employed in engineering problems, such as development of minimum cost offshore pipeline systems.[7] Network analysis determines the minimum distance through a grid of origin

[7] Natural Resource Analysis Center, Systems Evaluation Division, "Design of Economical Offshore Natural Gas Pipeline Systems," 1968, p. 2.

and destination points. For this reason, it is useful as a link to solve transportation problems. The network program was used in this study to select and to identify all segments of a route to find the lowest cost to move a commodity between any two points in the grid, even though there are several thousand feasible alternatives.

The network problem is solved by identifying origin and demand points, or "nodes" and all "links" that connect these nodes. Distances necessary in computing the minimum distance between all nodes in the grid are:

$$K = \frac{(N-1)\ N}{2}$$

where:

K = number of distances

N = number of nodes

Cost can be measured in terms of time, distance or money. In this study, cost was measured in miles.

The Transportation Linear Programming Model

Linear programming is a mathematical technique for analyzing a problem with several activities in which a linear function is maximized or minimized subject to a number of side conditions or restraints. The method, which grew out of applied mathematics has been refined so that it can be applied to a wide range of problems.[8]

A linear programming model may be defined as:

Minimize (Maximize) $Z = \Sigma\ Y_j X_j \quad j = 1,2,\ldots,n$ (3.1)

subject to the following constraints,

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[8] Beneke and Winterboer, Linear Programming Applications to Agriculture, p. 3.

$$\sum_{j=1}^{n} k_{ij} X_j \overset{>}{\underset{<}{=}} a_i \qquad j = 1,2,\ldots,n \qquad (3.2)$$

$$\text{and all } X_j \geq 0 \qquad j = 1,2,\ldots,n \qquad (3.3)$$

where k_{ij}, X_j and a_i are all known constants. The known constants are defined as follows:

k_{ij} is a coefficient assigned to each X_j;

Y_{ij} is the cost associated with each X_j

and a_i is the total restrained amount of

a resource associated with each X_j

For each constraint equation, only one sign, >, =, or < is applied, but may vary with each constraint.

The basic assumptions of this general linear programming model are:

(1) There is an objective function to be minimized (maximized) such as equation (3.1).

(2) The variables and constraints are linear in form and additive.

(3) The variables are non-negative as required by equation (3.3).

(4) Factors used are divisible such that fractional units are possible and attainable.

All X_i must be non-negative since activities cannot be produced in negative amounts. If this assumption were not made, the objective function could always be minimized (maximized) by adding greater amounts of a negative activity.

A solution is obtained if all constraints are met and a feasible solution is obtained. When all requirements are met and the objective function is minimized (maximized), the optimal solution has been obtained.

Problems which meet special requirements can be solved by more efficient methods than that of the generalized linear programming method. Transportation linear programming is one such type of model. It contains more restrictive assumptions than the general linear programming model previously described. Since the present problem meets those restrictions, the transportation model was used.

The transportation linear programming model can be mathematically stated with the function to be minimized and the side conditions expressed as:

Minimize $$Z = \sum_i \sum_j C_{ij} X_{ij} \quad (3.4)$$

where $i = 1,2,\ldots,m$

$j = 1,2,\ldots,n$

subject to

$$\sum_j X_{ij} = S_i \quad (3.5)$$

$$\sum_j X_{ij} = R_j \quad (3.6)$$

$$\sum_i S_i = \sum_j R_j \quad (3.7)$$

$$X_{ij} \geq 0 \quad (3.8)$$

where:

Z is the cost of all operations,

m is the number of supply points,

n is the number of demand points,

S_i is the supply of a commodity at the i^{th} location,

C_{ij} is the transfer cost of the commodity from location i to location j,

X_{ij} is the quantity of the commodity shipped from S_i to R_j such that the costs of the operation are minimized.

The assumptions can be interpreted as:

(1) There is an objective function to be minimized, such as equation (3.4).

(2) The sum of quantities flowing from origins is equal to the sum of demands at the destinations by equation (3.5).

(3) The sum of quantities flowing to the destinations is equal to the sum of supplies at the origins by equation (3.6).

(4) From equation (3.5) and (3.6), equation (3.7) follows. That is that total supply equals the total demand.

(5) The variables are non-negative as required by equation (3.8).

Equations (3.5) and (3.6) require that the commodity supplied at the origins and demanded by the destinations is homogeneous.[9] Therefore, a unit from any of the m origins is equally effective in supplying the needs for the j^{th} destination and a unit supplied to any of the n destinations is equally effective in reducing the supply at the i^{th} origin.

Another assumption of the transportation method, as implied by equation (3.4), is that the cost of moving a commodity from origins to destinations is independent of the number of units moved. The cost of interregional transfers must be constant, regardless of product flow between regions.

The transportation matrix, as shown in Figure 8, consists of m origins which ship to n demand points. The transportation matrix is read by rows from left to right. M origins can supply S_m to the corresponding destinations at the cost of C_{mn}. Total demand for n destination

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[9] Heady, Earl O. and Chandler, Wilfred, Linear Programming Methods, (Ames, Iowa: The Iowa State University Press, 1958), p. 363.

	Destinations	
	1 2 3 ... n	Supply
1	C_{11} C_{12} C_{13} ---C_{1n}	S_1
2	C_{21} C_{22} C_{23} ---C_{2n}	S_2
3	C_{31} C_{32} C_{33} ---C_{3n}	S_3
.	. . .	.
.	. . .	.
.	. . .	.
.	. . .	.
m	C_{m1} C_{m2} C_{m3} ---C_{mn}	S_m
R	R_1 R_2 R_3 R_n	

Figure 8. Transportation Matrix.

points is shown by R_n. There are m x n elements in the transportation matrix and each element has a corresponding cost, C_{mn}. This cost or rate can be expressed in terms of money, time or distance.

Rate Bank Development

The study area consisted of the Central Marketing Region and other outlying depots, plants and origins which are important to the central marketing system. Distance travelled was the cost element used in this study. The Ontario Milk Marketing Board does not pay for transportation on a per mile basis but calculates a rate for each hundredweight of milk moved by a formula for each transporter based on miles driven, size of truck, wages paid and other related cost items.[10] Since all factors in the payment schedule were not readily available, the number of miles per hundredweight was used as the rate and total mileage was used as the measure of efficient milk allocation.

The network consisted of 490 nodes which included 72 processing plants, 95 transporter depots, 322 producers, and the central marketing region office. This network gave miles from each node to every other node. Using data from the network, miles were calculated for each truck from the last stop on each route to all plants, then returning to the transporter's depot where the truck was garaged.

A portion of the rate bank used is shown in Table 3. The rate bank contains the cost on miles per hundredweight for each route pair combination to all plants. For example, in the first column, line one shows a cost of 0.5419 miles per hundredweight if milk from origin 174 is moved to plant 59. The rate bank became input for the transportation linear programming model. The model was then solved to give optimum mileage solutions.

[10] For a complete discussion of the rate formula, see: "How OMMB Pays for Transportation."

Table 3. Sample of Rate Bank Used in the Study.

