IOSR Journal of Mathematics (IOSR-JM)
e-ISSN: 2278-5728, p-ISSN: 2319-765X. Volume 15, Issue 3 Ser. I (May – June 2019), PP 63-74
www.iosrjournals.org

A Fuzzy Model for Cross-Functional Team Formation Based On Personality Traits

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Abstract
Despite the significance of cross-functional teams in today's business environment, a few analytical approaches have been proposed for team formation problem. The objective of this paper is to propose a cross-functional team formation model by which a predetermined number of individuals are selected from various expertise groups based on their personalities. The proposed model employs Five-Factor Model of personality traits as a framework for the assessment of team members' personalities. However, an inherent problem in team formation is thatassessing team member candidates with respect to these personality traits involves vagueness and subjectivity. In addition,the target level of personality traits in a team cannot be set precisely as it depends on the objectives and tasks that a team is expected to realize.Based on these premises, a fuzzy goal programming model forteammember selection is proposed and demonstratedwith an illustrativeexample.

Keywords:Cross-functionalteam formation, Fuzzy Goal Programming, Five-Factor Model

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Date of Submission: 08-05-2019 Date of acceptance: 24-05-2019

I. Introduction

Due to the competition based on agility and flexibility of today's business environment, cooperation of people with diverse knowledge, expertise and skills in cross-functional team setting has become a significant way to respond to customer expectations. However, despite the growing importance of cross-functional teams in organizations, there is still limited research about analytical models of team formation.

Tseng et al. (2004) developed a methodology for the multi-functional team formation based on fuzzy sets theory and grey decision theory. Shipley and Johnson (2009) developed an algorithm based on belief in the fuzzy probability of a cognitive style fitting a defined goal in order to facilitate the selection of employees who meet the project goals. Tavana, Azizi and Behzadian (2012) proposed a framework for player selection in soccer in which the alternative combinations of the selected players are evaluated with a fuzzy inference system and the best combinations for team formation are determined.

This paper presents an analytical model for allocating a predetermined number of individuals from various functional groups to form a cross-functional team with desired level of personality traits which is expected to maximize the outcomes of the team. In the proposed model, team composition is optimized by using fuzzy goal programming (FGP) approach due to the imprecision and subjectivity in determining the target levels of personality traits; and assessment of the team member candidates with respect to thesepersonality traits. Team members' personalities are assessed by using Five-Factor Model (FFM), which analyzes the personalities of individuals under five major dimensions.

The outline of this paper is as follows. In the following section, preliminaries about team composition, FFM personalitytraitsand their effects of on team outcomesand fuzzy sets will be discussed. In section 3, the proposed model will be presented and an application of the model will be illustrated in section 4. In the last section, conclusions of the paper will be presented.

II. Personality And Team Effectiveness

Due to the scope of the tasks they perform, cross-functional teams should be composed of members to provide the sufficient diversity and balance in terms of the required knowledge, skills and abilities (KSAs). Selecting the people with better individual KSAsis expected to result in a more effective team However, even if each team member is an expert in his/her field, this would not guarantee the overall team effectiveness because the interpersonal dynamics of the team affect the motivation of the team members and subsequently the team performance. Thus, the researchers have posited personality traits to be related to team performance (Driskell, Hogan and Salas, 1987).

Five-Factor Model (FFM) of personality traits (also called Big Five) has been developed in the early 1990s.The FFM framework of personality distinguishes five factors: extraversion, agreeableness, conscientiousness, emotional stability and openness to experience (McCrae and Costa, 1989; Barrick and Mount, 1991; Digman, 1990). FFM has brought a systematic approach for analyzing the effects of personality traits on individual job performance. Theyalso affect the way that individuals behave in a team.As individuals with different levels of these factors come together in a team setting, an overall team personality composition is resulted. In this paper, personality composition of teams is measured by elevation of the personality traits and diversity with respect to these personality traits. The elevation and diversity of a personality trait is measured as the average and the variance of team members' scores on that trait respectively. In the following paragraphs, five factors and their effects on the team attitudes and outcomes arediscussedbased on elevation and diversity measures.

2.1. Five factor model and its effects on the team outcomes

Extraversion refers to the degree which a person tends to be enthusiastic, gregarious, assertive, energetic, active and optimistic. Existence of extravert team members result in a positive attitude towards teamwork. Such a climate is expected to have a positive effect on the quality of the decisions (Schultz, Ketrow and Urban, 1995). Research also suggests that extraversion is consistently related to performance on creative and problem solving tasks (Reilly, Lynn and Aronson, 2002).

However, the inclusion of too many extraverts in a team may diminish the team's effectiveness due to the extraverts' focus on the social interaction (Neuman et al., 1999) rather than completion of the tasks. Reilly et al. (2002) state that extraversion may inhibit performance in tasks which require precise, sequential and logical behavior. Results of Barry and Stewart (1997) also showed that intermediate levels of the elevation of extraversion within a team lead to high team performance. Thus, the expectations concerning elevation of extraversion are diverse.

