GOAL PROGRAMMING: AN APPLICATION TO FINANCIAL ESTIMATION OF AND ORGANIZATION / INSTITUTION

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ABSTRACT

GOAL PROGRAMMING, a powerful and effective methodology for the modeling, solution, and analysis of problems having multiple and conflicting goals and objectives, has often been cited as being the “workhorse” of multiple objective optimization (i.e., the solution to problems having multiple, conflicting goals and objectives) as based on its extensive list of successful applications in actual practice. In this paper we would discuss the application of Goal Programming in financial estimation of an organization/institution using St. Brother’s Public School, Haryana, India as a case study. This paper shall help in making the masses aware of the use of Goal Programming in achieving the institution’s aim economically and financially. For this case study, five goals are considered in the order of priorities namely; Employment benefits (salary and allowance), General Expenses, CAPEX (capital expenditure), Revenue and the Total budget. The data on the financial estimates (of year 2013 and 2014) of St. Brother’s Public School, Haryana, India, is used to formulate a Goal Programming Problem and Weighted Pre-emptive Goal Programming method would be used to solve it. The process incorporates elements of operating cost and goal programming for budget reduction. It is also recommended that there should be a reliable financial estimate monitoring team that could efficiently evaluate operating cost annually.

Keywords: Goal Programming, Financial Estimation and Weighted Pre-emptive Goal Programming.

1. Introduction:

Financial estimation is a difficult process that requires co-ordination and co-operation among multiple units in the organization/institution. It requires a team of active and reliable decision makers who can design an efficient and effective financial estimation model. Though such models exist, they do not work effectively due to existence of multiple conflicting objectives. Decision making within an organization is often characterized by an attempt to satisfy a set of potentially conflicting objectives as completely as possible in an environment composed of limited resources, divergent interests and an annoying priorities in order to deal with situations in which all objectives cannot be completely and/or simultaneously satisfied. And such decision making capable of managing multiple conflicting goals and their priorities is the Goal Programming Model.

In daily life, so many examples are observed where the aim is to maximize and
minimize (at the same time), a certain function of one or more parameters.

Example:

- Senior manager under the gun to cut costs may decide that the best way to do so is to reduce head-count (number of people as staff). At the same time, they continue to send a message that the company’s revenue-generation goals must be met. To fulfill the second goal, managers actually need more workers, which conflicts with the mandate to cut staff.

- Head of department of the institution may decide to increase CAPEX (Capital Expenditure) while simultaneously reducing the revenue.

Ignizio [6], pointed out that actual real world problems invariably involve non-deterministic system for which a variety of conflicting inconsistent objectives exist. Goal Programming provides a way of finding a single optimal solution to such conflicting objectives simultaneously.

Simplicity and ease of use of Goal Programming has resulted in growth of its popularity in several areas such as: management of human resources, transportation, site selection, production, accounting and financial resource management, marketing and quality control, agriculture and forestry, and telecommunication [1]. Goal Programming provides more flexibility for modeling the estimation process; this flexibility provides the analyst with a platform from which his knowledge and experience can be an input to the parameter’s estimation.

Goal Programming, was developed by [2]. Since then many researchers have done a lot of work about extensions of goal programming methodology (such as preemptive/lexicographic linear goal programming, integer goal programming (Schneiderjans and Hoffman, 1992), extended lexicographic goal programming (Romero, 2001), etc.) and extensive surveys on fields of its applications ([8]; Schneiderjans, 1995; [6] (such as production planning, capital budgeting planning, agricultural running planning, etc.).

2. Financial Estimation:

Operating costs are the expenses which are related to the operation of an institution or an organization or simply a business, or to the operation of a device, component, piece of equipment or facility. They are the cost of resources used by an organization just to maintain its existence. Financial estimation, i.e.; budgeting:

- Provide a forecast of revenues and expenditure, i.e., construct a model of how a business might perform financially if certain strategies, events and plans are carried out.
- Enable the actual financial operation of the business.
- Establish the cost constraint for a project, program, or operation.

However, [4] financial estimation emphasizes on the supremacy of the revenue constraint while budgeting, decision makers are constrained by limitation on revenue raising power and/or the perception of impending limitations and fears about the revenue sources as in Table 1.

(Refer Table 1 Here)

2.1 Objectives of the Study:
The objectives of this study are:

- To apply Goal programming model to financial estimation of an organization/institution; a real world problem to find optimum solution among variety of conflicting goals of St. Brother’s Public School, India.
- To minimize the total weights and priorities associated with meeting the requirements for optimal financial estimation of the institution.

