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Human Resource Allocation Model using Linear Programming

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ABSTRACT: Over the past few decades each and every organization, be it an industry for production, a unit of manufacturing, a government organization, a limited corporation, a banking sector or an educational institution is focusing on increasing profit margin. And in order to do that, one of the key factors is achieving maximum output with minimum resources (input). Therefore, it has become extremely important for organizations to plan the use of resources in the most optimum way.
In this research, Linear Programming has been used to optimize the use of resources. Resources can be anything that act as an input. They can be men, material, money or other assets that can be used by an organization or an individual in order to function effectively. There are laws available in linear programming that are very effective in optimizing the resources. They have been used in this research and Human Resourcehas been tested and tried to optimize in this paper. The results have been further compared with the existing system to provide a proper insight on whether they can be helpful in creating a proper plan for optimization for an organization.

I. INTRODUCTION

The parameter that has been tried to optimize here is the Human Resource. Human Resource Allocation at first may not sound like a resource or resource optimization, however if a deeper analysis is done, it will be found that it is also one of the area where resources can be saved or utilized optimally in order to get the best output. Improper allocation of resources especially if it is Human Resource, can lead to wastage of energy and manpower. If wrong man is allocated to the job, he can not only bring down the productivity but can also prolong the output time and can also affect the quality of the output. Therefore, it becomes extremely important to allocate the right man to the specified job.

Use of Linear Programming in solution

In around last 65 years linear programming has been used extensively in military, financial, industrial, accounting, marketing and agricultural sectors. Although these are all diverse sectors, Linear Programming can be used to solve them. All linear programming questions have four properties in common.

All the linear programming questions either maximize or minimize some quantity, they can be profit or cost. We usually call this property as the ***Objective Function*** of a linear programming question. The major concern for any manufacturing organization can be to maximize the profit. In case of any financial or military sector the concern can be to reduce the cost. Whatever the case may be, the Objective function has to be clearly written and stated [2]

The second property that any linear programming question has in the presence of ***constraints*** or restrictions [3]. That is to say it is the limit to which we can pursue the objective. Like, in any production company, the production can be limited by number of assembly lines or availability of manpower. Therefore, after the second property, we can state that maximization or minimization of a quantity subject to the limited resources.

There should be ***alternative course of actions***. One or more alternative solutions to the problem in question must be available. So that we have options to choose from. If no alternative option is available, we will not need linear programming. Linear programming is all about choosing the best.

The objective and the constraints in any linear programming question should be ***expressed in terms of a linear equation***. By saying linear equation what is meant to be said that the equation should be a first order equation. Like, $2A + 4B = 8$ or $3A + 7B \geq 16$ are acceptable equations, however, $3A^2 + 4B^3 + 5AB = 24$ is not an acceptable equation because it has A^2 and also B^3 and then AB as terms in it. None of such can be included in a linear programming equation.

Apart from the above mentioned four properties, there are also some assumptions that need to be made while formulating a linear programming question. They are: certainty, proportionality, additivity, divisibility, nonnegative variables. We should be certain that objectives and constraints are certain, that is they do not change with time. All the variables are in exact proportions. The total of all the objectives and constraints can be added and are divisible. Also, none of the objective or constraint is a negative number, as they all are real values and cannot be negative in any case.

Using all of these properties and assumptions a linear programming problem has to be formulated. Only then can a reliable solution be expected out of the solution. During this entire thesis, all these properties and assumptions have been kept in mind while formulating a problem.

All the three input variables considered to be essential resources have been formulated into objective functions and all the constraints have been duly considered. The alternatives have been studied and then linear equation has been formed to solve each and every case in the problem. An individual model has been formed for each case.

To solve a Linear Programming equation, we will be using a software called Linear Program Solver (LiPS) v1.11.1. It is an optimization package used for solving linear programming models. It has the capability to solve all kinds of problems such as Maximization problems, Minimization problems, integer problems, goal problems etc. It takes the optimization equation, variables and constraints as the input and generates the optimum solution as the output. It can also draw graphs for the output.

Some notable features of the program are:

- The program is based on efficient implementation of the modified simplex method that is specifically designed to solve large scale problems.
- It provides not only an answer to the problem but also a detailed solution process as a sequence of simplex tables, so that it can also be used for teaching learning purposes of linear programming.
- It provides the sequence of sensitivity analysis, which enable us to study the behavior of the model when the parameters are changed. They include changes in coefficient of the objective function, changes in variables, changes in constraints, changes in rows and columns of matrices etc.
- It also supports goal programming which supports weighted and Lexicography GP methods. Goal programming methods are intended for solving multi-objective optimization problems.

