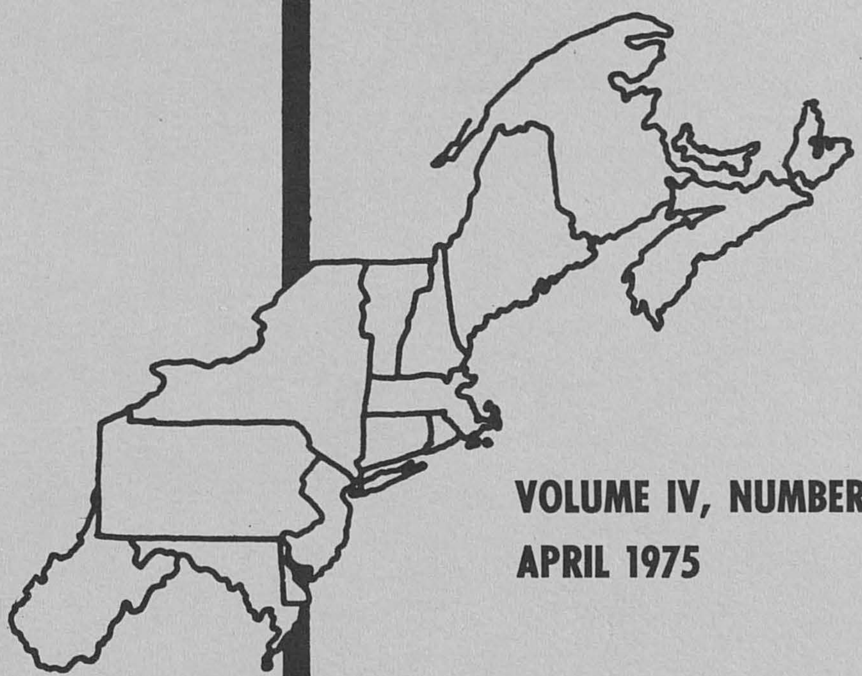
JOURNAL OF THE

Northeastern Agricultural Economics Council



VOLUME IV, NUMBER 1
APRIL 1975

ENERGY AND COST CONSIDERATIONS IN THE DISTRIBUTION OF BULK DAIRY FEED IN THE NORTHEAST*

J. P. Davulis, Resource Economist
R. A. Andrews, Professor
G. E. Frick, Agricultural Economist (ERS, CED, USDA)

Institute of Natural and Environmental Resources
University of New Hampshire

The energy crisis has awakened interest in delivery systems, efficient fuel utilization, and alternatives for reducing delivery costs. Inquiries into the potential for energy and cost savings that exist within our economy are of immediate concern.

This paper appraises the potential for increasing efficiency within the distribution system of bulk dairy feed in the Northeast. A more efficient utilization of energy resources could be realized by instituting changes within the present delivery system. While the conclusions drawn regarding efficiency in the distribution system are specific to the dairy industry, they have general applicability to the delivery of other products distributed on a regular basis.

Modeling the System

A simulation model was employed to duplicate the important features found in bulk delivery of dairy feed in the Northeast. A hypothetical spatial region of 850 square miles was defined to contain 168 dairy farms. Each farm had twenty or more milk cows for a regional total of 8,388 milk cows. The area was assumed to be serviced by three bulk dealers.

The amount of bulk feed needed annually by a farm in the region was a function of the number of milk cows and replacements on that farm. Critical variables were the storage capacity for bulk feed on the farm (bin size) and the biological storage life of the mixed feed on the farm (shelf-life). These two aspects are interrelated. A farmer's conception of the storage life of the feed he purchases will in part determine the size of the feed bin that he has and the frequency of his deliveries.

---

* Published with the approval of the Director of the New Hampshire Agricultural Experiment Station as Scientific Contribution Number 769.

For example, a dairy farmer with 40 milk cows and 10 replacements purchases about 88 tons of mixed feed annually. If such a farmer believed that the most desirable storage life of the feed on his farm was 7 days, he would desire a feed bin only large enough to accommodate a 7-day supply (or, a 1.7 ton bin). Allowing for a margin of safety, he would order 1.5 tons of bulk feed from his feed dealer every week. Such a farmer would be minimizing his bin cost as he can be fairly confident that he can get a bulk delivery anytime. On the other hand, if the farmer believed that his feed was satisfactory for as long as 35 days, he could utilize an 8.4 ton bin and order eight tons of mixed feed every five weeks.

