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APPLICATION OF GOAL PROGRAMMING MODEL FOR ALLOCATING TIME AND COST IN PROJECT MANAGEMENT: A CASE STUDY FROM THE COMPANY OF CONSTRUCTION SEROR

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Abstract: The objective of this paper is to apply one of the techniques of multiple-objective programming (goal programming) to a project management problem. Mubiru [8] proposed a goal programming model for allocating time and cost in project management. In order to test this model, a case study was accomplished in the company of construction, SEROR, Algeria.

Keywords: Goal Programming, Project Management, Cost, Time.

MSC: 90C29.

1. INTRODUCTION

Project management decision issues have long attracted interest from both practitioners and academics, Thien-Fu.L [10]. It is the process of planning, scheduling and controlling projects. Planning phase involves clearly defined goals and objectives of the project; scheduling phase involves determining the time and sequence interdependencies between project activities; and the control phase involves dealing with unexpected events in order to maintain the time and budget requirements.

Projects have several objectives to be accomplished: time of completion, budget, labor and material costs. Projects problems involving multiples objectives can be solved

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using multiple – objective programming. This paper applies one of the techniques of multiple-objective programming denominated goal programming.

The goal programming technique was originally developed by Charnes and Copper [2]. "This technique allows taking into account simultaneously many objectives while the decision-maker is seeking the best solution from among a set of feasible solutions. The popularity of goal programming is due, in part, to the fact that it is easy to understand and the fact that it easy to apply since it constitutes an extension of linear mathematical programming for which very effective solving algorithms are available ", Aouni and Kettani [1]

This study aims to apply Mubiru [8] goal programming model for allocating time and cost in project management in a SEROR company. Following a literature review, this paper contains a description of the goal programming model used in the study, and the obtained results.

2. LITERATURE REVIEW

There have been various studies relating to the application of goal programming in project management. Mukherjee and Bera [9] examined the project selection decision using goal programming technique. The model was applied to Indian coal mining industry. The model indentifies five goals:

- Capital investment goal.
- Cost of production goal.
- Profit goal.
- Manpower goal.
- Demand goal.

Gyu and John [4] applied a goal programming model for project selection and resource planning. The decision model used is 0-1 goal programming model, which is validated by applying it to case study from the Woodward Governor Company.

Lee and Kim [5] suggest in their study an improved information system project selection methodology, which reflects interdependencies among evaluation criteria and candidate projects, by using network process within 0-1 goal programming model.

Masood *et al* [7] developed a project selection model for health service institutions that incorporated research and development, investments plans, capital budgeting, etc. The decision model used is 0-1 goal programming model, which is validated by applying it to a real project selection data.

Fabiane *et al* [3] applied goal programming to a Brazilian forest problem. The goal programming model was used seeking to reach the following goals: wood harvest (pine), wood harvest (auraucaria), eva-mate harvest, tourism, employees, diversity of flora and diversity of fauna.

Liang [6] focuses on developing a two-phase fuzzy mathematical programming approach for solving the multi-objective project management decision problems in a fuzzy environment. The model designed minimizes simultaneously total projects costs, total completion time, and crashing costs with reference to direct costs, indirect costs, contractual penalty costs, duration of activities, and the constraint of available budget.

Mubiru [8] proposed a goal programming model for allocating time and cost in project management. A construction company case was utilized to illustrate his model. This model is applied in our study, too.

3. GOAL PROGRAMMING MODEL

Mubiro [8] proposed a goal programming model for allocating time and cost in project management. He has formulated the goal programming problem as follows:

$$\text{Minimize } Z = \sum_{k=1}^{3} \sum_{i=1}^{3} P_k(i) \left(D_k^+ + D_k^- \right)$$

subject to：

$$\sum_{j=1}^{3} \sum_{i=1}^{3} X_{ij} - D_1^+ + D_1^- = T_i$$

$$\sum_{j=1}^{3} \sum_{i=1}^{3} C_{ij} X_{ij} - D_2^+ + D_2^- = TC_i$$

$$\sum_{j=1}^{3} \sum_{i=1}^{3} A_{ij} X_{ij} - D_3^+ + D_3^- = LMC_i$$

$$X_{ij}, A_{ij}, C_{ij}, D_1^+, D_1^-, D_2^+, D_2^-, D_3^+, D_3^- \geq 0$$

In the above:

(i=1,2,….n): Set of projects.

