Practical Exercise 8

Designing milk routes based on data/efficient vehicle routing

Objectives: *Improve expertise in designing of milk routes in order to reduce cost and time in milk procurement.*

Milk procurement is the major activity of a milk processing firm or cooperative. The share of transportation cost in the total cost of milk procurement varies from 50 to 50 per cent and considerably affects the profit margin of the processing plants. The transportation cost could be significantly reduced if the milk transportation routes are designed is such a way that it costs less per unit of milk. An efficiently designed milk route will not only reduce cost of transportation but also reduce spoilage of milk by reducing the time involved in transportation. Therefore, two objectives in designing milk routes are reducing the cost and time per unit of milk transported.

An efficient route is the supply chain management from villages (collection centres) to processing plant at best quality standards and at the lowest cost.

However, development of the most efficient and least cost routes for a fleet of vehicles serving a given network of stops is a very complicated, time-consuming task. In most cases, the availability of many alternative routing patterns makes it virtually impossible for a route manager to effectively evaluate all possibilities.

Methodology

Quantitative methods varying from simple hand calculations to sophisticated techniques requiring computer assistance are available to aid the route manager in developing an efficient routing network.

The "lockset method of sequential programming," first presented by Clark and Wright is mostly used for the routing analysis. "lockset" analysis indicates the number of routes as well as the sequence of stops on each route. Mainly three restrictions included are (1) availability of various vehicle sizes, (2) capacity of each vehicle and (3) time.

A hypothetical routing problem

This hypothetical example has been taken from Auburn University (1979) publication on 'Efficient Vehicle Routing- A milk distribution example' for making the students understand the basic purpose of designing routes. In the example, lockset method uses an iterative procedure to link customers on a route so that total travel distance might be minimized.

Three conditions must be met before customers can be linked on the same route. These are:

(1) Both customer X and Y must still be linked to the origin;

(2) Customer X and Y were on separate routes prior to linking; and

(3) All operational restrictions (number of vehicles available, vehicle capacity, etc.) that have been imposed on the problem are satisfied.

The location of four customers and a single distribution centre for the hypothetical problem are illustrated in the figure.

Table 1. Distance between customers and the distribution center

From customer Number	To distribution center (Miles)	To customer (Miles)			
		1	2	3	4
1	20	0	24	17	27
2	25	24	0	9	15
3	37	17	9	0	24
4	13	27	15	24	0

An illustration of customers and distribution center locations for hypothetical problem:

1. The first step is to establish a distance or cost matrix. Table 1 illustrates distances between each of the four customers and between each customer and the distribution center. It was assumed initially that each customer was on a separate route, giving the highest cost solution for the routing network, total travel of 190 miles.

2. The second step is to calculate the distance saved coefficient (DSC) for each possible combination of two stops. The DSC is the distance to be saved if customers X and Y are served on the same route rather than on separate routes. The DSCs are calculated with the following formula:

$$DSC = D_{dx} + D_{yd} - D_{xy}$$

where:

D_{dx} represents the distance between the distribution center and customer X;

D_{yd} represents the distance between customer Y and the distribution center; and

D_{xy} represents the distance between customer X and Y.

Table 2. Distance saved coefficients for the hypothetical routing problem

No. of Customer combination		Distance from distribution center to customer X (Miles)	Distance from distribution center to customer Y (Miles)	Distance from customer X to Customer Y (Miles)	Distance saved coefficient (Miles)
X	Y				
1	2	20	25	24	21
1	3	20	37	17	40
1	4	20	13	27	6
2	3	25	37	9	53
2	4	25	13	15	23
3	4	37	13	24	26

After DSCs for all pairs of customers have been computed, route development can begin. At each iteration, customers are added to a route based on the value of their DSC. Customer combinations with the greatest values are added first if they meet the three necessary conditions stated earlier, i.e., each still linked to origin, each on separate routes, and no other constraints violated.

In the hypothetical problem, the customer combination with the highest DSC was the combination formed by stops 2 and 3. By linking these customers onto the same route, a savings of 53 miles was obtained. The new route is DC-2-3-DC. The customer

combination which resulted in the next highest DSC was to combine customers 1 and 3. Since customer 3 was still connected to the distribution center, it was possible to combine customers 3 and 1 into the present route. A savings of 40 miles was obtained. The route is now DC-1-3-2-DC.

The next largest DSC was 26, from customer combination 3 and 4. Since customer 3 had already been linked with customers 1 and 2, linking customer 4 in the route with customer 3 would be in violation of one of the conditions imposed by the 'lockset method'. Customer 3 is no longer connected to the origin, therefore, acceptance of this combination into the route would result in an increase in distance travelled. This combination was omitted. Customer combination of 2 and 4 had the next highest DSC.

Since necessary conditions were met, it was possible to include this combination of customers into the route generating a savings of 23 miles. The final route sequence is DC-1-3-2-4-DC or reverse, assuming that travel could be made in either direction.

By using the lockset method, a savings of 116 miles was obtained. Total delivery distance was reduced from 190 miles with each customer on a separate route to 74 miles with a single route serving all customers.

Activity

1. Study the transportation model, its objectives and methods to solve.

STUDY QUESTIONS

1. Prepare a list of other methods/softwares available to design milk routes.
2. Estimate the final route using the lockset method and state the distance saved.

From Customer (number)	To distribution centre (miles)	To Customers (distance in miles)			
		1	2	3	4
1	28	0	20	18	30
2	37	25	0	10	20
3	40	20	10	0	25
4	15	30	20	25	0