

Research paper

RECRUITMENT MODEL IN MANPOWER PLANNING UNDER FUZZY ENVIRONMENT

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Abstract:

Manpower planning seeks to make the links between strategy, structure and people. The purpose of manpower planning is to get a better matching between manpower requirements and manpower availability. Recruitment in Manpower planning plays an important role. Generally problems related to recruitment are solved by applying stochastic techniques. In this paper, we consider recruitment under fuzzy environment and solution is obtained using cluster analysis and fuzzy technique.

Keywords: fuzzy number, cluster analysis, ranking function.

1. Introduction:

Manpower Planning is a two-phased process, because manpower planning not only analyses the current human resources but also makes manpower forecasts and thereby draw employment programme. Manpower planning helps the firm in following manner:

- Shortages and surplus can be identified so that quick action can be taken wherever required.
- The entire recruitment and selection programme are based on manpower planning.
- It also helps to reduce the labour cost as excess staff can be identified and thereby over staffing can be avoided.
- It recognizes the available talents in concern and training programme can be done to enhance those talents.
- With the help of manpower planning we can utilize the human resources which are available which will increase the growth and diversifications of business.

Manpower planning is the process of acquiring and utilizing human resources in the organization. It is divided into two complementary approaches. One approach is based on a stochastic process and the other is based on optimization process. This paper is based on the second approach. Recruitment in manpower planning for various assignments with required talents plays an important role in human recourse development. The main goal of recruitment in manpower planning is to provide the required number of qualified employees who completes the job in a minimum time.

Consider a new organization with n jobs that need employees who are talented in areas that are related to their jobs. By cluster analysis technique the job seekers are grouped (or clustered) based on their knowledge required for the company. The problem is to find the optimal number of persons from each cluster to various sections of a job, so as to minimize the time required to complete the job.

This problem was solved by using stochastic programming by M. Jeeva [1]. We have discussed this problem under fuzzy environment. Generally the expected time taken to complete a job is taken to be deterministic, but it need not be always as the time cannot be predicted, that is a job may not be completed in a given time due to some unpredictable reasons like machine failure, lack of electricity, etc. Hence the time taken by each person to complete an allotted job is assumed to be fuzzy and the constraints involved in this problem are fuzzy constraints. So the problem considered here will be a fuzzy linear programming problem (FLPP). Here the FLPP model is solved by applying the fuzzy techniques.

2 : Literature review:

Manpower planning has been approached and solved by many methods available in the literature[3],[5],[6],[7]&[8]. Due to its complexity different models have been developed. Thomas R. Robbins and Terry P. Harrison describe manpower planning with limited hiring opportunities in which they have presented the value of stochastic modeling. A. Srinivasan, P. Mariappan and S. Dhivya presented stochastic models on time to recruitment in a two grade manpower system using different polices of recruitment. S. Parthasarathy, M. K. Ravichandran & R. Vinoth presented an application of stochastic models with grading system in manpower planning. S. Nirmala and M. Jeeva have used optimization approach and developed a mathematical model which minimizes the manpower system cost during the recruitment and promotion period which are determined by the changes that take place in the system. S. Parthasarathy, R. Vinoth, and M. Chitra, made an attempt to determine the expected time to recruitment and its variance when threshold follows gamma distribution. K. Nilakantan, Jayaram K. Sankaran and B.G. Raghavendra have constructed a model of hierarchical manpower systems –called the proportionality Markov manpower system model, which follow proportionality policies in recruitment and promotion of their staff, ostensibly with a view to safeguard the career interests of their existing employees. Fuzzy application in manpower planning is a developing process at this stage. Designing Of Fuzzy Mathematical Model For Manpower Planning (Case: Twenty Millions Army) was done by Azar A.*,Najafi E. Fuzzy input and output data were applied for manpower forecasting by Hong Tau Lee. T De Feyter and other co-authors evaluated Recruitment Strategies Using Fuzzy Set Theory in Stochastic Manpower Planning. There are several approaches for a recruitment model in manpower planning.

3 : Preliminary definitions

Fuzzy set: Let X be a universe of discourse. Then a subset A of X is said to be a fuzzy set if A has a membership function $\mu: X \rightarrow [0,1]$, defined as $\mu(A) = \{(x, A(x)) / x \in X \text{ \& } 0 \leq A(x) \leq 1\}$.

