GOAL PROGRAMMING FOR DECISION ANALYSIS OF MULTIPLE OBJECTIVES

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I. Introduction

It is only in the past twenty to thirty years the scientific decision analysis has emerged as an important area of management. Some leading authorities of management theory have gone so far as to define decision analysis as synonymous with management(18).

Increased emphasis on decision analysis is the result of the aggregate effects of advances in technology, the ever-increasing complexity of environment, and the improved capability of decision makers. In an attempt to improve rationality in decision making, greater emphasis has been placed on techniques which would provide more concrete information about the decision environment and the outcomes of action. Hence, the trend of decision making has developed toward the quantitative and computer-oriented approaches. Decision analysis has become an analytical process which employs modern

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scientific method and systematic investigation to aid the decision maker in identifying the optimum course of action.

Modern decision technology does not completely relpace the intuitive decision making approach which has been widely practiced in the past and even today. The intuitive approach is based upon the experience of the decistion maker who has become known for his decision making abilities. He has a general awareness of the situation and he has some personal insights about the future outcomes. With or without scientific decision analysis, a decision maker usually exercises some degree of personal judgment in the final choice making. Modern decision analysis, therefore. should be intended to enrich and sharpen the judgment of the decision maker.

The primary difficulty in modern decision analysis is the treatment of multiple conflicting objectives. The question becomes one of value trades in the social structure of conflicting interests. It is indeed extremely difficult to answer questions such as what should be done now, what can be deferred, what alternatives are to be explored, and what should be the priority structure. A formal decision analysis which is capable of handling multiple conflicting objectives through the use of priorities may be a new frontier of management technology. This article explores the goal programming approach for decision analysis of multiple conflicting objectives under complex environmental constraints.

II. Modern Decision Analysis

The traditional concept of "economic man" not only postulates that he is "economic" and "rational" but also suggests that he is the "optimizer." The economic man is assumed to be one who strives to allocate his scarce resources in the most economic manner. He is assumed to possess the knowledge of the relevant aspects of decision environment, a stable system of preference, and the skill to analyze the alternative courses of action. However, recent developments in the theory of firm have raised a serious question as to whether such assumptions of economic man can be applied by the decision maker in an organization in any realistic sense.

For an individual to be perfectly rational in decision analysis, he must be capable of attaching a definite preference to each possible outcome of the alternative courses of action. Furthermore, he should be able to specify the exact outcomes by employing scientific analysis. According to broad empirical investigation, however, there is no evidence that any one individual is capable of performing such exact analysis for a complex decision problem. Moreover, there is considerable doubt that the individual's value system is exactly identical to that of the firm for the determination of what is best for the organization.

As an optimizer, the primary role of economic man is assumed to be maximization of profits. If this were the situation in reality, decision analysis would not be such a difficult task. In reality, the decision maker may have only a vague idea, if even that, as to what is the best outcome for the organization in a global sense. Furthermore, he is often quite incapable of identifying the optimum choice due to either his lack of analytical ability or the complexity of the organizational environment. There is an abundance of evidence which suggests that the practice of decision making is affected by the epistemological assumptions of the individual who makes the decision (1). Indeed, the practice of scientific methodology and rational choice are not always directly applicable to decision analysis. The decision maker is constantly concerned with his environment, and he always relates possible decision outcomes and their consequences to the environment with its unique conditions. Stated differently, the decisionmaker is extremely concious of the implications of the decision to his surroundings rather than simply considering isolated economic payoffs. This concern with the environmental context of the decision prompts a variety of modifications which further removes him from the classical concept of economic man.

The concept of the individual profit maximizer in classical economic theory does not sufficiently provide either a descriptive or normative model for the decision maker in an organization(1). To be sure, the concept of profit is difficult, if not all but impossible, to define. Even when it is defined, it is extremely difficult to measure profit. Another problem is that there exists a considerable degree of varied opinion about the objectives of an organization. One study, which investigated the goal structures of twenty-five corporations as described by the top management revealed a wide range of political, social, economic, and ethical aspects which portrayed an image quite different from the economic man(16). The items most frequently stated as the primary goal of the corporation were as follows:

Primary Objective	Frequency
Personnel	21
Duties and responsibility to society in general	19
The consumer needs	19
Stockholders interests	16
Profit	13
Quality of product	11
Technological Progress	9
Supplier relations	9
Corporate growth	8
Managerial efficiency	7
Duties to government	4
Distributors relations	4
Prestige	2
Religion as an explicit guide in business	1

It appears that in reality the decision maker is one who attempts to attain a set of multiple objectives to the fullest possible extent in an environment of conflicting interests, incomplete information, limited resources, and limited ability to analyze the complex environment. Such an attempt necessitates modern decision analysis so that the decision maker may strive toward the concept of economic man within the given environmental constraints. In this context, a management theorist has suggested that in today's complex organizational environment the economic man is not trying to maximize, instead he trys to satisfice(17).

