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DETERMINATION OF OPTIMUM EMPLOYEE- TRAINEE SIZE FOR A PROJECT

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ABSTRACT

The main objective of trainee management in any organization is to minimize training related costs or maximize revenue or performance of the trainees, subject to available resources .Also on- the- job training is a training method that is planned, organized and conducted at the employee's worksite. During that training, the trainees will work with other regular employees. They are all assigned to different sections of an on-going project. In this paper three models are discussed to find the optimum number of regular employees and trainees from each section to work in the project so that the profit is maximum. In one model, climbing hill technique is applied to find the optimum solution .Some numerical examples are also discussed.

KEYWORDS: Employee-trainee, Size On-the job training, Maximum profit, Linear Integer Programming, climbing hill technique.

1. INTRODUCTION

Employee training and development are specially designed to enhance efficiency and morale of the employees at work .Success of training efforts fundamentally depends on the method of training used. Four major methods of training are (i) On –the job training (ii) class room training (iii) vestibule training (iv) Measurement development.

On-the –job training is a training method that is planned, organized and conducted at the employee's worksite .Some organizations like to arrange that type of training for their new recruits who will work with the regular employees so that they can learn more about their job and the organization from their co-workers.

There may be different sections in an organization .Whenever the organization undertakes a project ,each section is assigned a specific job to carry out in a given time of operation to complete the project .Since there are different sections the training given will also be different .However the project requires the coordination of all the sections .

In this paper the problem of finding the optimum number of regular employees and trainees from each section to be assigned to the project is addressed with the help of three models. One of the models makes use of the climbing-hill technique.

2. BASIC CONCEPTS

Suppose there are N sections in that organization. Let $x_1, x_2, \ldots x_N$ regular employees and $y_1, y_2 \ldots y_N$ trainees from those N sections be assigned a specific job to carry out in a given time of operation to complete an on-going project.

Let r_{1i} and r_{2i} be the revenue from production or service by an employee and a trainee respectively from section i.Then $r_{1i} > r_{2i}$ (some trainees may be as efficient as regular employees). Generally the performance of trainees is considered to be slightly lower than that of regular employees since the regular – employees have more experience .Accordingly they are paid more than the trainees.

Let c_{1i} and c_{2i} be the salary and stipend respectively for a regular employee and a trainee working in section i during the project .Then $C_{1i} > c_{2i}$

Now in all the three models to be discussed in this paper, the objective function will be taken as

Maximize profit P= Total revenue -Total salary

$$= \sum_{i=1}^{N}(r_{1i}x_i + r_{2i}y_i) - \sum_{i=1}^{N}(c_{1i}x_i + c_{2i}y_i)$$

$$= \sum_{i=1}^{N}[(r_{1i} - c_{1i})x_i + (r_{2i} - c_{2i})y_i] \text{ ---------- (1)}$$

It is obvious that the objective of any management will be to get maximum profit by engaging optimum number of regular employees and trainees for a particular project which requires the co-ordination of all N sections.

3. MODEL I

Here we consider a simple model in which linear integer programming technique is applied to find the optimum solution .The two main constraints that are paramount are project duration and production capacity.

If the maximum required time for the project activities in section i is T_i manhours, let each regular employee and each trainee of section i contribute t_{1i} and t_{2i} manhours respectively for carrying out the project .Then the corresponding constraint is

$$t_{1i}x_i + t_{2i}y_i \le T_i \qquad i=1, 2\ldots\ldots N \text{ --------------- (2)}$$

The production capacity can be measured by the maximum quantity the employee or trainee can produce or the maximum service they can render .Let M_i be the minimum capacity or service the project requires from section i personnel ,

If m_{1i} and m_{2i} are the maximum capacity of a regular employee and a trainee in section i respectively ,then the constraint is

$$m_{1i}x_i + m_{2i}y_i \ge M_i, \qquad i=1,2\ldots\ldots N \text{ -------------(3)}$$

Also we can have one more constraint regarding the total number of regular employees and that of trainees .Let it be assumed that the total number of regular employees is k times the total number of trainees i.e. $(x_1 + x_2 + \dots \dots . x_N) = k\,(y_1 + y_2 \dots \dots + y_N)$ ------------- (4)

Generally number of regular employees will be more than number of trainees Thus K >1

Thus the linear integer programming problem for the model under consideration is

$$\text{Max } Z = \textstyle\sum_i [(r_{1i} - c_{1i})x_i + (r_{2i} - c_{2i})y_i]$$

Subject to

$$t_{1i}\, x_i + t_{2i} y_i \le T_i \qquad i=1 \dots N$$

$$m_{1i}\, x_i + m_{2i} y_i \ge M_i \qquad i=1 \dots N$$

$$(x_1 + x_2 + \dots \dots . x_N) = k\,(y_1 + y_2 \dots \dots + y_N)$$

$$x_i, y_i \ge 0 \text{ \& integers}$$

To make the model clear, two numerical examples can be seen now.