Origin	Destination	Rate[1]
174 30830A	5904301	0.5419
174 30830A	43071001	0.1999
174 30830A	42089201	0.2125
174 30830A	24141401	0.5791
174 30830A	47158901	0.2377
174 30830A	41223201	0.2170
174 30830A	63307701	0.1717
174 30830A	30317401	0.2291
174 30830A	64344101	0.5168
174 30830A	25436701	0.2219
174 30830A	21471501	0.4935
174 30830A	31544401	0.2205
174 30830A	17575401	0.5186
174 30830A	57610601	0.4402
174 30830A	54708101	0.4084
174 30830A	68718820	0.5980
174 30830A	11738202	0.5899
174 30830A	61753601	0.5576
174 30830A	12778101	0.5540
174 30830A	34807901	0.2403
174 30830A	3807910	0.5442
125 31585A	59043401	0.2464
125 31585A	43071001	0.2304
125 31585A	42089201	0.2180
125 31585A	24141401	0.1608
125 31585A	47158901	0.2244
125 31585A	41223201	0.2188
125 31585A	63307701	0.3700
125 31585A	30317401	0.2156
125 31585A	64344101	0.1544
125 31585A	25436701	0.3656
125 31585A	21471501	0.1004
125 31585A	31544401	0.2296
125 31585A	17575401	0.0976
125 31585A	57610601	0.1396
125 31585A	54708101	0.1108
125 31585A	68718820	0.1336
125 31585A	11738202	0.2212
125 31585A	61753601	0.2524
125 31585A	12778101	0.1288
125 31585A	34807901	0.2044
125 31585A	3807910	0.4076

[1]Miles per hundredweight

SECTION IV

ANALYSIS OF BULK MILK ALLOCATIONS

The problem confronted by this study was to select from among "reasonable" choices that combination of truck assignment to plants which will minimize farm to plant cost of transportation.

Solving complex econometric models by computer is recognized by the author as only one step in the planning progess. Answers so generated suggest possible solutions to the difficult problem of bulk milk delivery from the farm to the processing plant.

Milk from each farmer must be picked up at least every other day and delivered to some receiver who will use that milk. (One day of this cycle is referred to as "day A", the other as "day B.") With many producers, transporters, and processing plants involved, the number of "reasonable" choices as to which producer shall be serviced by which truck to be assigned to what plant are practically unlimited. Further complicating the problem is the farm production of two kinds of milk, fluid and industrial. Fluid milk in surplus can be mixed with industrial milk.

There are three basic levels of solutions. One is the farm stop routing and scheduling of pickup trucks. A second is the selection of a plant or plants to which each truck is to be assigned. The third is the day to day diversion of milk from one plant to another to adjust flow of milk to meet changes in supplies and/or demand from time to time.

This study deals only with the second level; the selection of a plant or plants to which each truck is assigned. Obviously, all three levels should be simultaneously considered if optimum results are to be achieved.

Analysis of Truck Assignment to Processing Plants

This study developed answers to five of the many possible "what if" questions. The procedure used was to compare the cost of five "reasonable" alternative plant assignments by use of the computer model compared with the assignments made by manual methods. These five comparisons were for the following situations involving bulk milk assignment:

1. Day A industrial
2. Day B industrial
3. Day A and B industrial, which allows for some shift from one to the other day
4. Day A fluid
5. Day A fluid and industrial as if all milk were of one class

Truck assignment by computer for this study used a two-step process. The first step was to solve for the least-cost solution of the allocation of milk to plants for each of the five comparisons mentioned above.

The second step was to make practical adjustments in the solution. These adjustments could take any form the dispatcher felt would best satisfy the situation at hand. Some truck-plant combinations could be switched for example, to accomodate personal preferences of transporters or plant managers. Historic assignment could be evaluated. Since the flow of milk is not constant and since utilization by some plants is increasing while others are decreasing, the dispatcher is constantly making adjustments in the assignment list.

In each case, the dispatcher would know the cost of accomodation and would be in a better position to evaluate its worth.

This study was concerned only with dispatcher type adjustments to eliminate the assignment of part of one load to a given plant and the remainder to a second plant. The linear programming model used was selected in part because it is better able to handle the large size and complex nature of the problem rather than a generalized linear programming method. However, this model will sub-divide truck loads to the last unit (in this case 100 pounds) and possibly reallocate it to a second plant if the capacity in the first plant is limited.

There are computer routines which will allocate these split loads, but for reasons already given, dispatchers must evaluate each assignment weighing non-cost considerations and it is believed the method used herein can be utilized at the same time. This procedure met the test of practicality since each of the five "adjusted" solutions were within 30 miles of the optimal computer solution.

A comparison of the assigned quantities to each plant in the case of combined days A and B for industrial milk is shown in Table 4. Similar results were obtained for the other computer allocations in this study. It is noted that most plants would receive their supply of milk to within a few percentage points.

The amount required by each plant was found by summing actual loads delivered on that day. Since these loads can vary significantly from day to day in actual operations, the linear programming requirements of meeting amounts of milk required by each plant to the exact point, are somewhat unrealistic. Therefore, some variations were allowed provided they were within the range of actual experience.

Table 4. Differences Between Actual and Model Allocation to Processing Plants. Day B Industrial Bulk Milk.

Destination	Actual Cwts Delivered	Cwts Allocated	Difference	Percent Allocated
5	1300.00	1300.00	0.00	100.0
49	3860.55	3679.51	-181.04	95.3
3	2941.08	2986.44	+ 45.36	101.5
11	2400.00	2400.00	0.00	100.0
34	1303.06	907.05	-396.01	69.6
13	233.74	233.74	- 1.00	99.6
19	1086.65	1269.00	+182.35	116.8
68	180.00	180.00	0.00	100.0
22	1349.63	1652.87	+303.24	122.5
30	609.72	692.18	+ 81.46	113.3
31	1160.00	1008.71	-151.29	87.0
56	223.59	303.79	+ 80.20	135.9
10	502.45	502.45	0.00	100.0
54	297.33	223.59	- 73.74	75.2
17	608.27	638.90	+ 30.63	105.0
12	738.40	775.53	+ 37.13	105.0
18	343.23	338.71	- 4.52	98.7
27	346.71	306.78	- 39.93	88.5
32	278.22	363.38	+ 85.16	130.6
74	262.99	262.99	- 1.00	100.0
73	180.93	180.93	0.00	100.0
Totals	20206.55	20206.55		

Additional reassignment by the dispatcher, of course, could be made. Where there are large differences in amounts delivered, diversions could be made or a truck actually assigned to another plant on an every-other delivery day basis.

For example, load 3900 was split in the basic solution between plants 22, 56, and 54. In Table 4, which is after adjustment, it is shown to deliver the total load to plant 56 giving an excess of 80.20 hundredweights for that day. Plant 54 would have a shortage of 73.74 hundredweights of milk for that day. On the next day of the cycle, load 3900 could be delivered to plant 54, thereby erasing the deficit and allowing plant 56 to use up excess milk from the previous day's delivery.