In addition to the above discussed realities, organizational structure based on reward-punishment relationship and the bureaucratic process further complicates decision analysis. It is not only the welfare of the organization that is important, but the welfare of the decision maker himself and others within the organization also becomes critical decision constraints. Especially in organizations of the public sector, decision making of an official has profound impact upon the lives of many people. The official must make a decision although he may not even know what is "good" for the people. In fact, quite possibly the people themselves may not know what is "good" for them. There is no protection against the enormous complexities of the society. As a society, therefore, we have learned to appreciate statistics and numbers in order to analyze the preference and desires of the mass. Modern decision analysis attempts to assist the decision maker to introduce rationality in the analysis of alternatives in order to achieve multiple conflicting objectives.

III. Analysis of Multiple Objectives

Organizational objectives vary according to the character, type, philosophy of management, and particular environmental conditions of the organization. There is no single universal goal for all organizations. Profit maximization, which is regarded as the sole objective of the business firm in the classical economic theory, is one of the most widely accepted objectives of management. As reviewed above, in today's dynamic business environment, profit maximization is not always the only objective of management. In fact business firms quite frequently place higher priorities on non-economic goals than on profit maximization. Or, firms often seek profit maximization while pursuing other non-economic objectives. We have seen, for example, firms place a great emphasis on social responsibilities, social contributions, public relations, industrial and labor relations, etc. Whether such objects are sought because of outside pressure or voluntary management decisions, non-economic objectives exist and they are gaining a greater significance. The recent public awareness of the need for ecology management and the gaining momentum of consumerism may have forced many firms to reevaluate their organizational objectives.

The problem of multiple conflicting objectives is much more real and apparent in the public sector and non-profit organizations. Suppose the government is studying the feasibility of constructing a new airport in Washington, D.C. Here, there are many conflicting objectives and interests. The study must consider the capacity of the airport, accessibility of the location, traffic flow planning, architectural style for the national prestige, noise level for the nearby residents, conservation of natural life in the area, etc.

Many of the formal solution techniques we have used for decision analysis have been primarily concerned with making the "right" choice among a set of alternatives. In other words, the basic problem has been selecting the "superior" over "inferior" alternatives. However, the nature of major decision problems has changed drastically in recent years and a serious doubt has been raised as to the adequacy of many solution techniques for contemporary problems. Many of today's decision problems that require scientific analysis do not lend themselves to a clear-cut solution by certain cardinal criteria. For example, many social problems involve multiple incompatible objectives in the jungle of conflicting interests. The question is not that of selecting the "social good" over "social evil," but it is often the choice problem between social evil vs. social evil or social good vs. social good.

Let us consider the example of strip mining controversy. In this day of environmental concern, any sensible person, not necessarily a naturalist or conservationist, can easily enumerate many of the problems involved in strip mining. However, we should not forget the increasing energy demands in the United States. It is estimated that the national energy demand will double by 1980. With the rapidly diminishing natural gas reserves and the remote possibility of sufficient nuclear energy production for the total energy demand, increased coal production is an important national concern. We simply cannot affort the luxury of deciding whether we should or should not mine coal. Rather, the decision problem is that of determining the most efficient way to mine coal, i.e., by conventional underground mining, strip mining, or some combination of both methods. Both methods of mining contribute to social problems. Strip mining, although it is in most cases the more economical method of producing coal, involves many ecological problems. On the other hand, conventional underground mining creates health problems for workers, i.e., black-lung disease, the constant danger, working in a cramped space, etc. Should we say, then, that strip mining ought to be banned altogether to preserve the environment? That implies that we would rather allow greater danger to miners working underground to satisfy the greater demend for coal. At least one thing is certain. Unless a new technological breakthrough is realized, the national demand for coal has to be met in some way. In satisfying this demand, there are multiple conflicting objectives and interests.

The point of this discussion in that problems involving multiple objectives cannot easily be solved by traditional numerical analysis. Many contemporary decision problems faced by industry, government, and other institutions will increasingly require identification of more elusive and abstract objective functions. The objective function no longer will be restricted to a cardinal criterion; rather it will involve general criteria related to the common good.. Certainly, costs will remain to be important decision variable because it determines the resource requirements. However, its function will be shifted from that of the objective function to a decision constraint.