Farms were associated with the feed dealers in a random manner to simulate a situation of competition among the dealers. In effect, each feed dealer serviced some farms in each town of the region. The furthest distance between towns in the region was 45 miles.

A feed dealer was assumed to route his deliveries for a particular day by first servicing the closest farm needing feed, then the closest farm to the antecedant, and so on until his truck was empty, or until a minimum delivery could not be made. If a farmer cannot be serviced on the day he orders feed, he is serviced on the next working day. A five day work week with eight hour days was assumed. Truck capacity was 15 tons of mixed grain.

Situations Simulated

Six distribution situations were analyzed to evaluate the impact of institutional changes on fuel utilization and delivery costs.

(1) First, a situation representing current feed delivery practices was evaluated to provide a base measure of the resources presently used in the bulk delivery of feed. Service areas were assumed to overlap, and there was a duplication of delivery routes as exists in actual practice. The three feed dealers required a one ton minimum delivery; all farms were assumed to have feed storage capacities of 1.5 tons or more. The range of shelf-life was 7 to 50 days (a particular shelf-life was randomly assigned to each of the 168 farms).

The actual bin size on a farm was determined by the number of cows and the shelf-life associated with the farm. A farmer was assumed to reorder feed when the supply in his bin fell to three percent of capacity. It was assumed that farmers would order enough feed to fill their bins.

(2) The second situation differs from the above only in that the shelf-life was set at a minimum of 14 days for all farms. This situation assessed the impact of increased minimum shelf-life on fuel utilization and delivery costs. In effect, the minimum size of

delivery was increased and the frequency of trips reduced. As a consequence, some farms were forced to expand their feed storage capacity.

(3) The third situation increased minimum shelf-life even further, up to 25 days. Again, the number of days between delivery was lengthened, and the size of individual deliveries increased along with increases in bin size.

(4) Situation four is similar to the first in that the shelf-life was chosen randomly between 7 and 50 days, but the minimum delivery was increased to 3 tons; this, in turn, required a minimum bin size of 3.5 tons. This situation allowed the evaluation of the impact of a larger minimum delivery requirement on resource utilization.

(5) The fifth situation assumed a range of shelf-life from 25 to 50 days and a 3 ton minimum delivery requirement. This case allowed an estimation of energy and cost savings that would result from both a larger minimum delivery requirement and a narrower range of shelf-life.

(6) The final situation attempts to estimate the greatest energy and cost savings that could be realized within the distribution system. Here, the farms were associated with the feed dealers on the basis of least distance from farm to supplier with the result that an exclusive delivery territory was defined for each dealer. Further, a three ton minimum delivery requirement and a shelf-life range of 25 to 50 days was imposed. Of course, this delivery situation would represent a most extreme institutional change.

Distribution Cost

Distribution cost can be expressed in a system of simple equations. Given the location and volume of feed service required of the feed firms, the total distribution cost is computed for the entire region as follows:

$$(1) \quad TDC_R = \sum_{i=1}^{k} TDC_i$$

where, TDC_R = total distribution cost for the region

TDC_i = total distribution cost for the i^{th} feed firm providing delivered feed equal to v_i

v_i = total volume of feed service provided by the i^{th} feed firm

The total distribution cost for the i^{th} firm is:

$$(2)\quad TDC_i = FC_{v_i} + (LC)\,(T_{v_i}) + (TC)\,(M_{v_i})$$

where, FC_{v_i} = fixed cost associated with providing delivered feed equal to v_i

LC = average labor cost per hour (specified at $3.25 per hour)

T_{v_i} = total time associated with providing delivered feed equal to v_i

TC = average truck cost per mile (specified at $0.30 per mile)

M_{v_i} = total mileage associated with providing delivered feed equal to v_i

The fixed cost for the i^{th} feed firm is:

$$(3)\quad FC_{v_i} = f(FC, T_{v_i})$$

where, FC = annual fixed cost associated with owning and operating one bulk feed truck

