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"A GOAL PROGRAMMING APPROACH TO SECURITY WORK FORCE PROBLEMS WITH DEP UNDERSTANDING"

A GOAL PROGRAMMING APPROACH TO SECURITY WORK FORCE PROBLEMS WITH DEP UNDERSTANDING

By

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ABSTRACT

In this paper we discuss the goal programming model which is basically a modified form and an extension of the linear programming model, the first of the paper concerns the origin of goal programming, types of goal programming models, and the objectives of goal programming models. In the second part, the differences and similarities between goal programming and linear programming models are looked into the third part of the paper takes a look at the limitation of goal programming GP models, good and poor modelling practices in GP formation. The fourth part, a short review of literature on GP s given, while the fifth part concentrates on areas where GP models can be applied in a security work force and some problems are considered in terms of deploying personal armed and unarmed to two different locations at the same time,a model for training recruits withing a stipulated time period, and corse schedule model for three categories of staff,all modes aim to optimize materials and reduce costs .

Illustrate the method of goal programming made simpler, which is the title of this paper and also shows how to avoid getting /accepting a dominated solution in GP problems. In the final part of the papers the summary and conclusion of the work are presented.

KEYWORDS

Dominated solution, goal programming, linear programming, scheduling, skill acquisition

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INTRODUCTION

Goal programming GP is said to be the oldest approach within the field of multiple criteria decision making (MCDM). This technique is employed in situation where linear programming cannot handle multiple objectives, and the units of the constraint variables may be inconsumable or have different units.

Goal programming has been credited to have started with the of[1] Churns, et al 1955 on a work they carried out on constrained regression. The overall purpose of goal programming is the simultaneous satisfaction of several goals relevant to the decision -making problem under consideration irrespective of their units of measurements. There are two major types of GP models, the non -preemptive and the preemptive variants.

Differences and similarities between GP and LP

In goal programming, the deviational variables that is, the undershoot/overshoots are minimized but in linear programming the objective functions are either maximized or minimized. While goal programing handles multiple objective problems with conflicting units LP takes care 0f only one objective function with al the constraints having a single unit GP has soft constraints while the constraints of an LP problem are herd constraints while GP models make use deviational variables which enable all goals to be stated as equations similarities abound between LP and GP models or problems. The first one is that both problems required the formulation of a model unorder to transformed a real word decision problem into a prescribed format. Both LP and GP models are concerned with optimization of resources that is, either to maximize profit or minimize losses, subjected to a set of constraints that is limited resources. In both models, and variables (xi) involved must be nonnegative (xi greater than or equals to D) and both the constraints and objective functions are all linear in nature.A GP model has multiple objectives with trade-offs. Deviations from constraints are penalized and these constraints are soft ,unlike in an LP problem where these constraints are hard.

Both LP and GP involve rational thinking in the decision-making process and also each give room for sensitivity analysis of the model.

LIMITATION OF GOAL PROGRAMMING

[2]Romero 1991 traced one of the limitation of GP problem to be fact that a GP may provide a solution that may be nonefficient and[3] Zeleky 1981 stated that a GP model may provide inferior solution however, [4]Hanman has offend a method that can avoid the issue of nonefficient solutions in addition,[5] Masud and Hwang (1981) also preffered suggestions on how not to obtain inferior solution in the using the GP method.

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Romero has given a detailed account of and prior modelling practice in goal programming [6] Iginizio (1985 pp) has also given similar reasons along that line and more than 6 goals stated is likely to provide a worthless result.

LITERATURE REVIEW

It's has been widely reported that GP first appeared on the work of[7] Charnes, Cooper and Ferguson in a paper they presented in 1955[6], [Iginizio 1985, [2]Romero (1991), [8]Schniederda remarked there are two excellent books on review of literature on goal programming by covering the period of 1961 to 2008. The book by [8]Schniendergans 1995 listed about 35 books dealing on goal programming from 1961 up to 1994 and the other books by[9] Raviracavindran 2011 including a work done in 1948.Belaid and Ossama(2001)[10],published a chronicled developments in the use of Goal progamming models between 1960 and 2000. Orumie and Ebong 2014[11] give detailed accounts of other published articles on GP .H,ere we present some work done in goal programming after the period covered by the authors mentioned above.

[12]Mohamed Aly(2013) presented a 6 weeks scheduling period model of staff scheduling at a telecommunication center using goal programming model and the result showed a significant increase both in efficiency and staff .]13]AT de Almanda et al 2018 critically examined the challenges in multi criteric decision methods.[14] Marler and Arova 2004 had taken a survey of multi objective optimization method for engineers and reported that no single method is superior.

