

**A GOAL PROGRAMMING MODEL  
FOR FINANCIAL MANAGEMENT OF A HEALTHCARE SYSTEM**

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**ABSTRACT**

*After the II world war, the, Industrial world faced a depression and to solve the various industrial problems. Industrialist tried the models, which were successful in solving their problems. Industrialist learnt that the techniques of operations research can conveniently apply to solve industrial problems. Then onwards, various models of operations research /Goal Programming have been developed to solve industrial problems. In fact Goal Programming models are helpful to the managers to solve various problems; they face in their day to day work. These models are used to minimize the cost of production, increase the productivity and use the available resources carefully and for healthy industrial growth. Goal programming is an extension or generalisation of linear programming to handle multiple, normally conflicting objective measures and is a branch of multi-objective optimization, which in turn is a branch of multi-criteria decision analysis. In this paper, a goal programming model is developed for financial management of healthcare system in Hyderabad, by considering the goals: asset, liability, equity, profit, income of the health care system. The data was collected from the health care system's financial statements from 2010 to 2016. The problem was solved using PM-QM for windows and the results are analyzed.*

**Key words:** *Goal Programming, Financial Management, Asset, Liability, Equity, Profit, Income.*

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**1. INTRODUCTION**

For efficient performance of health care system the financial management is very important. A health care system without proper financial management can't meet the requirements of the market. The various researches have been made so far and the researchers have been continually exploring the application goal programming on financial performance of health care system. MunjaLee [1] had discussed financial analysis of health care system by using liquidity, stability, growth, activity and profitability. Claverley *et.al* [2] had analyzed the financial performance of health care system by using short-term cash holdings, capital structure and profitability. Goldstein *et.al* [3] used net income on share holders equity, cash holdings, working capital flow, short -term liquidity, debt structure, accounts receivable recovery, return on asset and cash flow are as indicators for the financial performance of health care system. Trinh *et.al* [4] used profitability, fixed asset acquisition, working capital efficiency, liquidity, and debt service coverage ratio are the indicators for health care system performance.

The earlier studies were limited to discuss the performance of health care system, but not discussed the goals defined by the management are achieved or not. Financial management of health care system involves multiple criteria and goals, so it requires multiple criteria decision model, particularly goal programming model .In this study we considered asset, liability, income, equity, profit for financial management of a large health care system in Hyderabad.

Goal programming is widely used tool in multi criteria decision analysis [5]. Since goal programming techniques have been applied to many areas such as, plant management [6], portfolio decision analysis [7], marketing executive tour scheduling [8], nurse scheduling [9], agriculture [10], tourism[11], chemical industry [12,], project selection [13], health care planning [14] and many more. In the field of financial management goal programming techniques have been used in portfolio management [15, 16], asset liability management [17], budget planning [18], funding allocation [19] and many more.

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## 2. METHODOLOGY

2.1 The generalized goal programming model is formulated as follows

$$\text{Minimize } z = \sum_{k=1}^K \sum_{i=1}^m w_{ki} P_k (d_i^- + d_i^+)$$

$$\text{Subject to } \sum_{i=1}^m a_{ij} x_j + d_i^- - d_i^+ = b_i \quad (j = 1, 2, \dots, n)$$

$$x_j, d_i^-, d_i^+ = \text{nonnegative variables} (i = 1, 2, \dots, m, j = 1, 2, \dots, n)$$

Where

$Z$  = the sum of the weighted deviational variables

$w_{ki}$  = The relative weight assigned to  $k$  priority level for the  $i^{\text{th}}$  goal constraint

$P_k$  = the  $k^{\text{th}}$  pre-emptive priority

$d_i^-$  = a negative deviational variable describing under achievement of the  $i^{\text{th}}$  goal

$d_i^+$  = a positive deviational variable describing over achievement of the  $i^{\text{th}}$  goal

$a_{ij}$  = technical coefficient for the decision variable  $x$

$x_j$  =  $j^{\text{th}}$  decision variable

$b_i$  = the right-hand-side value for the  $i^{\text{th}}$  goal constraint

In the goal programming the objective function is the minimization of the deviational variables. For a goal both the under achievement ( $d_i^-$ ) and over achievement ( $d_i^+$ ) cannot be achieved at a time, hence either one or both deviational variables is zero, that is  $d_i^- \times d_i^+ = 0$ .

