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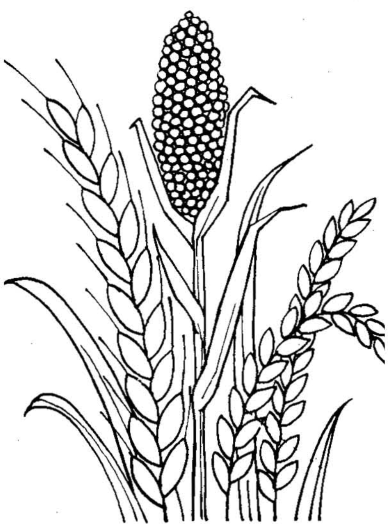

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ECONOMIC PARAMETERS OF PUBLIC SECTOR MILK MARKETING IN NORTH-WESTERN INDIA — AN APPLICATION OF ANALYTICAL, NUMERICAL AND SIMULATION TECHNIQUES

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Milk market infrastructure represents committed capital meant for maximizing economic welfare functions of both the producers and consumers of milk. The investment in this vital area of dairy development is considered important because in its absence, the desirable integration of production and consumption activities under the existing milk markets will be negligible. Economic viability of the public sector milk market which is realisable by avoiding the welfare waste from all its necessary stages of milk procurement, processing and distribution is the basic pre-requisite for fulfilment of its committed objective of economic welfare of the society.

Systems analysis approach based on mathematical model appears to be of great significance for suggesting ameliorative measures in various sub-systems of the study plants. The work already done in this direction confined to the use of models based on ordinary least squares.[1] However, procurement and distribution expenses being endogenous variables their inclusion as such in the set of pre-determined variables is bound to yield biased and inconsistent direct least squares estimators.[2] The use of two-stage least squares would, therefore, be more appropriate to get good results in such a situation. The research work report on numerical approach in public sector milk market did not go beyond optimization of product-mix and interpretation of MVPs.[3] An insight into the sensitivity of original optimum solution and optimum product plan at the full capacity of the study plants could generate useful information for decision-making. Such information, though useful, often may not be adequate for decision-making. The decision-maker would also like to know the likelihood of occurring various values of the chosen criterion.

Probabilistic simulation models are capable of generating such information. However, in the past simulation remained conspicuous by its absence in the analysis of dairy industry. The present study is, therefore, an attempt to generate useful information on public sector milk marketing.

DATA AND METHODOLOGY

Major components of the methodology employed involve criteria used for the selection of the study plants, nature of data collected and brief description of the techniques followed.

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1. Pritam Singh and Jagdeesh C. Kalla, "Optimum Resource-Mix for a Public Sector Milk Product Plant in North Western India", *Asian Journal of Dairy Research*, Vol. 1, Nos. 3/4, 1982, pp. 218-226.

2. J. Johnston: Econometric Methods, Second Edition, McGraw-Hill Kogakusha Ltd., Tokyo, 1972, p. 343.

3. Jagdeesh C. Kalla, T.P. Gangadharan and V.K. Kesavan: Costing and Optimisation of Product-Mix – A Case Study of Milk Products Factory, Vijaywada (A.P.), Division of Dairy Economics, Statistics and Management, National Dairy Research Institute, Karnal, Haryana, 1982, p. 37.

Selection of the Study Plants

Commensurate with the objectives of this study three milk plants,* one representing fluid milk factory and the other two representing multiproduct milk factories were purposively selected from the public sector of North-Western India. Among the criteria employed in the selection include minimum running life of five years, easy access to the records and plants of the same organization. For the sake of comparison and reference, the selected plants were denoted as 'C', 'L' and 'V' and these notations have been preserved throughout this study. The plants 'C', 'V' and 'L' were commissioned in 1961, 1962 and 1974 respectively.

TECHNIQUES OF ANALYSIS

The following three approaches were used to meet the required objectives.

