Operating Cost Distribution for Gotel Communication, Yola using Goal Programming Model

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ABSTRACT

In this study, we created a weighted goal programming model for the Gotel Communication's operating costs. The television and radio broadcasting center wants to keep operating costs as low as possible. Five (5) operating costs; employee benefits, capital costs, revenue, general costs, and overall budget were taken into account.

Microsoft Excel™ was used to calculate the weight of each priority utilizing the analytical hierarchy process. To find the solutions of the objective function, decision variables, and deviational variables, the POM QM (formerly DS for Windows) was utilized. According to the model's conclusions, the Gotel Communication Center can successfully complete all five of the goals that have been looked at using the goal programming model's ideal solution. This suggests that the Gotel Communication Center's operational costs are reasonable, but that there is room for improvement in four areas: the overall budget, revenue, capital expenditures, and employment benefits. Additionally, the operational cost's ratio of item values can be changed to raise the desired level. In addition, the study can assist in identifying the new targeted values for the organization's goal of continued improvement.

(Keywords: goal programing, operating cost, analytics hierarchy process, AHP)

INTRODUCTION

Distribution of operating costs is a challenging procedure that calls for coordination and collaboration between many organizational or institutional divisions. It requires a group of proactive and trustworthy decision-makers who can create a model for allocating operating costs that is both efficient and effective. These models certainly exist, but since there are so many competing goals, they are ineffective. In order to deal with circumstances in which all objectives cannot be fully or simultaneously satisfied, decision-making within an organization is frequently characterized by an attempt to satisfy a set of potentially conflicting objectives as completely as possible in a context of limited resources, divergent interests, and annoying priorities. And such decision making capable of managing multiple conflicting goals and their priorities is the goal programming model.

There are, however, a variety of objectives that have been looked at as helpful in reducing an organization's running costs. Goal programming is used in Vasantha Lakshmi, Harish Babu, and Uday Kumar's (2021) financial planning to reconcile disparate and conflicting objectives. The primary objectives of his study are to maximize capital structure and gross earnings. As a case study, they discuss the use of goal programming to optimize financial planning for an organization called SVR in Karnataka, India. Also according to Rahman (2018), queue optimization is carried out on port scheduling in order to create a compromise solution that will simultaneously meet a number of design goals in order to lower the expense incurred and the amount of time.

According to Jyoti (2016), goal programming aims to meet an institution's or organization's economic and financial objectives while reducing costs. Kamran (2013) contends that any budget planning necessitates the estimation of various cost components.

A subset of multi-objective optimization, which is a subset of multi-criteria decision analysis, is goal programming. It can be viewed as a generalization or extension of linear programming that can deal with various, frequently at odds objective measurements. Each of these metrics has a target value that must be attained. Then, in an achievement function, unwanted deviations from this set of target values are eliminated. Depending on the goal programming variation utilized, this may be a vector or weighted sum. Goal programming is based on the idea that whether objectives are met or not, they will be replaced with another target whose optimization will produce results as similar as feasible to the original objectives. Since the decision-maker is satisfied when the target is met, if non-achievement is reduced to zero, it signifies the goal has actually been attained.

METHODOLOGY

General Goal Programming

The generalized linear goal programming is defined as:

$$Minimize\ Z=\sum_{i=1}^{m}\sum_{k=1}^{n_i}P_i(w_{ik}^{-}d_i^{-}+w_{ik}^{+}d_i^{+})$$

$$subject\ to$$

$$\text{goal constraints}\ \sum_{j=1}^{n}\left(a_{ij}x_j+d_i^{-}-d_i^{+}\right)=b_i \quad i=1,2....m,\ j=1,2...n$$

$$\text{system constraints}\ \sum_{j=1}^{n}\left(a_{ij}x_j\right)\begin{bmatrix}\le\\=\\\ge\end{bmatrix}b_i$$

$$d_i^{-},d_i^{+},x_j\ge 0$$

W_{ik}^{-}, $W_{ik}^{-}\ge 0$ denote the relative weights to be applied to each of the variables with k = 1….n_i.

Different classes are allocated to the non-Archimedean transcendental value of P_i inside the ith category. The preemptive priority factors, or P_i, are solely used as a ranking symbol and can be used to indicate that no distinctions between different kinds of goals will be allowed. It is believed that an objective function will reduce the ordering of deviation variables.

