Vehicle Routing at Baroda Union*

J agdish Patel looked at the cost figures for the last six months and he knew the meeting with the chairman was not going to be very pleasant. The chairman was once again going to raise the issue of milk prices paid to farmers. Jagdish, General Manager (Procurement) of Baroda District Co-operative Milk Producer's Union Ltd (Baroda Union), had observed that neighbourhood unions like Kheda and Valsad were giving much better milk prices to farmers than what Baroda was paying. As he looked at the cost figures once again, he knew he had to do something about transportation costs for milk procurement, as it was the most significant part of the operating cost under the control of the management. Jagdish was aware that in another two months they will have to start the work on issuing a tender for the next year's transportation contracts. Baroda Union had been working with the same procurement routes for the last couple of years and these routes were evolved historically. Jagdish felt that Baroda Union will not be in a position to reduce the transportation costs unless they could come up with a more scientific way of designing these routes. He was just wondering whether he could apply any of the ideas that he had picked up when he recently attended an executive programme on logistics management.

Background

Baroda Co-operative Union was set up in late 1960s with the Anand model in mind. As per the Anand model, each village forms a co-operative society of all farmers who had surplus milk available with them. As each village-level society would not have enough volume to justify setting up a milk processing plant, all the village co-operative societies in a district would form a union, which in turn would collect milk from all societies and process it in a centralized processing plant. The basic philosophy was that as milk was a perishable commodity farmers would not get remunerative prices for their surplus milk unless they own the processing facility. Traditionally, middleman used to exploit farmers by paying them ridiculously low prices. Baroda Union had membership of 700 village-level co-operatives spread all over the district. These 700 societies were covered by 44 truck/tempo routes, wherein milk was collected twice a day and 365 days in a year. Since these 700 societies were geographically spread out, the union had faced a difficulty in getting milk in time from some of the far-flung societies. Given the perishable nature of the product, it was important that the time lag between milking and processing should not exceed seven hours. So Baroda Union had set up one chilling centre at Bodeli so as to take care of this problem of distances. Out of the 700 societies, about 180 societies were connected to the chilling centre through 12 procurement routes. Milk procured from these societies would be brought to the chilling centre where it would be kept in a chilled condition, and from there it would be sent to a centralized processing centre via special tankers. The remaining 580 societies were directly connected to the processing centre at Baroda through 32 truck/tempo routes. Each vehicle route would cover approximately 15 societies depending on the total supply of milk and is given a specified schedule (see Exhibit 3 for a sample route).

The main concern was that because of its perishable nature, milk must either get processed or kept in a chilled condition so as to avoid curdling. If milk gets curdled, the Union could not use that milk in any productive way. During the summer season about 5 per cent of the milk was received in a curdled form.

The main objective of the Union was to minimize total costs so that members (farmers) would get the highest payment per litre of milk. Last year's data showed that transportation costs in milk procurement accounted for 17 per cent of costs (see Exhibit 1 for costs break-up).

Milk Routes

Since Baroda union was already 30 years old, it had by and large stable routes and every year they floated a tender wherein transport contractors are asked to bid for pre-specified routes. The tender also specified the type of vehicle (truck or tempo) required. In the tender all the details were provided. For various reasons, the price quoted per kilometre varied significantly across routes (see Exhibit 2 for detailed data on the same, for a few of the routes of the Bodeli

Exhibit 1: Cost per litre of milk for Baroda Union.

Expense component	Percentage of cost
Transportation	17.50
Processing	15.00
Salary & Wages	15.60
Packaging	20.50
Distribution	13.00
Admn. Expenses	8.90
Others	9.50
Total	100.00

Exhibit 2: Tender details for sample routes of Bodeli chilling centre.

Route number	Type of vehicle	Contractor name	Rate per kilometre
51	Tempo	Ghanshyamdas	3.00
		Ibrahimkhan	3.28
52	Tempo	Dhanishran	3.38
		Rajput	3.50
54	Tempo	Salimbhai	3.78
		Galubhai	4.26
55	Tempo	Ghanshyamdas	2.68
		Shantilal	2.72
		Jugalkishore	3.36
		Girdhari	3.52
60	Tempo	Jashwant	4.60
		Dhanisharan	4.66
62	Tempo	Gabubhai	3.34

chilling centre). Since milk procurement was quite seasonal in nature, the Union designed routes keeping in mind peak procurement, which took place in the winter. Actually there were two seasons, winter and summer. Procurement in the summer would drop down to about 50 per cent of the winter procurement level.

