American Journal of Operational Research 2020, 10(3): 45-48
DOI: 10.5923/j.ajor.20201003.01

Improved Multi Goal Programming Technique

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Abstract Multi Goal Programming (MGP) is an extension of Goal Programming used for achieving multiple conflicting goals simultaneously. Several MGP techniques have been developed and used for solving multi goal optimization problems during last three decades. These MGP techniques are based on minimization of sum of deviations between goals and their achievements. For the incommensurate goals, the summing these deviations seems illogical. This problem has been resolved in the proposed an improved MGP technique for solving MGP problems. The results of solving two examples by these technique have shown the superiority of the Improved MGP technique.

Keywords Goal Programming, Single Goal Programming, Multi Goal Programming

1. Introduction

Multi Goal Programming is a technique often used to find a compromised solution in achieving multiple conflicting goals. MGP was introduced by Charnes and Cooper [1] and further extended by Ignizio [2], Tamiz, Jones, and Romero [5], and Romero [6]. Weighted Sum Goal Programming (WSMGP) and Preemptive Goal Programming (PGP) techniques have been popularly used by Ajayi-Daniels [14], Kanan, Acharya and Acharya [10] and Qahtani, El–Hefnawy, El–Ashram, and Fayomi [13] for solving multi goal programming problems. Dave, Abha [8] and Cinthia [9] suggested the application of multi goal programming for managing agriculture efficiently. A sustainable development plan for India was prepared using MGP by Gupta, Fügenschuh and Ali [11]. Mohammadiana, Babaeia, Jarrahi, and Anjomrouzb [12] used MGP for scheduling the nurse shifts in a hospital for improving the efficiency of the nursing services to the patients. Goal programming technique was applied to determine the optimal number of students to be enrolled in different disciplines by Rashid, Halim and Hassan [15]. Ojo, Farayibi and Akinnuli [16] used multi goal programming for procurement of various equipments in a manufacturing industry. Priyadharshini and Anju [17] applied the goal programming for solving the transport problem. A Several variants of multi goal programming have also been proposed in the past three decades. However, proper attention has not been given to the conceptual framework of the techniques. Few methodological issues of MGP and weight sum multi goal programming (WSMGP} have been discussed in the limited studies by Min, and Storbeck [3], Rifai [4], Orumie, and Ebong [7]. The present study points out a few weaknesses in the basic structure of MGP/WSMGP techniques and proposes an improved technique for generating appropriate solutions.

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Received: Sep. 23, 2020; Accepted: Oct. 6, 2020; Published: Oct. 15, 2020
Published online at http://journal.sapub.org/ajor

2. Methodologies to Solve MGP Problems

2.1. Existing MGP Model

The existing multi goal programming model can be expressed as:

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

Subject to:

Goal Constraints

$$\sum_{j=1}^{n} a_{ij} X_j - d_i^+ + d_i^- = g_{i,} \quad for\ i = 1 \ldots . m$$

System constraints

$$\sum_{j=1}^{n} a_{ij} X_j = b_{i,} \quad for\ i = m+1 \ldots \ldots p$$

There are 'm' Goals, 'p' System constraints and 'n' decision variables

Z= Objective function/ Summation of all deviations

a_{ij}= the coefficient associated with j^{th} variable in i^{th} Goal/constraint

X_j= the j^{th} decision variable

g_i = the right hand side value of i^{th} goal

b_i= the right hand side value of i^{th} constraint

d_i^-= negative deviational variation from i^{th} goal (under achievement)

d_i^+= positive deviational variation from i^{th} goal (over

achievement)

2.2. Misconceptions in the Existing MGP Model

a. The MGP models help the decision-maker to obtain an appropriate solution for achieving multiple goals. Often multiple goals are conflicting and are achievable only at the expense of other goal/s. The goals may be incommensurable. The summation and subtraction of deviations of multi dimensional values seems not logical.
b. In the presence of high deviations in the coefficients of decision variables of different goals, the MGP solution may be biased towards the goal/s with higher values of coefficients.

3. Improved MGP Model

The abovementioned problems can be resolved by scalarizing the objective function as described below. This makes the deviations free of dimensions.

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

Subject to:
Goal Constraints

$$\sum_{j=1}^{n} a_{ij} X_j - d_i^+ + d_i^- = g_i \quad for\ i = 1 \ldots . m$$

System constraints

$$\sum_{j=1}^{n} a_{ij} X_j = b_{i,} \quad for\ i = m+1 \ldots \ldots p$$

The above techniques have been used to solve the following examples.

