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Multi-objective faculty course assignment problem based on the double parametric form of fuzzy preferences

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Abstract

This paper presents a mathematical model of the multi-objective faculty course assignment problem based on the double parametric form of fuzzy preferences. The fuzzy preferences are based on an analysis of faculty feedback given by students and an analysis of the results of the previous year's examination of students. The proposed model is developed utilizing faculty members' preferences, the preferences of an administrator for faculty members to courses, and fuzzy preferences based on faculty feedback and student result analysis. The double parametric approach solves a timetabling problem based on information from a university's hypothetical numerical data. The fuzzy programming technique with linear membership function is applied to generate efficient and non-dominated allocations with better optimal values and degree of satisfaction of objective functions for different values of parameters α and β for fuzzy preferences. Results are found using LINGO19.0 software.

Keywords: *course scheduling, double parametric, 0-1 integer programming, timetabling, fuzzy programming technique*

1. Introduction

Faculty course assignment problem is allocating courses to faculty members under several hard and soft constraints. This is a sub-problem of the educational timetabling problem. Every institution such as academics, sports, transportation, health, etc., comes across the timetabling problem overall in the world. Timetabling is allocating events like courses and examination duties to resources like teachers, workers, and doctors over space such as a classroom or operation room satisfying several constraints. Constraints define solution space and there are two types of constraints such as hard, which must be satisfied by the solution, and soft which are to be satisfied as far as possible that is these constraints can be violated. The feasibility of the allocation problem is determined by hard constraints and the quality of the allocation plan is determined by soft constraints [9, 12, 23].

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Faculty course assignment is an NP-complete problem because it is easy to verify the solution but very difficult to solve. However, as the size of the problem increases accordingly complexities to determining its solution are increased exponentially. Therefore, it is generally tackled by resolving it into co-related stages which are an iterative process. Many people consider it. Schnierjans and Kim [20] presented a faculty course model and solved it by goal programming with preferences. This model was extended by Badri [6] who assigned courses to faculty members and paired course-faculty to time slots based on preferences for courses as well as a time slot in two phages. Furthermore, Badri [7] combined a two-phase model into a single-phase one, in which courses are assigned to faculty members as well as pair of courses and faculty members taken together to time slots simultaneously based on preferences of faculty members to courses. Werra [12] introduced the basic class teacher model and mentioned how they could be inserted in a general program that produces usable allocations using edge coloring of the graph. Asratian and Werra [5] considered a generalized class-teacher model that extends the basic class-teacher model for an assignment that corresponds to some situations that frequently occur in the basic training program of universities and schools.

Ozdemir and Gazimov [18] developed three-step process consisting of the analytic hierarchy process, scalarization, and the subgradient method to solve a non-convex multiobjective faculty course assignment problem based on participant's average preferences and presented an effective way to solve the model. Daskalaki and Birbas [11] presented a two-stage relaxation procedure that solves efficiently the integer programming formulation of a university timetabling problem. The class faculty assignment problem investigated by Yakoob and Sherali [1, 2] resemble many class scheduling problems. The faculty course assignment problems are solved by constraints-based methods, graph-based approaches, cluster-based methods, population-based approaches, hill climbing, meta-heuristics methods, multi-criteria approaches, case-based reasoning, fuzzy-based approaches, hyperheuristics, self-adaptive approaches, etc. Cruz et al. [10] presents a metaheuristic with distributed processing that finds solutions for an optimization model of the university course timetabling problem. Bakir and Aksop [8] formulated a 0-1 integer programming model for the problem of course scheduling for the Department of Statistics at Gazi University, Turkey, which assigns courses to periods and classrooms. Ngo et al. [17] introduce a mathematical model to assign constrained tasks (the time and required skills) to university lecturers, which generates a calendar that maximizes faculty expectations. Esmaeilbeigi et al. [13] introduce a multiphase course timetabling problem and present mathematical formulations and effective solution algorithms to solve it in a real case study. Goh et al. [14] studied the post-enrolment course timetabling problem that focuses on finding an efficient allocation of courses onto a finite number of time slots and rooms. Algethami et al. [3] proposed a multi-objective mixed-integer programming model for preregistration university course scheduling combined with faculty-related constraints.

Rappos et al. [19] present a mixed-integer programming model for solving the university timetabling problem which considers the allocation of students to classes and the assignment of rooms and periods to each class. Arratia et al. [4] presented a university course timetabling problem with the assignment of a professor-course-time slot for an institution in Mexico. Tassopoulos et al. [22] studied the school timetabling problem in the case of Greek high schools. It has been observed from the literature that fuzzy preferences are incorporated with a possibilistic approach but not with a double parametric approach. This paper mainly deals with the allocation of courses to faculty members with a double-parametric approach. To develop the presented model, preferences of faculty members based on two parameters, result analysis and feedback analysis are considered. These parameters are uncertain due to insufficient or vague information. Therefore, the fuzzy approach is incorporated into the model. If we do not consider results and feedback in fuzzy numbers, then it is very difficult to reach the reality of the system. That is why we considered results and feedback as fuzzy parameters. However, it is not possible to obtain its solution without a fuzzy approach. Using a single parametric form, the order of the fuzzy system in crisp form is doubled. On the other hand, a double parametric form of fuzzy numbers converts the fuzzy system into a crisp system of the same order. So, computationally required less time. We have developed a multi-objective faculty course assignment problem (MOFCAP) with preferences of faculty members and administrators as well as feedback and result-based fuzzy preferences. The model is solved by fuzzy programming technique with linear membership function and results are obtained by LINGO19.0 software.