The question still remains as to whether we can use the conventional numerical objective function approach (e.g. linear programming) for today's complex decision problems. It is apparent that solution methods based on numerical criteria are not capable of producing acceptable solutions to problems that involve highly abstract objective criteria such as welfare to the taxpayer, public health, consumer protection and satisfaction, community image of the firm, etc. It should be pointed out that numerical solution techniques are still being used for contemporary decision problems by estimating the numerical measures of abstract objective criteria in terms of a convenient numerical value, i.e., utilities, profits, costs, etc. However, the process often results in a considerable degree of fabrication and distortion of information in order to express abstract criteria in numerical values (8). Hence, the model solution is of very little value to the decision maker. The only alternate method to the numerical approach for problems involving multiple conflicting objective criteria is the ordinal solution approach. Goal programming based on the ordinal solution approach appears to be the most appropriate, flexible, and powerful technique for complex decision problems involving multiple conflicting objectives.

IV. Goal Programming Approach

Goal programming is a special extension of linear programming. Goal programming is capable of handling a decision problem with a single goal and multiple subgoals, as well as a problem with multiple goals and multiple subgoals (2, 7, 9). Often goals set by management are achievable only at the expense of other goals. Furthermore, these goals are incommensurable. Thus, there is a need to establish a hierarchy of importance among these conflicting goals so that low order goals are considered only after the higher order goals are satisfied or have reached the point beyond which no further improvements are desirable. If management can provide an ordinal ranking of goals in terms of their contributions or importance to the organization and all relationships of the model are linear, the problem can be solved by goal programming.

In goal programming, instead of trying to maximize or minimize the objective criterion directly, as in linear programming, the deviations between goals and what can be achieved within the given set of constraints are to be minimized. In the simplex algorithm of linear programming, such deviations are called "slack" variables. These deviational variables take on a new significance in goal programming. The deviational variable is represented in two dimensions, both positive and negative deviations from each sub-goal or goal. Then, the objective function becomes the minimization of these deviations, based on the relative importance or priority assigned to them. In other words, the objective function is comprised of only these deviational variables.

The solution of any linear programming problem is limited by quantification. Unless management can accurately quantify the relationship of the variables in cardinal numbers, the solution is only as good as the inputs if it is that good. The distinguishing characteristic of goal programming is that it allows for an ordinal solution. Stated differently, management may be unable to obtain information on the cost or value of a goal or a subgoal, but often upper or lower limits may be stated for each subgoal. Usually the manager can determine the priority of the desired attainment of each goal or subgoal and rank the priorities in ordinal sequence. Economically speaking, the manager faces the problem of the allocation of scarce resources. Obviously, it is not always possible to achieve every goal to the extent desired by management. Thus, with or without goal programming the manager attaches a certain priority to the achievement of a particular goal. The true value of goal programming is, therefore, its contribution to the solution of problems involving multiple, conflicting goals according to the manager's priority structure.

The general goal programming model can be mathematically expressed as

(7):

$$\text{Minimize } Z=\sum_{i=1}^{m}(d_i^+ + d_i^-)$$

$$\text{subject to } Ax-Id^+ + Id^- = b$$

$$x,d^+,d^- \geq 0$$

where m goals are expressed by an m component column vector $(b_1,b_2, \cdots\cdots, bm)$, A is an $m \times n$ matrix which expresses the relationship between goals and subgoals, x represents variables involved in the subgoals$(x_1,x_2, \cdots\cdots x_n)$, d^+ and d^- are m component vectors for the variable representing deviations from goals, and I is an identity matrix in m dimensions.

The manager must analyze each one of the m goals considered in the model in terms of whether over or underachievement of the goal is satisfactory. If overachievement is acceptable, d_i^+ can be eliminated from the objective function. On the other hand, if underachievement is satisfactory, d_i^- should not be included in the objective function. If the exact achievement of the goal is desired, both d_i^- must be represented in the objective function.

The deviational variables d_i^+ and d_i^- must be ranked according to their priorities, from the most important to the least important. In this way the low order goals are considered only after the higher order goals are achieved as desired. If goals are classified in k ranks, the priority factor $P_j(j=1,2, \cdots\cdots, k)$ should be assigned to the deviational variables, d_i^+ and d_i^-. The priority factors have the relationship of $P_j >>> P_{j+1}(j=1,2,\cdots\cdots,k)$, which implies that the multiplication of n, however large it may be, cannot make P_{j+1} greater than or equal to P_j. Of course, it is possible to refine goals even further by decomposing the deviational variables. To do this, additional and constraints and additional priority factors are required.