α – cut of a fuzzy set : α – cut of a fuzzy set is a crisp set that is defined as the set of all values of X that has membership degree greater than or equal to α . i.e. also denoted as ${}^{\alpha}A = \{x \in X / A(x) \geq \alpha\}$

Fuzzy number: A fuzzy number is a fuzzy set that is defined on R , the set of all real numbers, that satisfies the following conditions: (i) normal, (ii) convex and (iii) Support is bounded.

Triangular fuzzy number: A triangular fuzzy number A denoted as $[a, b, c]$ is a fuzzy number whose membership function is of the form

$$A(x) = \begin{cases} \frac{(x-a)}{(b-a)} & \text{if } a < x < b \\ 1 & \text{if } x = b \\ \frac{(c-x)}{(c-b)} & \text{if } b < x < c \\ 0 & \text{otherwise} \end{cases}$$

Trapezoidal Fuzzy number: A trapezoidal fuzzy number A denoted as $[a, b, c, d]$ is a fuzzy number whose membership function is of the form

$$A(x) = \begin{cases} \frac{(x-a)}{(b-a)} & \text{if } a < x < b \\ 1 & \text{if } b < x < c \\ \frac{(c-x)}{(c-b)} & \text{if } c < x < d \\ 0 & \text{otherwise} \end{cases}$$

4: Application of cluster analysis technique:

Assume that there are n jobs available in the organization for which new recruitment is made. Here we apply a well known cluster analysis technique, namely the k – means method to divide the given n jobs seekers into K ($=n$) homogeneous clusters, (say) $G_1, G_2, \dots, G_n$. Each cluster is formed based on their specialization in each job as stated by them in their applications required for the organization. Based on their efficiency level defined by the organization, the applicants in each cluster are examined and are divided into two clusters using selection criteria. The selected clusters be denoted as $C_1, C_2, \dots, C_n$ where $C_i \subseteq G_i, i = 1, 2, \dots, n$. Within the selected clusters candidates are ranked based on their performance skills.



In this model our goal is to determine the optimal number of persons selected from various clusters to perform various jobs with the objective of minimizing the total time taken to complete all the jobs. Here in order to avoid infeasible solution we assume that the number of persons required for the jobs from the j th cluster should not exceed the number of persons available in the j th cluster. Also the number of persons required to complete all the jobs should not exceed the number of persons available from all the clusters. Let $\widetilde{x}_{ij}$ denote the number of persons selected for the i^{th} job from j^{th} cluster and $\widetilde{t}_{ij}$ be the mean time taken to complete a unit production of a product from the i^{th} job by a person from the j^{th} cluster. Here in this paper we have made some assumptions which are listed below.

1. The time $\tilde{t}_{ij}$ is considered to be a fuzzy number, as it need not be deterministic always.
2. The expected man hours from each cluster are fixed as a fuzzy number.
3. The available machine hours for each Job are fixed as a fuzzy number.
4. The organization fixes a range for target on the number of employees for each job
5. The number of persons in the clusters must be same as the number of persons required to complete all the jobs, so as to employ all the persons selected.

6. The organization also wants every employee to be capable of handling any kind of job given by them, even though they are specialized in particular area.

The details of the problem are mentioned in the table below:

Clusters Jobs	C ₁	C ₂	...	C _n	Available machine time	Required no of persons
Job 1	$\widetilde{t}_{11}$	$\widetilde{t}_{12}$	...	$\widetilde{t}_{1n}$	$\widetilde{a}_1$	$\widetilde{x}_1$
Job 2	$\widetilde{t}_{21}$	$\widetilde{t}_{22}$	...	$\widetilde{t}_{2n}$	$\widetilde{a}_2$	$\widetilde{x}_2$
.	.	.		.	.	.
.	.	.		.	.	.
.	.	.		.	.	.
Job n	$\widetilde{t}_{n1}$	$\widetilde{t}_{n2}$	...	$\widetilde{t}_{nn}$	$\widetilde{a}_n$	$\widetilde{x}_n$
Expected man hours	$\widetilde{b}_1$	$\widetilde{b}_2$		$\widetilde{b}_n$		
Expected persons	$\widetilde{y}_1$	$\widetilde{y}_2$		$\widetilde{y}_n$		