[15]Seyda and Tamer 2018 did a literature review on scheduling and planning in service with goal programming up to 2018 and reported that these are 142 studies in Emerald, science direct, Istor, Springer, Taylor and Francie Google scholar e t c, Database.

[16]11kay (2022) conducted a Bi- Objective programming for airline crew pairing and the optimal result obtained have advantages against their competitions and saved millions of dollars. the objective of goal programming is to minimize the deviation between the achievement on the goal and aspiration levels. The achievement when compared to other airline that solved their crew scheduling problem using other method of GP, Gholizadeh 2013 used goal programming method in optimization of paper product.[17] Rivaz and Saeidl 2021 developed a method for solving a multiobjective linear programming problem under uncertainity practices when the parameters are given in internal forms.[18] Mohammadian et al 2018, prepared a GP model for schedule of shifts for nurse based on nurse preferences and a result that showed a higher efficiency of optime scheduling improved work justice and performance of the nurses and also increases their satisfaction from the scheduling process.

[19]Todavic, et al (2015,prepared police officer scheduling using programming and the result showed that optimization of scheduling reduces the time to obtain a healthy scheduling and allows for experimentation with different forms organizational work of officers and to obtain optimal scheduling of employers to be resolved in other fields.[20] Sharma and Jain(2016)

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found out that a multiple objective model for nurse scheduling accounts for both hospital objective and nurse preference. They also started that goal programming model is very useful in hospitals for two days competing decision – environment.

[21]OZder et al (2018)discovered that problem of assigning the most appropriate security personnel to determined places s handled by a goal programming.Nirmn and Khan2023[22],used GP model to schedule police officers duty patrol and standby.

PROBLEM SETTING. The paper is concerned with formulation goal programming models which will assist decision makers in a security work force,the Nigerian Security and Civil Defence Corps (NSCDC) to take decisions in its work force planning at the state level.

MODEL FORMULATION

The basic linear Goal programming problems is formulated as follows according to Cooper(1975):

Goal Programming. Case I: The Absolute format

$$\text{Min} \left| \sum a_{il} X_j - g_i \right| \qquad (1.1)$$

where X represents a set from which **the choices of vectors« x, must be affected. The** a_i**. . and** g_i **are constants and** $i\varepsilon$ **l refers** to the index set while the vertical **strokes are taken to mean** the absolute value for the expression which **they enclose.** We can regard the g_i as "goals", **since the functionals**

n

$$f_i(x) = \left| a_{ij} x_j - g. \right| \qquad (1.2)$$

have **the** poperties prescribed for **a goal programming**

Using **deviational variables** ,we can equation (1.1) as:

_ Where, d_i^- ,and d_i^+ are arbitrary constraints the basic goal programming problem is formulated as:

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$$\text{Min} \sum_{i=1}^{n} (d^{-}_{i} + d_i^{+}) \qquad (1..3)$$

Subject to;

$$\sum_{j=1}^{n} a_{ij}\, x_j - d_i^{+} + d_i^{-} = b_i$$

The following steps are always taken in any model formulation.

(i)define the variables and constraints.

(ii)formulate the constraints equation.

(iii) develop the objective function.

NUMERICAL EXAMPLES OF A SECURITY WORK FORCE APPLICATION OF GP .

Examples of security work force problems and goal programming solution. The first case is from a stated where the commandant of a security force has obtained person to train some selected personnel from the Junior, middle, and Senior cadre for training in three skills, A, B, and C. ana some staff are chosen each cadre for training on each skill.

EXAMLE 1.

Table 1. gives the number chosen for each of the three cadres for the various skills with the cost of training for each skill level. The last line of each cadre shows the number chosen from each cadre for training in the three skills.

TABLE 1 TRAINING OF STAFF ON DIFFERENT SKILLS

	SKILL	CADREJUNIOR	MIDDLE	SENIOR	COST OF TRAINING ( )
A	X1	10	7	5	100,000
B	X2	8	5	4	120,000
C	X3	3	4	10	140,000
TOTAL		126	83	86	

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Formulate a GP problem for the commandant assuming he/she has 6 goals to be considered according to the following four (decreasing) priority levels.

Priority1 cost of training to be at most 20000000

Priority2 not more than 114 junior staff cadre should be trained

Priority3 at most 70 senior staff should be trained

Priority4 at least 70 staff of the middle cadre should be trained

70 staff are trained in skill C. personnel in skill B.