Agreeableness reflects an individual's tendency to be helpful, courteous, trusting, friendly, tolerant and cooperative. Researchers expect these traits to facilitate interpersonal attraction (Neuman and Wright, 1999), cooperation (Barrick et al. 1998), conflict resolution, task cohesion (Van Vianen and De Dreu, 2001) and social cohesion (Taggar, 2002). However, high cohesiveness can also result in groupthink (Janis, 1972). Guzzo and Waters (1982) also found that the highest quality task decisions were made by team members when they reduced the behaviors related to agreeableness during task performance.

Similar to emotional stability, presence of a single disagreeable team member is expected to disrupt cooperation. The few empirical results also reveal that a lower variability in agreeableness results in better team performance (Mohammed and Angell, 2003). Thus, a negative relationship is expected between variability in agreeableness and team performance.

Conscientiousness refers to the degree to which a person tends to be dependable, thorough, organized, ambitious, hard-working, and persevering (Digman, 1990; Barrick and Mount, 1991). Since conscientiousness is the most consistent predictor of individual performance, researchers expect that a high elevation with respect to conscientiousness will also result in task commitment, effort, cooperation and focus toward team goal completion and subsequently in a higher team performance (LePine, 2003).

Researchers hypothesize that homogeneity with respect to conscientiousness will lead to cohesion (Van Vianen and De Dreu, 2001) and; in contrast, heterogeneity may lead to conflict and diminish a team's effectiveness (Molleman et al., 2004). Thus, a negative effect of variability in team member conscientiousness on team performance is predicted. The empirical studies have also demonstrated that higher team performance is reached when teams have a lower variability with respect to conscientiousness (Barrick et al., 1998; Kichuk, 1999).

Emotional stability refers to the degree that a person is calm, secure and steady. These traits lead to ease of cooperation and coordination, task orientation and a relaxed team atmosphere. The elevation of emotional stability is expected to be positively related to team performance.Results of empirical studies also support this expectation (Kichuk and Wiesner, 1998; Molleman et al., 2004).

Researchers hypothesize that the presence of a single or just a few unstable team members will have a negative effect on team effectiveness since cooperation of team members and team cohesion may be disrupted (Van Vianen and De Dreu, 2001; Mohammed and Angell, 2003). Therefore, variability in emotional stability is expected to be negatively related to team performance.

Openness to experience refers to the tendency to be curious, imaginative, broad-minded, and intelligent. Team members with these traits are expected to adapt easily to new situations, develop new ideas, and look for alternative solution methods for problems (LePine, 2003). Thus, positive relationships between elevation of openness to experience and team performance should be expected in creative tasks, or tasks performed under conditions of high uncertainty, such as radical innovation; and on the contrary, it is less important, or even detrimental, when the task is of a more routine nature (Reilly et al., 2002). If all team members are highly open to experience, this may result in conflict and diminish the cohesion (Van Vianen and De Dreu, 2001). Thus, diversity in terms of openness to experience is expected to be negatively related to team performance.

2.2. Fuzzy Sets and Fuzzy Numbers

A fuzzy set can be defined mathematically by assigning each possible element in the universe of discourse a value representing its grade of membership to the fuzzy set (Klir and Yuan, 1995). Fuzzy sets have imprecise boundaries that facilitate gradual transition from membership to non-membership and vice versa. This gradual transition enables a powerful representation of measurement uncertainties and representation of vague or ill-defined concepts expressed in natural language (Klir and Yuan, 1995). Triangular fuzzy numbers (TFNs) are used throughout this paper due to their simplicity and computational efficiency. A TFN is a special class of fuzzy number whose membership function is defined by three real numbers expressed as (a, b, c). A TFN is represented as follows.

$$\mu_{\tilde{A}}(x)=\begin{cases}(x-a)/(b-a), & a\le x\le b\\ (c-x)/(c-b), & b\le x\le c\\ 0, & otherwise\end{cases} \tag{1}$$

Let $\tilde{A}=(a_1,a_2,a_3)$ and $\tilde{B}=(b_1,b_2,b_3)$ be two triangular fuzzy numbers. The arithmetic operations on these two triangular fuzzy numbers are as given below (Zimmermann, 1994).

$$\tilde{A}\oplus\tilde{B}=(a_1+b_1,a_2+b_2,a_3+b_3) \tag{2}$$

$$\tilde{A}\otimes\tilde{B}=(a_1\times b_1,a_2\times b_2,a_3\times b_3) \tag{3}$$

$$\tilde{A}/\tilde{B}=\left(a_1/b_3,a_2/b_2,a_3/b_1\right) \tag{4}$$

$$k\tilde{A}=(ka_1,ka_2,ka_3)\ \forall k>0, k\in R \tag{5}$$

$$(\tilde{A})^{-1}=\left(1/a_3,\ 1/a_2,\ 1/a_1\right) \tag{6}$$

Distance between $\tilde{A}$ and $\tilde{B}$ based on vertex method (Chen, 2000):

$$d(\tilde{A},\tilde{B})=\sqrt{\frac{1}{3}\left[\left(a_1-b_1\right)^2+\left(a_2-b_2\right)^2+\left(a_3-b_3\right)^2\right]} \tag{7}$$

III. The Proposed Model for Cross-Functional Team Member Selection

3.1. Model Overview

The objective of the model is to select a predetermined number of candidates from each technical KSA group to form a cross-functional team so that the most suitable team composition in terms of personality traits is maintained (see Figure 1). In this paper, team composition is optimized with respect to elevation and diversity measures.