Analytical Approach

This method is deductive by nature and involves expressions of the model by graphic solutions or by mathematical computations. Second stage least squares approach deserves to be one of the analytical methods. In the first stage procurement expenditure and distribution expenditure were purged of their stochastic components by regressing them separately on pre-determined variables and obtaining their regression values. These regression values in the second stage were used as independent variables in the structural model. The form of the mathematical model is presented below:

$$\ln Y_1 = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 D$$

$$\ln Y_2 = \ln k + C_1 \ln X_1 + C_2 \ln X'_2 + C_3 \ln X_3 + C_4 D$$

$$\ln Y = \ln \alpha + \beta_1 \ln \hat{Y}_1 + \beta_2 \ln \hat{Y}_2 + \gamma_1 \ln X_1 + \gamma_2 \ln X''_2 + \gamma_3 \ln X_3' + \gamma_4 \ln X_4 + \delta D$$

where

Y_1, Y_2 and Y indicate procurement expenditure, distribution expenditure and gross returns respectively,

X_1 stands for milk expenditure,

X_2, X'_2 and X''_2 indicate transportation charges of procurement section, of distribution section and expenditure on fuel of production section respectively,

X_3 and X'_3 indicate manufacturing expenses and power charges of manufacturing section,

X_4 stands for labour charges of manufacturing section,

D takes value zero for the months of lean season and one for those of flush season of each year,

a, k and α indicate constants of the respective equations, b_{is}, C_{is}, β_i, γ_i and δ indicate regression coefficients of their respective variables.

* The names of the milk plants are kept secret as desired by the authorities of Dairy Development Corporation.

This model was used for each study plant. The selection of the form of the model was made on the basis of its ability to indicate 'returns to scale' of milk marketing infrastructure.

Numerical Approach

In this approach the algorithm is started with a trial (initial) solution and continued with a set of rules for improving it towards optimality. Linear programming and sensitivity analysis fall well in the purview of this approach, hence employed in the present study. The general linear programming model is given below:

Maximize $$Z = \sum_{j=1}^{n} C_j X_j$$

Subject to

$$\sum_{i=1}^{m} \sum_{j=1}^{n} A_{ij} X_j \leqslant b_i$$

$$X_j \geqslant 0.$$

where

C_j stands for net returns from jth milk product,

X_j indicates jth milk product,

A_{ij} stands for requirement of ith resource per plant of jth product, and

b_i indicates availability of ith resource.

Optimization of the product-mix was made at the existing levels of resources as well as at the full capacity for 'L' and 'V' plants with appropriate upper and lower bounds for certain milk products.

Further, sensitivity of the original optimum solutions to the changes in the price vector of the objective function was also attempted.

Simulation Technique

Simulation analysis was used to develop the probability profile for the profit of each plant by randomly combining the values of variables like expenditure of milk, procurement, manufacturing, administrative activities and distribution which have a bearing on the chosen criterion.

From the simulated probability distribution the following values were calculated.

$\bar{\pi} = \Sigma p_i \pi_i$ where $\bar{\pi}$ is the expected value of profit π, π_i is the mid-point of the class interval i and p_i is the probability associated with class interval i.

$\sigma(\pi)$ is the standard deviation of the distribution of π. It is expressed as $[\Sigma p_i (\pi_i - \bar{\pi})^2]^{\frac{1}{2}}$

Further, probabilities of π being equal to or greater than some specified values were also obtained.

RESULTS AND DISCUSSION

The reponsiveness of procurement and distribution expenses to various factors was analysed for the selected palnts and the results are presented in Table I. The table revealed that a significant reduction in the procurement and distribution expenses can be made by reducing avoidable waste in their respective transportation costs. Expenditure of milk showed an inverse significant relationship with procurement and distribution costs in the case of plant 'V'. This paradoxical relation may partly be due to excess capacity in the 'V'. This paradoxical relation may partly be due to excess capacity in the procurement and distribution sections of the plant and partly due to an

TABLE I—RESULTS OF FIRST STAGE LEAST SQUARES

Sr. No.	Parameters	Plants		
		C	L	V
1.	ln a	2.8264	4.2695	5.7524
2.	b_1	0.0182 (0.0229)	0.0042 (0.0569)	−0.1066*** (0.032)
3.	b_2	0.7905*** (0.0306)	0.6957*** (0.0919)	0.7039*** (0.0758)
4.	b_3	−0.0210* (0.0114)	0.0048 (0.0694)	0.0314 (0.0377)
5.	R^2	0.9530	0.6225	0.7405
6.	ln k	2.6724	5.0472	12.6709
7.	C_1	−0.0057 (0.0128)	0.1377* (0.0734)	−0.2382*** (0.0696)
8.	C_2	0.9067*** (0.0402)	0.5259*** (0.0583)	0.5593*** (0.0631)
9.	C_3	−0.0345* (0.0197)	−0.1052 (0.1365)	−0.2715*** (0.0917)
10.	C_4	0.0064 (0.0063)	−0.0459 (0.0552)	0.1245** (0.0564)
11.	R^2	0.9436	0.7611	0.7610