2.2 Significance of the Study:

The knowledge gained from this study may:

- Help the organization to achieve the goals of optimum utilization of funds available for its improvement.
- Assist and guide decision makers of the institution in proper allocation of operating cost.
- Guide in annual forecast of budget of the organization [4].

2.3 Restriction of the Study:

The study is restricted to the financial estimation of St. Brother’s Public School, India. The financial estimates of the institution were used for the study. The scope of this study is restricted to applications of Goal Programming approach to real life manufacturing situations in the multi-objective environment.

3. Statement of the Problem:

Managing the budget is a critical task for financial decision making.

- As a result of absence of a powerful quantitative allocation model, the capital and revenue are allocated inadequately, and without order of significance.
- The funds allocated to the organizations/institutions are usually mismanaged and are not utilized properly. This results in deceleration of the growth of the institution.
- The budgets are operated negligently due to unavailability of a reliable and active budget monitoring team.

4. Research Methodology:

The method of Goal Programming consists of formulating an objective function in which optimization comes as close as possible to specified goals. Ijiri (1965), developed the concept of priority factors, assigning different priority levels to goals and different weights for the goals at the same priority level. [8] and [5] have discussed the subject of goal programming which is an extension of linear programming (LP).

In GP, there is no single objective function as in LP. The deviations between the goals within the given set of constraints are minimized. The objective primarily contains deviational variables that represented in two dimensions in the objective functions, a positive and a negative deviation from each sub-goal and for constraint. The objective function becomes the minimization of these deviations, based on the relative importance or priority assigned to them.
5. Goal Programming Formulation:
The formulation of GP model is similar to that of LP model. The general model can be stated as follows:

Minimize: \[ z = \sum_{i} w_{i} (d_{i}^{-} + d_{i}^{+}) ; \]
\[ i = 1, 2, \ldots, m \] (1)

Subject To: \[ \sum_{j} a_{ij} + d_{i}^{-} - d_{i}^{+} = b_{i} ; \]
\[ i = 1, 2, \ldots, m, j = 1, 2, \ldots, n \] (2)
and \[ x_{j}, d_{i}^{-}, d_{i}^{+} \geq 0 ; \text{for all } i, j \] (3)

where,
\[ b_{i} = \text{m-component column expressing m goals} \]
\[ a_{ij} = \text{coefficient for the } j^{\text{th}} \text{ decision variable in the } i^{\text{th}} \text{ constraint} \]
\[ x_{j} = \text{decision variable} \]
\[ w_{i} = \text{weights of each goal} \]
\[ d_{i}^{-} = \text{deviational variable representing the amount of under-achievement of } i^{\text{th}} \text{ goal} \]
\[ d_{i}^{+} = \text{deviational variable representing the amount of over-achievement of } i^{\text{th}} \text{ goal} \]

In case, goals are classified in k ranks, the pre-emptive priority factors (P1, P2, …, and so on) should be assigned to deviational variables \( d_{i}^{-} \) and \( d_{i}^{+} \) according to their order of importance.

6. Basic Steps in Formulating the Model:
The basic steps involved in formulating a goal programming model are as follows:

- Determine decision variables (the \( x^{\prime}s \))
- Determine the deviational variables (the \( d^{\prime}s \) and \( d^{+} \'s \))
- Specify the goals
- Determine the pre-emptive priorities and assign weights
- State the objective functions of the deviation to be minimized

7. Data Analysis Technique Used:
For analysis of the data collected from the Financial Planning and Management department of St. Brother’s Public School, India, (year 2013 and 2014) for this study, we would use the weighted pre-emptive GP method.

8. Analysis of Data:
The summary of financial estimates of the institution St. Brother’s Public School, India, over the period 2013 and 2014, showing the rounded off values of Employment benefits, General expenses, CAPEX, Revenue, Total budget, are given as in Table 2.

(Refer table 2 Here)

The figures of the financial estimates are large enough to make the optimization process difficult. Therefore making them short results in the following coded estimates as in Table 3.

(Refer Table 3 Here)

9. Assignment of Weights and Priorities:
The decision maker must analyze each one of the m goals in terms of whether under or over –achievement of the goal is satisfactory, then assign weights and priorities accordingly. If over-achievement
is acceptable $d_i^+$ (surplus variable in LP) can be removed from the objective function. If under-achievement is acceptable, $d_i^-$ (slack variable in LP) can be removed from the objective function. If exact achievement of the goal is derived, both $d_i^-$ and $d_i^+$ must be included in the objective function and ranked according to their pre-emptive priority factors from the most important to the least important.