(j=1,2,3) : Three distinctive phases for each project to be successfully completed.

(K =1,2,3): Three goals for each project to be achieved.

Z : Value of objective function.

$P_k(i)$ ：Preemptive priority of K*th* goal.

D_k^+ : Overachievement of K*th* goal.

D_k^- ： Underachievement of Kth goal.

X_{ij} : Time allocated for project i during phase j.

T_i : Total time of completion.

C_{ij} : Monthly total costs (including miscellaneous costs).

TC_i : Total cost (Budget) of entire project.

A_{ij} : Monthly labor and material costs.

LMC_i : Labor and material cost.

4. IMPLEMENTATION

4.1. *Data description*

In order to test the model proposed by Mubiru [8], a case application is taken from a SEROR company in Algeria. SEROR was founded in May 1980. It is specialized in engineering studies and infrastructure construction. It is present in several regions through several major projects. SEROR has collaborated with the French company building FRECINET in order to introduce new technologies. Today, SEROR has become one of the first companies in the "Building and Construction" sector.
The SEROR company had three projects which were to commence at the same time. The estimated monthly costs in carrying out the projects are presented in table 1. The total allocations and project duration are presented in table 2.

Table 1: Monthly breakdown of costs (in Algerian dinar DZ)

Project N°	Project phase	Action plan	Monthly labor and material costs	Monthly total costs including miscellaneous expenses
	1	Planning	1423258.44	2386547.43
1	2	Schedul.	4506985.06	75574001.95
	3	Control	948838.96	1591031.62
	1	Planning	1597936.82	2796937.57
2	2	Schedul.	50601332.38	88569689.86
	3	Control	1065291.21	1864625.05
	1	Planning	2016867.27	3450578.49
3	2	Schedul.	6367463.46	109268318.7
	3	**Control**	**1344578.18**	**2300385.66**

Table 2: Total allocations and project duration

Project N°	Total labor and material costs (DZ)	Total costs including miscellaneous expenses (DZ)	Duration (months)
1	53609401.24	89893286.53	6
2	60188953.25	105351315.31	8
3	**75968667.06**	**129971789.61**	**11**

The following priorities were desirable for each project:

Project 1 :

$P_1(1)$: complete project in 6 months.

$P_2(1)$: keep total project expenditure within budget (89893286.53 Algerian dinar).

Project 2 :

$P_1(2)$: complete project in 8 months.

$P_2(2)$: keep total project expenditure within budget (105351315.31 Algerian dinar).

Project 3 :

$P_1(3)$: complete project in 11 months.

$P_2(3)$: keep total project expenditure within budget (129971789.61 Algerian dinar).

4.2. Problem formulation for case study

The SEROR company wanted to allocate time to each phase of the project (planning, scheduling and control) in order to achieve the time and total expenditure goals.

Project 1 :

$$\text{Minimize } Z = P_1(1)\,D_1^+ + P_1(1)\,D_1^- + P_2(1)\,D_2^+ + P_2(1)\,D_2^-$$

subject to :

$$X_{11} + X_{12} + X_{13} - D_1^+ + D_1^- = 6$$

$$2386547.43\,X_{11} + 75574001.95\,X_{12} + 1591031.62\,X_{13} - D_2^+ + D_2^- = 89893286.53$$

$$1423258.44\,X_{11} + 4506985.06\,X_{12} + 948838.96\,X_{13} - D_3^+ + D_3^- = 53609401.24$$

$$X_{11}, X_{12}, X_{13}, D_1^+, D_1^-, D_2^+, D_2^-, D_3^+, D_3^- \geq 0$$

Project 2 :

$$\text{Minimize } Z = P_1(2)\,D_1^+ + P_1(2)\,D_1^- + P_2(2)\,D_2^+ + P_2(2)\,D_2^-$$

subject to :

$$X_{21} + X_{22} + X_{23} - D_1^+ + D_1^- = 8$$

$$2796937.57\,X_{21} + 88569689.86\,X_{22} + 1864625.05\,X_{23} - D_2^+ + D_2^- = 105351315.31$$

$$1597936.82\,X_{21} + 50601332.38\,X_{22} + 1065291.21\,X_{23} - D_3^+ + D_3^- = 60188953.25$$

$$X_{21}, X_{22}, X_{23}, D_1^+, D_1^-, D_2^+, D_2^-, D_3^+, D_3^- \geq 0$$

Project 3 :