The paper is organized as follows. In Section 2, we discuss and formulate the multi-objective faculty course assignment problem based on double parametric form, Section 3 discusses methodology, Section 4 presents the numerical computations, Section 5 discusses results and the conclusion is provided in the last section.

2. Problem formulation

All educational institutions face the problem of allocation of courses to faculty members every semester, which is a complex problem. Here, we develop a multi-objective faculty course assignment problem (MOFCAP) with feedback and result analysis based on fuzzy preferences. The fuzzy preferences of results and feedback are converted into crisp form with the double parametric form.

2.1. Problem formulation of multiobjective faculty course assignment problem (MOFCAP) using faculty feedback and result

Based on feedback and result analysis, the following parameters and decision variables are used to formulate the MOFCAP.

Parameters

$I = \{1, 2, \ldots, m\}$ – the list of all the courses
$J = \{1, 2, \ldots, k\}$ – the list of all faculties
h_i – total number of lecture hours for the ith course in a week
l_j, u_j – lower and upper bounds for the jth faculty member's weekly load, respectively
t_{ij} – preference level of the ith the course by the jth instructor ($t_{ij} \geq 1, 1$ – the most desired the course)
a_{ij} – administrative preference level for the assignment of the course to the jth faculty
$\widetilde{b_{ij}}$ – fuzzy preferences based on faculty feedback for the course i to faculty member j
$\widetilde{c_{ij}}$ – fuzzy preferences based on result analysis for the course i to faculty member j

Decision variable

Decision variable x_{ij} represents assignment of ith course to jth faculty and is defined as

$$x_{ij} = \begin{cases} 1, & \text{if course } i \text{ is assigned to faculty } j \\ 0, & \text{otherwise} \end{cases} \tag{1}$$

Objective functions

1. Minimize the preferences of the faculty members for courses

$$Z_l(x) = \sum_{i=1}^{m} x_{ij} t_{ij},\; l = 1, 2, \ldots, n-4, j = 1, 2, \ldots, n \tag{2}$$

2. Minimize the preferences of all faculties

$$Z_{n-3}(x) = \sum_{i=1}^{m} \sum_{j=1}^{k} x_{ij} t_{ij} \tag{3}$$

3. Minimize the administration's total preference level

$$Z_{n-2}(x) = \sum_{i=1}^{m} \sum_{j=1}^{k} a_{ij} x_{ij} \tag{4}$$

4. Minimize the fuzzy preferences based on the feedback of faculty given by students

$$Z_{n-1}(x) = \sum_{i=1}^{m} \sum_{j=1}^{k} \widetilde{b_{ij}} x_{ij} \tag{5}$$

5. Minimize the fuzzy preferences based on analysis of student examination results

$$Z_{n}(x) = \sum_{i=1}^{m} \sum_{j=1}^{k} \widetilde{c_{ij}} x_{ij} \tag{6}$$

Subject to constraints

1. Every course must be assigned to only one faculty

$$\sum_{j=1}^{n} x_{ij} = 1,\; i = 1, 2, \ldots, m \tag{7}$$

2. The weekly load of every faculty must be between his lower and upper limits

$$l_j \leq \sum_{i=1}^{m} x_{ij} \leq u_j,\; j = 1, 2, \ldots, n \tag{8}$$

Fuzzy preferences are converted into crisp form by a double parametric form of a fuzzy number [15, 16, 21].

2.2. Double parametric approach

Zadeh [25, 26] introduced the concept of fuzzy sets. Insufficient information on real-world problems is important as it imposes high uncertainty. Even though, past data are presented, performing the parameters does not require fulfilling their past model in the future. To deal with these issues with the concerned problem, the uncertain parameters are presented with fuzzy numbers.

2.2.1. Triangular fuzzy number

A triangular fuzzy number is a fuzzy number $\tilde{A}$ which is defined by the numbers a, b and c $(a < b < c)$ and its graph is a triangle with a vertex at $x = a$ and the base on the $[a, b]$ interval as shown in Figure 1.

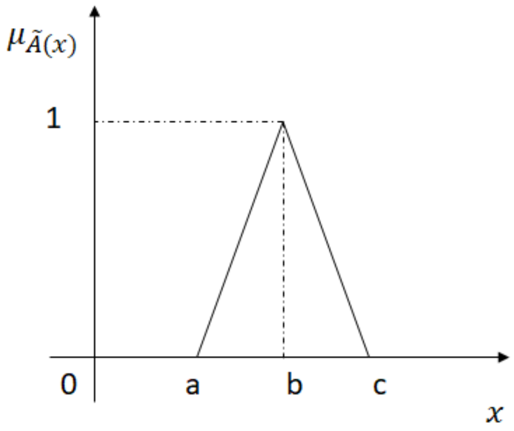

Figure 1. Triangular fuzzy number

For simplicity, the left threshold value a, the midpoint b, and the right threshold value c are used to represent a triangular fuzzy number $\tilde{A}\,(a, b, c)$ where its membership function of $\tilde{A}$ is given by triangular fuzzy number denoted by $\tilde{A}\,(a,\ b,\ c)$ of crisp number with $a < b < c$ represented by Figure 1 and its membership function is defined as

$$\mu_A(x) = \begin{cases} \dfrac{x-a}{b-a}, & \text{if } a \le x \le b \\ \dfrac{c-x}{c-b}, & \text{if } b \le x \le c \\ 0, & \text{otherwise} \end{cases}$$