Comparison for Day A, Industrial Bulk Milk

Trucks would have been driven 374 fewer miles to deliver industrial milk on day A if the computer assisted assignment had been followed. There were 76 origins from which milk was delivered to 21 plants on day A.

The actual or manual truck to plant assignment required 3454 miles be driven from last stops on each route, to the assigned plant, and return to the transporter's depot. (See Appendix A, Table 1.) If trucks had been assigned as listed in Appendix B, Table 1, the distance driven would have been only 3080.

Due to the adjustment process previously described, the amount of milk supplied to individual industrial plants did not necessarily equal the actual amount of milk supplied. However, such variations are well within those with which dispatchers normally cope on a day to day basis.

Comparison for Day B, Industrial Bulk Milk

There were 79 origins from which milk was delivered to 21 processing plants. Computer assigned trucks would have reduced distance driven by 420 miles on day B.

The miles required to move 20207 hundredweights of milk was 3313 miles. Movements are shown in Appendix A, Table 2. The computer assignment for industrial bulk milk, day B, cost 2893 miles. Table 2 in Appendix B shows individual truck-plant assignments.

Comparison of Industrial Bulk Milk Days A and B Combined

An analysis was made which considered both A and B day industrial bulk milk eligible for the total two-day demand for each plant. Possible savings also could be realized by switching days of delivery to the plant.

Actual movement involved 155 origins supplying 40602 hundredweights of industrial bulk milk to 23 processing plants. These were arrived at by combining the actual movements shown in Appendix A, Tables 1 and 2. Actual allocation required 6767 miles to deliver both cycles of industrial bulk milk.

The model required 5951 miles to move the two-day total of milk, a saving of 816 miles for the two-day cycle. The possibility of switching delivery days from A to B or B to A increased the potential for reduction by only 64 miles over computer scheduling of each day of the cycle separately. Assignment of individual loads are shown in Table 3, Appendix B.

Comparison for Day A, Fluid Milk

Moving the fluid bulk milk to processing plants required a greater number of trucks and a greater number of miles than daily industrial milk movement. Twenty-one processing plants received 40779 hundredweights from 140 origins. This allocation required 9721 miles be driven. Individual truck assignment is shown in Appendix A, Table 3.

The computer assisted model allocated the milk using only 9392 miles. The model required 329 miles less for day A than manual assignment.

Comparison Day A for All Grades of Milk in One Pool

In addition to efficiencies gained by the reallocating of present truck assignments or combining route days, savings can also be realized by creating one milk pool. That is, making all milk produced eligible for fluid consumption by bringing industrial milk producer standards to the level of class I milk.

Fluid and industrial bulk milk origins and destinations for day A were combined to simulate milk allocation to plants from one producer pool. This involved 216 origins supplying 60915.43 hundredweights of milk to 42 processing plants. The model required 11912 miles to allocate the trucks compared with the actual distance of 13175 miles. Individual truck assignments are shown in Appendix B, Table 5.

SECTION V

SUMMARY AND CONCLUSIONS

This chapter consists of both a summary and conclusions of this case study of bulk milk movement. Also included in this chapter are the limitations of the study and of the models used in the analysis, and a section in which the need for further study in this area is outlined.

Summary

Transportation costs are continually increasing in today's marketing system. This is particularly true in an industry where not only capacity but timeliness is also important due to the perishability of the commodity involved.

This study dealt only with the movement of milk from the last stop of a route to the processing plant and back to the transporter's depot or garage. The study did not deal with the stop sequence of route pickup. The model was applied to several different possible situations to attempt to measure efficiencies which might be present. This involved not only reallocation of actual operations, but also other alternatives which can be taken by the marketing board.

An analysis was made of: (1) A day industrial bulk milk movement, (2) B day industrial bulk milk movement, (3) A and B day industrial bulk milk movements combined, (4) A day fluid bulk milk movement, and (5) A day fluid and industrial bulk milk movement combined as if there were only one class of milk.

The data base used for the study were bulk milk load reports taken from actual records of the Ontario Milk Marketing Board. Other data came from research done by Schruben and Schmidt[11] on cost of diversion in the central milk marketing region. The transportation linear programming model as previously discussed was then implemented to simulate possible milk flow patterns.

The computer assisted allocation of industrial milk on day A required 3080 miles be driven. Actual movement of the milk required 3454 miles be driven. This shows a saving of 374 miles per day A of the milk pick-up cycle.

Industrial bulk milk on day B was allocated by the computer assisted model. This required 2893 miles be driven. A total distance of 3313 miles was incurred in actual movement. This shows a savings of 420 miles over actual movement.

When both days of industrial bulk milk were combined, total distance by model allocation was 5951 miles. Actual movement of the milk required 6767 miles be driven. The model allocated the milk at a savings of 816 miles.

Allocation of day A fluid milk by the model required 9392 miles be driven. Actual movement was accomplished using 9721 miles. The model allocation required 329 miles less than actual movement.

When both fluid and industrial milk were made eligible for comsumption at any plant on day A, the model assigned the milk using 11912 miles

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[11]Unpublished research.

compared to 13175 miles used in the actual movement of the milk. The model shows a potential savings of 1263 miles over actual movement.

Conclusions

Significant savings were found by the model in the allocation of actual milk movement in the central marketing region of the Ontario Milk Marketing Board. It was also found that there could be potential savings realized by switching route days and also by making all milk eligible for fluid consumption.

The model showed possible savings of 374 miles and 420 miles on days A and B, respectively, for industrial bulk milk allocation. Table 5 shows actual versus model totals. This gives a total savings of 794 miles

Table 5. Rates, Total Costs, Savings and Percent Saved of Actual Versus Model Allocation

	Total Cost	Miles Saved	Percent
Industrial			
Day A actual	3454		
Day A model	3080	374	89.2
Day B actual	3313		
Day B model	2893	420	87.3
Day A+B actual	6767		
Day A+B model	5973	794	88.3
Day A+B model (all origins combined)	5951	816	87.5
Fluid			
Day A actual	9721		
Day A model	9392	329	96.6
Industrial + Fluid			
Day A actual	13175		
Day A Ind+Fl	12472	703	94.7
Day A (all origins combined)	11912	1263	90.3

for total industrial milk movement. Table 5 shows the total savings over the two-day period. However, by allowing routes to switch A and B days, the model showed a savings of 816 miles over actual movement and 22 miles less than a combination of the individual day's model allocation. This would indicate, that at the present, routes are not structured in a manner which would allow for much greater efficiencies than those that can be had by allocating each day of the cycle separately.

Potential savings of 329 miles were shown by model allocation over actual assignment of fluid bulk milk. Fluid milk moves mainly to Toronto processing plants which cuts down on possible savings since only a few miles can be saved by switching trucks within the city. However, only the central marketing region was involved in this study. If the total system of regions were considered, greater savings in the fluid section probably could be realized.

The greatest savings potential is in the creation of one pool of milk. If the marketing board were to raise industrial milk standards whereby all milk would qualify for fluid use, 1263 miles would be saved over actual allocation of day A's total supply of milk. Thus, by making all milk eligible for fluid consumption, origins which previously could only move to industrial plants could now be used as fluid sources. This creates a greater flexibility since industrial origins close to fluid plants can replace more expensive fluid origins.