A team’s elevation score with respect to a personality trait is the arithmetic mean of its members’ scores on that personality trait. In order to obtain the best team composition, decision makers must consider the objectives, expected outcomes and tasks of the team and determine the elevationtargets of the personality traits accordingly. For instance, a creative task, such as product design, may require a higher elevation score in “openness to experience” whereas, a higher elevation score in “openness to experience” may inhibit team performance in less creative or procedural team tasks. However, setting targets for the elevation of personality traits is a difficult task in practice since it involves vagueness and subjectivity; and thus, it is more rational to consider them as fuzzy. In this paper, fuzzy aspiration levels for the elevation of personality traitsaredetermined by using the linguistic variables in Table 1 (Chen, 2000).

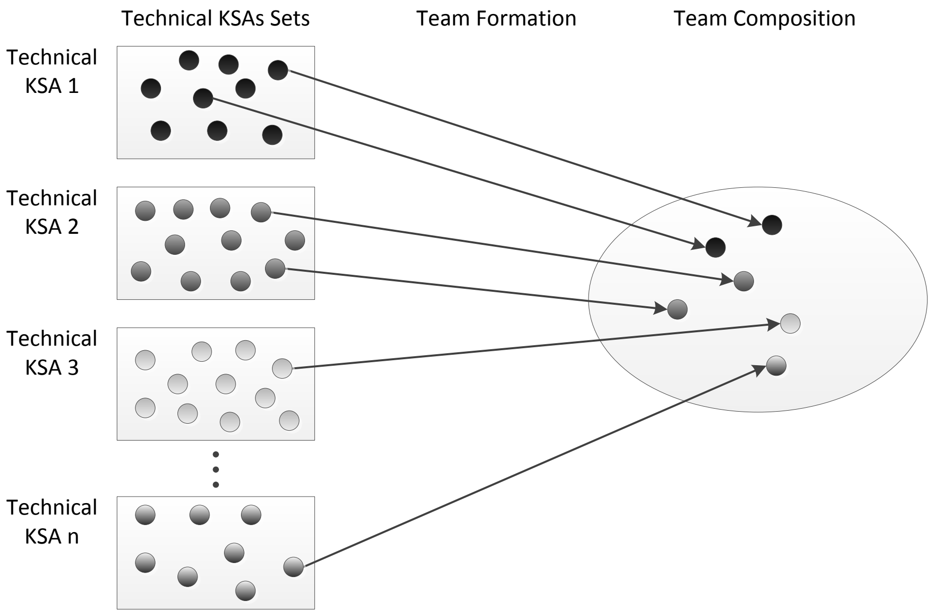

Fig. 1 Team formation problem.

Table 1 Linguistic variables and corresponding fuzzy numbers.

	Triangular Fuzzy Scale
Very Poor (VP)	(0, 0, 1)
Poor (P)	(0, 1, 3)
Medium-Poor (MP)	(1, 3, 5)
Fair (F)	(3, 5, 7)
Medium-Good (MG)	(5, 7, 9)
Good (G)	(7, 9, 10)
Very Good (VG)	(9, 10, 10)

Based on the objectives and tasks of teams, diversity within a team with respect to some of the personality traits may be especially required. For a team to be composed of diverse members with respect to a particular trait while achieving its desired elevation, it must include members whoseratings are evenly distributed in a certain range includingits target elevation.In other words, ratings of some selected members mustexceed the target elevation while the others underachieve with respect to that personality trait.In this paper, overachievement and underachievement of a team member is represented bypositive and negative deviations from the target elevation respectively. In the proposed model, the deviation of a team member with respect to a personality trait is calculated by Eq. (7)as the distance between his/her rating on that trait and its target elevation. Then, this distance is compared with the target elevation of that personality trait by using the ranking method proposed by Chou, Dat and Yu (2011); and categorized as being a positive or a negative deviation.After determination of positive and negative deviations of team members with respect to each trait, the averageof positive and negative deviationswith respect to each trait is obtained by dividing the selected members' total positive and negative deviation by the team size. These average deviations are then used as the inputs of achievement functions by which achievement degrees with respect to both elevation and diversity of personality traits are obtained.Therefore,in the proposed model, the diversity target of each personality trait is modeled by determining appropriate shapes and parameters forthetwo achievement functions which are designed on the basis of average positive and average negative deviations from the corresponding elevation target. For this purpose, the distances between the linguistic variables given in Table 2were obtained by Eq. (7); and they are proposed as a reference for determining the parameters of the achievement functions. For instance, the decision makersgenerally may want to set a team's target elevation for conscientiousness as "very good" andmay also determine "good" as the minimum acceptable level. Thus, based on this policy, the parameters of achievement function for the average negative deviation with respect to conscientiousness may be determined as (0, 0, 1.291) as shown in Figure 2a,referring to the distance between VG-G pair as shown in Table 2.

Table 2 Distances between the linguistic variables.

