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Research Article

A Goal Programming Model for Budgetary Allocation of an IT Organization

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Abstract. Goal Programming has become one of the renowned approaches for dealing with multi-objective decision-making challenges due to its versatility in resolving multi-objective decision-making problems. This work presents a strategy for executing an IT company's budget allocation to achieve maximum employment benefits, organizational income, and overall costs while limiting the institution's total budget. The proposed model has illustrates using real-world data, with the outcomes exhibiting that this model helps decision-makers by allowing for a collaborative decision-making process to enhance the planning framework and meet the objective of creating acceptable solutions.

Keywords. Goal programming, Budget allocation, IT industry

Mathematics Subject Classification (2020). 90C29, 90B70

1. Introduction

A budget allocation in an organization is a financial estimate of all expenditures over a specific period. It is vital since it is proportional to the achievements and revenue of the company. For an organization, planning the budget allocation helps: (i) ensure that the resources are being used accurately and adequately; (ii) generate the best optimal choices; and (iii) exhibit liability. Allocation of the operational budget is a difficult task as it necessitates collaboration and cooperation across different organizational divisions. It involves the development of a group of responsible and dependable decision-makers capable of designing an effective and efficient operational budget allocation model. Although such models exist, they are ineffective due to the availability of several competing aims. Decision-making is frequently characterized by an

attempt to satisfy as fully as possible a set of potentially conflicting goals in an environment of limited resources, competing interests, and managing priorities to deal with situations in which all objectives cannot be completely satisfied simultaneously. Such decisions handle multiple conflicting goals with priorities accomplished by the Goal Programming model. The Goal Programming Problem is a generalization of the Linear Programming Problem that deals with many competing goals. This model has a wide range of applications in various fields, including accounting, human resources, manufacturing, agriculture, and telecommunications. It helps to identify the deviations in an organization's goals. These deviations minimize as and when the multiple objectives exist. Today, a network of academics is employing the GP model for its various applications and areas to make complicated real-world judgments. There are various cases in the optimization problem space where the aim is to maximize and reduce particular functions that comprise many difficulties. One of the problems that businesses face while attempting to reduce their expenditures is the challenge of operating cost optimization. Operating costs are the expenses associated with running a business, an organization, a firm, a device, a component, a piece of equipment, or a facility. It is the total cost of all the resources used by the firm to stay in business. Operating cost allocation, often known as budgeting, creates a model of how a corporation would perform financially if particular strategies, events, and plans are adopted. However, the distribution of operational costs reveals the occurrence of income restrictions during budgeting. Decision-makers are constrained by the limits on the strength of revenue growth, counting their knowledge of boundaries. Over the last several years, considerable progress has it made in developing the algorithm for addressing this budgeting problem by utilizing the Goal Programming paradigm. In the recent past, new decision-making approaches have emerged, particularly in *Multi-Criteria Decision-Making* (MCDM). Goal Programming is one of the MCDM methods that consider various objectives, and the solution achieved theoretically fulfills the practical outcomes.

2. Literature Review

Aouni and Kettani [1], summarized that the Goal Programming model has a vast future in adapting and obtaining results for any stated problems. Charnes and Cooper [4], have introduced the Linear Programming model in 1960 but now the GP model which is an extension of the LP model is widely used and has become popular in the 21st century. Today, several network of researchers is using the GP model for various applications and fields in order to make decisions that are complex in real-life. Kumar and Babu [8] provided the review of capital budgeting and nine mutually exclusive projects of large-scale industry. The approach used here is Goal Programming as one of the alternative methods. Babu *et al*. [2] presented the Goal Programming model based on the *Analytic Hierarchy Process* (AHP) for budget allocation planning in hospital administration. Yahia-Berrouiguet and Tissourassi [13], presented an application of Goal Programming model for allocating time and cost in project management problem. The model is illustrated with a case study from the company of construction seror. Dan and Desmond [5], proposed a Goal Programming model application to budgetary allocation of an institution of higher learning. Jyothi *et al*. [7], applied Goal Programming model to budgetary allocation in garbage disposal plant as a performance and safety management and tested the model with a real-life data. Mubiru [10], performed a Goal Programming model for

allocating time and cost in project management problem. Kwak and Diminnie [9], used a Goal Programming model for allocating operating budgets of academic units. Gupta and Sinha [6], used the GP model for allocating resources to university management by considering fractional goals. Rynća and Ziaeian [11] applied the goal programming in the management of the 7P marketing mix model at universities as a case study problem. Wise and Perushek [12] used goal programming as a solution technique for the acquisitions allocation problem.

