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Optimization of Financial Resources Through Goal Programming

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Abstract
Goal programming is used to manage a set of conflict objectives by minimizing the deviations between the target values and the realized results. The original objectives are re-formulated as a set of constraints with target values and two auxiliary variables. Two auxiliary variables are called positive deviation d+ and negative deviation d−, which represent the distance from this target value. The objective of goal programming is to minimize the deviations hierarchically so that the goals of primary importance receive first priority attention; those of second importance receive second-priority attention, and so forth. Then, the goals of first priority are minimized in the first phase. Using the obtained feasible solution result in the phrase, the goals of second priority are minimized, and so on.

Keywords: Goal programming, Operations Research, multi-dimensional objective function,

INTRODUCTION

The goal programming (GP) technique has become a widely used approach in Operations Research (OR). GP model and its variants have been applied to solve large-scale multi-criteria decision-making problems. The GP technique was first used by Charnes and Cooper in 1960s. This solution approach has been extended by Ijiri (1965), Lee (1972), and others. The Goal Programming Method is an improved method for solving multi-objective problems. Goal programming is one of the model which have been developed to deal with the multiple objectives decision-making problems. This model allows taking into account simultaneously many objectives while the decision-making is seeking the best solution from among a set of feasible solutions. The goal programming technique is an analytical framework that a decision maker can use to provide optimal solutions to multiple and conflicting objectives. Goal programming is a special type of technique. This technique uses the simplex method for finding optimum solution of a single dimensional or multi-dimensional objective function with a given set of constraints which are expressed in linear form. In goal programming technique, all

management goals, where one or many, are incorporated into the objective function and only the environmental conditions, i.e.; those outside the management's control are treated as constraints. Moreover, each goal is set at a satisfying level which may not necessarily be the best obtainable, but one that management would be satisfied to achieve given multiple and sometimes conflicting goals. The computational procedure in goal programming is to select a set of solutions which satisfies the environmental constraints and providing a satisfactory goal, ranked in priority order. Low ordered goals are considered only after the higher ordered goals are satisfied. If ordinal rankings of goals can be provided in terms of importance or contributions and all goal constraints are linear in nature, the solution of the portion can be obtained through Goal Programming. In solution of LGP models, performed to minimize the deviation of determined target according to priority and weight coefficients defined by decision maker's are carried. Goal programming method is not only a technique to minimize the sum of all deviations, but also a technique to minimize priority deviations as much as possible. The results of multi-objective problem solutions are affected by the decision of the manager or decision maker. Therefore, when there is a concession between goals, there will be deviations according to the decisions made. The direction and extent of these deviations play important roles in this type of problem.

In our opinion, goal programming is still to be one of the stronger methods available. It has a close correspondence with decision-making in practice. Furthermore, it has some attractive technical properties. Several empirical findings from decision-making practice are, in our opinion, rather convincing to demonstrate the practical usefulness of multiple goal programming. As mentioned by several writers, the method corresponds fairly well to the results of the behavioral theory of the firm. In practice, decision-makers are aiming at various goals, formulated as aspiration levels. The intensity with which the goals are strived for may vary from goal to goal; in other words, different 'weights' may be assigned to different goals. The use of aspiration levels in decision-making is also reported by scientists from other fields, like for instance psychology. In the same way, also pre-emptive priorities are known in real life problems. Support for this in fact lexicographic viewpoint is provided by Fishburn (1974) and Monarchi et al (l976). A more concrete example of the correspondence of multiple goal programming and practice is provided by Ijiri (1965), who views multiple goal programming as an extension of break-even analysis, which is widely used in business practice. The above plea for multiple goal programming is of a so roe what theoretical nature. Of course, the operational usefulness of multiple goal programming can only be shown in practice. Although it is a relatively 'young' method, many applications have been reported in literature. To give an idea, we have listed some of these applications, especially in the field of business and managerial economics (Nijkamp and Spronk 1977). One of the technical advantages of multiple goal programming is that there is always a solution to the problem, even if some goals are conflicting, provided that the feasible region R is non-empty. This is due to the inclusion of the deviational variables y. and y. . These variables show whether the goals are attained or not, and in the latter case they measure the distance between the realized and aspired goal levels. Another advantage of multiple goal programming is that it does not require very sophisticated solution procedures. Especially the linear goal programming problems can be solved by easily available linear programming routines. An important drawback of multiple

goal programming is its need for fairly detailed a priori information on the decision-maker's preferences.