Linguistic variable pairs	Distance	Linguistic variable pairs	Distance
VG-G	1.291	**MG-F**	2.000
VG-MG	2.944	**MG-MP**	4.000
VG-F	4.830	**MG-P**	5.686
VG-MP	6.782	**MG-VP**	6.782
VG-P	8.386	**F-MP**	2.000
VG-VP	9.345	**F-P**	3.697
G-MG	1.732	**F-VP**	4.830
G-F	3.697	**MP-P**	1.732
G-MP	5.686	**MP-VP**	2.944
G-P	7.348	**P-VP**	1.291
G-VP	8.386		

As shown in Figure 2b, a trapezoidalachievement function may also be designed for conscientiousness with the parameters (0, 0, 0.5, 1.291). In this case, the decision makers still want to select members who have ratings in the interval of VG and G. However, since an average negative deviation between 0 and 0.5 have an achievement degree of 1, the model is more relaxed compared to the former achievement function. Thus, more diversity in the team with respect to conscientiousness is allowed in the final solution.

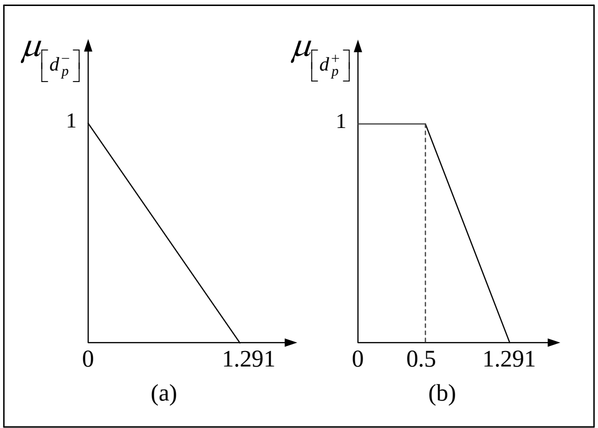

Fig. 2 Sample achievement functions.

The mathematical model proposed in this paper find the best combination of team members based on the candidates' distances to the elevation targets, and the achievement functions designed on the basis of diversity targets. The objective function of the mathematical model includes the weighted sum of one-sided and two-sided achievement values which are based on the deviations of selected members from the elevationtargets. One-sided deviations are included in the objective functionfor the personality traits whose only average positive or only average negative deviation is considered.When two-sided deviations are included, the achievement values with respect to average positive and average deviations are aggregated by taking their minimum or maximum. Thus, when achievement values with respect to positive and negative deviations for a particular personality trait are aggregated by minimum function, underachievement and overachievement of elevation targets are used simultaneously to determine the overall achievement.However, when a certain amount of either positive or negative deviation is acceptable, the maximum function is used for aggregation of achievement values.

3.1. The proposed model

The proposed solution approach includes two phases: i) Preparation and ii) Mathematical modeling. The following notation is used in these phases.

n : Number of technical skill groups.

m_j : Number of candidates in technical skill group j , $j = 1,..,n$.

N_j : Number of employees to be selected from technical skillgroup j .

N : Team size.

$\tilde{a}_{ijp}$: Score of employee i in technical skill group j with respect topersonality traitp; $\tilde{a}_{ijp} = (l_{ijp}, m_{ijp}, u_{ijp})$, $i = 1,..,m_j;\ j = 1,..,n;\ p = 1,...,5$.

$\tilde{Z}_p$: Target elevation of personality trait p, $\tilde{Z}_p = (l_p, m_p, u_p)$.

$\tilde{E}_p$: Actual elevation of personality trait p.

$d^+_{\max}$: The upper limit of positive deviation target.

$d^+_{\min}$: The lower limit of positive deviation target.

$d^-_{\max}$: The upper limit of negative deviation target.

$d^-_{\min}$: The lower limit of negative deviation target.

d^-_{ijp} : Distance between $\tilde{a}_{ijp}$ and $\tilde{Z}_p$ for $\tilde{a}_{ijp} < \tilde{Z}_p$.

d^+_{ijp} : Distance between $\tilde{a}_{ijp}$ and $\tilde{Z}_p$ for $\tilde{a}_{ijp} > \tilde{Z}_p$.

d^-_p : Average of distances between $\tilde{a}_{ijp}$ and $\tilde{Z}_p$ for $\tilde{a}_{ijp} < \tilde{Z}_p$.

d^+_p : Average of distances between $\tilde{a}_{ijp}$ and $\tilde{Z}_p$ for $\tilde{a}_{ijp} > \tilde{Z}_p$.

w_p : Importance weight of personality trait p,p = 1,…, k.

λ^-_p : Achievement degree with respect to negative deviation from the target level of personality trait *p*.

λ^+_p : Achievement degree with respect to positive deviation from the target level of personality trait *p*.

λ^{AND}_p : Achievement degree with respect to both positive and negative deviation from the target level of personality trait *p*.

λ^{OR}_p : Achievement degree with respect to positive or negative deviation from the target level of personality trait *p*.

The preparation phase consists of the following steps:
Step 1: Determine the number of membersto be selected from each technical skill group.
Step 2: Form a list of candidates categorized under only oneof the technical skill groups.
Step 3:Assess each candidate with respect to the five personality traits in FFM by using the linguistic variables in Table 1.

Step 4:Determine the target elevation of each personality trait($\tilde{Z}_p$)by using the linguistic variables in Table 1.

Step 5:Construct achievement functions for average positive, and average negative deviations with respect to each personality trait based on Step 4 and distance values in Table 2.