Table 1

4.3. Mathematical Formulation of FLPP model:

To determine x_{ij} , for which $\sum_{i=1}^n \sum_{j=1}^n \widetilde{t}_{ij} \widetilde{x}_{ij}$ is minimum, (4.3.1)
subject to

$$\sum_{i=1}^n \widetilde{x}_{ij} = \widetilde{y}_j, \quad \text{for all } j = 1, 2, \dots, n \quad (4.3.2)$$

$$\sum_{j=1}^n \widetilde{x}_{ij} = \widetilde{x}_i, \quad \text{for all } i = 1, 2, \dots, n \quad (4.3.3)$$

$$\sum_{i=1}^n \widetilde{x}_i = \sum_{j=1}^n \widetilde{y}_j \quad (4.3.4)$$

$$\sum_{j=1}^n \widetilde{t}_{ij} \widetilde{x}_{ij} \leq \widetilde{a}_i \quad \text{for } i = 1, 2, \dots, n \quad (4.3.5)$$

$$\sum_{j=1}^n \widetilde{t}_{ij} \widetilde{x}_{ij} \leq \widetilde{b}_j \quad \text{for } j = 1, 2, \dots, n \quad (4.3.6)$$

$$\widetilde{x}_{ij} \geq 0 \quad \text{for all } i, j = 1, 2, \dots, n \quad (4.3.7)$$

The above model can be treated as a fuzzy transportation problem with additional constraints and can be solved to obtain an optimal solution to the problem. This FLPP is solved by considering two cases. In case 1 the model is solved under the assumption that the inequalities (4.3.5) and (4.3.6) are not involved, where as in case 2 the model includes the inequalities and is solved using fuzzy techniques.

5. Fuzzy transportation without the additional constraints:

5.1. Case 1: Application of Yager's Ranking Procedure:

In this section we solve the FLPP using Yager's ranking function[2]. The function $R: F(X) \rightarrow (-\infty, \infty)$, defined by $R(A) = \frac{1}{2} \int_0^1 [c_L + c_R] d\alpha$, where $A \in F(X)$, the set of all fuzzy sets defined on X and R , the set of all real numbers and c_L is the lower bound and c_R , the upper bound of the α -cut of A . Here the inequalities in (4.3.5) and (4.3.6) are not considered. Now the problem reduces to ordinary transportation problem.

Algorithm:

1. Consider table 1 by deleting the a_i 's and b_j 's.
2. Check the problem to be a balanced one. If not so make it a balanced one by adding a dummy row/column, whichever is required.
3. Convert each fuzzy number into real number using the Yager's ranking function.
4. Now solve the problem using any method available in the crisp case. Here VAM is adopted.
5. Obtain the optimal solution and the optimal value.

Example:1

Consider a new organization with three different types of jobs, which wants to employ people for the posts with the condition that every employee must be capable of handling all the three jobs. First the applicants are grouped into three clusters G_1, G_2, G_3 using K- means method by applying some similar conditions on the efficiency in each job required by the organization. Then the persons from each cluster are examined by means of interview by the organization based on its designed norms on efficiency in each job and each cluster is divided into binary clusters of selected and non-selected ones. The persons from the selected clusters are ranked based on their efficiency. Let the three final selected clusters for the jobs J_1, J_2, J_3 be C_1, C_2, C_3 respectively. The matrix related to the time is given below:

Clusters Jobs	C_1	C_2	C_3	Available time	Required no. of persons
Job 1	[3, 5,11]	[4,6,16]	[3, 8, 9]	[40, 180, 400]	[16,20,24]
Job 2	[4, 6,16]	[3, 4, 9]	[3,5,11]	[60, 180,480]	[20,25,30]
Job 3	[4, 9,18]	[6,8,14]	[2, 4, 6]	[50,270,630]	[26,30,34]
Exp man hrs	[70,270,630]	[60,200,480]	[30,150,410]		
Expected persons	[26,30,34]	[20,25,30]	[16,20,24]		

Table 2

Solution:

Step1: Eliminating the inequality constraints the problem reduces to a balanced fuzzy transportation problem.