One more step in the procedure to be considered is the weighting of those deviational variables at the same priority level, i.e., variables with the same P_j coefficient. The criterion to be used here is the minimization of the opportunity cost or regret. This implies that the coefficient of regret σ_i, which is positive, must be assigned to the individual deviational variables on the same goal level. The coefficient σ_i simply represents the relative amount of unsatisfactory deviation from the goal. Therefore, deviational variables on the same goal level must be commensurable, although deviations which are on different goal levels need not be commensurable.

V. An Illustration of Goal Programming Solution

In order to illustrate how goal programming can be applied to decision problems with multiple conflicting goals, let us examine the following simple example.

The American Electronics, Inc. produces the most sophisticated color television sets. The company has two production lines. The production rate for line 1 is 2 sets per hour and for line 2 it is 1.5 sets per hour. The regular production capacity is 40 hours a week for both lines. The gross profit from an average T.V. set is $100. The president of the firm has the the following goals for the next week in ordinal ranking.

(A) Meet the production goal of 180 sets for the week. This can be expressed

$2x_1+1.5x_2+d_i^- - d_i^+ = 180$

where, x_1: operation hours of line 1

x_2: operation hours of line 2

d_i^-: underachievement of production goal

d_i^+: production in excess of 180 sets

(B) Limit the overtime operation of line 1 to 5 hours. The regular operation hours can be expressed as:

$x_1+d_2^- - d_2^+ = 40$

$x_2+d_3^- - d_3^+ = 40$

where, d_2^-: underutilization of regular operation hours line 1

d_2^+: overtime operation in line 1

d_3^-: underutilization of regular operation hours line 2

d_3^+: overtime operation in line 2

Thus, the limitation of overatime operation of line 1 to 5 hours will be:

$d_2^+ + d_{21}^- - d_{21}^+ = 5$

where, d_{21}^-: deviation between 5 hours of overtime and actual overtime

d_{21}^+: overtime operation of line 1 beyond 5 hours.

(C) Avoid the underutilization of regular working hours for both lines. Differential weights should be assigned according to the production rate of each line.

(D) Limit the sun of overtime operation for both teams. Again, differential weights should be assigned according to the relative cost of overtime hour. It is assumed that the cost of operation is identical for the two production lines.

Before the complete model is formulated, there are a couple of points to be considered. First, the third goal implies that the company has a policy of no involuntary lay-offs. This may be because the plant is unionized and the contract prohibits any lay-off, or it may be the policy of the organization. Since the productivity of line 1 is 2 sets per hour, whereas it is only 1.5 for line 2, the president wishes to avoid the underutilization of regular working hours of line 1 a great deal more than line 2. The ratio will be 2 for d_2^- and 1.5 for d_3^-, or if we wish to assign integers, 4 to 3 to d_3^-. The next point to be considered is the fourth goal. The criterion to use for the differential weights is the relative cost of overtime. The prodution rates ratio for lines are 2 to 1.5. Therefore, the relative cost involved with an hour of overtime for line 2 is greater than that of line 1. The relative cost of overtime ratio for two lines will be 3 to 4.

Now, the goal programming model can be formulated.

$$\text{Min. } Z = P_1 d_1^- + P_2 d_{21}^+ + 4P_3 d_3^- + 3P_3 d_3^- + 4P_4 d_3^+ + 3P_4 d_2^+$$

$$\text{subject to} \quad 2x_1 + 1.5x_2 + d_1^- \qquad - d_1^+ \qquad = 180$$

$$x_1 \qquad + d_2^- \qquad - d_2^+ \qquad = 40$$

$$x_2 \qquad +d_3^- \qquad -d_3^+ \qquad =40$$
$$d_{21}^- + d_2^+ - d_{21}^+ \qquad = 5$$
$$x_1, x_2, d_1^-, d_2^-, d_3^-, d_{21}^-, \ d_1^+, d_2^+, d_3^+, d_{21}^+ \geq 0$$