Step 6:Compute the total utility values of $\tilde{Z}_p$ and $\tilde{a}_{ijp}$ for all *i*, *j* and *p*by Eq. (8) and Eq. (9) as proposed by Chou, Dat and Yu (2011) (see Figure 3). In Eq. (8) and Eq. (9), α represents the degree of optimism of a decision maker.

$$u_T^\alpha(\tilde{Z}_p) = \frac{1}{2}\left(\begin{array}{l} \alpha\left[\dfrac{u_p - x_{\min}}{u_p - m_p + x_{\max} - x_{\min}} + \dfrac{m_p - x_{\min}}{(m_p - u_p) + (x_{\max} - x_{\min})}\right] \\ +(1-\alpha)\left[\dfrac{l_{ijp} - x_{\min}}{(l_p - m_p) + (x_{\max} - x_{\min})} + \dfrac{m_{ijp} - x_{\min}}{m_p - l_p + x_{\max} - x_{\min}}\right] \end{array} \right) \tag{8}$$

$$u_T^\alpha(\tilde{a}_{ijp}) = \frac{1}{2}\left(\begin{array}{l} \alpha\left[\dfrac{u_{ijp} - x_{\min}}{u_{ijp} - m_{ijp} + x_{\max} - x_{\min}} + \dfrac{m_{ijp} - x_{\min}}{(m_{ijp} - u_{ijp}) + (x_{\max} - x_{\min})}\right] \\ +(1-\alpha)\left[\dfrac{l_{ijp} - x_{\min}}{(l_{ijp} - m_{ijp}) + (x_{\max} - x_{\min})} + \dfrac{m_{ijp} - x_{\min}}{m_{ijp} - l_{ijp} + x_{\max} - x_{\min}}\right] \end{array} \right) \tag{9}$$

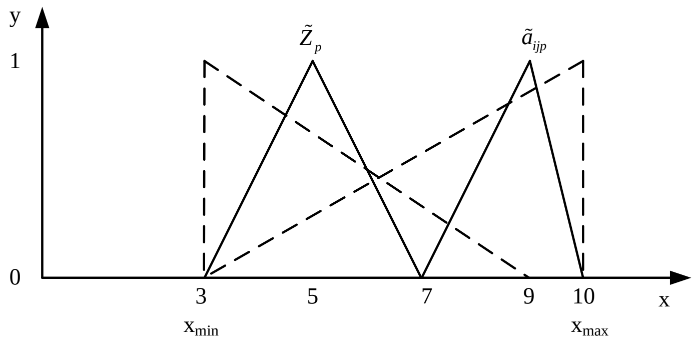

Fig. 3A sample rankingcase for $\tilde{Z}_p$ and $\tilde{a}_{ijp}$ ($\tilde{Z}_p = (3,5,7)$, $\tilde{a}_{ijp} = (7,9,10)$).

Step 7: Byusing Eq. (10) and Eq. (11), calculate the positive and negative deviation of candidatesfrom the target elevation for each personality trait.

$$d^{+}_{ijp} = \begin{cases} d(\tilde{a}_{ijp}, \tilde{Z}_p), & u^{\alpha}_{T}(\tilde{a}_{ijp}) > u^{\alpha}_{T}(Z_p) \\ 0, & otherwise \end{cases} \tag{10}$$

$$d^{-}_{ijp} = \begin{cases} d(\tilde{a}_{ijp}, \tilde{Z}_p), & u^{\alpha}_{T}(\tilde{a}_{ijp}) < u^{\alpha}_{T}(Z_p) \\ 0, & otherwise \end{cases} \tag{11}$$

In the second phase,team composition is optimizedthrough a mathematical model as follows.
Decision variables:

$$x_{ij} = \begin{cases} 1, & \text{if employee } i \text{ in technical skill group } j \text{ is selected as a team member} \\ 0, & \text{otherwise} \end{cases} \tag{12}$$

Mathematical model:

$$\text{Maximize Z} = \sum_{p=1}^{k_1} \lambda_p^{AND} w_p + \sum_{p=k_1+1}^{k_2} \lambda_p^{OR} w_p + \sum_{p=k_2+1}^{k_3} \lambda_p^{-} w_p + \sum_{p=k_3+1}^{5} \lambda_p^{+} w_p \tag{13}$$

Subject to

$$\lambda_p^{AND} = \min(\mu_{[d_p^-]}, \mu_{[d_p^+]}),\ p = 1,\dots,k_1 \tag{14}$$

$$\lambda_p^{OR} = \max(\mu_{[d_p^-]}, \mu_{[d_p^+]}),\ p = k_1+1,\dots,k_2 \tag{15}$$

$$\lambda_p^{-} = \mu_{[d_p^-]},\ p = k_2+1,\dots,k_3 \tag{16}$$

$$\lambda_p^{+} = \mu_{[d_p^+]},\ p = k_3+1,\dots,5 \tag{17}$$

$$\mu_{[d_p^+]} = \begin{cases} 1, & d_p^+ \le d_{\min}^+ \\ \dfrac{d_{\max}^+ - d_p^+}{d_{\max}^+ - d_{\min}^+}, & d_{\min}^+ \le d_p^+ \le d_{\max}^+ \\ 0, & d_p^+ \ge d_{\max}^+ \end{cases} \tag{18}$$