Clusters Jobs	C ₁	C ₂	C ₃	Required no. of persons
Job 1	[3, 5,11]	[4,6,16]	[3, 8, 9]	[16,20,24]
Job 2	[4, 6,16]	[3, 4, 9]	[3,5,11]	[20,25,30]
Job 3	[4, 9,18]	[6,8,14]	[2, 4, 6]	[26,30,34]
Expected persons	[26,30,34]	[20,25,30]	[16,20,24]	

Table 3

Step 2: On applying Yager's ranking function, the above table reduces to the following table:

Clusters Jobs	C ₁	C ₂	C ₃	Required no. of persons
Job 1	6	8	7	20
Job 2	8	5	6	25
Job 3	10	9	4	30
Expected persons	30	25	20	75

Table 4

Step 3: the solution to the above problem is as follows:

the optimal solution is $X_{11} = 20$, $X_{22} = 25$, $X_{31} = 10$, $X_{33} = 20$ and the optimal value is 425 hours.

5.2. Case 2 Fuzzy transportation problems with additional constraints:

Suppose the inequalities (4.3.5) & (4.3.6) are not eliminated, then the problem becomes a fuzzy transportation problem with additional constraints. Here in this case we solve the problem in two different ways. Firstly, the problem is solved using Yager's ranking function and secondly by split and bound method introduced by Pandian & Anuradha [4]. The method applied here is particularly used to solve the transportation problem with additional constraints

5.2.1. Application of fuzzy techniques:

Algorithm:

- Step1: Consider the table1 with fuzzy time. Check whether the problem is balanced ($\sum_{i=1}^n \widetilde{a_i} = \sum_{j=1}^n \widetilde{y_j}$). If not, then use dummy column/row and make it balanced.
- Step 2: Using fuzzy Vogel's approximation method, the solution is obtained to the problem in table 1 by considering the additional constraints as the supply and demand.
- Step 3: Once the solution is obtained, delete the maximum fuzzy number that is present in non allocated cells.
- Step 4: With the deleted cell in table 1, solve the problem by considering the expected no. of persons and required no. of persons as the supply and the demand.
- Step 5: Obtain the solution to the problem.

Illustration:

Consider the example 1 discussed in section 6. By applying the above procedure to the example, the solution to this problem is given as

$$X_{11} = (16, 20, 24) \quad X_{22} = (20, 25, 30) \quad X_{31} = (10, 10, 10) \quad X_{33} = (16, 20, 24)$$

Optimal value: (180, 370, 858)

The crisp solution:

$$X_{11} = 20, \quad X_{22} = 25, \quad X_{31} = 10, \quad X_{33} = 20 \text{ and the optimal value : 444.5 hours.}$$

5.2.2. Application of split and bound method:

Procedure to Split and Bound Method:

1. Convert the fuzzy numbers to interval numbers (α – cuts can be expressed as interval numbers).
2. Using the lower bound of the intervals form a table similar to the original problem.
3. Solve the problem and obtain the solution and the optimal value by using method given in section 6.1.
4. Similarly form a table using the upper bound of the intervals and obtain the solution for the same as is done the above step.
5. Combine the solutions that are obtained in step 2 & 4, so that the solution obtained in step 2 forms the lower bound and the solution from step 4 forms the upper bound.
6. Obtain the optimal value by combining the optimal values obtained in step 3 and 4.
7. From this solution the required fuzzy solution is obtained.

Illustration: Consider example 1. Here we solve the problem using split and bound method [4]. In this method, we calculate the α – cut for each fuzzy number and then solve the problem using split and bound method.

269 Step 1: consider table 2 of example 1 in sec 6. Find the α -cuts for each fuzzy number in table 2.
 270 The following table is obtained:
 271

Job/Clusters ▼	C1	C2	C3	Jobcompletion time	Reqd. no.of persons
J1	$[3+2\alpha, 11-6\alpha]$	$[4+2\alpha, 16-10\alpha]$	$[3+5\alpha, 9-\alpha]$	$[40+140\alpha, 400-220\alpha]$	$[16+4\alpha, 24-4\alpha]$
J2	$[4+2\alpha, 16-10\alpha]$	$[3+\alpha, 9-5\alpha]$	$[3+2\alpha, 11-6\alpha]$	$[60+120\alpha, 480-300\alpha]$	$[20+5\alpha, 30-5\alpha]$
J3	$[4+5\alpha, 18-9\alpha]$	$[6+2\alpha, 14-6\alpha]$	$[2+2\alpha, 6-2\alpha]$	$[50+220\alpha, 630-360\alpha]$	$[26+4\alpha, 34-4\alpha]$
Expected man hours	$[70+200\alpha, 630-360\alpha]$	$[60+140\alpha, 480-280\alpha]$	$[30+120\alpha, 410-260\alpha]$		
Expected no of persons	$[26+4\alpha, 34-4\alpha]$	$[20+5\alpha, 30-5\alpha]$	$[16+4\alpha, 24-4\alpha]$		

