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A Decision Making Model in Production Planning using Lexicographic Goal Programming Approach under Preemptive Priority Structure

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Abstract

This paper envisages Lexicographic Goal Programming (LGP), where the goals are arranged according to their priorities. So it is renamed as LGP under preemptive priority structure.. The method of LGP developed by Ignizio in production scheduling for a large food manufacturer has been illustrated. This goal programming procedure appears to be most appropriate technique in developing a production planning model to attain multiple conflicting goals with varying priorities.

Keywords: Lexicographic Goal Programming.

Introduction

Since twenty years several attempts have been made by Dauer and Kruegar [1], Cohon to deal with multi objective mathematical programming problems (MMPP) where several objectives exist. Goal programming (GP) is one of these techniques, applied in wide range. In recent years LGP is a modern tool used in solving such MMPP in farm planning, academic planning, transportation problem etc. In Lexicographic Goal Programming all the objectives are transformed into goals by assigning their relative weights and then designed according to their priorities. So it is renamed as LGP under preemptive priority structure. Ignizio [4] developed an algorithm of LGP. Sarma, Sellani and Houam applied LGP in production planning. In this paper we illustrate the method of LGP by Ignizio [4] in production scheduling for a large food manufacturer.

A production planning problem is concerned with short term problems of the most efficient utilization of existing company resources manpower, raw materials, plant capacity, machine availability etc. Our present paper hopes to explain the conceptual and logical structure of a preemptive prioritized goal programming and its application to a major food manufacturer of India.

Methodology

The general LGP model can be mathematically expressed as

Minimize : $P_1(W_{i1}^- d_{i1}^- + W_{i1}^+ d_{i1}^+)$

Minimize : $P_2(W_{i2}^- d_{i2}^- + W_{i2}^+ d_{i2}^+)$

Minimize : $P_K(W_{ik}^- d_{ik}^- + W_{ik}^+ d_{ik}^+)$

Minimize : $P_t(W_{it}^- d_{it}^- + W_{it}^+ d_{it}^+)$

$i = 1,2,3................m$ tms

Subject to

$$\sum_{j=1}^{n} a_{ij} x_j + d_i^- - d_i^+ = b_i \qquad i = 1,2,3................m$$

$$x_j, d_i^+, d_i^- \geq 0 \qquad j = 1,2,3................n$$

$$i = 1,2,3................m$$

Where

a_{ij} : The goal constraint coefficients.

x_j : The decision variables.

P_K : The kth priority level

and $P_1 >>> P_2 >>> P_3 >>> P_K >>> P_t$

$>>>$ implies much greater than.

W_{ik}^- : The weight associated with under deviation $d_{ik}^- (\geq 0)$ at the priority level P_K.

W_{ik}^+ : The weight associated with over deviation $d_{ik}^+ (\geq 0)$ at the priority level P_K.

d_{ik}^- and d_{ik}^+ are renamed for the actual deviational variables d_i^- and d_i^+ respectively to represent them at the priority level P_K.

LGP Problem Formulation

The problem relates to a food manufacturing corporation of India producing a number of food products. The manufacturer is always faced the problem of utilizing the number of laborers of different categories assigned for different products, through out the year. So it requires a perfect plan with available resources and existing labour force to maximize profit.

The model is based on the following assumptions:

1. It should be kept in view that sufficient machine power and required raw

materials are available to produce each product.

2. Manpower should be properly distributed among all products. Also laborers may be grouped according to their efficiency and particular group of laborers may be utilized for more than one products to minimize productive cost.
3. It may be guideline that the waste products may be utilized properly or transported somewhere.

The flexible goals are taken for this purpose

Manpower goal

It indicates that the laborers should be utilized at different wages for different products according to necessity. Also laborers of a particular department may do over time duty in other department for smooth conduct of the management. So labourers are to be considered in more than one phase.

Resource goal

Other than laborer wages certain amount of money must be required in buying and transporting raw materials from different sources.

Contingent goal

It indicates that a certain amount of money may be reserved from contingent expenditure such as mechanical repair and replacement bonus to labpourers, transport of products etc.

Profit goal

It indicates the maximum profit of the corporation.

It is the decision of the management to assign ranks to their priority. Thus a preemptive prioritized LGP can be designed. We consider the following decision variables for our problem.

x_1 : Number of laborers utilized in producing salt

x_2 : Number of laborers utilized in producing Tea

x_3 : Number of laborers utilized in producing Oil

x_4 : Number of laborers utilized in producing Bread

x_5 : Number of laborers utilized in producing Jam

x_6 : Number of tins to keep oil (one laborer is necessary to make one such packet)

x_7 : Number of polythene packets to keep bread (one laborer is necessary to make one such packet)

x_8 : Number of Jars to keep Jam (3 laborers are utilized to prepare 10 Jars)

x_9 : Number of packets of waste products to make fertilizer

The following table gives different costs associated with different products.