Goal programming is used to manage a set of conflict objectives by minimizing the deviations between the target values and the realized results (Rifai 1994). The original objectives are re-formulated as a set of constraints with target values and two auxiliary variables. Two auxiliary variables are called positive deviation d+ and negative deviation d−, which represent the distance from this target value. The objective of goal programming is to minimize the deviations hierarchically so that the goals of primary importance receive first priority attention; those of second importance receive second-priority attention, and so forth. Then, the goals of first priority are minimized in the first phase. Using the obtained feasible solution result in the phrase, the goals of second priority are minimized, and so on. The explicit definition of goal programming was given by Charnes and Cooper (1961).

Goal programming is one of the oldest multi criteria decision making techniques aiming at optimizing several goals and at the same time minimize the deviation for each of the objectives from the desired target. The concept of goal programming evolved as a result of unsolvable linear programming problems and the occurrence of the conflicting multiple objectives goal. Multiple objectives arise in production companies because of several departments with different functions, In fact the basic concept of goal programming is whether goals are attainable or not, an objective may be started in which optimization gives a result which come as close as possible to the indicated goals. The objective of goal programming is to minimize the achievement of each actual goal level. If non-achievement is minimized to zero, the exact attainment of the goal has ken accomplished. For a single goal problem, the formulation and solution is similar to linear programming with one exception. The exception is that if complete goal attainment is not possible goal programming will provide a solution and information to the decision makers.

In problem with more than one goal, the manager must rank the goals in order of importance. The procedure is to minimize the deviational variables of the highest priority goal and proceed to the next lower goal. Deviation from this goal is then minimized, the other goals are considered in order of priority but lower order goals are only achieved as long as they do not distract from the attainment of the higher priority god. In order to minimize either underachievement or overachievement of a particular goal, a variable called a" deviational variable" is assigned to the goal. This variable represents the magnitude by which the goal level is not achieved. If the value of the deviational variable is small, the goal is more nearly achieved than if the value is relatively large i.e. optimality occurs when deviational variables of the different goals have been minimized to the smallest possible value in order of importance. In general the principle idea of goal programming is to convert original multiple objective into a single goal. The resulting model yields what is usually called an efficient solution because it may not be optimum with respect to all the conflicting objectives of the problem. There are two algorithms for solving goal *programming* problems. Both methods convert the multiple goals into a single & objective confliction. In the weights methods, the single objective function is the weighted sum of the conflictions representing the goals of the problems, that is, it considers all goals simultaneously within a composite objective confliction, comprising the

sum of all respective deviations of the goals from their aspiration levels. The deviations are then weighted according to the relative importance of each goal. To avoid the possible bias effect of the solution to different measurement unit goal, normalization takes place (i.e. the model minimizes the sum of the deviations from the target). The pre-emptive method starts by prioritizing the goals in order of importance. i.e. it is based on the logic that in some decision making sperms, some goals seems to prevail. The procedures begin with comparing all the alternatives with respect to the higher priority goals and continue with the next priories until only one alternative is left. The mode! is then optimized using one goal. at a time such that the optimum value of a higher priority goal is never deemed by a lower priority goal. The two methods do not generally produce the same solution and neither is one method, however, superior to the other because each technique is designed to satisfy certain decision makers' preferences.

GOAL PROGRAMMING MODEL

A model is a simplified representation of a real system and phenomenon. It is a formal description of a real system. Models are mere abstractions revealing the features that are relevant to the real system behavior under study. The nature of models that are appropriate for management decision and planning is such that can be used to represent for example production planning problems. The type of model that can be appropriate for management will include model that can be used to represent management plans in numeric or algebraic forms. The model is commonly used with the intention to gain insight into the general nature of a particular problem in terms of what particular factor is responsible and how. However, there are a number of purposes for which a model can be constructed.

The multi-objective models in the context of manufacturing were formulated and solved in recent past to provide information on the tradeoff among multi-objectives. However, although it represents a viable approach to production plaguing, MOGP is not as widespread among manufacturing companies as desired. The modeling approach of goal programming does not maximize or minimize the objective function directly as in Linear Programming but seeks to minimize the deviations (both positive and negative) between the desired goals and then results obtained according to priorities.

The general goal programming formulation considered for variables, constraints and -pre-emptive priority levels is

$$\text{Min } P_1(w_{i1}^- d_{i1}^- + w_{i1}^+ d_{i1}^+) \text{ ; for } i = 1,2,\dots,m$$

$$\text{Min } P_2(w_{i2}^- d_{i2}^- + w_{i2}^+ d_{i2}^+) \text{ ; for } i = 1,2,\dots,m$$

$$\vdots$$

$$\text{Min } P_k(w_{ik}^- d_{ik}^- + w_{ik}^+ d_{ik}^+) \text{ ; for } i = 1,2,\dots,m$$

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

$$x_j, d_i^-, d_i^+ \geq 0$$

$$P_1 \ggg P_2 \ggg \cdots\cdots \ggg P_k$$

Data of the Problem

NATCO Company located in Hyderabad, Telangana is selected as the case study in this paper. The data of financial statement including Revenue, Expenses, Net profit, fixed assets, Loans and Equity shares are obtained from the NATCO company annual report. The details are summarized in Table 1.