T_{v_i} = total time associated with providing delivered feed equal to v_i

Equation (3) expresses a relationship between the actual hours of truck operation and the possible number of hours of truck operation. That is, a work year for one truck is assumed to be 2,080 hours and associated with each truck are certain fixed costs. Thus, given the total number of hours necessary for a firm to provide a certain volume of service, the fixed cost associated with that volume of feed can be determined. The fixed cost associated with a 15 ton bulk feed truck was estimated to be $5,865 (comprised of depreciation at $2,565 per year, interest at $2,050 per year, and taxes and licenses at $1,250 per year). Equation (3) considers trucks as divisible units. This is justifiable to the extent that feed firms service non-dairy farms in the region as well as other farms outside the region.

Approximating the Present System

There is little uniformity among the delivery practices of feed dealers. For example, a recent study of feed dealers in New Hampshire and Vermont found that 25 percent of those offering bulk delivery required no minimum tonnage for a delivery [1,2]. Of those feed supply firms that did have a minimum delivery requirement, the average was 2.4 tons and the range was from one to four tons. The degree of service competition among feed dealers, as indicated by the duplication of delivery areas, was found to be substantial.

Thus, the present distribution system involved in bulk delivery of dairy feed may best be represented by Situations 1 and 4, above. In the first situation, the minimum delivery requirement was 1 ton; and, in the fourth situation, it was 3 tons. Table 1 presents the simulated output, annual resources utilized and cost incurred in servicing the region for these two cases as well as for the other situations simulated.

The results obtained for Situations 1 and 4 are quite similar. The annual delivery of 18,310 tons of mixed feed requires more than 5,200 man-hours of labor in both cases. The utilization of diesel fuel was about 13,100 gallons in the first situation and 12,200 in the fourth situation. In terms of the amount of diesel fuel required annually per milk cow, 1.6 gallons are required in the first situation and 1.5 gallons in the fourth situation. Delivery cost per ton was $3.06 and $2.94, respectively.

Situation 4, however, represents a more efficient utilization of resources. If Situations 1 and 4 can be thought of as policy alternatives, the latter would result in a reduction of 7 percent in the number of gallons of diesel fuel utilized and a 4 percent reduction in total distribution cost.

Improving the Delivery System

Situations 2 and 3 reflect the effect of changing minimum shelf-life on the efficiency of the delivery system. In the second situation, the range of shelf-life was between 14 and 50 days; and in the third, the range was between 25 and 50 days. In both cases, the minimum delivery requirement was 1 ton, and thus comparison with Situation 1 is appropriate.

Situation 2 results in a total fuel savings of 2,100 gallons (or 16 percent). Likewise, Situation 3 results in a fuel savings of 2,820 gallons (or 22 percent). In the second situation, delivery cost was computed to be $2.71 per ton and in the third case it was $2.64 per ton. Total distribution cost was reduced by 12 and 14 percent, respectively.

The fifth situation, on the other hand, employed a 3 ton minimum delivery requirement and a shelf-life range between 25 and 50 days. The annual amount of diesel fuel required to service the region was computed to be 10,105 gallons (23 percent less than Situation 1 and 17 percent less than Situation 4). Total distribution cost was 17 and 14 percent less than Situations 1 and 4, respectively. Average delivery cost per ton was $2.54.

Table 1
Effect of Institutional Changes on the Efficiency of the Delivery System[a]

Item	Unit	Situations Simulated					
		1	2	3	4	5	6
Parameters:							
Range of shelf-life	Days	7-50	15-50	25-50	7-50	25-50	25-50
Minimum delivery requirement	Tons	1.	1.	1.	3.	3.	3.
Minimum bin size	Tons	1.5	1.5	1.5	3.5	3.5	3.5
Simulated output:							
Feed delivered	Tons	18,310	18,310	18,310	18,310	18,310	18,310
Distance travelled	Miles	78,865	66,275	61,950	73,405	60,615	27,160
Quantity per delivery	Tons	5.0	6.5	7.7	5.6	8.1	8.1
Resources utilized:							
Labor	Man-hours	5,340	4,895	4,905	5,230	4,670	3,920
Diesel fuel[b]	Gallons	13,145	11,045	10,325	12,235	10,105	4,525
Diesel fuel per cow	Gallons	1.6	1.3	1.2	1.5	1.2	0.5
Delivery costs:							
Total cost	Dollars	56,075	49,595	48,360	53,770	46,530	35,615
Cost per ton	Dollars	3.06	2.71	2.64	2.94	2.54	1.95

a/ Situations 1-5 assume a random association of farms with feed dealers; Situation 6 assumes an allocation on the basis of least distance.

b/ It was assumed that a bulk feed truck averaged six miles per gallon of diesel fuel.