The α-cut of the triangular fuzzy number $\tilde{A}\,(a,\ b,\ c)$ defined as

$$A_\alpha = \left[A^L_\alpha,\ A^R_\alpha\right] = \left[(b-a)\,\alpha + a,\ (b-c)\,\alpha + c\right],\ \alpha \in [0,\ 1]$$

2.2.2. Double parametric form of fuzzy numbers [21, 24]

Let $\tilde{\mu} = [\underline{\mu}(\alpha), \bar{\mu}(\alpha)]$ be a parametric form of a fuzzy number $\tilde{A}$, then one may represent the double parametric form in crisp values as $\bar{\mu}(\alpha, \beta)$=$\beta[\bar{\mu}(\alpha) - \underline{\mu}(\alpha)] + \underline{\mu}(\alpha)$, where α, $\beta \in [\,0, 1]$. The embedding parameter β denotes the deforming parameter such that if $\beta = 0$ then $\tilde{\mu}(\alpha, 0) = \underline{\mu}(\alpha)$ (lower bound fuzzy number), and if β = 1 then $\tilde{\mu}(\alpha, 1) = \bar{\mu}(\alpha)$ (upper bound fuzzy number). In this way, the computational time of the double parametric form will be less than the computational time of the single parametric form.

The objective functions (5) and (6) are fuzzy objectives, which are converted by a double parametric approach as follows:

$$\widetilde{b_{ij}}(\alpha,\beta) = [\widetilde{b_{ij}}(\alpha)]_\beta = \beta[\bar{b_{ij}}(\alpha) - \underline{b_{ij}}(\alpha)] + \underline{b_{ij}}(\alpha)$$
$$\widetilde{c_{ij}}(\alpha,\beta) = [\widetilde{c_{ij}}(\alpha)]_\beta = \beta[\bar{c_{ij}}(\alpha) - \underline{c_{ij}}(\alpha)] + \underline{c_{ij}}(\alpha)$$

In the formulation of the developed double parametric fuzzy model, the fuzzy objectives are first converted into interval-based fuzzy objectives. Subsequently, the resulting objective functions are transformed by applying the double parametric approach using the embedding parameter where this parameter β, which deforms from 0 to 1, reduces the computational and analysis work to obtain the solutions. The fuzzy multi-objective mathematical model of the faculty-course assignment problem (FMOFCAP) can be formulated as follows: A mathematical model based on the double parametric form of fuzzy preferences of MOFCAP:

2.2.3. Model-1: MOFCAP based on the double parametric form of fuzzy preferences

The double parametric approach based multi-objective faculty course assignment problem is formulated as follows:

$$\min\left[Z_1(x), Z_2(x), \ldots, Z_{n-2}(x), Z_{n-1}(x), Z_n(x)\right] \tag{9}$$

$$Z_k(x) = \sum_{i=1}^{m} x_{ij} t_{ij}, k = 1, 2, \ldots, (n-4) \text{ and } j = 1, 2, \ldots, n \tag{10}$$

$$Z_{n-3}(x) = \sum_{i=1}^{m}\sum_{j=1}^{n} x_{ij} t_{ij} \tag{11}$$

$$Z_{n-2}(x) = \sum_{i=1}^{m}\sum_{j=1}^{n} a_{ij} x_{ij} \tag{12}$$

$$\tilde{Z_{n-1}}(x,\alpha,\beta) = \min\left(\widetilde{b_{ij}}(\alpha,\beta) = [\widetilde{b_{ij}}(\alpha)]_\beta = \beta[\bar{b_{ij}}(\alpha) - \underline{b_{ij}}(\alpha)] + \underline{b_{ij}}(\alpha)\right) \tag{13}$$

$$\tilde{Z}_n(x,\alpha,\beta) = \min\left(\widetilde{c_{ij}}(\alpha,\beta) = [\widetilde{c_{ij}}(\alpha)]_\beta = \beta[\bar{c_{ij}}(\alpha) - \underline{c_{ij}}(\alpha)] + \underline{c_{ij}}(\alpha)\right) \tag{14}$$

$$x_{ij} = \begin{cases} 1, & \text{if course } i \text{ is assigned to faculty } j \\ 0, & \text{otherwise} \end{cases} \tag{15}$$

Subject to the constraints

$$\sum_{j=1}^{n} x_{ij} = 1, i = 1, 2, \ldots, m \tag{16}$$

$$l_j \leq \sum_{i=1}^{m} x_{ij} \leq u_j, j = 1, 2, \ldots, n \tag{17}$$

This MOFCAP based on the double parametric form of fuzzy preferences is solved by fuzzy programming technique with linear membership function as discussed in the next section.

3. Solution of MOFCAP based on the double parametric form of fuzzy preferences by a fuzzy programming technique

For finding the solution of the MOFCAP based on the double parametric form of fuzzy preferences by fuzzy programming technique, first this model is solved for a single objective function for each objective function to find out the positive ideal solution (PIS) and negative ideal solution (NIS) of the model. Now, define a membership function $\mu(Z_k)$ for the kth objective function. Here the linear membership function is utilized to find a compromise solution. After utilizing the linear membership functions model is transformed into the following model.

