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COMPETENCY AND TEAM DYNAMICS BASED PROJECT TEAM FORMATION MODEL

Nükhet ARI // Fatih Yasin GÜNER // Tümay TOPÇU

Academic Supervisor: Prof. Dr. İbrahim AKGÜN // Company Supervisor: Fatih HABACI

ABDULLAH GÜL UNIVERSITY

DEPARTMENT OF INDUSTRIAL ENGINEERING

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INTRODUCTION

ASELSAN is one of the leading companies in the defense industry in terms of manufacturing technology. The company, which tries to follow innovative approaches in order to ensure the development of its employees, aims to evaluate its employees in the most efficient way with target and competency-based performance evaluations. Therefore, the planning of human resources within the scope of project management in the company, which also carries out project-based studies, contains a very critical decision-making process as it includes a high number of employees.

During project planning, success of the project is highly affected by how well the employees meet the project requirements. Additionally, the psychological state and behavior that each member of the team reflects on their environment reveals the concept called team dynamics. In this case, technical skills, social skills, which are the most fundamental requirements in a project, and team dynamics that will ensure the team's harmony in the project are the factors that affect the success and efficiency of the project. The study aims to gain a new perspective to the literature by examining these three factors affecting productivity simultaneously.

SYSTEM UNDER CONSIDERATION

In the procurement department, activities are generally performed on a project basis. Therefore, key activities of the projects and the skills expected from the employees assigned to these projects differ. However, some of the competencies required for the project cannot be listed. Root causes of this issue can be explained as these competencies cannot be measured exactly or this measurement process cannot be done regularly. The fact that the talent requirements of each project are different, some of them cannot be measured, and this process has time-consuming technical details prevent the company from following a systematic approach when creating a project-based team.

Not being able to follow a systematic approach while building a project-based team causes the team building process to be prolonged and in some cases, the team is formed without fullyevaluating the needs of the project. Therefore, it is known that the established project team has moved away from the optimum and the team might not be able to provide the necessary technical competence. This may affect performance and satisfaction level of team members. Insufficient technical level of team members may cause delays in the time flow of the project, may create a need for changes in team members, and may require different contractors for the project. Therefore, the company needs to standardize the project team assignment process with a systematic approach and ensure that the assignments are made in the most appropriate way.

PROBLEM DEFINITION

Considering all the factors affecting the project efficiency, there is a need to develop a system that ensures that the employees are assigned to the project team, monitors the workload of the employees depending on the projects, and confirms that the technical skills of the employees assigned to the projects are above the required thresholds during the project stages. Therefore, this study supports strategic level decisions by solving the project team building problem, which will maximize both the technical and social skills and team dynamics of the selected employee at the same time, and considers the workload of the employee, with a multi-objective optimization model. In addition, it is aimed to minimize the level differences between the established teams in terms of skill levels and team dynamics.

METHODOLOGY

It is determined that a multi-objective team formation model is needed in order to make the best selection of the personnel who work in the teams. In this direction, three different models are developed. When more than one project team is needed to be formed, the projects should be evaluated at the same time. Therefore, the models are able to create more than one project at a time.

It is stated in previous sections that the teams are formed according to the skill levels of the personnel and team dynamic. Thus the level at which the personnel meet each skill, the threshold values of the technical skills needed at the stages of the project, the weights of the skills, the team dynamic score, the current workload of the personnel and the workload of the added projects are used as inputs in the model.

MATHEMATICAL MODEL

Indices

i = personnel, (i = 1, …, I)
j = week, (j =1, …, J)
p = projects, (p =1, …, P)
t = technical skills, (t = 1, …, T)
s = soft skills, (s = 1, …, S)

Data

g_1 = weight of objective M1
g_2 = weight of objective M2
K_{it} = technical skill rating of the i^{th} personnel for skill t
L_{is} = soft skill rating of the i^{th} personnel for skill s
$R_{i,i'}$ = working relationship rating between the i^{th} candidate and i'^{th} candidate
H_{tp} = technical skill threshold required by skill t in project p
w_{tp} = weight of technical skill t in project p
w_{sp} = weight of soft skill s in project p
d_{ij} = cumulative workload of personnel i in week j
f_{ijp} = workload of project p for personnel i in week j
c_p = number of members in the team for project p
n = weekly workload threshold

Decision Variable

X_{ip} = 1, if personnel i is selected for project p
0, otherwise
$Y_{i,i'p}$ = 1, if X_{ip} and $X_{i'p}$ are equal to 1 in project p
0, otherwise

In the models, the same indices, data and decision variables are used. However, the objective functions and constraints differ.