$$\mu_{[d_p^-]} = \begin{cases} 1, & d_p^- \le d_{\min}^- \\ \dfrac{d_{\max}^- - d_p^-}{d_{\max}^- - d_{\min}^-}, & d_{\min}^- \le d_p^- \le d_{\max}^- \\ 0, & d_p^- \ge d_{\max}^- \end{cases} \tag{19}$$

$$\sum_{i=1}^{m_j} x_{ij} = N_j, \ \forall j \tag{20}$$

$$d_p^+ = \frac{1}{N}\sum_{j=1}^{n}\sum_{i=1}^{m_j} d_{ijp}^+ x_{ij}, \ \forall p \tag{21}$$

$$d_p^- = \frac{1}{N}\sum_{j=1}^{n}\sum_{i=1}^{m_j} d_{ijp}^- x_{ij}, \ \forall p \tag{22}$$

where $N = \sum_{j=1}^{n} N_j$ (23)

The objective function of the model (13) maximizes the weighted sum of the achievement values with respect to the personality composition goals of the team. This sum consists of four components which may be used by decision makers to design various team composition objectives. The first componentis based on the achievement value λ_p^{AND}; and it involves k_1 goals, in which deviations onboth sides of the elevationtargets are minimized (Eq. 14). The second component of the objective function isbased onthe achievement value λ_p^{OR};and thus, minimizing the deviations on either side of the elevation targets is acceptable (Eq. 15). This component makes possible to design goals by which team members with smalldeviation value (either positive or negative) with respect to some particular personality traits are regarded as acceptable. The third component involves $k_3 - k_2$ goals, in which only the negative deviations from the elevation targets are considered (Eq. 16).Similarly, the fourth component involves $5 - k_3$ goals, in which only the positive deviations from the elevationtargets are minimized (Eq. 17). The achievement functions relevant to these goals are given in Eq. (18) and Eq. (19).

Eq. (20) states that N_j members must be selected from technical KSA set j. The average of the positive and negative deviations of the selected individuals from the aspiration levels with respect to personality traits (d_p^+ and d_p^-) are calculated by Eq. (21) and Eq. (22). In the solution of the model, the actual elevation with respect to each personality trait is calculated by Eq. (24).

$$\tilde{E}_p = \left(\sum_{j=1}^{n}\sum_{i=1}^{m_j} \tilde{a}_{ijp} x_{ij}\right) / N, \ \ \forall p \tag{24}$$

IV. Illustrative Example

Consider an IT company planning to carry out a software development and implementation project for a client. Based on the scope of the project and the total workload, the company plans to form a team of 2 programmers, 1 network specialist and 2 system analysts (n = 3 and N = 5). Currently the company employs 20 programmers, 10 network specialists and 10 system analysts. Considering the scope of the project, the linguisticelevation targets and crisp importance weights shown in Table 3were determined.The linguistic limits of the team members were also set by the decision makers; and corresponding negative and positive deviations from the elevation targets were determinedaccordingly as given in Table 3.

Table 3 Parameters of achievement functions based on positive and negative deviations.

Index	Personality Traits	Weight	Target Elevation	TFNs	Linguistic limits of elevation	Achievement Functions (Neg. Dev.)	Achievement Functions (Pos. Dev.)
1	Agreeableness	0.125	F	(3, 5, 7)	MG-F-MP	(0.5, 0.5, 2)	(0.5, 0.5, 2)
2	Extraversion	0.125	F	(3, 5, 7)	MG-F-MP	(0.5, 0.5, 2)	(0.5, 0.5, 2)
3	Openness to experience	0.150	F	(3, 5, 7)	MG-F-MP	(0.5, 0.5, 2)	(0.5, 0.5, 2)
4	Conscientiousness	0.450	VG	(9, 10, 10)	VG-G	(0, 0, 1.291)	-
5	Emotional stability	0.150	VG	(9, 10, 10)	VG-G	(0, 0, 1.291)	-

The performance of the candidates with respect to each personality trait was assessed by two supervisors in the company as shown in Table 4 and Table 5. The linguisticassessments made by two decision makers were aggregated by calculating the arithmetic average of the corresponding triangular fuzzy numbers.After determining all required parameters and assessment of the candidates, the steps in the first phase of the solution were realized. Then, the model was formulated as follows.

Table 4 Assessment of team member candidates by decision maker 1.

	Programmers																				Network Specialists										System Analysts & Designers									
Personality Traits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Agreeableness	VG	MP	F	MG	G	MG	G	MG	MP	G	F	G	VG	P	G	F	G	F	G	VG	MG	MG	F	MG	F	MG	G	MG	MG	MP	F	MP	G	F	MG	MG	MG	MG	F	F
Extraversion	MP	G	MG	VG	F	MG	F	F	F	G	VG	MP	G	MP	MG	MP	VG	MP	MG	G	MP	F	F	MP	MG	F	F	F	MP	MG	MG	F	F	MG	MG	G	F	MG	MP	MG
Conscientiousness	MG	G	G	VG	G	MG	VG	G	G	VG	G	VG	MG	G	G	VG	VG	G	VG	G	G	G	VG	G	G	MG	VG	VG	MG	VG	G	MG	G	G	MG	VG	VG	MG	VG	G
Openness to Experience	F	MP	P	G	F	G	F	G	MG	F	F	G	MG	MG	MG	F	G	MP	G	F	MP	F	F	MG	MP	F	MP	F	F	MP	MP	MP	G	G	MP	F	VG	VG	MP	G
Emotional Stability	G	VG	MG	MG	G	G	VG	MG	VG	G	G	VG	MG	MG	G	F	G	MG	G	VG	G	MG	VG	MG	G	VG	G	VG	MG	G	G	MG	G	MG	G	MG	F	MG	G	G

Table 5 Assessment of team member candidates by decision maker 2.