SOLUTION

Let: skill A=X_1 variable

B=x_2 variable

C= x_3 variable

Let d^-_i=negative deviation (below the desired result)

d_i^+=positive deviation (above the desired result)

Let min z

subject to

$$100000x_1+1200000x_2+14000x_3+d_1^- - d_1^+ = 20000000 \quad (2.1)$$

$$10x_1+28x_2+3x_3+d^-_2-d_2^+ = 110 \quad (2.2)$$

$$8x_1+4_2+10x_3+d_3^- - d_3^+ = 70 \quad (2.3)$$

$$7x_1+5x_2+4x3+d^-_4-d^+_4 = 83 \quad (2.4)$$

solving(2.3) through (2.7) the equations below:

$$10x1+8x2+3x3=112 \quad (2.5)$$

$$7x1+5x2+4x3=83 \quad (2.6)$$

$$5x1+4x2+10x3=80 \quad (2.7)$$

We get x_1= 6, x_2=5, x_3=4

For goal 1;

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600000+6000+560000+d_1^- -d_1^+ =2000000

1760000+d_1^- -=2000000, ,d_1^+ $_1^-$ = 0

Hence, d_1^- = *#240,000, less than the expected spending, or 12% gain out of the expected cost*

d_1^- Goal 2. achieved 2.
goal 3. 30+20+40+d_3^- -d_3^+ =70

90+d_3^- -d_3^+=70, d_3^- = 0, -d_3^+ = 20,or,28.6% above the expected result,hence goal 3 is achieved.

3. goal 4. 42+25+16+d_4^- -d_4^+=70,

83 + d_3^- -d_3^+ =70

d_4^- = 0, -$d_{4=}^+$ = 13, *or* 18.57 % *above the expected result*.Goal 4 is achieved.

. Goal 5. At most 70 staff are trained in skill C

3x3+4x3+10x3+n5-p5=70

17x3+d_5^- -d_5^+= 70,

68+d_5^- -d_5^+=70, d_5^- ,2, d_5^+= 0, the goal 5 (i) is under achieved by 2 staff or 2.86%

EXAMPLE 3. Application of GP in deployment of armed and unarmed personnel for operations at two different locations at the same time.

The commandant of state security work force has two groups of personnel that he wants to deploy for two operations. The two groups of personnel are the armed group AG and the non - armed group NAG, and the two operations are code-named as operation x1, and x2. To carryout operation x1, 25 personnel and 20 personnel are needed from AG and NAG, respectively. And in order to carry out operation x2, 45 personnel and 35 personnel are needed from AG and NAG, respectively in addition, operation x1 and x2, cost 700 and 500 Naria per each personnel feeding and allowance per day. The number of personnel are 605 and 475 for the AG and NAG respectively.

(a)formulate a linear programming model for the commandant.

(b)formulate a GP model for the above information if the commandant has 5 goals to be considered according to the following 4 (decreasing) priority levels.

1. At most 10500 Naria should not be splint daily.

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2. Not more than 510 personnel from AG should be used for the two operations.

3. Not less than 320 personnel from both AG and

4. NAG should be involved in operation x_2

5. At least (a) 7 personnel of AG, and (b) 7 personnel of NAG should be used in any operation

Solution

(a)the table below table 1 shows the summary of the LP information.

Table 2. summary of personnel

Operation	cost per- personnel	no of AG personnel	no of NAG personnel
X1	700	25	20
X	500	45	35
Total number Of personnel.		515	405

For the LP

Minimize Z =700700x_1+500$x2$ (3.1)

Subject to:

25x1+45x2 = 515 (3. 2)

$20x_1 + 35x_2$ = 405 (3.3)

x_1, x_2 _> 0 ,

$x_1 * x_2$ =0 (3.4)

It is also given that

Goal 1 $700x_1+500x_2 - b_1^+ + b^-_1 = 9100$ (3.5)

Goal 2. $25x_1+45x_2 - b^+_2 + b^-_2 = \leq 510$ 3.6)

Goal 3 .$20x1 + 35x_2 - b^-_3 + b^-_3 \leq 390$ 3(3.7)

Goal 4 (i). $X_1 - b^+_4 + b_4^- \geq 7$ (3.8)

(ii) $x_2 + b_5^- - b^+_5 \geq 8$ (3. 9)

Solution.

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Looking through equations (3.1) to (3.9),we can identify that the true value of Z, has been given in equation (3.5),so we solve equation (3.2) and (3.3) simultaneously to see if the values obtained therein will satisfy equation (3.5). Solving equations .(3.2),and (.4 simultaneously we We find that ,$x_{1=8\ and}\ x_2$ $_{=7}$.these values satisfy equ(3.5) perfectly on substituting the values ,x_1 =8, ,x_2 =87

9100 - b^+ + b_1^- =9100,

b^+ = d_1^- = 0. Goal 1. achieved.