The single objective model of MOFCAP based on the double parametric form of fuzzy preferences with linear membership function is as follows:

$\max \lambda$ subject to the constraints:

$$\lambda \leqslant \frac{u_k - f_k(x)}{u_k - l_k},\ k = 1, 2,\ \ldots,\ n \tag{18}$$

and constraints (16) to (17), where linear membership function is defined as

$$\mu(Z_k) = \begin{cases} 1, \text{ if } f_k(x) \leqslant l_k \\ \dfrac{u_k - f_k(x)}{u_k - l_k}, \text{ if } l_k < f_k(x) < u_k \\ 0, \text{ if } f_k(x) \geqslant u_k \end{cases} \tag{19}$$

This single objective model is solved using LINGO software. The algorithm of model is as follows:

Input: ***Parameters:*** $(Z_1, Z_2, Z_3, \ldots\ \ldots, Z_k, n, I, J, h_i, u_j, l_j, a_{ij}, \widetilde{b_{ij}}, \widetilde{c_{ij}}, x_{ij})$
Output: *Optimal allocations of* **MOFAP based on double parametric form**
read *Parameters*
formulate model **MOFAP based on double parametric form**
objective $= .8$
while *objective* $\leq n$ **do**
    Compute **PIS and NIS**
    print *PISandNIS*
    fit linear membership function
    Define α, β
    for $\alpha \leftarrow [0, 1]$ **do**
        Compute allocations
        if *Allocations accepted* **then**
            print Compromise allocations
        else {*Allocations rejected*}
            Change the value of α
        end if
    end for
end while

Algorithm 1. MOFAP based on double parametric form by fuzzy programming technique

4. Computational test

To test the efficiency presented model, the hypothetical data-based case of allocation of courses to faculty members in institutes is studied and discussed. The details of the case study are as follows: Suppose there are 12 faculty members and 20 courses. The mathematical model is developed utilizing the preferences of faculty members, an administrator, and the fuzzy preferences based on faculty feedback and result analysis.

Table 1. Faculty preferences for the courses of MOFAP with the double parametric form of fuzzy preferences

	1	2	3	4	5	6	7	8	9	10	11	12
1		3	4	4	2	2	3		1			
2				3	4			1	2		4	2
3	4	1			2	3			3	2		
4		4	3	2	3		3	4		4	2	1
5		3			1			2				2
6	1	2			3							
7			4			2				1		
8			1							2		
9		2	1	3	4	3	3		4			
10		3	2		2	1	4		3	2		
11		3		4			2				1	
12				1		3						
13	2							1				4
14					1		4	3				2
15		4		3	4	3	1				2	
16		1			3			2				
17			4	1		1						
18							2					
19		4			3		1					
20					1		2	3				

The mathematical model is developed utilizing the preferences of faculty members, administrators, and fuzzy preferences based on faculty feedback and result analysis. This will assign courses to faculty members by maximizing the satisfaction of faculty members, the administrator, and students under several constraints. $I_j \subset I$ is the set of indices showing the courses that faculty j can take, $j = 1 - 12$. P_k is the set of courses desirable to take at the kth preference level and in this study, we assume that k = 1, 2, 3, 4. h_i is the total number of lecture hours for the ith course in a week, l_j, u_j are lower and upper bounds respectively, on the jth faculty weekly load; t_{ij} preferences of the ith course by the jth faculty member, $t_{ij} \geq 1$. 1 indicates the most desired course). a_{ij} is the administrative preference level for the assignment of the ith course by the jth faculty. b_{ij} is the previous result of the ith course by the jth faculty for the assigning. Table 1 represents faculty members' preferences for courses. In particular, faculty member 1 preferred the fourth preference for course 3, the first preference for course 6, etc. Similarly, the preferences of other faculties can be interpreted from Table 1. Table 2 represents the preferences of the administrator for faculties to courses. Here, the second preference of administrator for faculty member 1 to course 3; second preference for course 6 etc. Similarly, the preferences of administrators for faculties to courses can be interpreted from Table 2.

Table 2. Administrator preferences for faculty members to courses of MOFAP with the double parametric form

	1	2	3	4	5	6	7	8	9	10	11	12
1		2	2	2	1	3	2		3			
2				1	3			2	2		3	1
3	2	3			4	2			1	3		
4		1	1	3	2		4	3		2	4	3
5		2			3			4				2
6	2	3			1							
7			2			3				3		
8			3							4		
9		1	3	2	3	2	2		2			
10		4	1		1	3	3		4	1		
11		2		1			1				2	
12				2		2						
13	4							2				3
14					3		3	1				4
15		1		2	2	1	2				1	
16		4			1			3				
17			3	4		2						
18							3					
19		3			2		2					
20					3		4	3				

Table 3. Fuzzy preferences based on the feedback analysis for faculty members to courses of MOFAP with the double parametric form