$d_{i=}^{+}$is the positive deviation variable from overachieving the i^{th} goal

$d_{i=}^{+}$is the negative deviation variable from underachieving the i^{th} goal

x_j = is the j^{th} decision variable a_{ij} is the decision variable coefficient

b_i = the associated right hand side value

Since the deviational variables are dependent by definition, they cannot all be fundamental variables at once, according to their mathematical definition. This demonstrates that in any simplex iteration, only one of them can, at most, occupy a particular state. Several types of goal achievement are displayed in the table below.

$$d_i^{+}=\frac{1}{2}\left[\left|\sum_{j=1}^{n}\left(a_{ij}x_j-b_i\right)\right|+\sum_{j=1}^{n}\left(a_{ij}x_j-b_i\right)\right]$$

$$d_i^{-}=\frac{1}{2}\left[\left|\sum_{j=1}^{n}\left(a_{ij}x_j-b_i\right)\right|-\sum_{j=1}^{n}\left(a_{ij}x_j-b_i\right)\right]$$

Table 1: Model Goals.

Minimize	goal	If goal achieved
d_i^{-}	Minimize under achievement	$d_i^{-}=0,\ d_i^{+}\ge 0$
d_i^{+}	Minimize overachievement	$d_i^{+}=0,\ d_i^{-}\ge 0$
$d_i^{-}+d_i^{+}$	Minimize both under and over achievement	$d_i^{-}=0,\ d_i^{+}=0$

Assumptions of the Model

It is assumed for this model that:

i. Gotel Communication is interested in maximizing income, capital expenditure, and employment benefit while minimizing overall budget, general expenses.

ii. All of the decision-making variables have to be open to taking any value that falls within their given range.

iii. The amount of punishment for undesirable deviations from a target level is independent of the levels of undesirable deviations from the other objectives (Winston, 2004).

iv. All data coefficients are known.

Table 2: Gotel Communication Hypothetical Goals.

Goal	Objectives
1	Total budget (Minimize)
2	Revenue (Maximize)
3	Capital expenditure (CAPAX) (Maximize)
4	General expenses minimize
5	Employment benefit maximize

The Weighted Goal Programming Model Formulation for Gotel Communication

In Gotel communication operating cost distribution, the total budget, capital expenditure, general expenditure, and employment benefit are minimized while income is to be maximized. To decide whether to increase or decrease the goals, positive and negative deviation variables are introduced to the constraint. We are taking a two (2) year operational cost of Gotel communication into consideration. Goals and restrictions are determined, and the following steps are taken in developing and building the model:

Objective Function

$$Minimize \quad z = w_1 d_1^- + w_2 d_2^+ + w_3 d_3^- + w_4 d_4^- + w_5 d_5^-$$

Subject to:

$$a_{11}x_{11} + a_{12}x_{12} + a_{13}x_{13} + d_1^- - d_1^+ \geq b_1$$

$$\begin{pmatrix} \text{Total Budget} \\ \text{constraint} \end{pmatrix}$$

$$a_{21}x_{21} + a_{22}x_{22} + a_{23}x_{23} + d_2^- - d_2^+ \leq b_2$$

$$(\text{Revenue constraint})$$

$$a_{31}x_{31} + a_{32}x_{32} + a_{33}x_{33} + d_3^- - d_3^+ \geq b_3$$

$$\begin{pmatrix} \text{Capital Expenditure} \\ \text{Constraint} \end{pmatrix}$$

$$a_{41}x_{41} + a_{42}x_{42} + a_{43}x_{43} + d_4^- - d_4^+ \leq b_4$$

$$\begin{pmatrix} \text{General Expense} \\ \text{Constraint} \end{pmatrix}$$

$$a_{51}x_{51} + a_{52}x_{52} + a_{53}x_{53} + d_5^- - d_5^+ \geq b_5$$

$$\begin{pmatrix} \text{Employment Benefit} \\ \text{Constraint} \end{pmatrix}$$

$$x_j, d_i^-, d_i^+, \geq 0$$
$$where\ j = 1, 2, 3, \ldots, n \ \ and \ \ i = 1, 2, 3, 4, 5$$

Table 3: The Five Criterion Goals Considered.