Now, let us solve the above problem by a modified simplex method.(1) Since the goal programming model is a minimization problem, the simplex criterion will be $Z_j - C_j$. Here, C_j is a set of priority factors assigned to various deviational variables. Hence, $Z_j - C_j$ is a matrix rather than row as in linear programming. $Z_j - C_j$ values represent the degree of goal attainment associated with a unit of each variable. The optimum column must be identified according to the $Z_j - C_j$ value on the highest priority level P_1. For example in the first tableau in Table 1, the optimum column can be identified as x_1, as its $Z_j - C_j$ is the greatest at P_1 level. When no further improvements are possible at P_1 level(4th tableau), then P_2 level is examined, and so on. For those who are familiar with linear programming, it shouldn't

<Table 1> Simplex Solution of the Goal Programming Problem

C_j					P_1	$4P_3$	$3P_3$			$3P_4$	$4P_4$	P_2
	V	C	X_1	X_2	d_1^-	d_2^-	d_3^-	d_{21}^-	d_1^+	d_2^+	d_3^+	d_{21}^+
P_1	d_1^-	180	2	3/2	1				−1			
$4P_3$	d_2^-	40	1			1				−1		
$3P_3$	d_3^-	40		1			1				−1	
0	d_{21}^-	5						1		1		−1
	P_4	0								−3	−4	
$Z_j - C_j$	P_3	280	4	3						−4	−3	
	P_2	0										−1
	P_1	180	2	3/2					−1			
P_1	d_1^-	100		3/2	1	−2			−1	2		
0	X_1	40	1			1				−1		
$3P_3$	d_3^-	40		1			1				−1	
0	d_{21}^-	5						1		1		−1
	P_4	0								−3	−4	
$Z_j - C_j$	P_3	120		3		−4					−3	
	P_2	0										−1
	P_1	100		3/2		−2			−1	2		

(1) For a more detailed explanation of goal programming solution techniques, see(8).

C_j					P_1	$4P_3$	$4P_3$			$3P_4$	$4P_4$	P_2
	V	C	X_1	X_2	d_1^-	d_2^-	d_3^-	d_{21}^-	d_1^+	d_2^+	d_3^+	d_{21}^+
P_1	d_1^-	90		3/2	1	−2		−2	−1			2
0	X_1	45	1			1		1				−1
$3P_3$	d_3^-	40		1			1				−1	
$3P_4$	d_2^+	5						1		1		−1
Z_j-C_j	P_4	15						3			−4	−3
	P_3	120		3		−4					−3	
	P_2	0										−1
	P_1	90		3/2		−2		−2	−1			2
P_2	d_{21}^+	45		3/4	1/2	−1		−1	−1/2			1
0	X_1	90	1	3/4	1/2				−1/2			
$3P_3$	d_3^-	40		1			1				−1	
$3P_4$	d_2^+	50		3/4	1/2	−1			1/2	1		
Z_j-C_j	P_4	150		9/4	3/2	−3			−3/2		−4	
	P_3	120		3		−4					−3	
	P_2	45		3/4	1/2	−1		−1	−1/2			
	P_1	0			−1							
P_2	d_{21}^+	15			1/2	−1	−3/4	−1	−1/2		3/4	1
0	X_1	60	1		1/2		−3/4		−1/2		3/4	
0	X_2	40		1			1				−1	
$3P_4$	d_2^+	20			1/2	−1	−3/4		−1/2	1	3/4	
Z_j-C_j	P_4	60			3/2	−3	−9/4		−3/2		−7/4	
	P_3	0				−4	−3					
	P_2	15			1/2	−1	−3/4	−1	−1/2		3/4	
	P_1	0			−1							
$4P_4$	d_3^+	20			2/3	−4/3	−1	−4/3	−1/3		1	4/3
0	X_1	45	1			1		1	−1/4			−1
0	X_2	60		1	2/3	−4/3		−4/3	−1/3			4/3
$3P_4$	d_2^+	5						1	−1/4	1		−1
Z_j-C_j	P_4	95			8/3	−16/3	−4	−7/3	−25/12			7/3
	P_3	0				−3	−3					
	P_2	0										−1
	P_1	0			−1							

be difficult to follow the solution procedure presented in Table 1. It should be noted, however, that as long as there exists a negative value at a higher priority level in the same column, a positive Z_j-C_j value at a lower priority level cannot be introduced into the solution. The reason for this logic is very simple. When there exists a negative $Z_j - C_j$ value, it implies that if the variable in the column is introduced into the solution the degree of goal achievement at that priority level will be decreased. If a variable is introduced into the solution base because there exists a positive $Z_j - C_j$ value at a priority level despite the fact that there is a negative $Z_j - C_j$ at a higher priority level, it will result in a greater attainment of a goal at the expense of a more important goal. Table 1 indicates that the fifth iteration presents the optimum solution to the problem.