	Programmers																				Network Specialists										System Analysts & Designers									
Personality Traits	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	1	2	3	4	5	6	7	8	9	10	1	2	3	4	5	6	7	8	9	10
Agreeableness	VG	F	MG	MG	MG	MG	MG	MG	F	G	MG	MG	G	MP	G	F	G	F	G	VG	MG	G	MP	F	F	F	G	MG	F	F	MG	MP	MG	F	G	MG	F	MG	MG	F
Extraversion	F	G	G	VG	F	MG	MP	F	MP	G	VG	MP	MG	MP	G	MP	VG	MP	G	VG	F	MG	F	MG	G	MG	F	MG	F	G	MG	MG	F	G	MG	MG	F	MG	F	F
Conscientiousness	G	G	G	VG	G	G	G	G	MG	MG	VG	VG	G	G	MG	G	VG	G	G	VG	G	MG	G	G	MG	MG	G	G	MG	G	G	MG	G	VG	MG	VG	G	G	G	MG
Openness to Experience	MG	F	F	G	MG	MG	MG	MG	MG	F	MG	G	MG	F	G	F	G	F	MG	F	F	MG	MG	G	F	MG	MG	F	F	MP	MP	F	MG	G	F	MG	G	G	F	MG
Emotional Stability	G	VG	G	G	VG	G	VG	VG	G	VG	G	VG	G	G	G	MG	VG	G	VG	VG	G	G	VG	G	VG	VG	G	VG	G	VG	G	VG	VG	MG	G	VG	G	G	VG	G

$$\text{Maximize } Z = \sum_{p=1}^{3} \lambda_p^{AND} w_p + \sum_{p=4}^{5} \lambda_p^{-} w_p \tag{25}$$

Subject to

$$\lambda_p^{AND} = \min(\mu_{[d_p^-]}, \mu_{[d_p^+]}),\ p = 1,2,3 \tag{26}$$

$$\lambda_p^{-} = \mu_{[d_p^-]},\ p = 4,5 \tag{27}$$

$$\mu_{[d_1^-]} = \begin{cases} 1, & d_1^- \le 0.5 \\ \dfrac{2-d_1^-}{1.5}, & 0.5 \le d_1^- \le 2 \\ 0, & d_1^- \ge 2 \end{cases} \tag{28}$$

$$\mu_{[d_2^-]} = \begin{cases} 1, & d_2^- \le 0.5 \\ \dfrac{2-d_2^-}{1.5}, & 0.5 \le d_2^- \le 2 \\ 0, & d_2^- \ge 2 \end{cases} \tag{29}$$

$$\mu_{[d_3^-]} = \begin{cases} 1, & d_3^- \le 0.5 \\ \dfrac{2-d_3^-}{1.5}, & 0.5 \le d_3^- \le 2 \\ 0, & d_3^- \ge 2 \end{cases} \tag{30}$$

$$\mu_{[d_4^-]} = \begin{cases} \dfrac{1.291-d_4^-}{1.291}, & 0 \le d_4^- \le 1.291 \\ 0, & d_4^- \ge 1.291 \end{cases} \tag{31}$$

$$\mu_{[d_5^-]} = \begin{cases} \dfrac{1.291 - d_5^-}{1.291}, & 0 \le d_5^- \le 1.291 \\ 0, & d_5^- \ge 1.291 \end{cases} \tag{32}$$

$$\mu_{[d_1^+]} = \begin{cases} 1, & d_1^+ \le 0.5 \\ \dfrac{2 - d_1^+}{1.5}, & 0.5 \le d_1^+ \le 2 \\ 0, & d_1^+ \ge 2 \end{cases} \tag{33}$$

$$\mu_{[d_2^+]} = \begin{cases} 1, & d_2^+ \le 0.5 \\ \dfrac{2 - d_2^+}{1.5}, & 0.5 \le d_2^+ \le 2 \\ 0, & d_2^+ \ge 2 \end{cases} \tag{34}$$

$$\mu_{[d_3^+]} = \begin{cases} 1, & d_3^+ \le 0.5 \\ \dfrac{2 - d_3^+}{1.5}, & 0.5 \le d_3^+ \le 2 \\ 0, & d_3^+ \ge 2 \end{cases} \tag{35}$$

$$\sum_{i=1}^{20} x_{i1} = 2 \tag{36}$$

$$\sum_{i=1}^{10} x_{i2} = 1 \tag{37}$$

$$\sum_{i=1}^{10} x_{i3} = 2 \tag{38}$$

$$d_p^+ = \frac{1}{5}\sum_{j=1}^{3}\sum_{i=1}^{m_j} d_{ijp}^+ x_{ij}, \ \forall p \ ; \ m_1 = 20; \ m_2 = 10; \ m_3 = 10 \tag{39}$$

$$d_p^- = \frac{1}{5}\sum_{j=1}^{3}\sum_{i=1}^{m_j} d_{ijp}^- x_{ij}, \ \forall p \ ; \ m_1 = 20; \ m_2 = 10; \ m_3 = 10 \tag{40}$$