If both classes of milk are treated as separate pools, 703 miles can be saved by model allocation in the movement of day A's entire supply of milk. Therefore, substantial savings are still present when each segment of the day's milk supply is allocated separately. However, this still requires 4.4 percent more miles than moving the supply of milk if it were all eligible for fluid consumption.

Potential efficiencies lie in all combinations of origins and plants analyzed. The greatest potential would seem to be in creating one pool of milk. However, transportation savings would have to be weighed, along with other potential savings, against the costs which would be incurred in the combination of all industrial milk and it is possible that this small savings would not be greater than the cost of switching farmer pick-up schedules.

Limitations of the Study

The use of a model creates a situation in which assumptions must be made. However, a model can be used to accurately simulate the real world.

The transportation linear programming model assumes that loads can be split and that supply must be met exactly. The simplex method of linear programming can circumvent both these problems, but it also requires greater costs in time and money. Therefore, the transportation linear programming model is the best alternative at this time.

The model was employed on data which is highly seasonal in nature. Milk production is peaking in the spring which reflects back to plant demand. The model may not reflect accurately on other periods of changing milk production.

Need for Further Study

This study looked only at transportation efficiency in terms of miles saved. A different allocation would possibly occur from a model allocation which used cost in terms of cents per mile instead of miles per hundredweight. This would require working both with transporters and the Board in determining an accurate per mile cost for each truck.

Other costs need to be considered also. Unloading times at plants are a cost which must also be considered. A large number of small capacity trucks supplying one large plant requires a large cost in idle time as each truck waits to unload.

This study used the same number of trucks and routes as did actual movement. However, savings could probably be realized by route reorganization. This would create an added incentive for creating one pool of milk since an industrial truck and fluid truck may travel the same road picking up producers' milk. One truck could pick up all producers' milk along that road.

This study included only the central marketing region of Ontario which is the most important in the production of milk, although some outlying areas which are important to the central marketing system were also included. The entire province's milk flow should be analyzed since savings could occur not only in each marketing district, but also by changing flow patterns between districts.

BIBLIOGRAPHY

Beneke, Raymond R. and Winterboer, Ronald. Linear Programming Applications to Agriculture. First Edition. Iowa State University Press, Ames, Iowa, 1973.

Darrah, L. B. Food Marketing. New York: The Ronald Press Company, 1971.

Design of Economical Offshore Natural Gas Pipeline Systems. Report R-1. Natural Resource Analysis Center, Systems Evaluation Division, 1968.

Fedeler, Jerry A., Heady, Earl O., and Koo, Won W. "A National Grain Transportation Model," In Spatial Sector Programming Models in Agriculture, pp. 452-479. Earl O. Heady and Uma K. Srivastava. Ames, Iowa: Iowa State University Press, 1975.

Heady, Earl O. and Chandler, Wilfred. Linear Programming Methods. Ames, Iowa: The Iowa State University Press, 1958.

King, Richard A. "Transport Development and Economic Activity: Agricultural Industries," In Transportation and the Changing South Proceedings of a Two and a Half Day Conference By the Agricultural Policy Institute, Raleigh, N.C., June, 1967. A.P.I. Series 25. Ed. J. E. Nichols, Jr. Raleigh: University of North Carolina, 1967.

Kohls, Richard L. and Downey, W. David. Marketing of Agricultural Products, 4th ed. New York: The Macmillan Company, 1972.

Locklin, D. Philip. Economics of Transportation. Seventh Edition. Homewood, Illinois: Richard D. Irwin, Inc. 1972.

Nourse, Hugh O. Regional Economics. New York: McGraw-Hill, Inc., 1968.

Ontario Milk Marketing Board. "How Ontario Producers Pay for Bulk Milk Haulage." Toronto, Canada, Undated.

Ontario Milk Marketing Board. "What Milk Transportation is About." Toronto, Canada, Undated.

Thornton, H. M. "Food Wholesaling and Retailing," In Transportation and the Changing South. A.P.I. Series 25. Ed. J. E. Nichols, Jr. Raleigh: University of North Carolina, 1967.

Ulrey, Ivan W. The Economics of Farm Products Transportation, Marketing Research Report No. 843. Washington, D.C.: U.S.D.A. Economic Research Service, March, 1969.

APPENDIX A

Appendix A

Table 1. Origins and destinations, pounds, and miles for actual movement of industrial bulk milk, day A.

Origin	Destination	Pounds	Miles
2605	18	17053	10.2
3102	32	34913	20.7
1809	13	14252	4.3
1808	13	12716	3.7
2912	56	17717	53.3
2306	30	31007	59.0
2910	22	34271	55.9
2906	22	2885	57.2
2804	22	15582	31.8
2806	22	3385	41.2
2705	22	20274	22.6
3610	22	13331	31.9
2809	22	27720	25.6
2913	22	5692	69.1
2909	22	19573	60.1
2915	22	16103	66.9
1504	10	17711	9.3
1300	10	19313	3.8
2405	10	28281	4.4
1302	10	4267	1.0
113	31	56000	182.0
113	31	60000	182.0
3010	31	22474	100.9
2808	19	25386	57.7
2611	19	21467	25.7
1509	17	24023	14.7
1508	17	18816	12.4
1807	17	16047	8.8
2924	54	31800	60.6
114	68	18000	4.6
3106	26	14592	20.7
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
3700	57	16120	16.6
3002	27	20016	83.4
1801	12	16981	21.0
1507	12	17860	30.0
1800	12	16860	14.7
1805	12	20653	7.1

Appendix A Table 1 (Continued)

Origin	Destination	Pounds	Miles
101	5	50000	.2
101	5	80000	.2
2406	34	31699	148.2
4704	34	16635	96.9
4700	34	21368	76.9
3409	34	21145	81.5
3607	49	26972	52.5
2305	49	19746	30.7
2301	49	39798	20.7
2303	49	24845	38.0
2506	49	20840	25.5
2505	49	27022	26.7
2408	49	27401	32.6
2500	49	32153	26.8
3113	49	19374	46.4
3100	49	13534	41.6
3104	49	21638	33.0
188	49	50634	44.6
103	49	80000	83.4
103	49	80000	83.4
2109	3	12218	132.6
2203	3	16748	142.7
2202	3	18943	135.1
1104	3	13740	8.9
1100	3	18931	12.7
2108	3	36019	25.6
1101	3	11579	17.4
2101	3	18083	27.0
2100	3	29247	24.9
2107	3	25988	18.2
2105	3	32178	19.6
2102	3	23968	19.9
3008	3	18736	128.2
3011	3	27657	132.6
3013	3	18215	141.9
	Totals	2039495	3454.1

Appendix A

Table 2. Origins and destinations, pounds, and miles for actual movement of industrial bulk milk, day B.