VI. Application Areas of Goal Programming

An important property of goal programming is its capability to handle managerial problems which involve multiple incompatible goals according to the assigned importance of the goals. If management is capable of establishing ordinal importance of goals in a linear decision system, the goal programming model provides management with a method to analyze the soundness of their goal structure. In general, a goal programming model permits performance of three types of analysis: (1) it determines the input requirements to achieve a set of goals; (2) it determines the degree of attainment of defined goals with given resources; and (3) it provides the optimum solution under the varying inputs and goal structures. The most important advantage of goal programming is its great flexibility which allows model simulation with numerous variations of constraints and goal priorities.

Every quantitative technique has some limitations. Some of these are inherent to all quantitative tools and some are attributable to the particular characteristics of the technique. The most important limitation of goal programming belongs to the first category. The goal programming model simply provides the best solution under the given set of constraints and priority structure. The refore, if the decision maker's goal priorities are not in accordance with the organizational objectives the solution will not be the global optimum for the organization. A clear understanding of its assumptions and limitations is essential to effective application of any mathematical model. Goal programming is no exception to this prerequisite. The application of goal programming for managerial decision analysis forces the decision maker to think of goals and constraints in terms of their importance to the organization.

Goal programming can be applied to almost unlimited managerial and administrative decision areas. The following three are the most readil applicable areas of goal programming.

(1) Allocation Problems

One of the basic decision problems is the optimum allocation of scarce resources. Let us assume that there are n different input resources which are limited to certain quantities and there are m different type of outputs which result from various combinations of the resources. The decision problem is to determine the optimum combination of input resources to achieve certain goals set for outputs so that the total goal attainment can be maximized for the organization. A goal programming approach has been applied to the resource allocation problems in non-profit institutions (10, 15).

The study analyzes the resource requirements and actual allocation in order to achieve the administrative goals of the organization. Also, goal programming has been applied to the sales effort allocation problem in the marketing area (13).

(2) Planning and Scheduling Problems

Many decision problems involve some degree of planning and/or scheduling. In order to achieve certain goals in the future, decisions must be made concerning present and future actions to be taken. To accomplish desired outputs, the optimum combination of inputs in certain time period must be identified. These inputs may include manpower, materials, time, production capacity, technology, etc. Many problems such as production scheduling, location determination, financial planning, personnel planning, marketing strategy planning, etc. can be analyzed by goal programming.

Goal programming has also been applied to media planning (3,4), manpower planning(5), aggregate production scheduling(12), financial planning (14), and location determination (6).

(3) Policy Analysis

For government agencies and non-profit organizations, the basic decision problem involves the assignment of priorities to various goals and development of programs to achieve these goals. Such a decision process constitutes the policy analysis of the organization. Through the application of goal programming the organization is able to ascertain the soundness of its policies, input requirements for achievement of set goals, and the degree of goal attainment with the given resources(11). This review and evaluation process is an integral part of the policy analysis. Therefore, goal programming is particularly well suited for decision analysis in the public and non-profit organizations.

Here we have discussed but three apparent application areas of goal programming. No single list could possibly exhaus all the potential application fields of goal programming. Goal programming can be utilized in those areas where linear programming has been extensively applied. The real value of goal programming is realized for complex decision problems which involve multiple incompatible goals in multiple dimensions.

VI. Conclusion

Virtually all models developed for managerial decision analysis have neglected or often ignored the unique organizational environment, bureaucratic decision process, and multiple conflicting nature of organizational objectives. However, in reality these are important factors that greatly influence the decision process. In this paper, the goal programming approach is presented as a tool for the optimization of multiple objectives while permitting an explicit consideration of the existing decision environment.

Developing and solving the goal programming model points out where some goals cannot be achieved under the desired policy and, hence, where tradeoff must occur due to limited resources. Furthermore, the model allows the decision maker to review critically the priority structure in view of the solution derived by the model.

The goal programming approach is not the ultimate solution for all managerial decision problems. It requires that the decision maker be capable of defining, quantifying, and ordering objectives. The goal programming model simply provides the best solution under the given constraints and priority structure of goals. Therefore, some research questions concerning the identification, definition, and ranking of goals still remain. There is the need for future research to develop a systematic methodology to generate such information.

This paper has discussed the problem of decision analysis for multiple conflicting objectives. Analysis of multiple objectives is the new frontier of management decision analysis, and goal programming appears to be the most promising technique for such analysis.

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