The scope of this study is limited to applications of the Goal Programming model to real-time situations in the multi-objective decision-making problem. This study helps the organization to achieve the goals of optimum use of funds for its progress. Also, guide and assist decision-makers of the organization allocate the budget. This model illustrates an IT start-up based in Hyderabad, India (Web InfoTech Solutions Pvt. Ltd.). The company focuses on the architecture of dynamic web solutions for small and medium-size e-commerce organizations. The company started with an employee strength of 5, gradually progressing to 50 employees over ten years. The data is collected from the management department and financial planning from 2011 to 2018 years for this study. Here we used the method Weighted Pre-emptive Goal Programming and considered five goals: (i) Benefits of employment, (ii) General expenses, (iii) Special expenses, (iv) Organization revenue, and (v) Total budget.

3. Model Formulation

The main objective of our study is to develop a model of executing the budget allocation in an IT organization and to find an optimal solution by maximizing the Employee Benefits, Special Expenses, and the Organization Revenue, and by minimizing the General Expenses and the Total Budget of the organization. The above objectives are goals, and accordingly, goal constraints are classified.

3.1 Formulation of Goal Constraints

Goal 1: Maximize the employment benefits: It plays a vital role in any organization. The increase in the employment benefits like financial benefits, equality and diversity, company facilities, etc., results in the organization's revenue. The goal constraint for maximizing the employment benefits is as follows:

$$\sum_{i=1}^{8} E_i y_i \geq E_a\,,$$

$$\sum_{i=1}^{8} E_i y_i + d_1^- - d_1^+ = E_a\,. \tag{3.1}$$

Goal 2: Minimize the general expenses: It is always necessary to optimize other expenses like equipment costs, electricity, fuel, etc., for the benefit of an organization. The goal constraint for minimizing the general costs is as follows:

$$\sum_{i=1}^{8} G_i y_i \geq G_a\,,$$

$$\sum_{i=1}^{8} G_i y_i + d_2^- - d_2^+ = G_a\,. \tag{3.2}$$

Goal 3: Maximize the special expenses: Special expenses like furniture, infrastructure equipment, etc., are to be maximized as it helps in raising funds for an organization. The goal constraint for maximizing the special expenses is as follows:

$$\sum_{i=1}^{8} S_i y_i \geq S_a\,,$$
$$\sum_{i=1}^{8} S_i y_i + d_3^- - d_3^+ = S_a\,. \tag{3.3}$$

Goal 4: Maximize the organization revenue: Organization revenue plays a critical role in any project management and forms the basis for any future decisions and policies. The goal constraint for maximizing the organization revenue is as follows:

$$\sum_{i=1}^{8} R_i y_i \geq R_a\,,$$
$$\sum_{i=1}^{8} R_i y_i + d_4^- - d_4^+ = R_a\,. \tag{3.4}$$

Goal 5: Minimize the total budget: Managing the budget to bring it down to permissible limits is one of the major challenges in every project. The goal constraint for minimizing the general expenses is as follows:

$$\sum_{i=1}^{8} T_i y_i \geq T_a\,,$$
$$\sum_{i=1}^{8} T_i y_i + d_5^- - d_5^+ = T_a\,, \tag{3.5}$$

where y_i are the decision variables, Z is the value of the objective function, E_i are the employment cost in the ith year, E_a is the employment aspiration cost value, G_i are the cost of general expenses in the ith year, G_a is the aspiration value of general expenses, S_i are the cost of special expenses in the ith year, S_a is the aspiration value of special expenses, R_i are the organization revenue cost in the ith year, R_a is the aspiration value of organization revenue, T_i are the total budget cost in the ith year, T_a is the aspiration value of total budget, d_j^- are the under achievement deviation values, d_j^+ are the over achievement deviation values, $\forall\ i = 1,2,3,4,5,6,7,8$, and $j = 1,2,3,4,5$.

3.2 Aspiration Values (Target Values)

The target values of the budget of the company are as follows:

Goal Constraint 1. Maximize the benefits of employment by at least rupees 2 lakhs per annum.

Goal Constraint 2. Minimize the general expenses by at most rupees 0.5 lakh per annum.

Goal Constraint 3. Maximize the special expenses by at least rupees 2 lakhs per annum.

Goal Constraint 4. Maximize the organization revenue by at least rupees 4 lakhs per annum.

Goal Constraint 5. Minimize the total budget by at most rupees 9 lakhs per annum.

4. Numerical Illustration

The summary of budget estimations of the organization, in the period 2011 to 2018 showing the values of benefits of employment, other expenses, special expenses, organization revenue, total budget were given in Table 1 and rounded-off values of above constraints with priorities and weights in Table 3.