Origin	Destination	Pounds	Miles
2600	18	2035	4.3
2604	18	10700	4.5
2609	18	2070	9.3
2601	18	19518	7.8
3307	32	27822	65.2
1806	13	8320	6.5
1811	13	15054	2.2
5801	73	18093	36.4
2918	56	22359	34.9
2204	30	26960	67.7
3101	30	34012	54.3
2907	22	18251	65.1
3600	22	20268	30.8
2707	22	4756	29.0
2807	22	25725	26.4
2802	22	5843	26.0
3809	22	10599	74.1
3900	22	19780	81.5
2709	22	10875	16.8
2708	22	18866	15.9
1304	10	12789	6.7
1301	10	19691	3.2
1303	10	17765	1.2
113	31	60000	182.0
113	31	56000	182.0
2800	19	31441	55.2
2607	19	29614	21.6
2620	19	21768	15.6
1515	19	25842	34.6
1510	17	17201	7.3
1505	17	20847	11.0
1514	17	22779	13.2
2920	54	29833	59.7
114	68	18000	4.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
2201	27	18432	76.3
3110	27	16239	17.2
1803	12	20657	7.0

Appendix A Table 2 (Continued)

Origin	Destination	Pounds	Miles
1512	12	17320	5.3
1519	12	19066	23.9
1513	12	16796	22.9
101	5	50000	.2
101	5	80000	.2
4502	34	19089	105.0
4500	34	21647	116.9
4603	34	17249	115.0
4509	34	26225	99.2
3302	34	14938	59.6
2401	34	31158	153.9
103	49	80000	83.4
103	49	80000	3.4
188	49	54246	44.6
3505	49	4872	16.4
2307	49	22500	28.4
3513	49	20746	7.5
3507	49	18293	27.0
2304	49	30803	34.6
2300	49	41649	37.8
2304	49	3684	34.6
3605	49	29262	51.1
2203	3	17618	112.0
3009	3	19670	127.1
3012	3	21726	145.9
1201	3	3091	18.9
1102	3	15325	14.9
1103	3	17163	9.1
1200	3	22381	19.8
2111	3	18825	33.4
2110	3	22037	31.6
2104	3	29282	20.3
5805	74	26299	42.9
2106	3	47741	12.6
2103	3	25181	19.6
2112	3	19629	132.5
2200	3	14439	140.7
	Totals	2020655	3312.7

Appendix A

Table 3. Origins and destinations, pounds, and miles of actual fluid milk movement, day A.

Origin	Destination	Pounds	Miles
3902	59	10533	46.0
2922	59	25738	63.0
3806	59	30810	14.9
3803	59	10887	8.1
2914	59	18812	38.1
2921	59	29348	51.2
181	43	18000	141.4
181	43	52000	141.4
181	43	80000	141.4
3510	43	19263	49.2
3301	43	17002	44.9
4511	43	31030	82.2
4514	43	30946	82.0
4513	43	31090	83.6
4503	43	28789	93.7
2501	43	26435	72.7
3510	43	19110	48.5
3306	43	19665	48.0
3300	43	29495	79.0
3201	43	28013	52.5
166	42	46312	132.8
166	42	51700	132.8
5800	42	29391	154.1
5802	42	29798	155.5
3601	42	26994	121.3
3604	42	27496	123.2
3512	42	30130	104.9
5700	42	24947	120.5
5804	42	27762	124.5
4712	42	27080	80.1
4605	42	23702	129.8
4604	42	24096	104.5
103	42	60000	176.8
2905	24	11980	21.6
2904	24	11069	8.1
3810	58	24048	1[illegible].5
3506	47	13246	7[illegible].7
165	40	51481	125.2
2925	40	42643	129.4
116	40	80000	181.0
116	40	80000	181.0

Appendix A Table 3 (Continued)

Origin	Destination	Pounds	Miles
116	40	80000	181.0
116	40	80000	181.0
192	40	52000	148.0
192	40	52000	148.0
188	40	20000	140.4
188	40	40000	140.4
188	40	55000	140.4
188	40	60000	140.4
125	40	57500	111.9
125	40	55800	111.9
125	40	50000	111.9
103	40	80000	179.6
103	40	80000	179.6
114	40	51133	178.8
114	40	77873	178.8
174	41	44618	96.8
116	41	80000	182.0
116	41	80000	182.0
4701	41	5006	52.3
3303	41	17003	54.7
3406	41	18018	42.9
4507	41	26511	61.0
4505	41	17323	59.0
4510	41	24507	43.7
4516	41	30079	99.5
103	41	60000	177.2
3203	28	30291	10.8
4714	63	23705	22.5
4715	63	15503	6.4
3210	35	21614	43.1
2911	64	4419	3.0
4713	62	27315	19.1
4709	62	30248	12.8
4702	62	27726	5.8
3408	62	18585	50.7
3109	25	28365	9.1
3018	25	28365	7.1
3020	25	21231	42.2
3006	25	17334	45.1
3005	25	18504	3[illegible].3
2403	21	18631	[illegible]4.5
2615	21	28094	21.3
2617	21	26773	28.8
2701	21	17988	[illegible]2.2
2400	21	7077	[illegible]3.8
2402	21	26723	2[illegible].2
2613	21	17209	2[illegible].1
2614	21	18383	18.1

Appendix A Table 3 (Continued)

Origin	Destination	Pounds	Miles
2700	21	14396	45.3
3515	51	29782	41.6
3609	53	21200	33.4
3608	53	25730	33.4
3606	53	14378	16.5
3704	53	20483	19.4
3702	53	21905	18.0
2919	53	19219	37.3
3404	39	28851	32.9
2901	39	34073	140.1
3403	39	26677	38.5
115	39	37000	195.2
115	39	50000	195.2
3112	39	28515	59.0
3705	39	27252	115.8
3103	39	27315	66.5
3107	39	27950	92.0
3016	39	28804	111.9
3509	39	25775	59.1
3108	39	14910	96.5
3204	39	25731	64.0
3206	39	33395	63.0
103	39	60000	179.8
103	39	80000	179.8
3708	55	17276	4.7
3707	55	20465	5.8
3800	55	21609	7.8
3904	61	13749	29.5
3905	61	13437	35.6
3903	61	16722	3.0
3504	50	11150	12.0
3105	50	29021	24.2
3502	50	20834	8.1
3503	50	26791	8.1
2503	50	20509	14.7
3501	50	20991	11.4
3500	50	3689	7.9
3511	50	29169	7.4
	Totals	4052048	9721.4

APPENDIX B

Appendix B

Table 1. Origins and destinations, pounds, and miles for model allocation of industrial bulk milk, day A.