*** Significant at 1 per cent level of significance.
** Significant at 5 per cent level of significance.
* Significant at 10 per cent level of significance.
Constant and elasticities are as defined earlier.

upward movement in the price of milk procured. However, in the case of plant 'L' milk expenses showed positive and significant relation with the distribution cost. It may be further seen that an increase of one per cent in manufacturing expenses would decrease respective distribution expenses of plants 'C' and 'V' by 0.0345 and 0.2715 per cent. The relation between manufacturing and distribution expenses was also inverse in the case of plant 'L' but it was non-significant. Procurement cost function experienced downward significant shift during the flush season in the case of plant 'C'. Distribution cost function, on the other hand, observed upward significant shift in the case of plant 'V' during the flush season. The downward shift in procurement cost function may be attributed to the marginal transfer of some vehicles to the distribution section which is quite possible to dispose of surplus milk procured during flush season to distant places.

Income Responsiveness

Income response in dairy plants to various factors was examined with the help of a structural model incorporating estimates of endogenous variables in the set of pre-determined variables. The data of plant 'V' did not prove appropriate for this type of analysis. Hence the results of the plants 'C' and 'L' are given in the form of equations as follows:

$$y = 1{\cdot}2162^{\dagger}\ \hat{Y}_1^{-1\cdot1085***}\ \hat{Y}_2^{0\cdot4296}\ X_1^{0\cdot4355**}\ X_2''^{\,0\cdot0210}\ X_3'^{\,-0\cdot3377*}\ X_4^{-0\cdot4854**}\ e^{0\cdot5655D**} \quad \text{......Plant 'L'}$$

$$R^2 = 0.6763$$

$$y = 1941{\cdot}86\ \hat{Y}_1^{-0\cdot0649}\ \hat{Y}_2^{0\cdot2009}\ X_1^{0\cdot0785}\ X_2''^{\,-0\cdot1223**}\ X_3'^{\,0.1336***}\ X_4^{0\cdot4360*} \quad \text{......Plant 'C'}$$

$$R^2 = 0{\cdot}6918$$

(All the variables are previously defined)

† In the case of constant term of plant L, the decimal is to be shifted eleven places to the right.

Input-output data of both the plants were found to witness constant returns to scale. In the case of plant 'L', an increment in milk expenses would make positive significant contribution to gross returns. However, negative but significant elasticities associated with expenses on procurement, electricity and human labour revealed relatively excessive expenditure. It was further observed that during the flush season income function of plant 'L' could make scale neutral upward shift. In the case of plant 'C', an increase in the expenses on power and human labour would make positive significant addition to the gross returns. However, expenditure on fuel appeared to be disproportionately higher. Expenditure on distribution of milk products could witness positive contribution to gross returns of both the plants but it could not turn out significantly different from zero.

Normative Types and Size of Product Packets

Elimination of relatively less economical milk products is capable of generating additional net revenue from the same level of resources which may well be utilized for the economic welfare of the society. The consumers stand to gain from this process in the sense that they are not to pay for