## 3. DATA OF THE PROBLEM

Table-1 shows the data of the health care system (in Rs.millions).

**Table-1**

Item(goal)	Year							Total
	2010	2011	2012	2013	2014	2015	2016	
<b>Asset</b>	6,196.62	5,980.23	9,640.36	14,632.9	13,575.63	16,963.33	17,828.42	84,817.49
<b>Liability</b>	5,228.46	5,350.15	5,438.24	5,050.31	5,550.09	7,959.93	9,821.75	44,398.93
<b>Equity</b>	15,417.78	17,721.65	23,522.66	27,275.97	29,647.25	31,610.71	34,301.31	1,79,497.33
<b>Profit</b>	1,519.64	1,817.18	2,309.90	3,091.08	3,307.20	3,465.95	3,694.39	19,205.34
<b>Income</b>	18,587.45	23,522.66	28,279.20	33,488.18	38,840.88	46,380.62	54,779.64	2,43,878.63
<b>Total</b>	46,949.95	54,391.87	69,190.36	83,538.44	90,921.05	1,06,380.54	1,20,425.51	5,71,797.72

Table -2 shows the coded values (in Rs. trillions) of the health care system. We coded the values because to enable the analysis with small values.

**Table-2**

Item(goal)	Year							Total
	2010	2011	2012	2013	2014	2015	2016	
<b>Asset</b>	0.0062	0.0060	0.0096	0.0146	0.0136	0.0170	0.0178	0.0848
<b>Liability</b>	0.0052	0.0054	0.0054	0.0051	0.0056	0.0080	0.0098	0.0444
<b>Equity</b>	0.0154	0.0177	0.0235	0.0273	0.0296	0.0316	0.0343	0.1795
<b>Profit</b>	0.0015	0.0018	0.0023	0.0031	0.0033	0.0035	0.0037	0.0192
<b>Income</b>	0.0186	0.0235	0.0283	0.0335	0.0388	0.0464	0.0548	0.2439
<b>Total</b>	0.0470	0.0544	0.0692	0.0835	0.0909	0.1064	0.1204	0.5718

The decision variables are defined as follows

$x_1$  = the amount of financial statement in year 2010

$x_2$  = the amount of financial statement in year 2011

$x_3$  = the amount of financial statement in year 2012

$x_4$  = the amount of financial statement in year 2013

$x_5$  = the amount of financial statement in year 2014

$x_6$  = the amount of financial statement in year 2015

$x_7$  = the amount of financial statement in year 2016

### 3.1 The goal constraints

**Priority 1 (Asset Accumulation Goal):** The management of healthcare system wants to maximize the asset accumulation. So, we have to minimize the negative deviational variable  $d_1^-$ .

$$0.0062x_1 + 0.0060x_2 + 0.0096x_3 + 0.0146x_4 + 0.0136x_5 + 0.0170x_6 + 0.0178x_7 + d_1^- - d_1^+ = 0.0848$$

**Priority 2 (Liability Goal):** The management wants to minimize the liability. So we need to minimize the over achievement of the goal, that is positive deviational variable  $d_2^+$

$$0.0052x_1 + 0.0054x_2 + 0.0054x_3 + 0.0051x_4 + 0.0056x_5 + 0.0080x_6 + 0.0098x_7 + d_2^- - d_2^+ = 0.0444$$

**Priority 3 (Equity Goal):** The equity is to be maximized. So the under achievement variable  $d_3^-$  is to be minimized.

$$0.0154x_1 + 0.0177x_2 + 0.0235x_3 + 0.0273x_4 + 0.0296x_5 + 0.0316x_6 + 0.0343x_7 + d_3^- - d_3^+ = 0.1795$$