Origins	Destination	Pounds	Miles
188	49	50634	44.6
103	34	80000	164.8
103	3	80000	128.8
113	49	60000	96.0
113	49	56000	95.8
114	68	18000	4.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
101	5	80000	.2
101	5	50000	.2
2100	3	29247	24.9
2806	22	3385	41.2
2505	49	27022	26.7
2108	3	36019	25.6
4704	32	16635	83.5
2808	22	25386	24.8
3011	31	27657	107.3
2924	57	31800	51.2
2306	31	31007	66.0
3607	49	26972	52.2
2705	19	20274	29.4
3100	49	13534	41.6
1808	13	12716	3.7
1100	3	18931	12.7
2912	54	17717	54.1
2910	22	34271	55.9
1104	3	13740	8.9
2109	27	12218	72.8
2406	49	31699	57.6
1805	12	20653	7.1
2301	49	39798	29.7
2101	3	18083	27.0
2915	22	16103	65.7
2405	10	28281	4.4
1807	12	16047	8.8
1507	18	17860	22.7
3106	26	14592	20.7
2605	19	17053	22.6
1302	10	4267	22.6

Appendix B Table 1 (Continued)

Origin	Destination	Pounds	Miles
1504	10	17711	9.3
2506	49	20840	25.5
2408	49	27401	32.6
2611	17	21467	7.5
1300	10	19313	3.8
3102	34	34913	62.8
2107	3	25988	18.2
3113	49	19374	46.4
2809	22	27720	25.6
2102	3	23968	19.9
1801	12	16981	21.0
2202	31	18943	102.6
2909	22	19573	60.1
2500	49	32152	26.8
1101	3	11579	17.4
2203	31	16748	100.6
3104	49	21638	33.0
3002	30	20016	116.1
1508	17	18116	12.4
1800	12	16850	14.7
3013	27	18215	59.8
1509	17	24023	14.6
2303	49	24845	38.0
1809	13	14252	4.3
2305	49	19746	30.7
3008	30	18736	103.2
3010	31	22474	100.9
3610	19	13331	34.5
2105	3	32178	19.6
2913	22	5692	69.1
2804	22	15582	31.8
3700	56	16120	16.4
2906	22	2885	57.2
4700	32	21368	64.3
3409	31	21145	70.3
	Totals	2039495	3079.8

Appendix B

Table 2. Origins and destinations, pounds, and miles for model allocation of industrial bulk milk, day B.

Origin	Destination	Pounds	Miles
188	49	54246	44.6
103	3	80000	128.8
103	49	80000	83.2
113	49	60000	96.0
113	19	56000	49.3
114	68	18000	4.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
101	5	80000	.2
101	5	50000	.2
3605	22	29262	22.5
2106	3	47741	12.6
3307	30	27822	17.2
3900	56	19780	57.0
2807	22	25725	26.4
2709	22	10875	16.8
2104	3	29282	20.3
3505	49	4872	16.4
4502	32	19089	92.4
3513	49	20746	7.5
1515	17	25842	15.8
2918	54	22359	40.2
2800	22	31441	37.1
1806	13	8320	6.5
1803	12	20657	7.0
2609	18	2070	9.3
2200	27	14439	69.4
1303	10	17765	1.2
3809	56	10599	49.6
1510	17	17201	7.3
1201	3	3091	18.9
1514	12	22779	10.9
1103	3	17163	9.1
1513	12	16797	22.8
5805	74	26299	43.9
5801	73	18093	36.4
2103	3	25181	19.6
2401	49	31158	63.3
2802	22	5843	26.0

Appendix B Table 2 (Continued)

Origin	Destination	Pounds	Miles
2707	22	4756	29.0
2204	34	26960	75.8
1102	3	15325	13.9
3101	34	34012	62.4
3507	49	18293	27.0
3012	30	21726	104.3
1811	13	15054	2.2
3600	22	20268	30.8
2604	18	10700	4.5
2110	3	22037	31.6
1519	18	19066	28.6
1301	10	19691	3.2
2300	49	41649	37.8
2600	18	2035	4.3
2307	49	22500	28.4
2920	34	29733	141.4
2607	19	29614	21.6
3110	27	16239	17.2
2601	19	19518	17.2
2708	22	18866	15.9
1505	17	20847	11.0
1200	3	22381	19.8
4509	31	26225	87.8
2203	3	17618	112.0
2304	49	30803	34.6
2304	49	3684	34.6
3302	31	14938	45.7
2907	22	18251	65.1
2201	31	18432	101.5
4500	31	21647	106.7
1304	10	12789	6.7
1512	12	17320	5.3
4603	32	17249	101.1
2111	3	18825	33.4
2620	19	21768	15.6
3009	30	19670	106.6
2112	31	19629	115.2
	Totals	2020655	2892.7

Appendix B

Table 3. Origins and destinations, pounds, and miles of model allocation of industrial bulk milk, Days A and B.

Origin	Destination	Pounds	Miles
188	49	50634	44.6
188	49	64246	44.6
103	49	80000	83.2
103	3	80000	164.8
103	3	80000	129.2
103	3	80000	128.8
113	49	60000	96.0
113	49	56000	49.3
113	49	60000	96.0
113	49	56000	95.8
114	68	18000	4.6
114	68	18000	4.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
101	5	80000	.2
101	5	50000	.2
101	5	80000	.2
101	5	50000	.2
2100	3	29247	24.9
2806	22	3385	41.2
3605	49	29262	51.1
2505	49	27022	26.7
2108	3	36019	25.6
2106	3	47741	12.6
3307	31	27822	17.2
3900	56	19780	57.0
4704	31	16635	85.7
2807	22	25725	26.4
2808	22	25386	24.8
3011	31	27657	107.3
2709	22	10875	16.8
2104	3	29282	20.3
2924	57	31800	51.2
3505	49	4872	16.4
2306	34	31007	67.1

Appendix B Table 3 (Continued)

Origin	Destination	Pounds	Miles
4502	32	19089	92.4
3607	49	26972	52.2
2705	22	20274	22.5
3513	49	20746	7.5
3100	49	13534	41.6
1808	13	12716	3.7
1515	19	25842	34.6
2918	54	22359	40.2
1100	3	18931	12.7
2800	22	31441	37.1
2912	22	17717	56.5
2910	22	34271	55.9
1104	3	13740	8.9
1806	13	8320	6.5
2109	27	12218	72.8
2406	49	31699	57.6
1803	12	20657	7.0
1805	12	20653	7.1
2609	18	2070	9.3
2200	31	14439	94.6
1303	10	17765	1.2
3809	56	10599	49.6
2301	49	39798	29.7
2101	3	18083	27.0
2915	22	16103	66.9
2405	10	28281	4.4
1807	17	16047	8.8
1510	17	17201	7.3
1201	3	3091	18.9
1507	18	17860	22.7
1514	12	22779	10.9
3106	26	14592	20.7
2605	18	17053	10.2
1103	3	17163	9.1
1513	12	16797	22.9
5805	74	26299	43.9
1302	10	4267	1.0
1504	10	17711	9.3
5801	73	18093	36.4
2506	49	20840	[illegible]5.5
2103	3	25181	19.6
2401	49	31158	63.3
2408	49	27401	32.6
2802	22	5843	26.0
2707	22	4756	29.0
2204	34	26960	75.8
1102	3	15325	13.9
2611	17	21467	7.5

Appendix B Table 3 (Continued)

