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GOAL PROGRAMMING – A MULTI-OBJECTIVE DECISION MAKING TOOL

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ABSTRACT

Decision making is a process of selecting the best course of action from among various alternative available. The main aim of decision making is measured by the degree of organizational objectives achieved by the decision. Therefore, the organizational objectives provide the foundation for decision making. Decisions are also constrained by environmental factors such as government regulations, welfare of the public and long-run effects of the decision on environmental conditions. Hence, in order to determine the best course of action, a comprehensive analysis of multiple and often conflicting organizational objectives and environmental factors must be undertaken. Indeed, the most difficult problem in decision analysis is the treatment of multiple conflicting objectives. Goal Programming is a powerful and flexible technique that can be applied to a variety of decision problems involving multiple objectives. It is an important management optimization technique that helps the management in taking crucial and critical business decisions. It should, however, be pointed out that goal programming is by no means a panacea for contemporary decision problems. Goal programming is applicable only under certain specified assumptions and conditions. Most goal programming applications have thus far been limited to well-defined deterministic problems. Moreover, the primary analysis has been limited to the identification of an optimal solution that optimizes goal attainment to the extent possible within specified constraints. In order to develop goal programming as a universal technique for modern decision analysis many refinements and further research are necessary.

***Key Words:** Decision Variables, Deviational Variables, Structural Constraints, Goal Constraints.*

1. INTRODUCTION

Decision making is one of the major duty of the management. Decisions are of two types-tactical and strategic. Tactical decisions have impact on the business in the short-run; whereas, strategic decisions have far reaching effect on the business. Today, effective and timely decisions are crucial for successful management of organizations. The application of quantitative technique is, therefore, becoming more useful. These techniques were found application to industries. In the present scenario, the decision maker has to deal with vast data, number of alternatives and different decision situations before taking any decision. At the same time, the rapid diversification in industries is also adding to the complexity by making organizations multi-objective type. One of the most important and difficult aspects of any decision problem is to achieve an equilibrium among multiple and conflicting interests and objectives of various components of the organization. Many recent researches concerning the future of the industrialized society have echoed the same theme. When the society is based on enormous technological development and change, stability of the system must be obtained by achieving a delicate balance among such multiple objectives as industrial output, food production, pollution control, population growth, and use of natural resources, international co-operation for economic stability, and civil rights and equal opportunity provisions. There is obviously a need for continuous research in the analysis of multiple conflicting objectives. In real life situation, decision making is not an easy task. The decision maker has to come across situations under which he has to take decisions not only under certainty but also under uncertainty, risk, conflict and competition.

Various programming techniques such as linear and integer programming have the shortcoming that their objective function is measured in one dimension only. It is not possible to have multiple goals unless they all are measured in the same units. A new concept has been developed to supplement linear programming is goal programming which is capable of handling decision problems involving multiple goals.

2. CONCEPT OF GOAL PROGRAMMING

Decision making within an organisation is often characterised 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. In today's business environment Profit maximization or cost minimization are not always the only objectives that a firm sets forth. Often maximizing profit or minimizing

total cost is just one of the several goals, including such contradictory objectives as maximizing market share, high quality product, and full employment.

Basically, the method of goal programming consists of formulating an objective function in which optimization comes as close as possible to the specified goals. Hence the formulation of goal programming is similar to that of linear programming model. Here all specified goals are ranked in order of their priority and can be solved by a modified version of simplex method.

Goal programming is an optimization technique to solve problems with multiplicity of objectives, which are generally incommensurable and they often conflict each other in a decision making horizon.

Goal programming is a branch of multi-objective optimization, which in turn is a branch of multi-criteria decision analysis, also known as multiple-criteria decision making. This is an optimization programme. It can be thought of as an extension or generalization of linear programming to handle multiple, normally conflicting objective measures.

3. ORIGIN OF GOAL PROGRAMMING

The goal programming technique was originally introduced by Charnes and Cooper [1961], and further developed by Jaaskelainen [1969], Lee and Bird [1970], Lee [1972] and Ignizio [1976]. Then many researchers such as Kwak and Schniederjans [1979, 1985], Ignizio [1987, 1989], Hallefjord and Jornsten [1988], Reaves and Hedin [1993], Hemaida and Kwak [1994], Bryson [1995], Easton and Rossin [1996] etc., surveyed, case study and applications of goal programming and multiple criteria decision making (MCDM) and concentrate his views for overview of techniques for solving multiple objective mathematical programming problems.