Standard Model :

Objective Function

$$\max Z(M_1, M_2) = (g_1 \times M_1) + (g_2 \times M_2) \qquad (1)$$

$$\max M_1 = \sum_{i,p=1}^{I,P}\left(\sum_{t=1}^{T} w_{tp}\, K_{it}\, X_{ip} + \sum_{s=1}^{S} w_{sp}\, L_{is}\, X_{ip}\right) \qquad (2)$$

$$\max M_2 = \sum_{i,i',p=1}^{I,I',P} R_{i,i'}\, Y_{i,i'p} \qquad (3)$$

Subject to,

$$Y_{i,i'p} - X_{ip} \le 0 \qquad \forall\, i,i',p \qquad (4)$$
$$Y_{i,i'p} - X_{i'p} \le 0 \qquad \forall\, i,i',p \qquad (5)$$
$$X_{ip} + X_{i'p} - Y_{i,i'p} \le 1 \qquad \forall\, i,i',p \qquad (6)$$
$$\left(\sum_{i=1}^{I} X_{ip}\, K_{it}\right) - m_p\, H_{tp} \ge 0 \qquad \forall\, t,p \qquad (7)$$
$$\sum_{i=1}^{I} X_{ip} - m_p \le 0 \qquad \forall\, p \qquad (8)$$
$$X_{ip}\, d_{ij} + \sum_{p=1}^{P} X_{ip}\, f_{ijp} \le n \qquad \forall\, i,j \qquad (9)$$
$$X_{ip} \in \{0,1\} \qquad \forall\, i,p \qquad (10)$$
$$Y_{i,i'p} \in \{0,1\} \qquad \forall\, i,i',p \qquad (11)$$

In the first developed model, weighting method is used and the objective functions are defined as maximizing the sum of the technical and soft skills scores and team dynamic score of teams.

Maximin Model 1:

Objective Function

$$\max Z(M_1, M_2) = (g_1 \times M_1) + (g_2 \times M_2) \qquad \forall\, p \qquad (1)$$

Subject to,

$$M_1 \le \sum_{i=1}^{I}\left(\sum_{t=1}^{T} w_{tp}\, K_{it}\, X_{ip} + \sum_{s=1}^{S} w_{sp}\, L_{is}\, X_{ip}\right) \qquad \forall\, p \qquad (2)$$
$$M_2 \le \sum_{i=1}^{I} R_{i,i'}\, Y_{i,i'p} \qquad \forall\, p \qquad (3)$$
$$Y_{i,i'p} - X_{ip} \le 0 \qquad \forall\, i,p \qquad (4)$$
$$Y_{i,i'p} - X_{i'p} \le 0 \qquad \forall\, i,p \qquad (5)$$
$$X_{ip} + X_{i'p} - Y_{i,i'p} \le 1 \qquad \forall\, i,p \qquad (6)$$
$$\left(\sum_{i=1}^{I} X_{ip}\, K_{it}\right) - c_p\, H_{tp} \ge 0 \qquad \forall\, t,p \qquad (7)$$
$$\sum_{i=1}^{I} X_{ip} - c_p \le 0 \qquad \forall\, p \qquad (8)$$
$$X_{ip}\, d_{ij} + \sum_{p=1}^{P} X_{ip}\, f_{ijp} \le n \qquad \forall\, i,j \qquad (9)$$
$$X_{ip} \in \{0,1\} \qquad \forall\, i,p \qquad (10)$$
$$Y_{i,i'p} \in \{0,1\} \qquad \forall\, i,p \qquad (11)$$

In this model, while maximizing the skill and team dynamics scores, it was aimed that the created teams be balanced, therefore the objective function was changed to maximize the lowest score in each objective instead the score of the team.