Origin	Destination	Pounds	Miles
3101	34	34012	62.4
3507	49	18293	27.0
1300	10	19313	3.8
3102	34	34913	62.8
3012	30	21726	104.3
2107	3	25988	18.2
3113	49	19374	46.4
1811	13	15054	2.2
3600	22	20268	30.8
2604	18	10700	4.5
2110	3	22037	31.6
1519	12	19066	23.8
1301	10	19691	3.2
2300	49	41649	27.8
2809	22	27720	25.6
2102	3	23968	19.9
1801	12	16981	21.0
2600	18	2035	4.3
2202	31	18943	102.6
2909	22	19573	60.1
2307	49	22500	28.4
2920	54	29733	59.7
2607	19	29614	21.6
2500	49	32153	26.8
1101	3	11579	17.4
3110	31	16239	46.4
2601	19	19518	17.2
2708	22	18866	15.9
1505	17	20847	11.0
1200	3	22381	19.8
4509	31	26225	87.9
2203	31	16748	100.6
2203	3	17618	112.0
2304	49	30803	34.6
2304	49	3684	34.6
3104	49	21638	33.0
3002	30	20016	116.1
1508	17	18116	12.4
3302	31	14938	45.7
2907	22	18251	65.1
1800	12	16860	14.7
3013	27	18215	59.5
1509	17	24023	14.6
2201	31	18432	101.5
2303	49	24845	38.0
4500	31	21647	106.7
1304	10	12789	6.7
1809	13	14252	4.3

Appendix B Table 3 (Continued)

Origin	Destination	Pounds	Miles
2305	49	19746	30.7
3008	27	18736	71.9
1512	12	17320	5.3
3010	30	22474	93.9
4603	32	17249	101.1
2111	3	18825	33.4
3610	19	13331	34.5
2105	3	32178	19.6
2620	19	21768	15.6
3009	30	19670	106.6
2913	22	5692	69.1
2804	22	15582	31.8
2112	31	19629	115.3
3700	56	16120	16.4
2906	22	2885	57.2
4700	32	21368	64.3
3409	31	21145	70.3
	Totals	4060150	5951.5

Appendix B

Table 4. Origins and destinations, pounds, and miles of model allocation of fluid bulk milk, day A.

Origin	Destination	Pounds	Miles
174	42	44618	94.8
125	41	50000	109.4
125	41	55800	196.4
125	40	57500	111.6
181	42	80000	147.0
181	42	52000	147.0
181	63	18000	71.0
192	39	52000	147.8
192	39	52000	147.8
188	40	60000	140.4
188	41	55000	138.0
188	41	40000	138.0
188	50	20000	47.6
103	40	80000	179.6
103	40	80000	179.6
103	40	80000	179.6
103	40	60000	179.6
103	40	60000	179.6
103	40	60000	179.6
165	39	51481	125.0
166	39	51700	132.0
166	39	46312	132.0
116	40	80000	181.0
116	40	80000	181.0
116	40	80000	181.0
116	40	80000	181.0
116	40	80000	180.8
116	39	80000	180.8
114	40	77873	178.8
114	41	51133	176.4
115	30	50000	195.2
115	39	37000	211.2
3509	42	25775	56.1
2402	21	26723	20.2
2904	24	11069	8.1
3902	61	10533	13.9
3506	28	13245	40.9
2911	64	4419	3.0
3109	40	28365	103.2
4503	43	28789	93.7
3510	42	19263	49.0
3510	42	19110	45.7
3210	28	21614	14.9

Appendix B Table 4 (Continued)

Origin	Destination	Pounds	Miles
4713	43	27315	67.4
3512	41	30130	105.2
2921	59	29348	51.2
3810	58	24048	16.5
3702	53	21905	18.0
2901	39	34073	140.1
3108	55	14910	16.6
3103	41	27315	64.2
3905	59	13437	51.2
3016	25	28804	9.5
4605	62	23702	76.1
4714	62	23705	42.2
3800	55	21609	7.8
3511	50	29169	7.4
3403	40	26677	38.3
4516	62	30079	35.2
3203	41	30291	48.2
4701	43	5006	44.5
3601	47	26994	116.1
3606	53	14378	16.5
3201	42	28013	46.3
4709	43	30248	64.6
3608	53	25730	33.4
3501	50	20991	11.4
2503	50	20509	14.7
2919	53	19219	37.3
3515	42	29782	67.0
3500	50	3689	7.9
3303	43	17003	47.6
3803	59	10887	8.1
4505	43	17323	51.6
2701	21	17988	32.2
4604	43	24096	98.8
2400	21	7077	23.8
3404	35	22851	22.8
2614	21	18383	18.1
3301	42	17002	44.1
3707	55	20465	5.8
3502	50	20834	8.1
5802	43	29798	149.9
2914	59	18812	38.1
3504	50	11150	12.0
3020	25	21231	42.2
3806	59	30810	14.9
4712	43	27080	74.5
2617	21	26773	28.8
3704	51	20483	38.6
3204	42	25731	61.0

Appendix B Table 4 (Continued)

Origin	Destination	Pounds	Miles
3206	41	33395	60.4
2613	21	17209	25.1
3306	40	19665	47.0
4510	42	24507	42.5
4507	43	26511	53.5
3005	25	18504	31.3
3105	41	29021	108.4
3107	40	27950	91.8
3112	40	28515	58.8
3708	55	17276	4.7
3408	42	18585	38.3
2403	21	18631	24.5
3903	61	16722	3.0
3705	53	27252	33.7
5800	43	29391	148.5
3609	53	21200	33.4
2925	39	42643	129.2
3300	42	29495	80.5
3406	43	18018	34.7
2905	24	11980	21.6
2700	21	14396	45.3
2501	42	26435	66.5
4702	62	27726	5.8
5804	43	27762	118.9
2615	21	28094	21.3
4511	43	31030	82.2
4715	63	15503	6.4
4513	43	31090	83.6
2922	53	25738	54.0
3604	39	27496	122.4
3503	50	26791	8.1
5700	62	24947	67.2
3006	25	17334	45.1
3018	25	20365	7.1
3904	61	13749	29.5
4514	43	30946	82.0
	Totals	4080015	9391.6

Appendix B

Table 5. Origins and destinations, pounds and miles for actual movement of industrial bulk milk, day A.