4. NUMERICAL EXAMPLE

Let N=3 suppose the concerned linear integer programming is as follows .Here $r_{1i}, r_{2i}, c_{1i}, c_{1i}$ are in lakhs.

Example 1:

$$\text{Max } Z = 25x_1 + 20x_2 + 30x_3 + 15y_1 + 18y_2 + 23y_3$$

Subject to

$$160x_1 + 180y_1 \le 7900$$

$$120x_2 + 130y_2 \le 3400$$

$$200x_3 + 210y_3 \le 8040$$

$$50x_1 + 40y_1 \ge 2000$$

$$25x_2 + 20y_2 \ge 550$$

$$60x_3 + 45y_3 \ge 1800$$

$$(x_1 + x_2 + x_3) = 1.5\,(y_1 + y_2 + y_3)$$

$$x_1, x_2, x_3, y_1, y_2, y_3 \ge 0 \text{ \& integers}$$

Solution is (49,4,15),(0,22,24)

Z* = 2730 lakhs

Here the trainees are allotted more work load (measured interms of manhours) than the regular employees.

Example 2: Suppose the regular employees are given more workload and the first three constraints are

$$180x_1 + 160y_1 \leq 7900$$

$$130x_2 + 120y_2 \leq 3400$$

$$210x_3 + 200y_3 \leq 8040$$

while the other things remaining the same.

Then the solution is (44,0, 23),(0,28,16) with Z* =2660 Lakhs

Thus it is clear that the trainees should be given more workload in order to get more profit.

5. MODEL II

In the previous model the constraints are for production capacity and project duration .Now another set of constraints but with the same objective function can be considered .The constraints are for the number of personnel to be involved from each section and budget allocation .

Let N_i be the maximum number of personnel from section i to be involved in the project.

i.e. $x_i + y_i \leq N_i$ i=1 ...N -------(5)

If C_i be the budget amount for section i towards salary and stipend, then

$c_{1i}\, x_i + c_{2i}\, y_i \leq C_i$ i=1,.....N ----------- (6)

Thus the linear integer programming model for this model is

$$\text{Max } Z = \Sigma_i \left[(r_{1i} - c_{1i})x_i + (r_{2i} - c_{2i})y_i\right]$$

Subject to

$$x_i + y_i \leq N_i \text{ ,} i = 1, \ldots . N$$

$$c_{1i}\, x_i + c_{2i}\, y_i \leq c_i \text{ ,} i = 1, \ldots . . N$$

$$x_i, y_i \geq 0 \text{ \& integers}$$

As we see, it is a simple model.

6. MODEL III

In the previous models, the linear programming problem discussed have 2N decision variables and 2N constraints ,Hence there is no difficulty in solving them .Actually there are N sections and for each section we have two constraints separately. Thus we have 2N constraints, but it need not be the case always.

Suppose the upper bound for the total number of man hours for the trainees and regular employees together is given and the lower bound for the capacity of the trainees and regular employees together is also given as constraints, In that case we have 2N decision variables but only 2 constraints are there.

In that case the linear programming problem will be

$$\text{Max } Z = \sum_i [(r_{1i} - c_{1i})x_i + (r_{2i} - c_{2i})y_i]$$

Subject to

$$(t_{11}\, x_1 + t_{12}\, x_2 + \dots\dots + t_{1N}\, x_N) + (t_{21}\, y_1 + t_{22}\, y_2 + \dots\dots + t_{2N} y_N) \le T$$

$$(m_{11}\, x_1 + m_{12}\, x_2 + \dots\dots + m_{1N}\, x_N) + (m_{21}\, y_1 + m_{22}\, y_2 + \dots\dots + m_{2N} y_N) \ge M$$

$$x_i, y_i \ge 0 \text{ \& integers} \quad i = 1, \dots\dots N$$

7. HILL CLIMBING ALGORITHM

In Computer science, hill climbing is a mathematical optimization technique which belongs to the family of local search, it is an iterative algorithm that starts with an arbitrary solution to a problem and then attempts to find a better solution by incrementally changing a single element of the solution. If the change produces a better solution an incremental is made to the new solution, repeating until no further improvements can be found

The relative simplicity of the algorithm makes it a popular first choice amongst optimizing algorithms .It is used widely in artificial intelligence, for reaching a goal state from a starting node. Although more advanced algorithms such as simulated annealing or tabu search may give better results, in some situations hill climbing works just as well.