Let $w_{i,k}$ be the relative weights of the $d_i$ variable in the $k^{th}$ priority level for goal $i$, that could range from 2,3,4,5,6 , the most important goal has the highest weight as in Table 4.

(Refer Table 4 Here)

10. Target Value of Goals:
The target value of the goals of the budget of the institution are:

- Increase employment benefits at least up to 1.5 million ₹ per year.
- Reduce general expenses at most up to 1 million ₹ per year.
- Increase CAPEX at least up to 1.5 million ₹ per year.
- Increase revenue at least up to 5 million ₹ per year.
- Reduce Total budget up to 9 million ₹ per year.

11. Goal Formulation:
Let, $x_1 = $ amount allocated in 2013
$x_2 = $ amount allocated in 2014

Here, $x_1$, $x_2$ are the decision variables. For this problem, the goals would appear as:

- $1.3 x_1 + 1.35 x_2 \geq 1.5$
  (Employment benefits constraint) (4)
- $0.3 x_1 + 0.35 x_2 \leq 1$
  (General expenses constraint) (5)
- $1.25 x_1 + 1.4 x_2 \geq 1.5$
  (CAPEX constraint) (6)
- $4.5 x_1 + 4.7 x_2 \geq 5$
  (Revenue constraint) (7)
- $7.35 x_1 + 7.765 x_2 \leq 9$
  (Total budget constraint) (8)
- $x_1, x_2 \geq 0$ (9)

12. Goal Programming Formulation:
Let, $d_i^-$ = the negative deviation variable for under-achieving the $i^{th}$ goal
$d_i^+$ = the positive deviation variable for over-achieving the $i^{th}$ goal

The weighted pre-emptive goal programming model can be formulated as:

Minimize: $z = 2P_1d_1^+ + 4P_2d_2^- + 6P_3d_3^+ + 8P_4d_4^- + 10P_4d_5^-$ (Objective function)

Subject to:
- $1.3 x_1 + 1.35 x_2 + d_1^- - d_1^+ = 1.5$ (Employment benefits) (10)
- $0.3 x_1 + 0.35 x_2 + d_2^- - d_2^+ = 1$
  (General expenses) (11)
- $1.25 x_1 + 1.4 x_2 + d_3^- - d_3^+ = 1.5$
  (CAPEX) (12)
- $4.5 x_1 + 4.7 x_2 + d_4^- - d_4^+ = 5$
  (Revenue) (13)
7.35 x_1 + 7.765 x_2 + d_5^- - d_5^+ = 9 \\
(Total budget) \quad (14)

x_1, x_2, d_1^+, d_1^-, d_2^+, d_2^-, d_3^+, d_3^-, d_4^+, d_4^- , d_5^+, d_5^- \geq 0 \quad (15)

13. Solution:

On solving the problem using LINGO 14.0 software with total 8 solver iterations, we got the following values of variables:

\[
\begin{align*}
    x_1 &= 0 \\
    x_2 &= 2.857143 \\
    d_1^+ &= 2.357143 \\
    d_1^- &= 0, \\
    d_2^+ &= 0 \\
    d_2^- &= 0, \\
    d_3^+ &= 3.119378 \\
    d_3^- &= 0.6193775, \\
    d_4^+ &= 9.20174 \\
    d_4^- &= 0.7731751 \\
    d_5^+ &= 13.18571 \\
    d_5^- &= 0,
\end{align*}
\]

and goals as in Table 5.

(Refer Table 5 Here)

We can compare the target values and the optimized values we got after solving the problem in Fig. 1.

We can also see the final solution report by Lingo 14.0 software in Fig. 2.

14. Conclusion:

The complexity of financial estimation is a challenge to decision makers as well as researchers. In this goal programming model all the goals are almost fulfilled except ‘General Expenses’. This allowed a direct fusion of the decision makers with the goal of developing satisfactory solutions. We can further improvise the results by making changes in priorities and weights assigned in the model. We can also solve the problem using LINDO API software. It is also recommended that the budget should be properly managed and utilized. An active financial estimation team should monitor the operating cost of the institution timely.