II. RESOURCES UNDER OBSERVATION

A. Human Resource Allocation

The Human Resource Allocation problem also known as assignment problem are special problems where assignees are assigned to perform tasks. *E.g.* The assignees may be employees who need to be allocated to a specific task. Assigning people to works is a common application of the Human Resource Allocation problem. However, the assignees sometimes may or may not be people. They can also be machines, vehicles, plants or even time slots to be assigned these tasks. Such problems can be easily solved using the Linear Programming method [4]. However, there are some certain rules that need to be followed while trying to solve such problems [5]. They are:

- The number of assignees and the number of works should be same.
- Each assignee should be assigned exactly 1 work at a time.
- Similarly, each work should be done by exactly 1 assignee.
- There should be a parameter associated with the assignee – work relationship that has to be maximized or minimized while performing the work. This is often referred to as the Objective Function. E.g. minimize the cost or time or maximize the efficiency etc.
- The aim is to determine how all the assignments should be assigned to the assignees in order to fulfil the objective function in the best possible way.

Any situation or condition satisfying all the above rules can be solved extremely efficiently by any computer software capable of solving such assignment problems.

Resource allocation model are very much similar to the transportation model of linear programming, where the ultimate objective function is to minimize the time or cost of manufacturing the products or services by allocating one personnel to one work or one work to one personnel, or one destination to one origin or one origin to one destination only [8]. This model is basically a minimization model.

However, in certain cases, a need for maximization can also arise. For example, we may have to allocate the people to work in a way in order to maximize the efficiency. Therefore, if the need to maximize the objective function arises, then there are two methods for doing the same. The first method is to subtract all the variables of the matrix from the highest value in consideration or the second method is to multiply the matrix by -1 and carry on with further calculations [6].

Such problems address a very specific area which can seem to be very complicated at times and a manager or person in charge may spend hours trying to figure out the best optimum solution. In most of the cases the available resources such as people, machines etc. have varying efficiency while performing different activities.

Thus the cost, profit or time for performing the different activities is different. Hence the problem for consideration that arises is how should the assignment be made in order to optimize (maximize or minimize) the given objective function. The assignment model aids in many decision-making processes such as determining the optimum processing time in each machine for each operator, alignment of teachers and subjects in order to gain maximum results, designing a good plant input, etc [10]. This technique can also be used for other purposes by organizations such as minimizing the total travelling cost, or maximizing the sales. The human resource allocation problem are further of two types:

- Balanced:
  If the number of rows and the number of columns are equal i.e. the given matrix is a square matrix, the objective function is said to be a balanced one.
- Unbalanced:
  If the given objective function of the problem is not a square matrix, the problem is said to be an unbalanced assignment problem. In case the problem is an unbalanced one, dummy rows or columns are added as and when required so that the matrix becomes a square matrix again or rather a balanced matrix. In such cases the cost, time or other values for these dummy cells are assumed as zero.

In this dissertation, a department of ECE has been taken. Here 5 faculties are available to teach 5 different courses in a particular class. All the faculties possess the capability to teach at least one of the six subjects. The task is to determine which available faculty can be the best to teach a particular course *i.e.* which faculty should be assigned which course in order to get the best faculty to teach the course and can lead to better results. The complete details have been provided further.

III. MODEL

A. Data Accumulation

Results of students are a prime factor of performance for any educational institution. Any in order to maintain a good result, it becomes important that a good teacher is allocated to a particular course. For any course more than 1 SME may be available, alternatively 1 Person can be SME of more than 1 course. The challenge here lies in allocating the best faculty to any course, while ensuring that all the faculties have been allocated a course and all the course have one SME allotted to it [23].

Here we will try to allocate the best faculty to each subject. All the data collected are real data from the Final year subjects of Department of Electronics and Communication (ECE), Technical institute of Amrapali Group of Institutes *i.e.* AITS. This allocation will further be used for experimental purpose in the institute. As the head, it will be easy for me to implement the model if it is successfully formulated and will be under observation for a period of one semester. It will be observed that what is the change or improvement in the result of students after assigning faculties as per this model.