TABLE II — EXISTING AND OPTIMUM PRODUCT LEVELS FOR THE LEAN AND FLUSH PERIODS OF 1978-79

Sr. No.	Product	Unit	Plant L						Plant V					
			Lean			Flush			Lean			Flush		
			Existing	Optimum I	Optimum II	Existing	Optimum I	Optimum II	Existing	Optimum I	Optimum II	Existing	Optimum I	Optimum II
(1)		(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
1.	Table butter (20 gm.)	Qtls.	0.48	0.48	1,236	–	–	–	–	–	–	–	–	–
2.	Table butter (100 gm.)	Qtls.	47.69	47.69	3.25	105	105	–	–	–	–	–	–	–
3.	Table butter (200 gm.)	Qtls.	39.33	39.33	–	38.08	38.08	200	18.40	5.33	–	4.21	4.21	1,200
4.	Table butter (400 to 450 gm.)	Qtls.	–	–	–	–	–	–	44.46	49.33	1,240	723	–	–
5.	Table butter (500 gm.)	Qtls.	–	–	–	39.73	106	1,000	–	–	–	16.27	753	–
6.	White butter (500 gm.)	Qtls.	32.62	32.62	–	65.93	–	–	6.04	–	–	13.84	–	–
7.	Whole milk powder (1 kg.)	Qtls.	–	–	–	71.50	70.79	–	–	–	–	–	–	–
8.	Whole milk powder (10 kg.)	Qtls.	–	–	–	325	322	–	–	–	–	–	–	–
9.	Ghee (1 kg.)	Qtls.	126	125	928	190	188	–	9.07	–	–	23.82	–	–
10.	Ghee (2 kg.)	Qtls.	–	–	–	357	354	–	5.32	–	1,240	32.40	–	–
11.	Ghee (4 kg.)	Qtls.	–	–	–	111	110	750	25.92	22.79	–	–	–	–
12.	Ghee (16.5 kg.)	Qtls.	–	–	–	35	34	148	–	–	–	6.27	–	–
13.	Skim milk powder (450 gm.)	Qtls.	30.62	30.62	1,499	13.37	13.37	1,500	–	–	–	–	–	–
14.	Skim milk powder (25 kg.)	Qtls.	179	180	50.90	994	994	–	566	566	1,824	94	944	1,765
15.	*Paneer* (200 gm.)	Qtls.	0.55	–	–	3.37	–	–	–	–	–	0.56	–	–
16.	*Paneer* (500 gm.)	Qtls.	0.01	2.58	*	0.07	–	254	–	–	–	–	–	–
17.	Sweetened flavoured milk	00lts.	348	385	385	64.48	64.48	64.48	333	–	–	24.60	11.86	–
18.	*Lassi*	00lts.	48.56	–	–	4.74	–	–	29.14	–	–	–	–	–
19.	Standard milk (bottled)	00lts.	929	923	15,145	632	628	14,505	731	1,649	22,143	771	1,710	21,429
20.	Standard milk (poly pack)	00lts.	31.40	31.36	15,788	225	348	15,014	–	–	–	–	–	–
21.	Double toned milk (bottled)	00lts.	178	178	6,677	160	160	66	917	–	–	939	–	–
22.	Double toned milk (poly pack)	00lts.	–	–	–	88.18	88.18	88.18	189	3,115	8,858	210	280	8,577
23.	Milk cake (200 gm.)	Qlts.	0.48	–	–	3.05	1.65	–	–	–	–	0.88	–	–
24.	Milk cake (500 gm.)	Qtls.	–	–	–	–	–	–	–	–	–	0.08	3.66	–

Optimum I means existing level of resources.

Optimum II means relaxed level of resources.

* stands for very small figure

Figures of plant V against double toned milk (bottled) indicate quantity of toned milk (bottled) and figures against double toned milk (poly pack) indicate toned milk (bulk).

inefficiency in the production of milk products. It may be seen from Table II that in the case of plant 'L', milk products like *lassi*, *paneer* (200 gm.) and white butter (except during lean period at the existing availability of resources) failed to merit their entry into the optimum product-mix due to their higher production-cost in relation to their competitive market prices. In the case of plant 'V', *lassi*, white butter, ghee (1 kg.) and toned milk (bottled) were identified as relatively less profitable products on the basis of their rejection from the optimum product-mix both at the existing and relaxed availability of limited variable resources. None of the ghee lots entered the optimum plan even in the flush period in the case of plant 'V'. An unfailing entry of standard milk in the optimum product plans of plants 'L' and 'V' at both the existing and relaxed levels of resources confirmed the hypothesis of profitable sale of standardised fluid milk.

Sensitivity Analysis

Increments in net returns of slack product activities for which original optimum solution remained unaffected are presented in Table III. It may be seen from the table in the case of plant 'L', a minimum increase of Rs.95.61 in the net returns was observed for *lassi* at the existing availability of resources during the lean period for which the original solution remained insensitive. On the other hand, during the flush season *lassi* witnessed the highest increment of Rs.309.52 at the existing level of resources for which the original optimum solution remained valid. At the relaxed levels of resources, the optimum solution remained highly insensitive to increments in the net returns of white butter during the lean season. During the flush period, the original optimum solution remained highly sensitive to increase in the net returns of table butter (100 gm.) and the least sensitive to increment in the profitability of whole milk powder (1 kg.)