	1	2	3	4	5	6	7	8	9	10	11	12
1		$(3,4,5)$	$(6,7,8)$	$(3,4,5)$	$(2,4,6)$	$(1,2,3)$	$(2,3,4)$		$(1,2,3)$			
2				$(1,3,5)$	$(4,6,8)$			$(1,2,3)$	$(2,4,6)$		$(7,8,9)$	$(2,3,4)$
3	$(7,8,9)$	$(4,6,8)$			$(1,3,5)$	$(2,3,4)$			$(3,4,5)$	$(3,4,5)$		
4		$(3,5,7)$	$(4,5,6)$	$(5,6,7)$	$(3,4,5)$		$(4,5,6)$	$(4,5,6)$		$(4,5,6)$	$(4,5,6)$	$(1,2,3)$
5		$(2,4,6)$			$(1,2,3)$			$(2,4,6)$				$(3,5,7)$
6	$(1,2,3)$	$(2,3,4)$			$(4,5,6)$							
7			$(3,4,5)$			$(3,5,7)$				$(1,2,3)$		
8			$(2,3,4)$							$(2,4,6)$		
9		$(4,5,6)$	$(2,3,4)$	$(4,6,8)$	$(5,7,9)$	$(3,4,5)$	$(4,6,8)$		$(7,8,9)$			
10		$(4,6,8)$	$(1,2,3)$		$(2,3,4)$	$(1,2,3)$	$(4,5,6)$		$(6,7,8)$	$(3,4,5)$		
11		$(2,3,4)$		$(5,6,7)$			$(1,2,3)$				$(1,2,3)$	
12				$(1,2,3)$		$(2,3,4)$						
13	$(3,4,5)$							$(1,2,3)$				$(4,6,8)$
14					$(3,5,7)$		$(4,6,8)$	$(3,4,5)$				$(2,3,4)$
15		$(4,5,6)$		$(6,7,8)$	$(2,4,6)$	$(3,5,7)$	$(1,3,5)$				$(2,3,4)$	
16		$(1,2,3)$			$(5,6,7)$			$(2,3,4)$				
17			$(1,2,3)$	$(2,3,4)$		$(1,2,3)$						
18							$(2,3,4)$					
19		$(5,6,7)$			$(1,2,3)$		$(1,2,3)$					
20					$(2,3,4)$		$(2,3,4)$	$(5,6,7)$				

Fuzzy preferences based on feedback analysis and result analysis are presented in Tables 3 and 4, respectively. Table 5 represents the limits of courses to be assigned to faculty members.

Table 4. Fuzzy preferences based on result analysis for faculty members to courses of MOFAP with the double parametric form

	1	2	3	4	5	6	7	8	9	10	11	12
	1	2	3	4	5	6	7	8	9	10	11	12
1		(2, 3, 4)	(1, 2, 3)	(1, 3, 5)	(2, 4, 6)	(2, 3, 4)	(1, 3, 5)		(6, 7, 8)			
2				(4, 5, 6)	(1, 2, 3)			(4, 5, 6)	(3, 4, 5)		(5, 6, 7)	(3.5.7)
3	(1, 2, 3)	(6, 7, 8)			(2, 4, 6)	(3, 4, 5)			(4, 5, 6)	(3, 4, 5)		
4		(1, 3, 5)	(5, 7, 9)	(4, 6, 8)	(1, 3, 5)		(3, 4, 5)	(1, 2, 3)		(2, 4, 6)	(3, 4, 5)	(4, 5, 6)
5		(5, 6, 7)			(1, 2, 3)			(4, 5, 6)				(5, 6, 7)
6	(6, 7, 8)	(4, 6, 8)			(5, 6, 7)							
7			(1, 3, 5)			(2, 4, 6)				(6, 7, 8)		
8			(1, 2, 3)							(4, 5, 6)		
9		(2, 3, 4)	(1, 2, 3)	(1, 2, 3)	(1, 3, 5)	(3, 5, 7)	(4, 5, 6)		(1, 2, 3)			
10		(1, 2, 3)	(4, 5, 6)		(2, 3, 4)	(1, 2, 3)	(1, 2, 3)		(2, 3, 4)	(3, 4, 5)		
11		(1, 3, 5)		(3, 4, 5)			(3, 5, 7)				(4, 6, 8)	
12				(1, 2, 3)		(3, 5, 7)						
13	(2, 4, 6)							(4, 6, 8)				(1, 2, 3)
14					(1, 2, 3)		(1, 2, 3)	(4, 5, 6)				(3, 4, 5)
15		(1, 2, 3)		(3, 5, 7)	(1, 3, 5)	(5, 6, 7)	(4.5.6)				(4, 5, 6)	
16		(4, 6, 8)			(4, 5, 6)			(3, 4, 5)				
17			(1, 2, 3)	(4, 6, 8)		(1, 2, 3)						
18							(3, 4, 5)					
19		(1, 2, 3)			(4, 6, 8)		(1, 2, 3)					
20					(1, 2, 3)		(3, 5, 7)	(5, 6, 7)				

Table 5. Upper and lower limits of the number of courses to faculty members (fac-1–fac-12)

Limit	fac-1	fac-2	fac-3	fac-4	fac-5	fac-6	fac-7	fac-8	fac-9	fac-10	fac-11	fac-12
Upper	2	3	2	2	3	2	2	2	2	2	2	2
Lower	1	1	1	1	1	1	1	1	1	1	1	1

5. Results and discussion

In the numerical data discussed in the previous section, a mathematical model is formulated and solved by a fuzzy programming technique with a linear membership function. The results are obtained using LINGO software. Table 6 represents the courses assigned to faculties, and the compromise value and degree of satisfaction of objective functions are shown in Table 7 for $\alpha = 0.1$. In particular, for $\beta = 0.1$; the model assigns course 6 to faculty-1, courses 1, 2 to faculty-2, etc., with an overall degree of satisfaction, is $\lambda = 0.6$. This way, we can interpret the courses assigned to other faculties for other values of β. However, objective function $Z1$ achieved a compromised value of 1, and the degree of satisfaction (DOS) is 1, objective function $Z2$ achieved a compromised value of 5, and DOS is 0.7, etc., as noted in Table 7. Similarly, compromise values and degree of satisfaction can be interpreted from Table 7. Table 8 represents the courses assigned to faculties and the compromise value and degree of satisfaction of objective functions are shown in Table 7 for $\alpha = 0.1$.