4.1 Priorities and Weights

The decision-maker must analyse each of the 'j' goals, whether over achievement or underachievement of the goals is satisfactory, then assign priorities and weights accordingly. If over achievement is accepted i.e., d_j^+ can be removed from the objective function. If under achievement is accepted that is d_j^- can be removed from the objective function. If the exact achievement of the goal is derived, both d_j^+ and d_j^- must be included in the objective function and ranked according to their priority factors.

4.2 Problem Formulation

The objective function and constraints for the Goal Programming model with the assigned priorities and weights using equations (3.1)-(3.5) are, as follows:

$$\text{Min } Z = 6P_1d_4^- + 5P_2d_1^- + 3P_3d_3^- + 2P_4d_2^+ + 4P_5d_5^+$$

$$\text{Ssubject to } 15y_1 + 18.5y_2 + 23.5y_3 + 26y_4 + 29y_5 + 32.25y_6 + 35.75y_7 + 39.5y_8 + d_1^- - d_1^+ = 2;$$

$$3.5y_1 + 4.5y_2 + 5.75y_3 + 7.2y_4 + 8.5y_5 + 9.52y_6 + 10.7y_7 + 11.8y_8 + d_2^- - d_2^+ = 0.5;$$

$$13.5y_1 + 15y_2 + 16.65y_3 + 18.23y_4 + 19.5y_5 + 21.43y_6 + 20y_7 + 23.5y_8 + d_3^- - d_3^+ = 2;$$

$$55y_1 + 57y_2 + 59.75y_3 + 61.8y_4 + 63.5y_5 + 65.65y_6 + 68.23y_7 + 70.32y_8 + d_4^- - d_4^+ = 4;$$

$$87y_1 + 95y_2 + 105.65y_3 + 113.23y_4 + 120.5y_5 + 129.1y_6 + 134.68y_7 + 145.12y_8 + d_5^- - d_5^+ = 9;$$

$$y_i, d_j^-, d_j^+ \geq 0$$

where $i = 1,2,3,4,5,6,7,8$; $j = 1,2,3,4,5$.

Here, P_j's ($j = 1,2,3,4,5$) are the pre-emptive priority values, assigned for indicating the order of importance of each goal. Weights are assigned to each priority by the decision-maker according to the situation. The solution of the work is obtained by using Linear Programming Software (LIPS)for windows and results are discussed.

5. Interpretation of Results

On assigning different weights to the priorities, the results are as follows:

Objective function value $Z = 11.9088$, $y_2 = 0.0490596$, $y_6 = 0.0336122$.

Priority 1 (goal 4: Organization revenue), Priority 2 (goal 1: Benefits of Employment), and Priority 5 (goal 5: Total Budget) are fully achieved.

Priority 3 (goal 3: Special expenses) is not fully achieved as the target value is exceeded by 0.543796. Therefore, the actual special expenses should be 1.456 lakhs per annum ($2 - 0.543796 = 1.456$).

Table 1. Budget estimations outline

S. No.	Goal Constraints	Years (in lakhs)								Total
		2011	2012	2013	2014	2015	2016	2017	2018	
1	Benefits of Employment	15,00,000	18,50,000	23,49,990	26,00,000	29,00,000	32,24,550	35,75,100	39,50,000	2,19,49,640
2	General Expenses	3,50,000	4,50,000	5,75,100	7,20,000	8,50,000	9,52,050	10,70,000	11,80,000	61,47,150
3	Special Expenses	13,50,000	15,00,000	16,65,000	18,23,000	19,49,990	21,43,120	20,00,000	23,50,000	1,47,81,110
4	Organization Revenue	55,00,000	57,00,000	59,75,000	61,80,000	63,50,000	65,65,000	68,23,000	70,32,000	5,01,25,000
5	Total Budget	87,00,000	95,00,000	1,05,65,090	1,13,23,000	1,20,49,990	1,28,84,720	1,34,68,100	1,45,12,000	9,30,02,900

Table 2. Rounded-off budget estimations

S. No.	Goal Constraints	Years (in lakhs)								Total
		2011	2012	2013	2014	2015	2016	2017	2018	
1	Benefits of Employment	15	18.5	23.5	26	29	32.25	35.75	39.5	219.5
2	General Expenses	3.5	4.5	5.75	7.2	8.5	9.52	10.7	11.8	61.47
3	Special Expenses	13.5	15	16.65	18.23	19.5	21.43	20	23.5	147.81
4	Organization Revenue	55	57	59.75	61.8	63.5	65.65	68.23	70.32	501.25
5	Total Budget	87	95	105.65	113.23	120.5	129.1	134.68	145.12	930.03