In the case of plant 'V', during the lean period, the original optimum solution remained highly sensitive to the increments in the net returns of toned milk (bottled) at the existing level of resources and to increase in the net returns of ghee (4 kg.) at the relaxed levels of resources. During the flush period, a minimum increase of Rs.7.43 per quintal in the net returns was observed in the case of table butter (400 and 450 gm.) at both the existing and relaxed levels of resources to which the original optimum solution remained valid.

Simulation

Simulated probability distribution of profit of each plant was developed by randomly combining various values of expenses of milk, procurement, manufacturing, administration and distribution and deducting their sums from the randomly chosen gross income figures. The Chi-square test was used to test the normality of the simulated probability distribution of profit. Then $\bar{\pi}$, the expected value of profit π and $\sigma(\pi)$, the standard deviation of the distribution of π were computed and shown in Table IV.

TABLE III — SENSITIVITY OF ORIGINAL OPTIMUM SOLUTION TO INCREMENTS IN NET RETURNS OF PRODUCTS*

Sr. No.	Product activity	Plant L		Plant V	
		Lean	Flush	Lean	Flush
1.	White butter (500 gm.)	– (190.48)	128.31 † (128.31)	95.41 (146.84)	130.48 (130.48)
2.	Table butter (100 gm.)	–	– (35.65)		
3.	Table butter (200 gm.)	– (52.06)	–		
4.	Table butter (400 gm.) (450 gm.)	–	–	–	7.43 (7.43)
5.	Toned milk (bottled)	–	–	8.72 (10.02)	7.87 (7.87)
6.	Milk cake (200 gm.)	290.10	–	–	10.94 (400.99)
7.	Milk cake (500 gm.)	–	–	–	– (390.05)
8.	Sweetened flavoured milk	–	–	215.51 (268.53)	– (316.30)
9.	*Lassi*	95.61	309.52	341.94 (403.98)	–
10.	Whole milk powder (1 kg.)	–	– (248.73)	–	–
11.	Whole milk powder (10 kg.)	–	– (202.72)	–	–
12.	Skim milk powder	–	–	–	–
13.	Ghee (1 kg.)	–	–	37.74 (33.53)	–
14.	Ghee (2 kg.)	–	–	–	–
15.	Ghee (4 kg.)	–	–	– (2.88)	–
16.	*Paneer* (200 gm.)	142.07	268.61	–	166.91 (622.13)
17.	*Paneer* (500 gm.)	–	255.91	–	–

* This information pertains to only those products which failed to merit their entry into optimum plans.

† Upper figures are increments in net returns of products at the existing level of resources. Figures in brackets indicate the same at the relaxed level of resources.

Units of measurement for the products are the same as in Table II.

The most surprising finding of this analysis is that plant 'V', despite having completed its active life of 20 years, still expected to generate profit which is more than two times that of plant 'L' and sufficiently more than three times that of plant 'C' (Table IV). The probabilities of occurring larger profits are invariably higher in plant 'L' over those of plant 'C' but lower than those of plant 'V' (Table V).

TABLE IV — EXPECTED VALUE OF PROFIT, S.D. AND X^2

Sr. No.	Item	Plant L	Plant V	Plant C
1.	$\bar{\pi}$	16.19*	29.52	59.40
2.	$\sigma(\pi)$	9.66	15.83	27.82
3.	X^2	0.32	0.74	0.67

* Expected value of profit is in lakhs of rupees.

TABLE V — PROBABILITY OF OCCURRENCE OF DIFFERENT CLASSES OF PROFIT

Sr. No.	Class	Probability in plants C	L	V
1.	- 12–-6	0.0089	0.0081	0.0043
2.	- 6–-0	0.0358	0.0182	0.0068
3.	0-6	0.1004	0.0374	0.0112
4.	6-12	0.1867	0.0654	0.0172
5.	12-18	0.2417	0.0992	0.0235
6.	18-24	0.2157	0.1305	0.0339
7.	24-30	0.1326	0.1488	0.0426
8.	30-36	0.0562	0.1471	0.0559
9.	36-42	0.0164	0.1261	0.0638
10.	42-48	0.0033	0.0938	0.0766
11.	48-54	0.0005	0.0604	0.0838
12.	54-60	*	0.0338	0.0833

Class limits of profit are measured in lakhs of rupees.

* Stands for very small figure.