Name of the Products	Labor wage per one laborer	Resource cost for one laborer In lakh	Contingent expenditure cost in lakh
Salt(x_1)	2.9	2.9	23
Tea (x_2)	2.2	3.3	25
Oil (x_3)	4.7	3.3	21
Bread (x_4)	12.6	18.1	100
Jam (x_5)	14.5	16.9	48
Tin (x_6)	2.6	21.1	0
Polythene packet (x_7)	5.6	1.50	
Jar (x_8)	2.5	2.1	7.7
Fertilizer	15.1	15.1	0

Following are the goals associated in this model:

$$x_1 + x_2 + x_3 + x_4 + x_5 + x_6 + x_7 + 0.3x_8 + d_1^- - d_1^+ = 600$$

2. Total laborer wage goal

$$2.9x_1 + 2.2x_2 + 4.7x_3 + 12.6x_4 + 14.5x_5 + 2.6x_6 + 5.6x_7 + 2.5x_8 + 15.1x_9 + d_2^- - d_2^+ = 6030$$

3. Total resource goal

$$2.9x_1 + 3.3x_2 + 3.3x_3 + 18.1x_4 + 16.9x_5 + 21.1x_6 + 1.5x_7 + 2.1x_8 + 15.1x_9 + d_3^- - d_3^+ = 6030$$

4. Contingency expenditure goal

$$23x_1 + 25x_2 + 21x_3 + 100x_4 + 48x_5 + 7.7x_8 + d_4^- - d_4^+ = 12000$$

5. Minimum laborers required for salt, tea and oil

$$x_1 + x_2 + x_3 + d_5^- - d_5^+ = 250$$

6. Minimum laborers required for Bread and Jam

$$x_4 + x_5 + d_6^- - d_6^+ = 100$$

7. Minimum laborers required for oil only

$$x_3 + d_7^- - d_7^+ = 180$$

8. Minimum laborers required for bread only

$$x_4 + d_8^- - d_8^+ = 180$$

9. Minimum laborers required for Jam only

$x_5 + d_9^- - d_9^+ = 30$

10. Minimum laborers required for salt and bread only (no laborer can work for both)
$x_1 + x_4 + d_{10}^- - d_{10}^+ = 0$

11. Minimum and maximum laborers required for tins, polythene packets and jars respectively
$x_6 + x_7 + 0.3x_8 + d_{11}^- - d_{11}^+ = 150$
$x_6 + x_7 + 0.3x_8 + d_{12}^- - d_{12}^+ = 200$

12. Minimum and maximum laborers required to make tins only respectively
$x_6 + d_{13}^- - d_{13}^+ = 59$
$x_6 + d_{14}^- - d_{14}^+ = 80$

13. Minimum and maximum of fertilizers respectively
$x_9 + d_{15}^- - d_{15}^+ = 59$
$x_9 + d_{16}^- - d_{16}^+ = 70$

14. Gross marginal cost
$69x_1 + 50x_2 + 50x_3 + 88x_4 + 105x_5 + 124x_6 + 40x_7 + 8.4x_8 + 57x_9 + d_{17}^- - d_{17}^+ = 43500$

The objective function of the above model can be designed according to the importance of the goals in decision environment assigning properties to the goals in ordinal sequence and introducing their relative weights at the same priority level. The required objective function is

Minimize : $P_1(d_1^- + d_6^+ + d_{12}^+)$
Minimize : $P_2(6d_7^- + 1.3d_8^- + d_9^- + 2d_{13}^- + 2d_{15}^-)$
Minimize : $P_3(3d_5^- + d_{10}^- + 2d_{11}^- + 5d_1^+)$
Minimize : $P_4(2d_2^- + d_3^-)$
Minimize : $P_5(d_4^-)$
Minimize : $P_6(d_{14}^+ + 1.2d_{16}^-)$
Minimize : $P_7(d_2^+ + 2d_3^+)$
Minimize : $P_8(d_4^+)$
Minimize : $P_{19}(d_{17}^-)$

Using lexicographic computational procedure of Ignizio this problem can be solved and the goals yields the following solutions.

Decision variables

$$x_1 = 40,\ x_2 = 110,\ x_3 = 180,\ x_4 = 40,\ x_5 = 30$$
$$x_6 = 59,\ x_7 = 141,\ x_8 = 0,\ x_9 = 59$$

Deviational variables

$$d_2^- = 672.5,\ d_3^- = 1378.7,\ d_4^+ = 1210,\ d_5^+ = 80,\ d_6^- = 30,$$
$$d_{11}^+ = 50,\ d_{14}^- = 21,\ d_{16}^- = 11,\ d_{17}^- = 325$$

All other deviational variables are few. Hence the investment and profit per annum is

1. Total contingent expenditure = Rs.13210 lakh
2. Total labor wage cost = Rs.2051 lakh
3. Gross marginal cost = Rs.40249 lakh

Conclusion

In a practical situation the decision maker may not achieve each goal to the desired extent. This paper shows that by developing the priority based goal programming model for a production planning problem the decision can easily be made with the satisfaction of goals according to their relative importance. One primary advantage of this approach is that it allows for an ordinal solution.

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