Table 5

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 274 Step 2: consider only the upper bound of the α -cuts from table 5.
 275

JOB/Cluster ▼	C1	C2	C3	Job completion time	Reqd. no of persons
J1	$11 - 6\alpha$	$16-10\alpha$	$9- \alpha$	$400-220\alpha$	$24-4\alpha$
J2	$16-10\alpha$	$9-5\alpha$	$11 - 6\alpha$	$480-300\alpha$	$30-5\alpha$
J3	$18-9\alpha$	$14-6\alpha$	$6-2\alpha$	$630-360\alpha$	$34-4\alpha$
Exp man hrs	$630-360\alpha$	$480-280\alpha$	$410-260\alpha$		
Expected no of persons	$34-4\alpha$	$30-5\alpha$	$24-4\alpha$		

Table 6

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 278 Step 3: The solution to the problem in step2 is obtained:
 279 $X_{11}= 24-4\alpha, X_{22}= 30-5\alpha, X_{31}= 10, X_{33}= 24-4\alpha$
 280 Optimal value : $858-488\alpha$
 281

(5.2.1)

282 Step 4: Now find the solution using the lower bound of the α -cuts:
 283

JOB/Cluster ▼	C1	C2	C3	Job completion time	Reqd. no. of persons
J1	$3+2\alpha$	$4+2\alpha$	$3+5\alpha$	$40+140\alpha$	$16+4\alpha$
J2	$4+2\alpha$	$3+\alpha$	$3+2\alpha$	$60+120\alpha$	$20+5\alpha$
J3	$4+5\alpha$	$6+2\alpha$	$2+2\alpha$	$50+220\alpha$	$26+4\alpha$
Exp. Man hours	$70+200\alpha$	$60+140\alpha$	$30+120\alpha$		
Expected no of persons	$26+4\alpha$	$20+5\alpha$	$16+4\alpha$		

Table 7

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The solution to this problem:

$$X_{11}=16+4\alpha, X_{22}=20+5\alpha, X_{31}=10, X_{33}=16+4\alpha \quad (5.2.2)$$

$$\text{Optimal value: } 180+190\alpha$$

Combining the results from (5.2.1) & (5.2.2), the solution to table 5 is obtained as

$$X_{11}=[16+4\alpha, 24-4\alpha], X_{22}=[20+5\alpha, 30-5\alpha], X_{31}=[10, 10], X_{33}=[16+4\alpha, 24-4\alpha] \text{ and}$$

$$\text{Optimal value: } [180+190\alpha, 858-488\alpha].$$

The solution of table 5 can be discussed for different values of α as follows:

α	X_{11}	X_{22}	X_{31}	X_{33}	Optimal value
0	[16, 24]	[20, 30]	[10, 10]	[16, 24]	[180, 858]
$\frac{1}{2}$	[18, 22]	[17.5, 27.5]	[10, 10]	[18, 22]	[275, 614]
1	[20, 20]	[25, 25]	[10, 10]	[20, 20]	[370, 370]

The corresponding fuzzy solution and the fuzzy optimal value for the problem given by table 2 are

$$X_{11}=(16,20,24) \quad X_{22}=(20,25,30) \quad X_{31}=(10,10,10) \quad X_{33}=(16,20,24)$$

$$\text{Optimal value: } (180, 370, 858)$$

The Crisp solution to table 2 is :

$$X_{11}=20, X_{22}=25, X_{31}=10, X_{33}=20$$

$$\text{Optimal value: } 444.5 \text{ hours}$$

7. Conclusion:

The problem discussed here is solved in two different situations. In case 1 the problem is considered without the additional constraints and the solution for the same is obtained by applying Yager's ranking function. In case 2 the restrictions on available time and expected man hours constraints are considered and are solved by applying fuzzy techniques. The solution obtained in case 2 by both the methods are shown to be the same. This problem can also be solved using various technique like fractional programming, modified Vogel's method, etc.,

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