Table 1. Summarized NATCO company financial statement from 2015 to 2019 (In Crores).

Item (or)	Year					Total
Goal	2015	2016	2017	2018	2019	
Revenue	471159580	498375549	488554255	492311940	620819297	2571220621
Expenses	47190452	51149163	77635618	53900032	56474107	286349372
Net Profit	15176564	16180426	17144661	16534258	18430494	83466403
Fixed Assets	21078867	20880673	20005744	19158140	18357994	99481418
Loans	31360735	32673474	18242709	4651290	7551249	94479457
Equity Shares	750000	800000	850000	875000	900000	4175000
Total	586716198	620059285	622432987	587430660	722533141	3139172271

Table 2 gives a summary of NATCO company financial statements in coded values with weights between 2015 and 2019 in RM billion. The purpose of coding the values is to enable analysis with small figures.

Table 2. Coded values for summarized NATCO company financial statement from year 2015 to 2019 (In billion).

Item (or)	Year					Total
Goal	2015	2016	2017	2018	2019	
Revenue	0.4711	0.4983	0.4885	0.4923	0.6208	2.5712
Expenses	0.0471	0.0511	0.0776	0.0539	0.0564	0.2863
Net Profit	0.0151	0.0161	0.0171	0.0165	0.0184	0.0834
Fixed Assets	0.0210	0.0208	0.0200	0.0191	0.0183	0.0994
Loans	0.0313	0.0326	0.0182	0.0046	0.0075	0.0944
Equity Shares	0.0007	0.0008	0.0008	0.0008	0.0009	0.0041
Total(FMC)	0.5867	0.6200	0.6223	0.5873	0.7225	3.1391

Goal Programming Model Formulation and Application

The target value of the goals of the budget of the company are:

* Increase revenue by at least 0.6829 Billion per year.
* Manage expenses less than 0.0649 Billion per year.

* Increase Net Profit by at least 0.0199 Billion per year.

* Increase fixed asset at least 0.0198 Billion per year.

* Reduce loans up to 0.0101 Billion per year.

* Increase Equity Shares on average of 500 per year. i.e., 0.0092 Billions.

* Increase the value of financial statement managing constraint at least by 0.7949 Billion per year.

The decision variables are:

X_1= The amount of financial statement in year 2015.

X_2 = The amount of financial statement in year 2016.

X_3 = The amount of financial statement in year 2017.

X_4 = The amount of financial statement in year 2018.

X_5 = The amount of financial statement in year 2019.

The goal constraints;

$0.4711X_1 + 0.4983X_2 + 0.4885X_3 + 0.4923X_4 + 0.6208X_5 \geq 0.6829$ (Revenue Constraint)

$0.0471X_1 + 0.0511X_2 + 0.0776X_3 + 0.0539X_4 + 0.0564X_5 \leq 0.0649$ (Expenses Constraint)

$0.0151X_1 + 0.0161X_2 + 0.0171X_3 + 0.0165X_4 + 0.0184X_5 \geq 0.0199$ (Net Profit Constraint)

$0.0210X_1 + 0.0208X_2 + 0.0200X_3 + 0.0191X_4 + 0.0183X_5 \geq 0.0198$ (Fixed Assets Constraint)

$0.0313X_1 + 0.0326X_2 + 0.0182X_3 + 0.0046X_4 + 0.0075X_5 \leq 0.0101$ (Loans Constraint)

$0.0007X_1 + 0.0008X_2 + 0.0008X_3 + 0.0008X_4 + 0.0009X_5 \geq 0.0092$ (Equity Shares Constraint)

$0.5867X_1 + 0.6200X_2 + 0.6223X_3 + 0.5873X_4 + 0.7223X_5 \geq 0.7947$ (Financial statement Managing)

$X_1, X_2, X_3, X_4, X_5 \geq 0$(Non negativity constraints)

Goal Programming Formulation:

Let,d^-_i =the negative deviation variable for under-achieving the ith goal

d^+ = the positive deviation variable for over-achieving the ith goal.

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

The Objective function:

Minimum Z : $2 * P_1(d_1^-)$:Maximize the Revenue $+P_2(d^+)$:Minimize the Expenses $+P_3(d^-_3)$: Maximize the Profitability $+2*P_4(d_4^-)$:Maximize fixed assets $+2*P_5(d^+)$:Minimize the Loans

$*$ $+10\ P_6(d_6^-)$:Maximize the equity share$+P_7(d^-_7)$:Maximize the proportion of the values of the items in the financial statement.