Table 3. Budget estimations outline with priorities and weight

S. No.	Goal Constraints	Years (in lakhs)								Aspiration Values	Priorities	Weights
		2011	2012	2013	2014	2015	2016	2017	2018			
1	Benefits of Employment	15	18.5	23.5	26	29	32.25	35.75	39.5	2	P_2	5
2	General Expenses	3.5	4.5	5.75	7.2	8.5	9.52	10.7	11.8	0.5	P_4	2
3	Special Expenses	13.5	15	16.65	18.23	19.5	21.43	20	23.5	2	P_3	4
4	Organization Revenue	55	57	59.75	61.8	63.5	65.65	68.23	70.32	4	P_1	6
5	Total Budget	87	95	105.65	113.23	120.5	129.1	134.68	145.12	9	P_5	3

Table 4. Results concerning goal attainment

Variable	Value	Obj. cost	Reduced cost
Y_1	0	0	−2.507358936
Y_2	0.04906	0	0
Y_3	0	0	−2.096907316
Y_4	0	0	−4.513136022
Y_5	0	0	−9.348948723
Y_6	0.033612	0	0
Y_7	0	0	−136.1251152
Y_8	0	0	−17.94022914
d_1^-	0	40	−37.43252521
d_1^+	0	0	−2.567474791
d_2^-	0	0	−12
d_2^+	0.040757	12	0
d_3^-	0.543796	21	0
d_3^+	0	0	−21
d_4^-	0	60	−60
d_4^+	1.003039	0	0
d_5^-	0	0	−3.247350354
d_5^+	0	20	−16.75264965
Constraints	RHS	Slack	Dual price
Benefits of employment	2	0	2.567474791
General expenses	0.5	0	−12
Special expenses	2	0	21
Organization revenne	4	0	0
Total budget	9	0	−3.247350354

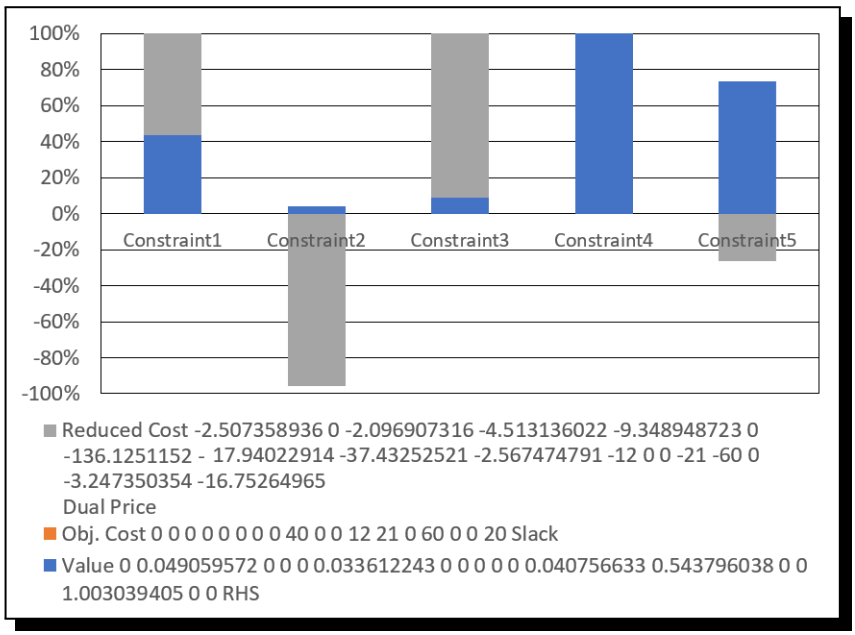

Figure 1. Graph concerning goal attainment

Priority 4 (goal 2: General expenses) is also not fully achieved as the target value is reduced by 0.0407566. Hence, the actual general expenses should be 0.5407566 lakhs per annum (0.5 + 0.0407566 = 0.5407566).

Tabular representation of result constraints is defined in Table 4 and graphical representation in Figure 1.

6. Conclusion

Fanatical planning has exotic implications for the performance of any organization. Good financial planning results in the profit of the organization. In this research, the Goal Programming model is used to reduce the deviations in the objective function, which supports decision making. Operating budget distribution is a demanding issue for decision-makers in every firm. This goal programming model might be a powerful tool, allowing the model to improve the integrated decision-making process within the planning framework. This paradigm assists decision-makers in achieving their aim of producing acceptable solutions. The model may be expanded and used in other sectors with similar requirements.

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Competing Interests

The authors declare that they have no competing interests.

Authors' Contributions

All the authors contributed significantly in writing this article. The authors read and approved the final manuscript.

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