Figure 2 represents the compromise values attained by objective functions. Figure 3 represents the degree of satisfaction of objective functions. It is clear from Figures 2 and 3 that fuzzy preferences compromise values are increased with increased values of β. The degree of satisfaction of objective function $Z14$ is increased and $Z15$ is decreased with increased values of β.

Table 6. Courses assigned to the faculties for $\alpha = 0.1$ of MOFCAP

Faculty member	$\beta = 0.1$	$\beta = 0.5$	$\beta = 0.9$
1	6	6	3, 6
2	1, 2	4, 16	4, 9
3	8, 10	8, 9	8
4	12	12	12
5	14, 20, 15	14, 20, 15	14, 20, 15
6	17	1, 17	1, 17
7	18, 19	18, 19	18, 19
8	13, 16	2, 13	2, 16
9	2	3	3
10	3, 07	7, 10	7, 10
11	4, 11	4, 11	4, 11
12	4, 5	5	5

Table 7. Compromise values of objective functions for $\alpha = 0.1$ of MOFCAP

Objective	$\beta = 0.1$		$\beta = 0.5$		$\beta = 0.1$	
function	Com. value	DOS	Comp. value	DOS	Comp. value	DOS
Z_1	1	1	1	1	3	0.6
Z_2	5	0.7	5	0.7	6	0.6
Z_3	3	0.7142857	2	0.8571429	1	1
Z_4	1	1	1	1	1	1
Z_5	2	0.8571429	2	0.8571429	2	0.8571429
Z_6	1	1	3	0.6	3	0.6
Z_7	3	0.75	3	0.75	3	0.75
Z_8	3	0.66667	2	0.83333	3	0.66667
Z_9	2	0.83333	3	0.66667	3	0.66667
Z_{10}	3	0.6	3	0.6	3	0.6
Z_{11}	3	0.6	3	0.6	3	0.6
Z_{12}	3	0.6	2	0.8	2	0.8
Z_{13}	48	0.6470588	48	0.6470588	47	0.6764706
Z_{14}	45.44	0.833666	63	0.8253968	81.56	0.7855021
Z_{15}	64.16	0.6110753	78.59	0.6832308	90.71	0.7582824

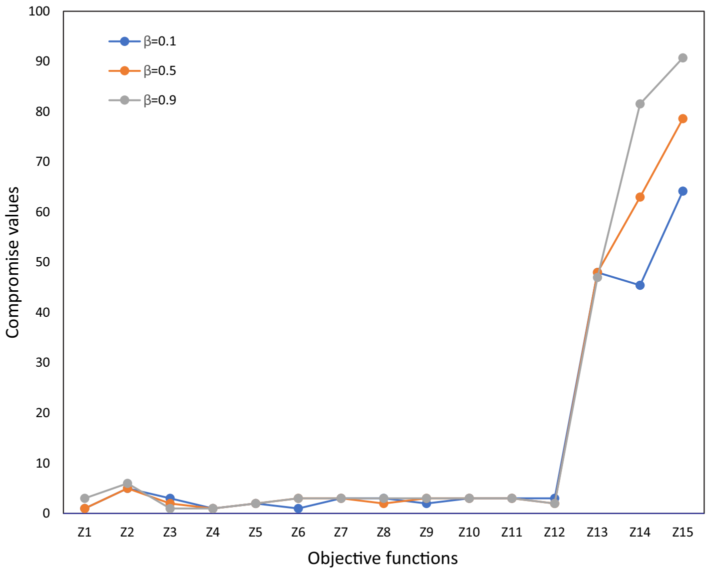

Figure 2. Compromise values of objective functions for $\alpha = 0.1$ of MOFCAP

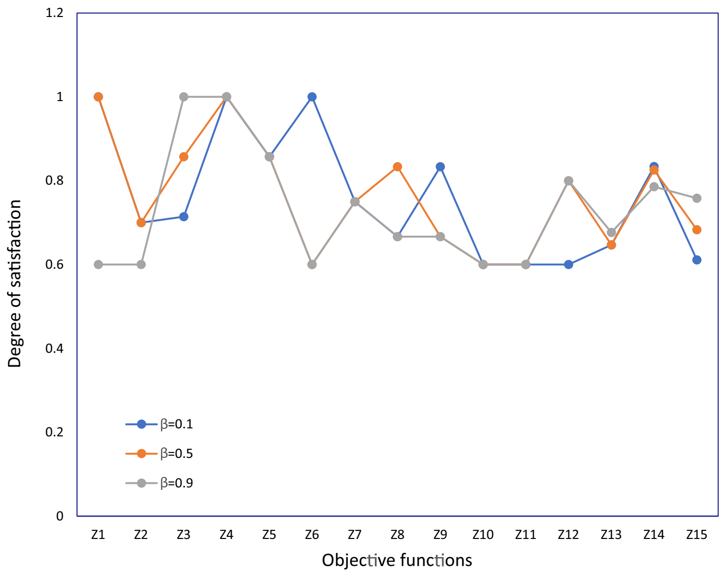

Figure 3. Degree of satisfactions of objective functions for $\alpha = 0.1$ of MOFCAP

For $\beta = 0.1$, the model assigns courses 6, 3 to faculty-1, courses 1, 9, 16 to faculty-2, etc., with the overall degree of satisfaction being $\lambda = 0.6$. In this way, we can interpret the courses assigned to other faculties for other values of β. However, objective function $Z1$ achieved a compromised value of 3 and DOS is 1; objective function $Z2$ achieved a compromised value of 6 and a degree of satisfaction (DOS) is 0.6, etc., as noted in Table 9. Similarly, compromise values and degree of satisfaction can be interpreted from Table 9. Figure 4 represents the compromise values attained by objective functions and Figure 5 represents the degree of satisfaction of objective functions. It is clear from Figures 4 and 5 that fuzzy preferences compromise values are increased with increased values of β. The degree of satisfaction of objective function $Z14$ is increased and $Z15$ varies with increased values of β.