4. Examples

Two examples have been solved using existing and Improved MGP.

Example 1

Goal-I: $16500X_1 + 18100X_2 + 15800X_3 + 17400X_4 + 14800X_5 = 73000$
Goal-II: $41X_1 + 35X_2 + 32X_3 + 39X_4 + 31X_5 = 165$
Goal-III: $430X_1 + 470X_2 + 380X_3 + 410X_4 + 440X_5 = 1500$
Goal-IV: $2300X_1 + 2400X_2 + 2100X_3 + 1900X_4 + 1800X_5 = 7000$
Subject to:
$X_1 + X_2 + X_3 + X_4 + X_5 = 4$
$2X_3 \geq 1$
$X_1, X_2, X_3, X_4, X_5 \geq 0$

Example 2

Goal-I: $6X_1 + 5X_2 + 3X_3 + 4X_4 = 55$
Goal-II: $700X_1 + 800X_2 + 900X_3 + 500X_4 = 9000$
Goal-III: $50X_1 + 55X_2 + 40X_3 + 60X_4 = 600$
Subject to:
$X_1 + X_2 + X_3 + X_4 = 11$
$X_1 \geq 1$
$2X_3 \geq 1$
$X_1, X_2, X_3, X_4 \geq 0$

5. Solution

Example 1 has been solved using single as well as MGP techniques. The results are presented in Table 1. All four solutions of single goal optimization are quite different. Each solution achieves one goal only and ignores the remaining three goals. The first solution achieves the first goal up to 71250 which seems superior to the remaining three goal achievements. The value of the second goal achieved was 159.50 which was close to its goal of 165. Similar results have been obtained in the achievements of third and fourth goals. The results of existing and improved MGP techniques are presented in the last two columns of Table 1.

The solution of the existing MGP technique is the same as the first solution of the single goal programming technique. This is due to larger values of the coefficients of decision variables of the first objective function. Similar problems may be noticed with the goals of different dimensions. However the improved MGP technique generated the solution that achieves all the goals simultaneously. The value of the first goal achievement is 68800 which is less than the single goal achievement of 71250 but superior over the remaining three single goal optimizations. The achievements of the remaining three goals were also compromising and acceptable. This reveals the superiority of improved MGP over the existing MGP technique.

Table 1. Goal Achievements in Single and Multi-Goal Programming

Goals		Single Goal Programming				Multi-Goal Programming	
		I	II	III	IV	Existing MGP	Improved MGP
X_i		0, 3.5, 0.5, 0,0	3.5, 0, 0.5,0,0	0, 0, 4, 0, 0	0,0,0.5,0, 3.5	0, 3.5, 0.5, 0, 0	0, 0, 0.5, 3.5,0
I	73000	71250	65650	63200	59700	71250	68800
II	165	138.5	159.5	128	124.5	138.5	152.5
III	1500	1835	1695	1520	1730	1835	1625
IV	7000	9450	9100	8400	7350	9450	7700

The solution of example 2 has been presented in table 2. The results of single goal optimization are similar to the first example. The single goal optimization of first goal has achieved it fully with its value 55 but ignored the second and third goal. The achievements of second and third goals have also generated similar results. The solution of existing MGP is same as the achievement of the second goal which is not achieving the remaining goals first and third. However, the improved MGP has achieved all the three goals simultaneously. It has achieved first objective fully with the achievements of second and third goals as 8750 and 592.50 respectively which are closer to their respective goals.

Table 2. Goal Achievements in Single and Multi-Goal Programming

Goals		Single Goal Programming			Multi-Goal Programming	
		I	II	III	Existing MGP	Improved MGP
X_i		5.75, 0, 0.5, 4.75	1, 7, 3, 0	5, 0, 0.5, 5.5	1, 7, 3, 0	1, 9.5, 0.5, 0
I	55	55	50	53.5	50	55
II	9000	6850	9000	6700	9000	8750
III	600	592.50	555	600	555	592.50

6. Conclusions

The present study tried to identify a few methodological issues in the existing MGP technique and proposed an improved MGP technique. Existing and improved MGP techniques have been tested with two suitable examples. The existing MGP technique failed to achieve all the goals simultaneously. However, the improved MGP technique have provided superior solution in achieving the desired goals simultaneusly.

Compliance with Ethical Standards

Conflict of interest: The author declares that there is no conflict of interest.

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