4. FEATURES OF GOAL PROGRAMMING

The key features of goal programming are:

(a) Goals are satisfied in order of priority established by the decision maker.

(b) Goals need not be satisfied exactly but only as close as possible.

5. ASSUMPTIONS AND GENERAL PRINCIPLES OF GOAL PROGRAMMING

(a) ***Additivity***: Additivity assumption implies that the level of penalisation for undesired deviational variables from a target level does not depend on the levels of unwanted deviational variables from the other goals.

(b) ***Proportionality***: Proportionality assumption in the goal programming model requires that the penalisation for an unwanted deviational variable from a target level is directly proportional to the distance away from the target level.

(c) ***Divisibility***: This assumption implies that all the decision variables should be free to take any value within their stated range, i.e., a decision variable cannot be forced to take an integer or a discrete value.

(d) ***Certainty***: This assumption implies that all the data coefficients are known with certainty.

6. METHODOLOGY OF GOAL PROGRAMMING

In goal programming technique, all management goals, whether one or many, are incorporated into the objective function and the only the environmental conditions, i.e., those outside the management's control are treated as constrains. 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 the given multiple and sometimes conflicting goals. In goal programming, management is made to set some estimated targets for each of their goals and to rank them in the order of their priorities or importance. Goal programming starts with the most important goal and continues until the achievement of a less important goal would cause the management to fail to achieve a more important one. In goal programming, each goal enters the problem formulation as an equality constraint which contains slack variables, indicating either under achievement or over achievement of goals. Thus goal programming allows for full or partial achievement of goals. Moreover, multiple goals of management are in conflict or are achievable only at the expense of other goals. Furthermore, these goals are incommensurable. Thus, the solution of the problem requires as establishment of a hierarchy of importance among these incompatible goals so that the low order goals are considered only after the higher order goals are satisfied or have reached the point beyond which no further improvements are desired.

7. APPLICATION OF GOAL PROGRAMMING

Goal programming is applicable in the following areas:

(a) ***Marketing***: Conflicting goals might be maximize market share, minimize advertising cost, maximize profit margin per item sold etc.
(b) ***Inventory control***: Minimize the number of stock-outs, minimize storage cost etc.
(c) ***Production***: Minimize time of manufacture, minimize cost, maximize quality control, maximize resource utilization etc.

8. FORMULATION OF GOAL PROGRAMMING MODELS

Model formulation is the process of transforming a real-world decision problem into a management science model. The formulation of goal programming is similar to that of linear programming model. To do so, all specified goals are ranked in order of their priority. The steps involved in the model formulation of goal programming model include:

(a) ***Identify decision variables and constants***: The first step in model formulation is the definition of choice variables and the right hand side constants. The right hand side constants may be either available resources or specified goal levels. It requires a careful analysis of the problem in order to identify all relevant variables that have some effect on the set of goals stated by the decision maker.
(b) ***Formulate all the objectives or goals of the programme***: For instance, typical goals might include, maximize profit, minimize cost, minimize overtime, minimize machine failure time, maximize utilization of personnel, limited man-power, limited raw-material, limited time, limited budget, and satisfy several legal restrictions.
(c) ***Formulate constraints*:** Through an analysis of the relationships among choice variables and their relationships to the goals, a set of constraints should be formulated. A constraint may be either a system constraint representing a relationship among the variables or a goal constraint that defines the relationship between choice variables and the goals. If further refinement of goals and priorities is required, it may be facilitated by decomposing certain deviational variables.
(d) ***Reduce the number of goals:*** Reduce the number of goals by eliminating of few negligibly important or redundant goals.
(e) ***Establish the objective function:*** Through the analysis of the decision maker's goals structure, the objective function must be developed.

Two types of variables will be a part of any model formulation – ***decision variables*** and ***deviational variables***. Similarly two classes of constraints exist in a goal programming model – ***structural constraints***, which are generally considered environmental constraints not directly related to goals and ***goal constraints***, which are directly related to goals.