**Priority 4 (Income Goal):** The management wants to maximize the income. We have to minimize the under achievement variable  $d_4^-$

$$0.0186x_1 + 0.0235x_2 + 0.0283x_3 + 0.0335x_4 + 0.0388x_5 + 0.0464x_6 + 0.0548x_7 + d_4^- - d_4^+ = 0.2439$$

**Priority 5 (Profitability Goal):** To maximize the profit, the under achievement variable  $d_5^-$  is to be minimized.

$$0.0015x_1 + 0.0018x_2 + 0.0023x_3 + 0.0031x_4 + 0.0033x_5 + 0.0035x_6 + 0.0037x_7 + d_5^- - d_5^+ = 0.0192$$

**Priority 6 (Financial Statement Managing Goal):** To maximize the proportion of the values in the financial statement the under achievement variable  $d_6^-$  is to be minimized

$$0.0470x_1 + 0.0544x_2 + 0.0692x_3 + 0.0835x_4 + 0.0909x_5 + 0.1064x_6 + 0.1204x_7 + d_6^- - d_6^+ = 0.5718$$

### 3.2 Objective function

$$\text{Minimize } Z = P_1d_1^- + P_2d_2^+ + P_3d_3^- + P_4d_4^- + P_5d_5^- + P_6d_6^-$$

## 4. RESULTS AND DISCUSSION

The problem was solved by using POM-QM for windows (formerly DS for windows). The following table-3 and 4 shows the results. The table-3 shows that

$P_1 = 0, P_2 = 0, P_3 = 0, P_4 = 0, P_5 = 0, P_6 = 0$ . Therefore all the goals are achieved and the optimal solution is derived.

**Table-3:** Goal achievement

Goal priority	Output	Achievement
$P_1$	0	Fully achieved
$P_2$	0	Fully achieved
$P_3$	0	Fully achieved
$P_4$	0	Fully achieved
$P_5$	0	Fully achieved
$P_6$	0	Fully achieved

**Table -4:** Deviation Variables

Goal priority	Negative Deviation Variable ( $d_i^-$ )	Positive Deviation Variable ( $d_i^+$ )
$P_1$	0	0.01019
$P_2$	0.00456	0
$P_3$	0	0
$P_4$	0	0.00082
$P_5$	0	0
$P_6$	0	0.00602

The table -4 shows the values of positive and negative deviational variables related to the goals from  $P_1$  to  $P_6$ . The first priority  $P_1$  is to maximize the total assets. The goal is fully achieved because the negative deviational variable  $d_1^- = 0$ . But the positive deviational variable  $d_1^+ = 0.01019$ , this means the asset of the health care system can be increased by 0.01019 trillion per year. The goal of liability reduction  $P_2$  is also achieved since  $d_2^+ = 0$ , but the negative deviational variable  $d_2^- = 0.00456$ , this means the liability can be decreased 0.00456 trillion per year. The third priority goal  $P_3$  is fully achieved since both the deviational variables  $d_3^-$  and  $d_3^+$  are zero; this means the equity amount 0.1795 cannot be changed in the 6 year period. The fourth priority goal  $P_4$  is maximizing income is also achieved, since the negative deviational variable  $d_4^- = 0$ , but the positive deviational variable  $d_4^+ = 0.0082$ , this indicates that the income per year can be increased by 0.0082 trillions. The profitability goal is fully achieved, since both  $d_5^-$  and  $d_5^+$  are zero, this indicates the total profit 0.0192 cannot be changed in the 6 years period. Lastly the goal  $P_6$  of maximizing the proportion of the values given in the financial statement is also achieved, because the negative deviational variable  $d_6^- = 0$ , but the positive deviational variable  $d_6^+ = 0.00602$  indicates that the proportion of the values given in the financial statement can be increased by 0.00602 trillion per year.

## 5. CONCLUSION

The model used in this paper indicates that the financial performance of health care system is good, because all the goals are achieved. But the four goals, namely asset, liability, income and proportion of the values of the financial statement can be modified to increase the aspiration level. The developed model can be used as a tool for financial performance of health care systems and other financial institutions also.

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