The Effective and Efficient Utilization of Resources of Productivity using Goal Programming

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ABSTRACT — *This paper presents an alternative approach by using a goal programming to determine the product-mix of the manufacturing system. The objective of this paper is to provide a methodology in order to make product-mix decision. No company would be keen to market a single product, unless it is a monopoly product. Most of the companies will be dealing with multiple products, in order to maximize the profits or minimize the total cost. The productivity is concerned with the effective and efficient utilization of resources in producing goods or services. The Linear Programming Problem applications have been developed for production scheduling, staffing, inventory control, capacity planning and produce mix decisions in business and industry. This paper will examine the test results.*

KEYWORDS *— Goal Programming, Product-Mix decisions, Optimization.*

INTRODUCTION

The concept of Goal Programming was introduced by CHARNES and COOPER (1961). The GP is capable of handling decision problems with single and multiple goals. The basic concept of goal programming involves incorporating all goals in one model which can be solved simultaneously.

In today's complex organizational environment the decision maker is regarded as who attempts to achieve a set of objectives to the fullest possible extent in an environment of conflicting interest, incomplete information and unlimited resources. The soundness of decision-making is measured by the degree of organization objectives achieved by the decision.

This paper presents the productivity which concerned with the effective and efficient utilization of resources in producing goods or services.

2. DATA OF THE PROBLEM

The company we have used in this study is a pioneer in manufacturing of electronic equipments. The demands of the electronic equipments have been continuously increasing. To fulfil the demand of the customers, the company has decided to establish a new production unit. The management of the company has also decided to produce three electronics equipments. The problem to be considered here is a typical production blending plan faced by the production planner.

Table 1(a): Profit Margin and Break-even Quantities

Product	Profit Margin (Rs.)	Break-even Production Volume
AHX	6000	500
BHX	8000	400
CHX	6000	200

Source: Primary Data

Table 1(b): Man-hours

Product	Turning	Milling	Pressing	Mech. Assy	Elec. Assy	Coil Winding	PCS Assy	Testing	Total (in-hours per unit)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	
AHX	1.9	2.3	2.0	1.9	2.1	1.8	2.1	1.8	15.9
BHX	1.7	1.2	1.6	2.1	1.9	2.1	1.8	1.2	13.6
CHX	2.8	1.9	2.2	2.3	2.6	2.9	2.5	1.2	18.4
Man-Hours available per annum	2820	2610	2750	2850	2900	2380	2840	2400	

Source: Primary Data

3. MODEL DEVELOPMENT

When the objective function, is to be maximized, the problem is formulated as LP model as follows:

Maximize X = f(x)

Subject to: $ax \leq b$

Where, a and b are constants and $x \geq 0$.

In GP, users are generally provided a target or aspiration level of achievement to each objective. Unwanted deviations of all objectives are then weighted according to their importance in the decision making environment. Finally, if finds a best possible solution that satisfies as many of the goals in the decision-making context.

3.1. Application

In order to maximize the profit, the problem is formulated as a linear programming as follows:

Let

X_1 = Number of units to be produced of product AHX,

X_2 = Number of units to be produced of product BHX,

X_3 = Number of units to be produced of product CHX,

P_j = Profit per unit for product j,

Q_j = Break even production volume of product j,

T_{ij} = Man hours required on machine I for product j,

T_i = Total man hours per annum available on machine I,

Where I = 1, 2 … 8; j = 1, 2, 3

Then, the problem becomes

$$\text{Maximize profit Z} = Z = \sum_{j=1}^{n} P_j X_j$$

– subject to $X_j > Q_j$

$\sum T_{ij} X_j \leq T_i$

3.2. *Objective function*

Minimize $(Z_1) = P_1 \left(w_p^- d_p^- + w_p^+ d_p^+\right) +$
$P_2 \left(w_m^- d_m^- + w_m^+ d_m^+\right) +$
$P_3 \left(w_{1q}^- d_{1q}^- + w_{1q}^+ d_{1q}^+\right) +$

$P_4 \left(w_{2q}^- d_{2q}^- + w_{2q}^+ d_{2q}^+\right) +$
$P_5 \left(w_{3q}^- d_{3q}^- + w_{3q}^+ d_{3q}^+\right)$

3.3. *Achievement functions*

Profit goal

Maximize the total profit to the target level P

$$\sum_{j=1}^{n} p_j X_j + d_p^- - d_p^+ = P$$

Here, the under achievement d_p^- is to be minimized.

Therefore,

$$\sum_{j=1}^{n} p_j X_j + d_p^- = P$$

Man-hours goal

Minimize the total man-hours used in manifesting all the products to the target level MH

$$\sum_{j=1}^{n} m_j X_j + d_m^- - d_m^+ = MH$$

Where, m = number of man-hours required per unit of the product j.

Hence the under-achievement d_m^- is to be maximized.

Therefore,

$$\sum_{j=1}^{n} m_j X_j + d_m^- = MH$$

Break-even quantity of production goal

Maximize the production quantity of production j from the minimum level Qj

$$X_j + d_{jq}^- - d_{jq}^+ = Q_j$$

Here over-achievement d_{jq}^+ is to be maximized.