The objective function (25) is the weighted sum of the achievement degreewith respect to positive and negative deviations which are divided into two groups, i.e. λ_p^{AND} and λ_p^-. Agreeableness, extraversion and openness to experience have been included in the first group of goals (λ_p^{AND}) since either underachievement or overachievement of these traits may have deteriorating effects on the team performance. For conscientiousness and emotional stability, only the achievement degrees with respect to negative deviations (λ_p^-) were included in the objective function since the target elevationsof these traits were defined as VG (very good).

The model has been solved by using Microsoft Excel Solver. The value of the objective function is 0.604 at the optimal solution. Based on the selected team members shown by the binary variables in Table 6 ($x_{ij} = 1$), none of the goals were totally satisfied since $\lambda_p^{AND} < 1, \text{ for } p = 1,2,3$ and $\lambda_p^- < 1, \text{ for } p = 4,5$ as given in Table 7. The highest achievement value was obtained for extraversion followed by conscientiousness and emotional stability; whereas the lowest achievement value was obtained for agreeableness.

Table 6 Binary variables of team member candidates.

Personnel index	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Programmers	0	0	0	0	0	0	1	0	0	0	0	1	0	0	0	0	0	0	0	0
Network Specialists	0	0	1	0	0	0	0	0	0	0										
System Analysts & Designers	0	0	0	0	0	1	0	0	1	0										

However, $\mu_{\left[d_p^-\right]}=1$ for agreeableness means that the objective with respect to negative deviation of agreeableness is totally met. Similar case is also valid for openness to experience. For these personality traits, the utility values ofactual elevations of agreeableness and openness to experience (at $\alpha=0.5$) exceed their elevation targets. This result is due to the selection of members whose ratings are greater than the target elevation; and hence, resulting in a high average positive deviation. The inverse of such case is valid for extraversion.

Table 7 Summary of model outputs.

Personality Traits & Technical KSAs	Elevation		Utility values		Deviation		Achievement values		
	Actual	Target	Actual	Target	Neg.	Pos.	$\mu_{\left[d_p^-\right]}$	$\mu_{\left[d_p^+\right]}$	λ_p^{AND}
Agreeableness	(4.6, 6.6, 8.4)	(3, 5, 7)	0.455	0.260	0.200	1.737	1.000	0.175	0.175
Extraversion	(2.8, 4.8, 6.7)	(3, 5, 7)	0.294	0.323	0.800	0.569	0.800	0.954	0.800
Openness to Experience	(4.2, 6.2, 8.0)	(3, 5, 7)	0.421	0.271	0.200	1.339	1.000	0.440	0.440
Personality Traits & Technical KSAs	**Actual**	**Target**	**Actual**	**Target**	**Neg.**	**Pos.**	$\mu_{\left[d_p^-\right]}$	$\mu_{\left[d_p^+\right]}$	λ_p^-
Conscientiousness	(8.4, 9.7, 10.0)	(9, 10, 10)	0.351	0.452	0.387	-	0.700	-	0.700
Emotional Stability	(8.4, 9.6, 9.9)	(9, 10, 10)	0.331	0.452	0.423	-	0.672	-	0.672

V. Conclusions

In this paper, apersonnel assignment model was presented to optimize the composition of cross-functional teams with respect to personality traits. The proposed model employs Five-factor Model of personality traits (Big Five)as a framework since there are vast amount of theoretical and empirical studies in the literatureabout the effect of Big Fivepersonality traitson the team composition. The previous literature in team personality composition mostly analyzed the effect of elevation and diversity of five personality traits on the team performance. However, these analysis were not used a basis of team formation model. In order to bridge this gap, elevation and diversity ofBig Five personality traits were used in this study as the basis for developing an optimization model for team formation problem.

The analysis of the team composition literature also revealed that setting targets for elevation and diversity of personality traitsdepend on many factors; and thus involves vagueness and subjectivity. Similar phenomenon is also valid for assessment of team member candidates as the decision makers cannot judge the candidates' personality traits precisely. Hence, a fuzzygoal programmingmodel based on personality elevation and diversity measures was developed. The proposed model allows the decision makers to design and form teams for different types of tasks by using linguistic variables for setting elevation targets; and fuzzy achievement functionsfor defining diversity levels with respect to the five personality traits.Since only a few quantitative studies are available on personality composition of teams, the proposed model can be used for various purposes in industry such as concurrent engineering and software development and implementationwhere team member selection isa crucial decision for the attainment of team objectives.Thedesign and development of team member selection software which will work as an integral part of human resource applications of organizations is considered; and may be recommended as a future work. In this way, the proposed model, or similar models, can provide the practitioners to form teams in a few minutes based on the teams' objectives and tasks since up-to-date personnel records is used as the major input for a team member selection model.Also, with such applications, the proposed team member selection models can be tested in larger and more complex real-life problems.

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