S. No	Verbal Judgement of Preference	Numerical Rating
1	Total Budget	TB
2	Revenue	R
3	Capital Expenditure	CE
4	General Expenses	GE
5	Employment Benefit	E

Application of Analytics Hierarchy Process (AHP)

The weights of the respected aims were determined for the sake of this investigation using the analytical method. Professor Thomas L. Saaty is credited with developing the hierarchical process (AHP) to analytic hierarchy process, one of the multi-criteria decision-making techniques. It is, in essence, a technique for obtaining ratio scale from paired comparisons. The input might come from objective judgment like satisfaction emotions and preference, or from actual measurement like pricing, weights, etc. Because people are not always consistent, AHP permits some little judgmental inconsistency. The consistency index is obtained from the principal Eigen value, and the ratio scales are derived from the principal Eigen vectors.

Table 4: The Pairwise Comparisons of the Five Criteria for the Gotel Communication.

S/NO	Pairwise Comparison	More Important Criterion	How Much More important	Numerical Rating
1	E-GE	E	Very strongly preferred	7
2	E-CE	CE	Very strongly to extremely preferred	8
3	E-R	R	Extremely preferred	9
4	E-TB	TB	Strongly to very strongly preferred	6
5	GE-CE	CE	Equally to moderately preferred	2
6	GE-R	R	Moderately preferred	3
7	GE-TB	TB	Moderately to strongly preferred	4
8	CE-R	R	Strongly preferred	5
9	CE-TB	TB	Moderately preferred	3
10	R-TB	R	Very strongly preferred	7

Table 5: Comparison Scale for Relative Importance.

	E	GE	CE	R	TB
E	1	7	8	9	6
GE	1/7	1	2	3	4
CE	1/8	½	1	5	3
R	1/9	1/3	1/5	1	7
TB	1/6	¼	1/3	1/7	1

Making a Comparison Matrix

Matrix form was made from the five goals above because we have five comparisons thus we have 5 by 5 matrix the diagonal element of the matrix are always 1.

Table 6: Making a Comparison Matrix.

	E	GE	CE	R	TB
E	1	7	8	9	6
GE	0.1428	1	2	3	4
CE	0.125	0.5	1	5	3
R	0.1111	0.3333	0.2	1	1
TB	0.1666	0.25	0.3333	0.1428	1
	1.5455	9.0833	11.5333	18.1428	15

Priority Vectors

Since we have 5 by 5 reciprocal matrix from the paired comparison, sum each column of the reciprocal matrix, then divide each element of the matrix with the sum of the column to have a relative weight. The sum of each column is 1. The normalized principal Eigen vector can be obtained by averaging across the rows.

Table 7: The Normalized Pairwise Matrix.

	E	GE	CE	R	TB	Priority
E	0.647039793	0.77064503	0.693643623	0.496064555	0.4	0.6014786
G E	0.092397282	0.110092147	0.173410906	0.165354852	0.266666667	0.161584371
C E	0.080879974	0.055046074	0.086705433	0.275591419	0.2	0.139644584
R	0.071886121	0.036693713	0.017341091	0.055118284	0.066666667	0.049541175
T B	0.10779683	0.027523037	0.028898927	0.007870891	0.66666667	0.04775127
					Total	**1.000000**

The Developed Weight Goal Programming Model

All of the data coefficients are known with certainty according to the model's underlying assumptions. As a result, we have developed the model below for this study as;

Objective Function:

0.6014786 d_1^- + 0.161584371 d_2^+ + 0.139644584 d_3^- + 0.049541175 d_4^- + 0.04775127 d_5^-

Subject to:

$25377865.13x_{11} + 101511472.5x_{12} + 5148275.62x_{13} + 2646700x_{14} \leq 134684316.3$
$7365215.30x_{21} + 758599x_{22} + 1163825x_{23} + 4646574x_{24} + 1485875.32x_{25} \leq 15420088.62$
$12728094.40x_{31} + 3182223.60x_{32} \leq 15910318$
$89544581.56x_{41} + 11230572.73x_{42} + 3369171.82x_{43} + 7861400.91x_{44} \leq 8976919301$
$18000000x_{51} + 200000000x_{52} + 145000000x_{53} + 20000000x_{54} \leq 383000000$
$x_{11}, x_{12}, x_{13}, x_{14}, x_{21}, x_{22}, x_{23}, x_{24}, x_{25}, x_{31}, x_{32} x_{41}, x_{42} x_{43} x_{44}, x_{51}, x_{52}, x_{53}, x_{54} > 0$

Method of Analysis

Microsoft Excel™ was used to calculate the weight of each priority utilizing the analytical hierarchy process. To find the solutions of the objective function, decision variables, and deviational variables, the POM QM (formerly DS for Windows) was utilized.