5 courses of ECE final year that run during the semester are Optical Fiber Communication (OFC), Wireless Communication (WC), Satellite Communication (SC), Mobile Computing (MC) and Non-conventional Energy Resources (NCER). Similarly 5 Faculties who can handle at least one of the six course are Mr. Upendra Kumar Singh (UKS), Mr. Hem Chandra Joshi (HCJ), Mr. Mudit Gupta (MGT), Mr. Vinod Mishra (VNM) and Mr. Satyajit Das (SJD).

B. Data Analysis

The table below shows relative ratings of a teacher to a course. After appropriate introspection and evaluation of each teacher's ability to teach a certain course, an efficiency rating out of 100 has been allotted. This includes, past results, student feedbacks, subject knowledge, research on the area, past developments etc. The problem now is how the faculties should be assigned to the courses so as to maximize the educational quality in the department. As we know that the assignment problems usually deal with the minimization situations, and the calculations are also easy that ways, so the above maximization problem is reduced to a minimization problem by finding the regrets matrix, as shown in Table 2.

Table 1: Relative rating of faculties to courses.

Faculty	Courses				
	OFC	**WC**	**SC**	**MC**	**NCER**
UKS	70	76	88	87	84
HCJ	79	80	82	90	89
MGT	82	84	77	81	86
VNM	88	89	85	81	77
SJD	92	74	82	84	86

Table 2: Regrets Matrix in HRAM.

Faculty	Courses				
	OFC	WC	SC	MC	NCER
UKS	30	24	12	13	16
HCJ	21	20	18	10	11
MGT	18	16	23	19	14
VNM	12	11	15	19	23
SJD	08	26	18	16	14

C. Formulation of LP Problem

In order to formulate the Linear Programming problem, we need to allocate variables for each condition. Let i be the name of the Faculty and j be the name of the course, so that X_{ij} denotes the value of regret matrix assigned to each faculty for every individual course.
For *e.g.* X_{11} means regret matrix rating of Mr. UKS for course of OFC and X_{35} means regret matrix rating of Mr. MGT for course of MC.

The problem can be modeled as:

$$\text{Minimize } \sum_{i=1}^{n} \sum_{j=1}^{n} C_{ij} X_{ij}$$

$$\text{Subject to } \sum_{j=1}^{n} X_{ij} = 1$$

$$\sum_{i=1}^{n} X_{ij} = 1$$

Where

X_{ij} = the assignment of teacher i to subject j

C_{ij} = the regret cost or time of assigning teacher i to

[24]

Now let us formulate the objective function for the problem.

The ***Objective Function*** for the problem will be:
MIN 30 X_{11} + 21 X_{21} + 18 X_{31} + 12 X_{41} + 08 X_{51} + 24 X_{12} + 20 X_{22} + 16 X_{32} + 11 X_{42} + 26 X_{52} + 12 X_{13} + 18 X_{23} + 23 X_{33} + 15 X_{43} + 18 X_{53} 13 X_{14} + 10 X_{24} + 19 X_{34} + 19 X_{44} + 16 X_{54}+ 16 X_{15} + 11 X_{25} + 14 X_{35} + 23 X_{45} + 14 X_{55}

Subject to:

Constraints:

$X_{11} + X_{21} + X_{31} + X_{41} + X_{51} = 1$ [Course OFC can be taught by only one faculty]
$X_{12} + X_{22} + X_{32} + X_{42} + X_{52} = 1$ [Course WC can be taught by only one faculty]
$X_{13} + X_{23} + X_{33} + X_{43} + X_{53} = 1$ [Course SC can be taught by only one faculty]
$X_{14} + X_{24} + X_{34} + X_{44} + X_{54} = 1$ [Course MC can be taught by only one faculty]
$X_{15} + X_{25} + X_{35} + X_{45} + X_{55} = 1$ [Course NCER can be taught by only one faculty]
$X_{11} + X_{12} + X_{13} + X_{14} + X_{15} = 1$ [Mr. UKS can teach only one course]
$X_{21} + X_{22} + X_{23} + X_{24} + X_{25} = 1$ [Mr. HCJ can teach only one course]
$X_{31} + X_{32} + X_{33} + X_{34} + X_{35} = 1$ [Mr. MGT can teach only one course]
$X_{41} + X_{42} + X_{43} + X_{44} + X_{45} = 1$ [Mr.VNM can teach only one course]
$X_{51} + X_{52} + X_{53} + X_{54} + X_{55} = 1$ [Mr. SJD can teach only one course]