9. SINGLE GOAL MODELS

A model in which the deviational variables associated with a single goal is incorporated into the objective function.

10. MULTIPLE GOAL MODELS

In multiple goal models, three types of models exist: multi-goal with equal or no priorities, multi-goal with priorities and multi-goal with priorities and weights.

10.1 Multiple Goals with Equal or No Priorities

A model in which deviational variables from more than one goals are incorporated into the objective function; all variables take on the same priority level.

10.2 Multiple Goals with Priorities

A model in which deviational variables from more than one goal are incorporated into the objective function; all variables are assigned a priority coefficient (P) which reflects the preferential ordering of the goals.

10.3 Multiple Goals with Priorities and Weights

A multiple goal priority model in which differential weights are employed in one or more priority levels to differentiate goal preference within the level.

11. PRE-EMPTIVE GOAL PROGRAMMING MODEL AND ARCHIMEDEAN GOAL PROGRAMMING MODEL

In goal programming there are two basic models: the pre–emptive model and the Archimedean model. In the pre–emptive model, goals are ordered according to priorities. The goals at a certain priority level are considered to be infinitely more important than the goals at the next level. Here the more important (upper

level) goals are optimised before lower level goals are considered. In pre-emptive goal programming, the user is able to provide levels, or targets, of achievement for each objective and prioritises the order. In this case, goals are ranked from most important to least important. Initially steps are taken to satisfy the most important goal. Then amongst all the solutions that satisfy the first goal, then try to come as close as possible to satisfying the second goal. Continue in this fashion until the only way that comes closer to satisfying a goal is to increase the deviation from a higher priority goal. With the Archimedean model, weights or penalties for not achieving targets must be specified and one attempts to minimize the weighted sum of goal under–achievement.

12. GRAPHICAL METHOD OF GOAL PROGRAMMING

The graphical method of solving goal programming problem is quite similar to the graphical method of linear programming. In linear programming, the method is used to maximize or minimize an objective function with one goal; whereas in goal programming, it is used to minimize the total deviation from a set of multiple goals. The deviation from the goal with the highest priority is minimized to the fullest extent possible before deviation from the next goal is minimized. The graphical presentation involves the following procedures:

(a) Formulate the appropriate goal programming problem
(b) Graph or plot all structural constraints and identify the feasible region
(c) Graph the lines corresponding to the goal constraints
(d) Identify the top-priority solution
(e) Move to the goal having the next highest priority and determine the best solution(s)
(f) Repeat step(e) until all priority levels have been investigated
(g) Identify the optimal solution which correspond to the most acceptable best value.

13. SIMPLEX METHOD OF GOAL PROGRAMMING

The purpose of presenting goal programming algorithm is to provide a table procedure that will handle problems with more than two decision variables. The table can be used to determine when specific goals are achieved and what trade-offs occurred in achieving the goals. The standard simplex method (modified) can be used to solve goal programming problem. Following steps are employed in the goal programming algorithm.

(a) Establish the initial simplex table

(b) Check for optimality

(c) Determine the new entering variable

(d) Determine the departing variable

(e) Develop new table

(f) Evaluate the next lowest priority goals(s)

14. CONCLUSION

Goal programming is relatively a new technique; its true potential is yet to be determined. However, it appears that the potential applicability of goal programming may be as wide as that of linear programming. Goal programming is a mathematical technique which treats the constraints of the linear programming problem as goals in the objective function. Optimization means coming "as close as possible" to achieve these goals in order of priority, as specified by the decision maker. It is applicable to single or multiple goals, although its greatest usefulness occurs when the multiple goals are conflicting and cannot all be satisfied simultaneously. Goal programming has a great deal of flexibility that is lacking in linear programming. Furthermore, the approach of multiple-goal attainment according to their priorities is readily suitable to most management decision problems. Thus goal programming is one of the mathematical tools, designed in context of solving the multi-objective problems in different areas for taking the efficient, timely and accurate decision. The various researches have been made so far and the researchers have been continually exploring this field for more than five decades and even today the process is on to gets a lucid picture of this tool attributing to clearly understanding the meaning of this technique in the perspective of problem solving relating to industry.

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