RESULTS

To solve the formulated problem, we made use of the software, quantitative method production and operation management (POM-QM) optimization system, Windows version 3.00, copyright @ 2006 developed by Howard J Weiss. The software also follows the 8th edition of the text; OR: introduction to operations by Hamdy A Taha. Enclosed is the output result of the problem.

Table 8: Solution of the Operating Cost.

Variables	Status	Values (in millions)
x_{11}	Basic	1.0
x_{12}	Basic	1
x_{13}	Basic	50.15
x_{14}	Basic	1.33
x_{21}	Non basic	0
x_{22}	Non basic	0
x_{23}	Non basic	0
x_{24}	Non basic	0
x_{25}	Non basic	0
x_{31}	Basic	253231000
x_{32}	Basic	57245690
x_{41}	Non basic	0
x_{42}	Non basic	0
x_{43}	Basic	7132192000
x_{44}	Non basic	0
x_{51}	Non basic	0
x_{52}	Non basic	0
x_{53}	Basic	8696661000
x_{54}	Non basic	0

DISCUSSION OF RESULT

In the optimum summary:

Z = 7132192000 million,
x_{11}= 1.0 million,
x_{12}= 1 million,
x_{13}= 80.15 million,
x_{14}= 1.33 million,
x_{31}= 253231000,
x_{32} = 57245690,
x_{43}= 7132192000
and x_{53}= 8696661000,
all the remaining variables are equal zero.

The fact that the optimum value Z is not zero indicate that at least one of the goals is not met. Specifically, x_{43}= D_5^+ = 7132192000, mean goal five is increasing the proportion or weights for the values of the capital expenditure C.E by at least 10% was overachieved by 7132192000 = D_4^- = 8696661000 means goal two of the doubling the investment was underachieved by 869666100.

Table 9: Solution of the WGP (Weighted Goal Programming)

Goal	**RHS**	**Negative Deviation d_i^-**	**Positive Deviation d_i^+**
Employment Benefit	134684300	0	253231000
General Expenses	15420090	0	57245690
Capital Expenditure	15910320	0	0
Revenue	8976920000	8696661000	0
Total Budget	38300000	0	7132192000

The values of deviational variables connected to the goals, both positive and negative, are displayed in Table 9. The initial objective is to reduce the overall budget. Because the negative deviational variables d_1^- =0 and d_1^+=713219200, the objective has been entirely attained. This means that we reduce the overall budget's underachievement by 713219200 million naira. Since d_2^+=0 and d_2^-= 8696661000, the goal of revenue maximization is likewise attained, we may reduce the overachieving of the revenue by 8696661000 trillion naira. Since d_3^-= 0 and d_3^+ = 0, which indicates that the third goal has been entirely attained, the capital expenditure cannot be changed. Since d_4^- = 0 and d_4^+ = 57245690, the objective of decreasing the general expenses has been attained, and we will reduce the underachieving of the general expenses by 57245690 million naira. Finally, because d_5^- = 0 and d_5^+ = 253231000, the employment benefit may be enhanced by 253231000 million naira, the employment benefit's goal of maximization is also attained.

CONCLUSION

The outcome indicates that Gotel Communication Centre is capable of achieving all five of the goals that have been analyzed based on the goal programming model's optimal solution, according to the findings of the model that has been proposed. This suggests that the Gotel Communication Center's operational costs are reasonable, but that there is room for improvement in four areas: the overall budget, revenue, capital expenditures, and employment benefits. Additionally, the operational cost's value distribution can be changed to raise the desired level. In addition, the study can assist in identifying the new targeted values for the organization's purpose of further development.

According to our findings, Gotel Communication Center should prioritize boosting employment benefits in order to achieve the objective of profit and income maximization rather than general expense minimization.

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