Hill climbing attempts to maximize or minimize a target function f(X) where X is a vector of continuous or discrete values .At each iteration hill climbing will adjust a single element in X and determine whether the change improves the value of f(X) .Any change that improves the value of f(X) is accepted and the process continues until no change can be found to improve the value of f(X) .Then the current X is the optimal solution.

This hill-climbing algorithm can be used in our trainees regular employees problem to find the optimal number of members to be assigned to each section .The procedure can be explained with the help of a single example.

8. NUMERICAL EXAMPLE

Let i =2 cost in lakhs, time in months

Max Z= $4x_1 + 5x_2 + 3y_1 + 2y_2$

$3x_1 + 2x_2 + 4y_1 + 6y_2 \leq 75$ ---------(1)

$2x_1 + x_2 + y_1 + 4y_2 \geq 35$ ---------(2)

$x_1, x_2, y_1, y_2 \geq 0$ & integers

One method is to think of an arbitrary solution to start with .Let us take $x_1 = x_2 = y_1 = y_2$ .From constraint (1) we get X= (5,5) ,Y = (5,5) ,Z* = 70 .

Then we move to the next step as follows

Let us start with the solution X=(5,5) ,Y=(5,5) Obviously we have to improve the solution slowly by changing the number of regular employees and trainees .Let x_i be changed to $x_i + \lambda_i$ and y_i to $y_i + \mu_i$ with $\lambda_i, \mu_i \epsilon$ (-1,1) .More specifically in each iteration we consider x_i's and y_i's (i=1,2) and check whether x_i becoming $x_i + \lambda_i, y_i$ becoming $y_i + \mu_i$ increase the value of the objective function and also satisfy the constraints (1) and (2) .

If they satisfy we modify current solution by setting $x_i = x_i + \lambda_i$, $y_i = y_i + \mu_i$, $\lambda_i, \mu_i \epsilon$ (-1,1) and repeat the process which will come to an end when no further improvement is possible

To search a larger neighbourhood we can make a change in the construction method that allows simultaneously changing x_i and x_j by λ_i and λ_j respectively and also y_i and y_j by μ_i and μ_j where $\lambda_i, \lambda_i, \mu_i, \mu_j \epsilon$ { -2,-1,1,2} .Here also the steps are repeated till we get the optimal solution .Now the current solution and the next solution are given in a tabular form as follows

Current Solution	Next Solution	Objective Function Value
(5,5),(5,5)	(5,6) ,(5,4)	73
(5,6),(5,4)	(6,6),(5,4)	77
(6,6),(5,4)	(6,7),(5,3)	80
(6,7),(5,3)	(7,7),(5,3)	84
(7,7),(5,3)	(6,8),(5,3)	85
(6,8),(5,3)	(7,8),(5,3)	89
(7,8),(5,3)	(7,8),(5,4)	Not feasible((1) not satisfied)
(7,8),(5,3)	(7,8),(6,3)	Not feasible((1) not satisfied)
(7,8),(5,3)	(7,9),(5,3)	Not feasible((1) not satisfied)
(6,8),(5,3)	(6,9),(5,2)	Not feasible((2) not satisfied)

Thus we get x_1 = 7, x_2 = 8, y_1=5, y_2= 3, Z* = 89 as the optimal solution .

If number of iterations is small, this manual method will be useful .But when the number is large, we can take the help of following computer program.

First we will have the algorithm and then the corresponding computer program Discrete Space Hill Climbing Algorithm

Step 1: Evaluate the initial state. If it is also a goal state, then return it and quit. Otherwise continue with the initial state as the current state.

Step 2: Loop until a solution is found or until there are no ne operators left to be applied in the current state

(a) Select an operator that has not yet been applied to the current state and apply it to produce a new state.

(b) Evaluate the new state

(i) If it is goal state, then return it and quit

(ii) If it is not a goal state but it is better than the current state ,then make it the current state

(iii) If it is not better than the current state, then continue in the loop

Program for Hill Climbing :-

```
Current Node =start Node;

loop do

L= NEIGHBORS (currentNode);

nextEval =  -INF;

nextNode = NULL;

for all x in L

if (EVAL(x) > next Eval)

nextNode=x;

nextEval = EVAL(x);

if nextEval <= EVAL(currentNode)

//Return currentnode since no better neighbours exist

return currentNode ;

currentNode =next Node;
```

Thus hill climbing algorithm will be useful wherever linear programming technique does not give a satisfactory solution.

9. CONCLUSION

In this paper three models have been discussed to find the optimum number of regular employees and trainees for each section to work in the project. The first two models have the application of usual linear programming technique while the third model uses hill-climbing algorithm which is only rarely used. Other popular metaheuristic methods such as Tabu search and Genetic Algorithm may also produce solutions of better quality.

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