Table 8. Courses assigned to faculties for $\alpha = 0.5$ of MOFCAP

Faculty member	$\beta = 0.1$	$\beta = 0.5$	$\beta = 0.9$
1	6, 3	6	6
2	1, 9, 16	4, 16	9, 16
3	8	8, 9	8
4	12	12	12
5	14, 20, 15	14, 20, 15	14, 20, 15
6	17	1, 17	1, 17
7	18, 19	18, 19	18, 19
8	2	2, 13	2, 13
9	3	3	3
10	7, 10	7, 10	7, 10
11	4, 11	4, 11	4, 11
12	4, 5	5	4, 5

Table 10 represents the courses assigned to faculties and compromise value and degree of satisfaction of objective functions are shown in Table 11 for α = 0.9. In particular, for β = 0.1, the model assigns course 6 to faculty-1, courses 4, 16 to faculty-2, etc., with an overall degree of satisfaction is λ = 0.6. This way, we can interpret the courses assigned to other faculties for other values of β.

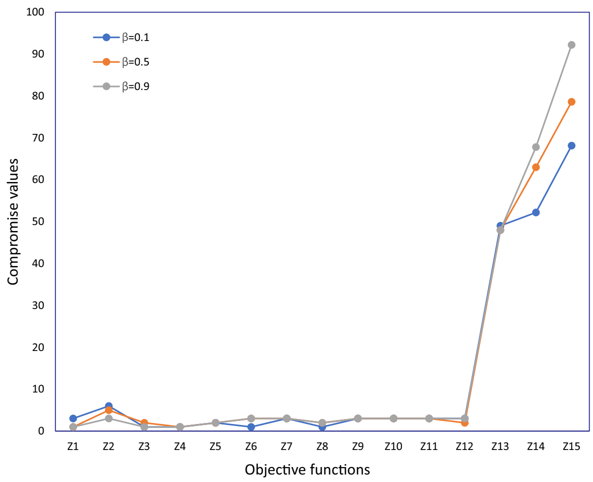

Figure 4. Compromise values of objective functions for $\alpha = 0.5$ of MOFCAP

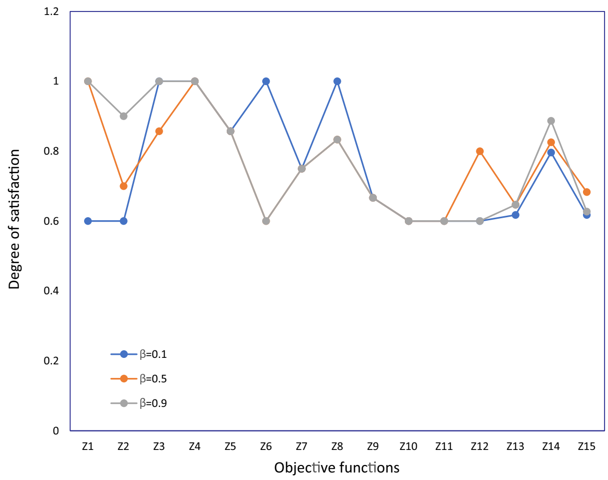

Figure 5. Degree of satisfactions of objective functions for $\alpha = 0.5$ of MOFCAP

Table 9. Compromise values of objective functions for $\alpha = 0.5$ of MOFCAP

Objective function	$\beta = 0.1$ Comp. value	DOS	$\beta = 0.5$ Comp. value	DOS	$\beta = 0.9$ Comp. value	DOS
Z_1	3	0.6	1	1	1	1
Z_2	6	0.6	5	0.7	3	0.9
Z_3	1	1	2	0.8571429	1	1
Z_4	1	1	1	1	1	1
Z_5	2	0.8571429	2	0.8571429	2	0.8571429
Z_6	1	1	3	0.6	3	0.6
Z_7	3	0.75	3	0.75	3	0.75
Z_8	1	1	2	0.83333	2	0.83333
Z_9	3	0.66667	3	0.66667	3	0.66667
Z_{10}	3	0.6	3	0.6	3	0.6
Z_{11}	3	0.6	3	0.6	3	0.6
Z_{12}	3	0.6	2	0.8	3	0.6
Z_{13}	49	0.6176471	48	0.6470588	48	0.6470588
Z_{14}	52.2	0.7964113	63	0.8253968	67.8	0.8868502
Z_{15}	68.16	0.6172967	78.59	0.6832308	92.2	0.6271262

Table 10. Courses assigned to faculties for $\alpha = 0.9$ of MOFCAP

Faculty member	$\beta = 0.1$	$\beta = 0.5$	$\beta = 0.9$
1	6	6	6
2	4, 16	4, 16	9, 16
3	8, 9	8, 9	8
4	12	12	12, 14
5	14, 20, 15	14, 20, 15	20
6	1, 17	1, 17	1, 17
7	18, 19	18, 19	18, 19
8	2, 13	2, 13	2, 13
9	3	3	3
10	7, 10	7, 10	7, 10
11	4, 11	4, 11	4, 11
12	5	5	4, 5