And the respective constraints are

$$0.4711X_1 + 0.4983X_2 + 0.4885X_3 + 0.4923X_4 + 0.6208X_5 + d^-_1 - d^+ = 0.6829$$
$$0.0471X_1 + 0.0511X_2 + 0.0776X_3 + 0.0539X_4 + 0.0564X_5 + d^-_2 - d^+ = 0.0649$$
$$0.0151X_1 + 0.0161X_2 + 0.0171X_3 + 0.0165X_4 + 0.0184X_5 + d^-_3 - d^+ = 0.0199$$
$$0.0210X_1 + 0.0208X_2 + 0.0200X_3 + 0.0191X_4 + 0.0183X_5 + d^-_4 - d^+ = 0.0198$$
$$0.0313X_1 + 0.0326X_2 + 0.0182X_3 + 0.0046X_4 + 0.0075X_5 + d^-_5 - d^+ = 0.0101$$
$$0.0007X_1 + 0.0008X_2 + 0.0008X_3 + 0.0008X_4 + 0.0009X_5 + d^-_6 - d^+ = 0.0092$$
$$0.5867X_1 + 0.6200X_2 + 0.6224X_3 + 0.5874X_4 + 0.7225X_5 + d^-_7 - d^+ = 0.7947$$
$$X_1, X_2, X_3, X_4, X_5, d_1^-, d^+, d^-_2, d^+, d_3^-, d^+, d^-_4, d^+, d_5^-, d^+, d^-_6, d^+, d_7^-, d^+ \geq 0$$

Solution and Discussion of Findings

We got the following values for the variables by solving the problem using *LINGO*18.0 software.

$X_1 = 0.000000$

$X_2 = 0.8272231X10^{-01}$

$X_3 = 0.000000$

$X_4 = 0.2589823$

$X_5 = 0.8282579$

$d^-_1 = 0.000000 \qquad d^+_1 = 0.000000$

$d^-_2 = 0.000000 \qquad d^+_2 = 0.000000$

$d_3^- = 0.000000 \qquad d^+_3 = 0.9449820X10^{-03}$

$d_4^- = 0.000000 \qquad d^+_4 = 0.2024305X10^{-02}$

$d^-_5 = 0.000000 \qquad d^+_5 = 0.000000$

$d_6^- = 0.8181204X10^{-02} \quad d^+_6 = 0.000000$

$d_7^- = 0.000000 \qquad d^+_7 = 0.6938798X10^{-02}$

RESULT AND ANALYSIS

The findings reveal that the value of z is not equal to zero. This means that the optimum solution satisfies the goals P1, P2, P3, P4, P5, P6 and P7 which are Revenue, Expenses, Net Profit, Fixed Assets, Loans, Equity Shares and Financial Managing constraint. We have almost achieved all the goals that have been set, few with negligible deviation. The values of positive deviation and negative deviation for P1 until P7 are as mentioned above. The first priority, P1 is to maximize the total revenue of the organization. The result shows that the value for negative deviation, d^-_1 is zero; and positive deviation, $d^+$is also zero, therefore, the goal is fully achieved. Likewise, the goal of Expenses reduction (P2) is also fully achieved since the both values of d^+ and d^- are zero. For goal 3 (P3), the value of $d_3^-$is zero while the value of d^+ is $0.944982 \quad 10^{-3}$. This shows that the net profit goal (P3) overachieved and the net profit of the organization can be increased by 0.0199 Billion per year. Besides, the goal of maximizing the Fixed Assets (P4) is also achieved since the value of d_4^- is zero and the value of d^+ is $0.2024305X10^{-02}$. This indicates that the fixed assets of the organization can be increased by 0.0198 billion per year. And also, the value of d^+ and d^- is zero, so it can be concluded that minimizing the loans (P5) is achieved. However, the goal 6 (P6) which is maximizing the equity shares is slightly under achieved by the value $d^-_6 = 0.8181204 * 10^{-02}$. This shows that the goal P6 has not been achieved completely whose target value is 0.0092 billion. Lastly, the goal of maximizing the proportion of the values of the items in the financial statement, P7 is also achieved because the value of d_7^- is zero and the value of d^+ is 0.6938798 10^{-02}. This shows that the proportion of the values of the items in the financial statement can be increased by 0.7947 billion per year.

CONCLUSIONS

The Goal Programming appears to be an appropriate, powerful and flexible technique for decision analysis of the troubled modern decision maker who is burdened with achieving multiple conflicting objectives under complex environmental constraints. The modeling approach does not attempt to maximize or minimize the objective function directly as in the case of conventional Linear Programming. Goal Programming model seeks to minimize the deviations between the desired goals and the actual results to be obtained according to the assigned priorities.

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