Milk was collected twice a day, once in the morning and once in the evening. Societies that did not have any motorable approach roads delivered the milk at some nearby point on the road or a nearby co-operative. Milk was collected in cans, which carried the name of the society for identification. The cleaned and empty cans required for the morning procurement were delivered while collecting the evening milk. Similarly, cans required for morning milk were delivered to societies during the evening trip. Each can could hold 40 litres of milk. The milk collected had to be delivered at the processing plant or chilling centre at specified hours. The contractor was given a grace time of one hour to take care of unforeseen circumstances on any particular day. If a contractor delayed delivery by more than an hour he had to pay a penalty. The routes have to be designed such that the truck arrivals are spaced out uniformly to avoid problems at the receiving dock. On reaching the processing centre or the chilling centre, the truck would have to join a queue and would be taken to the receiving centre on a first come first served basis. The truck would unload cans on the receiving dock. At the receiving dock each can is weighed and a sample is collected to check for milk curdling. Each truck took about 20–25 minutes at the receiving dock. If milk was found to be curdled, the respective cans were kept separately. Good milk was emptied into a tank. Societies that supplied curdled milk were paid only nominal rates. If the milk got curdled because of delay on the part of the transport contractor he would end up paying the differential charges to the respective societies.

Jagdish had called Ramesh, who handled designing routes and contractors, to discuss the idea of designing scientific routes. Ramesh was not very enthusiastic about the idea. After a long discussion Ramesh summarized his views as follows:

> I think over a period of time we have come up with routes that are quite optimal. Further, since the contractor bids on a route and not on kilometre basis, there is a chance that the overall distance in terms of kilometres may come down though the actual costs may go up. I know you are thinking of using some scientific way of designing routes. I have a feeling that you will get routes that are petal shaped. Petal-shaped routes are not going to be acceptable to societies that are near the plant but for those at the beginning of such a petal-shaped route. This is because their rate would go up. Also, it would result in substantial alterations in the collection times at the societies. Most of the farmers have worked out their milking times and other schedules around the current truck schedules. Do you think we can force a change in their present working schedule? Finally, they are the owners of this Union.

A Sample Problem

Jagdish knew that it would be very difficult to try out a new set of routes for the entire range of societies. Also, he was not sure about the applicability of using standard vehicle routing ideas of building scientific routes for a dairy kind of situation. To build his intuition about routing decisions, he decided to look at a smaller version of the problem. Since the Bodeli chilling centre involved only 12 routes, he thought it might be a good starting point for experimentation. He collected all the necessary data that would be required to do the meaningful exercise. From the 12 routes he further decided to narrow his focus to six selected routes (route numbers 51, 52, 54, 55, 60 and 62), which were in close proximity. Even these six routes accounted for 84 villages, which made the problem quite large. To reduce the problem size further, he decided to represent these six routes with modified routes that would have at most six pickup points in any route. All those societies, which were either geographically close to each other or fell by and large on a straight-line road, were combined and treated as one pickup point. These six modified routes with 33 pickup points are as shown in Exhibits 3 and 4. Jagdish calculated the distance matrix showing the values of all the pair-wise (34×34) distances for all the possible combinations. See Exhibit 5 for data on the distance matrix.

While designing routes he also had to ensure that the load on any route should not exceed the vehicle capacity and that the route length should be within some limit so as to handle issues related to curdling of milk. The time taken by a vehicle on any route would include travel time and waiting time at societies. Regarding travel times, he knew that road conditions varied and all roads were by and large classified as pakka road (good road) and kachha road (not a good road). To take care of this issue he decided to assume that a vehicle would run at an average

Exhibit 3: Route number 51.

Actual route			Modified route*
Society name	Milk collection time for morning route	Expected maximum quantity of milk in litres	Pickup point: representing the concerned society
Khandibara	6.00	70	1
Thadgam	6.25	210	1
Aathadungari	6.35	30	1
Jamba	6.55	130	2
Nalwant	7.05	250	2
Vadhay	7.25	160	2
Sandhaliya	7.35	490	3
Palasani	7.45	30	3
Kandwa	8.15	700	3
Kukawati	8.25	60	3
Nawagam	8.50	230	4
Vanthada	9.00	70	4
Pochamba	9.10	50	4
Kandha	9.20	60	5
Baroli	9.40	150	5
Nannupura	10.00	35	6
Haripura	10.20	130	6
Sindhikuwa	10.30	240	6
Bodeli	11.15	–	–

*Actual route would involve vehicle starting from Bodeli and visiting each of the 18 societies in the route and returning to Bodeli. In the modified route, societies Khndibara, Thadgam and Aathadungri would be represented by one point, which would be located at Thadgam and be called pickup point 1. The waiting time at this pickup point would be assumed to be 15 minutes as it actually represents three societies. So, the modified route 51 would be Bodeli-1-2-3-4-5-6-Bodeli.

Exhibit 4: Data on modified routes for the remaining five routes.