Goal 2. 25x_1+45x_2 -b^+_2 + b^-_2 =510,

200 +315 + b^-_2 - b^+ $_{=510}$.

515 = 510 $_+$ $b2^+$

5 = b^+_2 ,over achievement as desired.

Goal 3 .20x_1 + 35x_2 -b^+_3 + b^-_3 = 390

160+245 b^+_3 = 390

405-390 = b^+_3 , b^+_3 = 15, desired goal achieved.

Goal 4 (i). X_1 - b^+_4 $_+$ b_4^- =7

Goal 4 (i). 8 - b^+_4 $_+$ b_4^- = 7

8- 7 = b^+ , hence 7 = $b^+_{=}1$

+

All the goals were achieved as desired by the Decision Maker.

Example 4. Application of Goal Programming in planning Weapon Training Class.

In a Security Work Force.

In a certain security work force,it is required that for any one to carry arms that,he / she must have at least 2030 minutes of instruction on weapon training per week. The training is structured in such a way that the weapon Instructor should have 2030 minutes of weapon training time per week.

The weapon instructor can the lesson so that all the 90 students be handled at a time in an open place,45 students are to have lessons in a large shooting hall, and 18 students can have lesson

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in a small shooting hall ,and each student can is to have 15 minutes of individual lesson per week.

(a).Determine how many minutes that the weapon instructor should allocate to per week to instructions in the:

(i) Large shooting hall. Should not be used to hold lectures for mor than230 minutes per week because shortage of class rooms.
(ii) A student should spend at most 400 minutes on weapon training class per week

(b) (i) Formulate a Goal programming model for the weapon instructor.

(c) Assuming there is a new regulation that allows each student should have at least 400 minutes of weapon training lesson per week ,and the weapon instructor should not have more than 1950 minutes of lesson per week to avoid over work load.

Solution.

Given, lesson in open hall =90 minute

Individual instructions =15 minutes.

Let lesson in large shooting hall = x_1 ,lesson in the small hall = x_2

For the student total time required is as shown in (4.1),

$$90 + x_1 + x_2 + 15 = 375$$

$$x_1 + x_2 = 270 \quad (4.1)$$

For the instructor, taking 45 students means, visiting the large shooting hall twice,i.e.= $2x_1$,and tag the lecture in a small hall gives $4x_2$,each student having 15 minutes ,will give 15*90= 1350minutes.

Total weapon instructors lesson time is given in (2)

$$90+ 2x_1 + 5x_2 + 1350 = 2030 \quad (4.2)$$

$$2x_1 + 5x_2 = 590 \quad (4.2)$$

Solving (4.1) and (4.2) simultaneously have, $x_2 = 25$, $x_1 = 250$

Check. $90\ x_1 + x_2 + 15 = 375$

Students time: 90 +250 +20 +15=375

Instructors time : $90 + 2x_1 + 5x_2 + 1350 = 2030$

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90 +250*2 + 20*5 +15*90 = 2030.

For the GP part using our results in (a) and using deviations

$$90\ x_1 + x_2 + 15 = 375 \quad (4.1)$$

$$90 + 2x_1 + 5x_2 + 1350 = 2030 \quad (4.2)$$

$$375 - b_5^+ + b_5^- = 400 \quad (4.1a)$$

$b_5^+ = 0, b_5^- = 25$ It means that the student had 25 minutes of weapon training lesson less than the expected time per week

$$90 + 2x_1 + 5x_2 + 1350 - b_5^+ + b_5^- = 1950 \quad (4.2b)$$

$2030 - b_5^+ + b_5^- = 1950, b_5^- = 0,$

$- b_6^+ = 80$,hence the weapon Instructor had more 80 minutes of lecture time than expected.

SUMMARY

The paper has considered the basic differences and similarities between Linear programming and Goal programming problems. A short literature review of goal programming was presented and the applications of goal programming to a security work force was considered in the areas of skills training, deployment of staff for operational duty., training of staff in weapon handling all aimed at enhancing decision making and efficiency of service.Only Linear goal programming problems were considered in this paper.

Conclusion

From the problems considered,it is evident that to solve a goal programming problem effectively,a good knowledge of the formulation of the Linear programming model is a fundamental requirement. Goal programming is primarily concerned with the issue of underachievement and over achievement of any stated objective and unlike the linear programming model,handles confilicting objectives and different units altogether. Goal programming.

NOTES:

A. CONFLICT OF INTERESTS.

The authors Declear that there is no conflict of interest.

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