$$\text{Minimize } Z = P_1(3)\,D_1^+ + P_1(3)\,D_1^- + P_2(3)\,D_2^+ + P_2(3)\,D_2^-$$

subject to :

$$X_{31} + X_{32} + X_{33} - D_1^+ + D_1^- = 11$$

$$3450578.49\,X_{31} + 109268318.7\,X_{32} + 2300385.66\,X_{33} - D_2^+ + D_2^- = 129971789.61$$

$$2016867.27\,X_{31} + 63867463.46\,X_{32} + 1344578.18\,X_{33} - D_3^+ + D_3^- = 75968667.06$$

$$X_{31}, X_{32}, X_{33}, D_1^+, D_1^-, D_2^+, D_2^-, D_3^+, D_3^- \geq 0$$

4.3. Solution

Using LINDO software, project 1, 2, and 3 models yield the following results:

Project 1 :

X_{11} = Time allocated for planning = 0 months .

X_{12} = Time allocated for scheduling = 1.09 months .

X_{13} = Time allocated for control = 4.91 months .

$P_1(1)$ = Goal for completing project 1 on time is fully achieved, since $X_{11} + X_{12} + X_{13} = 0 + 1.09 + 4.91 = 6$ months , but this solution is illogical and impractical because without planning phase the project failed.

$P_2(1)$= goal for keeping total project expenditure within budgeted amount is partially achieved since

$2386547.43\ X_{11} + 75574001.95\ X_{12} + 1591031.62\ X_{13} =$
$2386547.43\ (0) + 75574001.95\ (1.09) + 1591031.62\ (4.91) =$
90187627.38 Algerian dinar

Total project expenditure = 90187627.38 Algerian dinar which is slightly above the budgeted amount of 89893286.53.

Project 2 :

X_{21} = Time allocated for planning $= 0$ months .

X_{22} = Time allocated for scheduling $= 1.04$ months .

X_{23} = Time allocated for control $= 6.96$ months .

$P_1(2)$ = Goal for completing project 1 on time is fully achieved, since $X_{21} + X_{22} + X_{23} = 0 + 1.04 + 6.96 = 8$ months , but this solution is illogical and impractical because without the planning phase the project failed.

$P_2(2)$= goal for keeping total project expenditure within budgeted amount is not fully achieved since

$2796937.57\ X_{21} + 88569689.86\ X_{22} + 1864625.05\ X_{23} =$
$2796937.57\ (0) + 88569689.86\ (1.04) + 1864625.05\ (6.96) =$
105090267.8 Algerian dinar

Total project expenditure = 105090267.8 Algerian dinar which is below the budgeted amount of 105351315.31.

Project 3 :

X_{31} = Time allocated for planning $= 0$ months.

X_{32} = Time allocated for scheduling $= 0.98$ months.

X_{33} = Time allocated for control $= 10.02$ months .

$P_1(3)$ = Goal for completing project 1 on time is fully achieved since $X_{31} + X_{32} + X_{33} = 0 + 0.98 + 10.02 = 11$ months , but this solution is illogical and impractical because without the planning phase, the project fails.

$P_2(3)$ = goal for keeping total project expenditure within budgeted amount is partially achieved since

$3450578.49\ X_{31} + 109268318.7\ X_{32} + 2300385.66\ X_{33} =$

$3450578.49\ (0) + 109268318.7\ (0.98) + 2300385.66\ (10.02) =$
130132816.64 Algerian dinar

Total project expenditure = 130132816.64 Algerian dinar which is slightly above the budgeted amount of 129971789.61.

5. CONCLUSION

The aim of this paper was to test a goal programming model proposed by Mubiru [8] for allocating time and cost in project management; a case study was accomplished in SEROR's company.

Results reveal that the model provides satisfactory levels of achievement for managing the three projects with preemptive goals, but the solution value (0) of time allocated for planning is illogical and impractical because without the planning phase, the project fails.

We suggest the introduction of additional constraints to the model by specifying the lower bound for each time allocated to planning, scheduling, and control.

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