The objectives of the model are set according to the requirements of the institution, St. Brother’s Public School, India after discussion. This is a basic model which can be applied by us and other researchers on bigger institutions and industries to optimize their budget and objectives of the model can be modified as per their requirement. This model could be a powerful tool, allowing to model the collective decision making process adapted to the context of budgeting.

References:


### List of Tables:

Table 1: Aims of Financial Estimation Model

<table>
<thead>
<tr>
<th>Item</th>
<th>Incorporates</th>
<th>Aim (To)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment benefits</td>
<td>Wages, salaries and allowances of staff and employer’s social security cost.</td>
<td>Increase</td>
</tr>
<tr>
<td>General Expenses</td>
<td>Raw materials (gas, fuel, labor, electricity), rent, advertising, insurance premium, taxes.</td>
<td>Reduce</td>
</tr>
<tr>
<td>CAPEX (Capital Expenditure)</td>
<td>Funds for maintenance of property (furniture, stationery, etc.), building, equipments.</td>
<td>Increase</td>
</tr>
<tr>
<td>Revenue (Turnover)</td>
<td>Sales, service revenue, fees earned, interest income.</td>
<td>Increase</td>
</tr>
<tr>
<td>Total budget</td>
<td>Capital expenditure, Revenue, Personnel cost, Overhead cost.</td>
<td>Reduce</td>
</tr>
</tbody>
</table>
Table 2: Outline of Financial Estimates

<table>
<thead>
<tr>
<th>Goal</th>
<th>Allocation in ₹ Per Year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
<td>2014</td>
</tr>
<tr>
<td>Employment benefits</td>
<td>1300000</td>
<td>135000</td>
</tr>
<tr>
<td>General expenses</td>
<td>300000</td>
<td>315000</td>
</tr>
<tr>
<td>CAPEX</td>
<td>1250000</td>
<td>1400000</td>
</tr>
<tr>
<td>Revenue</td>
<td>4500000</td>
<td>4700000</td>
</tr>
<tr>
<td>Total budget</td>
<td>7350000</td>
<td>7765000</td>
</tr>
</tbody>
</table>

Table 3: Coded Financial Estimates

<table>
<thead>
<tr>
<th>Goal</th>
<th>Allocation in Million ₹ Per Year</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
<td>2014</td>
</tr>
<tr>
<td>Employment benefits</td>
<td>1.3</td>
<td>1.35</td>
</tr>
<tr>
<td>General expenses</td>
<td>0.3</td>
<td>0.315</td>
</tr>
<tr>
<td>CAPEX</td>
<td>1.25</td>
<td>1.4</td>
</tr>
<tr>
<td>Revenue</td>
<td>4.5</td>
<td>4.7</td>
</tr>
<tr>
<td>Total budget</td>
<td>7.35</td>
<td>7.765</td>
</tr>
</tbody>
</table>

Table 4: Coded Financial Estimates with Weights and Priorities

<table>
<thead>
<tr>
<th>Goal</th>
<th>Allocation in Million ₹ Per Year</th>
<th>Total</th>
<th>Weights</th>
<th>Priority</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2013</td>
<td>2014</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employment Benefits</td>
<td>1.3</td>
<td>1.35</td>
<td>2.65</td>
<td>5</td>
</tr>
<tr>
<td>General Expenses</td>
<td>0.3</td>
<td>0.315</td>
<td>0.615</td>
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<tr>
<td>CAPEX</td>
<td>1.25</td>
<td>1.4</td>
<td>2.65</td>
<td>4</td>
</tr>
<tr>
<td>Revenue</td>
<td>4.5</td>
<td>4.7</td>
<td>9.2</td>
<td>3</td>
</tr>
<tr>
<td>Total Budget</td>
<td>7.35</td>
<td>7.765</td>
<td>15.115</td>
<td>6</td>
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</table>

Table 5: Optimized Financial Estimation

<table>
<thead>
<tr>
<th>Goal</th>
<th>Allocation in Million ₹ Per Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment benefits</td>
<td>1.57667</td>
</tr>
<tr>
<td>General Expenses</td>
<td>0.38877</td>
</tr>
<tr>
<td>CAPEX</td>
<td>1.582078</td>
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<tr>
<td>Revenue</td>
<td>5.4751589</td>
</tr>
<tr>
<td>Total budget</td>
<td>8.9999</td>
</tr>
</tbody>
</table>
List of Figures:

Figure 1: Optimized Financial Estimation

Figure 2: Solution Report by Lingo 14.0