Route number	Pickup point	Milk collection	Number of actual societies represented by the pickup point*
52	7	880	3
	8	260	2
	9	220	2
	10	230	2
	11	560	2
54	12	690	2
	13	820	3
	14	950	3
	15	570	2
	16	690	3
	17	210	2
55	18	130	3
	19	240	2
	20	890	4
	21	290	3
	22	800	4
60	23	610	2
	24	300	2
	25	100	2
	26	770	2
	27	930	3
62	28	220	2
	29	140	2
	30	370	3
	31	100	2
	32	360	2
	33	230	2

*Expected waiting time at the pickup point = 5 × Number of actual societies represented by the respective pickup point.

speed of 30 kilometres per hour. Based on his past experience he also knew that on an average a vehicle would spend about 5 minutes at each society to take care of loading, unloading and other activities like document transfer. Regarding vehicle capacity, he could safely assume that a typical tempo would be able to accommodate about 100 cans. Now that he had all the necessary data in place he hoped that he would be in a position to apply all the ideas that he had learnt during the executive programme on logistics to see if it would result in any substantial savings in transportation costs.

Discussion Questions

1. Identify the key challenges faced by the Baroda Union. How important is in-bound logistics for Baroda Union?

2. Suggest a suitable approach that Baroda Union can use for designing efficient routes for milk collection. What kind of conflicts are these revised routes likely to create at Baroda dairy? How should Baroda Union handle these issues?

3. In what way will the problem of designing optimal vehicle schedules be affected by the nature of ownership (corporate sector vis-à-vis co-operative dairy like Baroda Union)?

4. If you were Jagdish Patel, what would you do?

Exhibit 5: Distance matrix.

	0*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
0*	0																																	
1	48	0																																
2	49	7	0																															
3	44	12	7	0																														
4	51	29	22	18	0																													
5	43	35	30	24	13	0																												
6	31	23	21	15	22	19	0																											
7	40	8	12	12	29	33	18	0																										
8	35	18	16	10	20	20	5	14	0																									
9	26	40	38	31	29	18	17	34	22	0																								
10	21	36	35	28	31	22	13	29	18	7	0																							
11	25	29	28	21	27	21	6	22	11	12	7	0																						
12	39	12	18	19	36	39	22	7	19	38	32	26	0																					
13	34	14	17	14	30	32	15	6	12	30	25	18	8	0																				
14	27	21	24	22	36	35	16	13	16	29	22	17	12	6	0																			
15	32	17	17	12	26	26	8	10	6	24	19	12	14	6	10	0																		
16	22	27	27	22	31	26	9	19	12	17	11	6	21	14	11	10	0																	
17	15	34	36	33	44	39	22	26	25	27	20	19	24	20	13	20	14	0																
18	60	21	27	33	49	56	42	25	38	59	53	47	22	29	33	35	43	45	0															
19	56	27	34	38	56	61	44	28	41	60	53	47	22	30	32	36	43	40	12	0														
20	45	9	16	19	37	42	26	9	23	43	37	31	6	13	18	19	27	30	16	19	0													
21	35	22	28	28	45	46	28	17	26	41	34	29	10	15	13	20	24	20	25	20	15	0												
22	22	31	35	32	46	44	25	23	26	33	26	23	20	18	11	21	18	8	39	33	26	13	0											
23	20	28	29	24	34	29	12	21	15	19	11	8	22	15	11	12	3	11	44	42	28	23	15	0										
24	17	31	32	27	37	31	15	24	18	19	12	10	24	18	12	15	6	8	46	44	30	23	14	3	0									
25	21	29	29	23	31	25	9	21	13	16	9	5	23	16	13	12	2	14	45	45	29	24	19	3	6	0								
26	15	33	35	30	40	35	18	25	21	22	15	14	24	19	12	18	9	5	46	43	31	26	12	6	4	9	0							
27	11	37	40	35	45	39	23	30	27	25	18	19	24	24	16	23	15	4	49	45	35	25	12	12	9	14	5	0						
28	23	43	47	45	59	55	38	36	39	43	36	35	31	31	24	34	29	16	47	39	37	22	13	27	24	30	21	18	0					
29	25	33	37	35	50	48	29	26	30	38	30	28	21	21	14	24	22	12	38	31	26	13	4	20	19	23	16	15	10	0				
30	22	27	31	27	40	38	19	20	21	28	21	18	17	14	6	15	12	7	38	35	24	14	6	10	10	13	8	11	18	10	0			
31	18	32	35	31	43	39	21	24	24	28	20	18	22	18	10	19	13	2	42	38	28	18	6	10	8	14	6	7	16	10	4	0		
32	21	31	35	32	45	42	24	24	25	32	24	22	20	18	10	20	16	6	40	35	26	15	2	14	12	17	10	10	14	6	5	4	0	
33	13	39	42	38	50	44	28	31	31	31	24	24	29	26	18	26	19	6	48	43	35	23	10	16	13	19	10	6	12	12	12	8	8	0

* Note: 0 Represents Bodeli chilling centre.