Therefore, $X_j - d_{jq}^+ = Q_j$

3.4. *Constraints*

$$\sum_{j-1}^{n} T_{ij} X_j \leq T_i \quad i = 1, \dots \dots \dots \dots \dots .8$$

$X_i \geq Q_j$

$X_j, d_p^-, d_m^-, d_{jq}^+ \geq 0$

Where d_p^-, d_p^+ = under-achievement and over-achievement of profit goal, respectively,

d_m^-, d_m^+ = under-achievement and over-achievement of man hours goal Respectively

d_{jq}^-, d_{jq}^+ = under-achievement and over-achievement of break-even quality of production goal respectively.

w_p^-, w_p^+ = weights assigned to the under-achievement and over-achievement of profit goal respectively.

$1.9\ x_1 + 1.7\ x_2 + 2.8\ x_3 \leq 710$

$2.3\ x_1 + 1.2\ x_2 + 1.9\ x_3 \leq 710$

$2\ x_1 + 1.2\ x_2 + 1.9\ x_3 \leq 670$

$1.9\ x_1 + 2.1\ x_2 + 2.3\ x_3 \leq 600$

$2.1\ x_1 + 1.9\ x_2 + 2.6\ x_3 \leq 570$

$1.8\ x_1 + 2.1\ x_2 + 2.9\ x_3 \leq 560$

$2.1\ x_1 + 1.8\ x_2 + 2.5\ x_3 \leq 570$

$1.8\ x_1 + 1.2\ x_2 + 1.2\ x_3 \leq 780$

$x_1, x_2, x_3 \geq 0.$

This problem is solved by using the Simplex method and the values of the variables are obtained as follows:

$X_1 = 93,\ x_2 = 75\ x_3 = 81.$

Then the production quantities of various products are as follows:

$X_1 = 500 + x_1 = 593,\ X_2 = 400 + x_2 = 475,\ X_3 = 200 + x_3 = 281,$

Maximum profit Z = Rs. 90, 44,000.00

For the data given in table, the goal programming problem is formulated as follows:

Let,

$w_p^- = 7\ w_m^- = 6\ w_{1q}^+ = 5\ w_{2q}^+ = 4\ w_{3q}^+ = 4$

$P_1 = 7 \quad P_2 = 5 \quad P_3 = 4 \quad P_4 = 4 \quad P_5 = 5$

P = Rs. 10000000and T = 22000 hours

3.5. Objective function

$$Minimize\ Z_1 = 49\ d_p^- + 30\ d_m^- + 20 d_{1q}^+ + 16 d_{2q}^+ + 12 d_{3q}^+$$

Goals:

$6000\ X_1 + 8000\ X_2 + 6000\ X_3 + d_p^- = 10000000$

$15.9\ X_1 + 13.6\ X_2 - 18.4\ X_3 + d_p^+ = 22000$

$X_1 - d_{1q}^+ = 500$

$X_2 - d_{2q}^+ = 400$

$X_3 - d_{3q}^+ = 200$

3.6. Constraints

$1.9\ x_1 + 1.7\ x_2 + 2.8\ x_3 \leq 2820$

$2.3\ x_1 + 1.2\ x_2 + 1.9\ x_3 \leq 2820$

$2\ x_1 + 1.6\ x_2 + 2.2\ x_3 \leq 2750$

$1.9\ x_1 + 2.1\ x_2 + 2.3\ x_3 \leq 2850$

$2.1\ x_1 + 1.9\ x_2 + 2.6\ x_3 \leq 2900$

$1.8\ x_1 + 2.1\ x_2 + 2.9\ x_3 \leq 2800$

$2.1\ x_1 + 1.8\ x_2 + 2.5\ x_3 \leq 2840$

$1.8\ x_1 + 1.2\ x_2 + 1.2\ x_3 \leq 2400$

$X_1, X_2, X_3, d_m^-, d_{1q}^+, d_{2q}^+, d_{3q}^+ \geq 0.$

This GP problem is computed and the solution is obtained as follows:

$X_1 = 593$ $X_2 = 475$ $X_3 = 281$

$d_p^- = 956000$

$d_m^- = 940.0$ $d_{1q}^+ = 3$ $d_{2q}^+ = 75$

$d_{3q}^+ = 81$

Maximum profit achieved = Rs. 9044000.00
Minimum man hours utilized = 21059.1 hours
Optimum production quality of product AHX
$= x_1$

= 593 units

Optimum production quality of product BHX
$= x_2$

= 475 units

Optimum production quality of product CHX

$= x_3$

= 281 units

4. RESULTS AND ANALYSIS

In this paper, a Goal programming model is used to compute the optimum production quantities of various types. Optimum production quantity of products of electronic industry, and its results are compared with that of a linear programming model. The optimum production quantities obtained by using an LP model are: 593 units of AHX product, 475 units of BHX product, and 281 units of CHX product. The maximum profit is as Rs. 9,044,000.00 per annum. But the optimum production quantities obtained by using a GP model are: 593 units of AHX product, 475 units of BHX product, and 281 units of CHX product. The maximum profit is obtained as Rs. 9,044,000.00 per annum with the use of minimum man-hours of 21059.1 hours per annum. It is observed from the results that more than one goal are achieved by the use of GP model. The results obtained in these are expected to be of acceptable quality for the managerial decisions.

5. CONCLUSION

The application of LP and GP models are presented in this paper. Generally, LP models are used to achieve a single objective, where as GP models are used to achieve multiple objectives, provided two or more of these have presented conflicting objectives, and hence the more information is published to management decision making. In this paper, it is observed that the maximization of profit and the minimization of total man-hours are two conflicting objectives. It is also observed from the results that the better solutions are obtained by the GP model as compared to the LP model. In the application of GP model, the size of the problem increases proportional to the number of objectives, and hence the time to obtain the optimum solution.

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