Origin	Destination	Pounds	Miles
174	42	44618	94.8
125	41	50000	109.4
125	41	55800	109.4
125	40	57500	111.6
181	42	80000	147.0
181	42	52000	147.0
181	63	18000	71.0
192	39	52000	147.8
192	39	52000	147.8
188	49	50634	44.6
188	40	60000	140.4
188	41	55000	138.0
188	49	40000	44.6
188	49	20000	44.6
103	40	80000	179.6
103	40	80000	179.6
103	40	80000	179.6
103	40	80000	179.6
103	40	80000	179.6
103	40	60000	179.6
103	5	60000	61.8
103	5	60000	61.6
113	40	60000	179.0
113	41	56000	176.6
165	39	51481	125.0
166	39	51700	132.0
166	39	46312	132.0
116	39	80000	180.8
116	40	80000	181.0
116	40	80000	181.0
116	40	80000	181.0
116	40	80000	181.0
116	39	80000	180.8
114	40	77873	178.8
114	41	51133	176.4
114	68	18000	4.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
106	11	60000	.6
101	3	80000	89.0
101	5	50000	.2

Appendix B Table 5 (Continued)

Origin	Destination	Pounds	Miles
115	39	50000	195.2
115	19	37000	71.4
2100	3	29247	24.9
2806	22	3385	41.2
3509	42	25775	56.1
2402	21	26723	20.2
2904	24	11069	8.1
3902	61	10533	13.9
3506	50	13246	30.1
2911	64	4419	3.0
3109	40	28365	103.2
4503	43	28789	93.7
3607	47	26972	91.2
2705	22	20274	22.6
3806	59	30810	14.9
4712	43	27080	74.5
3100	49	13534	41.6
1808	13	12716	3.7
1100	3	18931	12.7
2912	53	17717	51.5
2910	39	34271	143.8
1104	3	13740	8.9
2109	27	12218	72.8
2406	21	31699	35.8
2617	49	26773	23.7
3704	51	20483	38.6
3204	28	25731	19.0
3206	41	33395	60.4
1805	12	20653	7.1
2613	39	17209	27.0
3306	32	19665	31.7
2301	49	39798	29.7
2101	3	18083	27.0
2915	53	16103	64.2
2405	10	28281	4.4
1807	12	16047	8.8
1507	21	17860	42.9
3106	27	14592	44.4
2605	18	17053	10.2
1302	10	4267	1.0
1504	10	17711	9.3
2506	49	20840	26.6
2408	49	27401	32.6
2611	17	21467	7.5
4510	42	24507	42.5
4507	43	26511	53.5

Appendix B Table 5 (Continued)

Origin	Destination	Pounds	Miles
1300	10	19313	3.8
3102	41	34913	72.9
3005	25	18504	31.3
3105	49	29021	23.8
3107	31	27950	76.3
3112	40	28515	58.8
3708	55	17276	4.7
2107	3	25988	18.2
3113	49	19374	46.4
3408	42	18585	38.3
2403	21	18631	24.5
3903	61	16722	3.0
2809	22	27720	25.6
2102	3	23968	19.9
3705	54	27252	26.5
1801	12	16981	21.0
5800	43	29391	148.5
2202	31	18943	102.6
2909	22	19573	60.1
3609	53	21200	33.3
3510	42	19263	49.0
3510	42	19110	45.7
3210	34	21614	41.1
2505	49	27022	26.7
4713	43	27315	67.4
3512	49	30130	.2
2921	59	29348	51.1
3810	58	24048	16.5
3702	53	21905	18.0
2901	22	34073	30.1
3108	26	14910	16.6
3103	34	27315	53.0
3905	59	13437	51.2
3016	40	28804	111.7
4605	62	23702	76.1
4714	62	23705	42.2
3800	55	21609	7.8
3511	50	29169	7.3
2108	3	36019	25.6
3403	31	26677	14.7
4516	62	30079	35.2
3203	41	30291	48.2
4701	43	5006	44.5
3601	35	26994	111.0
3606	53	14378	16.5
3201	41	28013	46.8
4709	43	30248	64.6
3608	50	25730	56.7
3501	50	20991	11.4

Appendix B Table 5 (Continued)

Origin	Destination	Pounds	Miles
2503	49	20509	14.3
2919	53	19219	37.3
4704	62	16635	34.3
3515	42	29782	66.9
3500	50	3689	7.9
3303	43	17003	47.6
2808	22	25386	24.8
3803	59	10887	8.1
3011	31	27657	107.3
4505	43	17323	51.5
2701	21	17988	32.2
4604	43	24096	98.9
2400	21	7077	23.8
3404	34	22851	18.2
2614	21	18383	18.1
3301	32	17002	33.6
3707	55	20465	5.8
3502	50	20834	8.1
2924	59	31800	37.0
5802	43	29798	149.9
2914	59	18812	38.1
3504	50	11150	12.0
2306	34	31007	67.1
3020	25	21231	42.2
2925	39	42643	129.2
3300	42	29495	80.5
3406	43	18018	34.7
2905	22	11980	57.6
2700	19	14396	20.6
2500	49	32153	26.8
1101	3	11579	17.4
2501	42	26[illegible]35	66.5
4702	43	27726	57.7
5804	43	27762	118.9
2615	21	28094	21.3
4511	42	31030	87.8
2203	31	16748	100.6
3104	49	21638	33.0
3002	25	20016	29.2
4715	63	15503	6.4
1508	17	18116	12.4
4513	42	31090	89.2
2922	57	19479	26.1
3604	39	27496	122.4
1800	12	16860	14.7
3013	25	18215	17.9

Appendix B Table 5 (Continued)

Origin	Destination	Pounds	Miles
1509	17	24023	14.6
2303	49	24845	38.0
3503	50	26791	8.1
1809	13	14252	4.3
2305	49	19746	30.7
3008	30	18736	103.2
5700	62	24947	67.2
3010	30	22474	93.9
3610	19	13331	34.5
2105	3	32178	19.6
3006	25	17334	45.1
2913	24	5692	33.2
3018	31	28365	94.7
2804	22	15582	31.8
3700	56	16120	16.4
2906	24	2885	23.7
3904	61	13749	29.5
4514	43	30946	82.0
4700	43	21368	58.9
3409	43	21145	65.6
	Totals	6117425	11911.9

AN ANALYSIS OF BULK MILK ALLOCATION AMONG SELECTED PROCESSING FACILITIES

by

Dennis Ray Schmidt

B.S., Kansas State University, 1974

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

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MASTER OF SCIENCE

Department of Agricultural Economics

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ABSTRACT

An analysis of bulk milk truck assignment to processing plants indicated that significant savings could be realized in transportation costs by the application of a linear programming model to a segment of the actual daily operations of a milk marketing board as they existed in April and May of 1975.

Data concerning the number of trucks used, pounds of milk hauled, and the plant delivered to was obtained from bulk milk collection reports. The location of processing plants and transporter depots were supplied by representatives of the marketing board. Producer locations were taken from marketing board records which showed county, township, and lot number.

The allocation of two separate pools or classes of milk and pertinent combinations of these classes were analyzed in this study. Industrial bulk milk was analyzed for each of two days in the producer pick-up cycle and a combination of both days of the cycle which allowed for producer pick-up to be switched between days. Fluid bulk milk for one day in the producer pick-up cycle was analyzed. A final analysis was made which considered all milk and all plant demand as if industrial and fluid were only one class of milk.

Potential mileage savings of 10.8 percent and 12.7 percent were found for industrial milk allocation over present manual allocation procedures. A savings of 12.5 percent of the total miles driven for industrial milk could be saved if the days on which the industrial producer's milk was picked up could be switched. A mileage savings

of 3.4 percent was shown for one day of the cycle for fluid milk pick-up and delivery. The greatest potential for total miles saved was shown for combining all milk into one class, eligible for either fluid or industrial processing. A savings of 9.7 percent of the total mileage could be realized.