Exclusive Delivery Territories

The sixth situation analyzed involves exclusive delivery territories for each of the feed dealers. The parameters were a range of shelf-life between 25 and 50 days and a 3 ton minimum delivery requirement.

If this institutional change in delivery practices were to be accomplished, annual distance travelled in servicing the region could be reduced by 66 percent in comparison to the first situation and by 63 percent in comparison to the fourth situation. The amount of fuel utilized per milk cow would drop to 0.5 gallons. The average cost of distributing a ton of mixed feed would be reduced to $1.95, and total distribution cost reduced by more than one third. This would mean a savings of $1.11 per ton compared to Situation 1 and $0.99 per ton compared to Situation 4.

Implimentation of Situation 6 would require substantial adjustments in the delivery structure. Feed firms would be assigned a portion of the total market, and competition from other feed dealers would be excluded. Each firm would be granted, in effect, a monopoly position within its territory. The allocation of an exclusive territory might be used by some firms to exploit dairymen with respect to the prices charged and/or quality of product and associated services. Public regulation would be needed to prevent such abuses.

Implication of Results

The results of the six simulations suggest that some fairly substantial gains in efficiency could be realized in the bulk delivery of dairy feed in the Northeast. Reductions in the frequency of delivery (increases in the minimum delivery requirement) could result in a reduction in fuel utilization between 7 and 23 percent, and a reduction in total cost between 4 and 17 percent. If exclusive delivery territories were to be adopted, the amount of diesel fuel utilized could be reduced to less than half the present requirements, and distribution cost reduced by more than one-third.

The potential efficiencies resulting from the above institutional changes in the delivery system would require a period of time to be realized. If, for example, some farmers were not able to receive frequent deliveries of feed, it would be necessary for them to purchase larger feed bins. Such changes in farm structure are assumed in the analysis. An important consideration beyond the scope of this paper is the economic trade off between energy and cost savings in feed distribution and the increased utilization of energy inputs in the production of the larger feed bins required because of institutional changes within the delivery system.

Conclusions

Dairy farmers in the Northeast annually purchase more than five million tons of mixed feed. The majority of this is bulk delivered. Generalizing from the results of this analysis, some crude estimates of the Northeastern situation are possible. From the results of Situation 1, as many as 20 million miles of route travel and 450 thousand man-hours are involved in bulk delivery and more than 3.5 million gallons of diesel fuel consumed annually.

If reductions in the frequency of feed delivery and/or increases in the minimum delivery requirement of feed dealers were instituted on a regional basis, possible energy savings of between 225 and 900 thousand gallons of diesel fuel could be realized annually. Distribution cost could be reduced between $600,000 and $2.5 million.

Conditions might warrant a shift to exclusive delivery territories. This could be associated with a chronic shortage of fuel as well as relatively higher fuel prices. It might evolve from a national policy to minimize fuel use. With exclusive delivery territories, as much as two million gallons of diesel fuel could be conserved annually in the Northeast, and total distribution cost reduced by more than one-third. This would represent a substantial energy and cost savings within the dairy sector.

References

1. Davulis, J. P., Andrews, R. A., Frick, G. E., The Distribution of Bulk Dairy Feed and the Energy Crisis, New Hampshire Agricultural Experiment Station, Research Report Number 35, April 1974.

2. Davulis, J. P., Andrews, R. A., Frick, G. E., Effect of Dairy Farm Size and Spatial Density on Regional Marketing Costs and Supply Firm Resource Use, New Hampshire Agricultural Experiment Station, Research Report Number 36, May 1974.