Optimized Solution to the problem using LiPS Software

In order to find the optimized solution to the Linear Programming problem function stated above, we use the software "LiPS" – Linear Program Solver v1.11.1.
For the computer solution, we create a new model by clicking on the 'New' and then select 'Table Model'. In the 'Model Parameters', we enter 'Number of Variables' = 25, 'Number of Constraints' = 10, 'Number of Objectives' = 1. Then we set 'Optimization Direction' to 'Minimization'. Following is the screenshot of the entries in the table

	X11	X21	X31	X41	X51	X12	X22	X32	X42	X52	X13	X23	X33	X43	X53	X14	X24	X34	X44	X54	X15	X25	X35	X45	X55		RHS
Objective	30	21	18	12	8	24	20	16	11	26	12	18	23	15	18	13	10	19	19	16	16	11	14	23	14	->	MIN
Row1	1	1	1	1	1																					=	1
Row2						1	1	1	1	1																=	1
Row3											1	1	1	1	1											=	1
Row4																1	1	1	1	1						=	1
Row5																					1	1	1	1	1	=	1
Row6	1					1					1					1					1					=	1
Row7		1					1					1					1					1				=	1
Row8			1					1					1					1					1			=	1
Row9				1					1					1					1					1		=	1
Row10					1					1					1					1					1	=	1
Lower ...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0		
Upper ...	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF	INF		
Type	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT	CONT		

Fig. 1. Screenshot of the entries in the table of HRAM.

Clicking on the 'Solve' button, solves the function to minimization and finds the optimal solution after 22 iterations. Following is the table of Results found at individual Variables

>> Optimal solution FOUND
>> Minimum = 55

*** RESULTS - VARIABLES ***

Variable	Value	Obj. Cost	Reduced Cost
X11	0	30	-28
X21	0	21	-14
X31	0	18	-8
X41	0	12	-7
X51	1	8	0
X12	0	24	-16
X22	0	20	-7
X32	0	16	0
X42	1	11	0
X52	0	26	-12
X13	1	12	0
X23	0	18	-1
X33	0	23	-3
X43	0	15	0
X53	0	18	0
X14	0	13	-8
X24	1	10	0
X34	0	19	-6
X44	0	19	-11
X54	0	16	-5
X15	0	16	-10
X25	0	11	0
X35	1	14	0
X45	0	23	-14
X55	0	14	-2

Fig. 2. Screenshot of the result generated in HRAM.

V. FURTHER DISCUSSIONS

Rewriting the results of Figure 2 in a tabular form, we can see that the values at minimum have been assigned a '1' and rest others have been assigned a '0'.

Table 3: Assigned Value Matrix.

Faculty	Courses				
	OFC	**WC**	**SC**	**MC**	**NCER**
UKS	0	0	1	0	0
HCJ	0	0	0	1	0
MGT	0	0	0	0	1
VNM	0	1	0	0	0
SJD	1	0	0	0	0

The table above has made our task very easy. Now we can clearly assign a course to a subject faculty. **Therefore, the total minimum regret that will maximize total teaching efficiency is given as:**
Total = 12 + 10 + 14 + 08 + 11
Total = 55

The result of the Linear programming can now be interpreted as:

- Assign the course of Satellite Communication to Mr. Upendra Kumar Singh
- Assign the course of Mobile Computing to Mr. Hem Chandra Joshi
- Assign the course of Non-conventional Energy Resources to Mr. Muditgupta
- Assign the course of Wireless Communication to Mr. Vinod Mishra
- Assign the course of Optical Fiber Communication to Mr. Satyajit Das

This assignment will be done during the semester and further observations will lead to a conclusion whether application of Linear programming helps in improving the result and overall resource quality of the organization. If this method is found to be successful after 3-4 observations in different departments, it will further be implemented in the entire institute.

VI. SUMMARY AND CONCLUSION

In the human resource allocation model, data of efficiency was obtained reliably for 6 different faculties capable of teaching 6 different subjects. Using linear programming, the faculty best fit to teach a particular subject was calculated. This will be implemented and observed that whether this model yields a better output than the orthodox allocation system.

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