Table 11. Compromise values of objective functions for $\alpha = 0.9$ of MOFCAP

Objective function	$\beta = 0.1$		$\beta = 0.5$		$\beta = 0.9$	
	Comp. value	DOS	Comp. values	DOS	Comp.values	DOS
Z_1	1	1	1	1	1	1
Z_2	5	0.7	5	0.7	3	0.9
Z_3	2	0.8571429	2	0.8571429	1	1
Z_4	1	1	1	1	1	1
Z_5	2	0.8571429	2	0.8571429	2	0.8571429
Z_6	3	0.6	3	0.6	3	0.6
Z_7	3	0.75	3	0.75	3	0.75
Z_8	2	0.83333	2	0.83333	2	0.83333
Z_9	3	0.66667	3	0.66667	3	0.66667
Z_{10}	3	0.6	3	0.6	3	0.6
Z_{11}	3	0.6	3	0.6	3	0.6
Z_{12}	2	0.8	2	0.8	3	0.6
Z_{13}	48	0.6470588	48	0.6470588	48	0.6470588
Z_{14}	61.08	0.8257817	63	0.8253968	60.70	0.8884688
Z_{15}	76.83	0.6779530	78.59	0.6832308	84.84	0.6197183

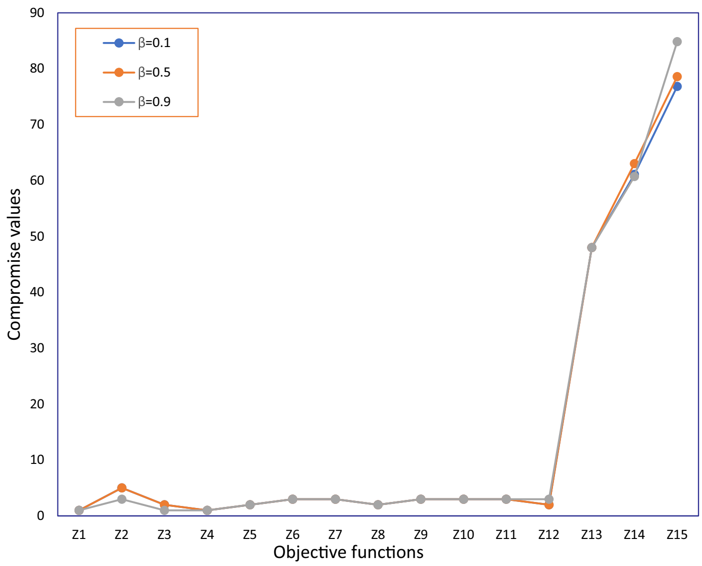

Figure 6. Compromise values of objective functions for $\alpha = 0.9$ of MOFCAP

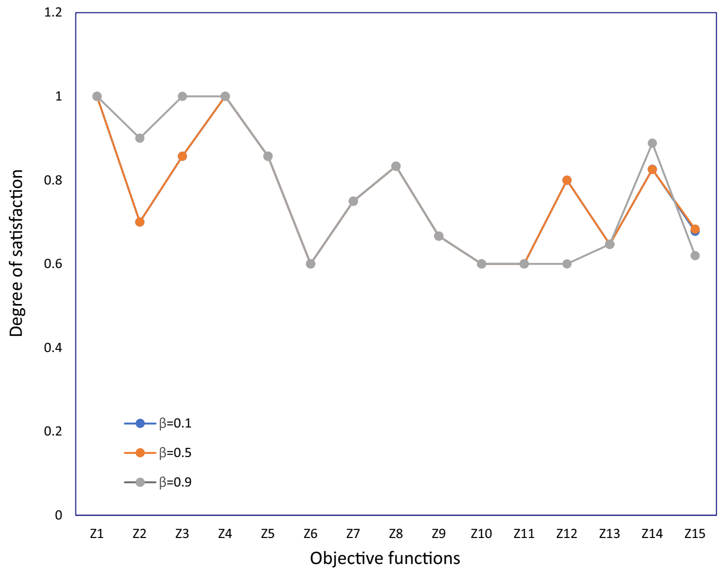

Figure 7. Degree of satisfactions of objective functions for $\alpha = 0.9$ of MOFCAP

However, objective function $Z1$ achieved a compromised value of 1, and DOS is 1, objective function $Z2$ achieved a compromised value of 5 and DOS is 0.7, etc., as noted in Table 11. Similarly, compromise values and degree of satisfaction can be interpreted from the table. Figure 6 represents the compromise values attained by objective functions and Figure fig7 represents the degree of satisfaction of objective functions. Fuzzy preferences-based compromise values are increased with increased values of β. The degree of satisfaction of objective function $Z14$ is increased and $Z15$ is varied with increased values of β.

6. Conclusions

This study presented a mathematical model of multi-objective faculty course assignment (MOFCA) problem with the double parametric form of fuzzy preferences. Fuzzy preferences are based on feedback analysis and result analysis. This mathematical model incorporates faculty preferences, administrator preferences, and fuzzy preferences. The computational results obtained satisfy all the preferences. Feedback and the result of the analysis are taken as a fuzzy number because it varies from student to student, faculty to faculty as well as a semester-to-semester. It is very difficult to take into consideration the crisp number. The double parametric form of fuzzy preferences is the first time utilized to develop faculty course assignment problem model. The fuzzy programming technique is utilized and results are obtained using LINGO software. The presented approach provides the optimal allocation plans with a better degree of satisfaction. It is useful for a decision maker to make the right quick decision.

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