Maximimn Model 2:

Objective Function

$$\max Z(Q) = Q \qquad (1)$$

Subject to,

$$Q \le \left(\sum_{i=1}^{I}\left(\sum_{t=1}^{T} w_{tp}\, K_{it}\, X_{ip} + \sum_{s=1}^{S} w_{sp}\, L_{is}\, X_{ip}\right)\right) \qquad \forall\, p \qquad (2)$$
$$Q \le \left(\sum_{i,i'=1}^{I,I'} R_{i,i'}\, Y_{i,i'p}\right) \qquad \forall\, p \qquad (3)$$
$$Y_{i,i'p} - X_{ip} \le 0 \qquad \forall\, i,i',p \qquad (4)$$
$$Y_{i,i'p} - X_{i'p} \le 0 \qquad \forall\, i,i',p \qquad (5)$$
$$X_{ip} + X_{i'p} - Y_{i,i'p} \le 1 \qquad \forall\, i,i',p \qquad (6)$$
$$\left(\sum_{i=1}^{I} X_{ip}\, K_{it}\right) - c_p\, H_{tp} \ge 0 \qquad \forall\, t,p \qquad (7)$$
$$\sum_{i=1}^{I} X_{ip} - c_p \le 0 \qquad \forall\, p \qquad (8)$$
$$X_{ip}\, d_{ij} + \sum_{p=1}^{P} X_{ip}\, f_{ijp} \le n \qquad \forall\, i,j \qquad (9)$$
$$X_{ip} \in \{0,1\} \qquad \forall\, i,p \qquad (10)$$
$$Y_{i,i'p} \in \{0,1\} \qquad \forall\, i,i',p \qquad (11)$$

In this model, it was aimed to minimize the score differences between project groups and skill and team dynamics, while maximizing the skill and team dynamics scores.

EVALUATION & INSIGHTS

Standard model after completed the 5th hour of runtime, it was understood that it would take much longer to reach the optimality because the relative gap was very high. In order to eliminate the possibility of problems that may arise from the prolongation of the assignment process in the current system, it is not recommended to use this model for large-scale problems.

By using obtained results from maximin model 1, the scores of the project teams with the lowest project team skill level and team dynamics were determined and a tradeoff graph was obtained by using these scores.

Table 1. Maximin Model 1's Results According to Weighting

Weight	Minimum Skill Score	Minimum Team Dynamics Score
0	1,787494	2
0,1-0,8	1,812501	2
0,9	1,895862	1,66
1	1,925642	0,67

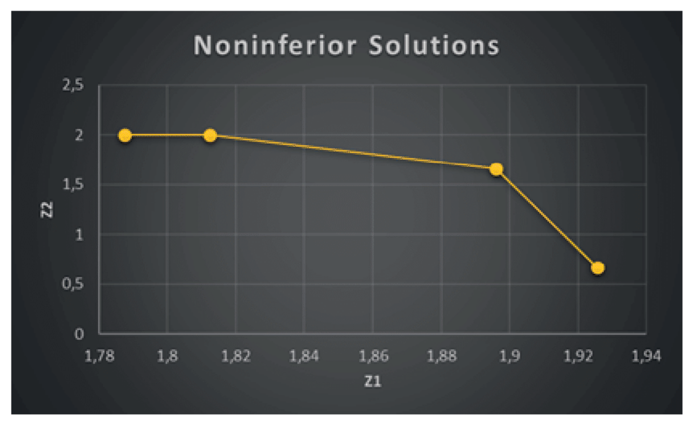

Figure 1. Maximin Model 1 Noninferior Solutions Graph

In Maximin Model 2, it was aimed to minimize the score differences between project groups and skill and team dynamics, while maximizing the skill and team dynamics scores. In the results obtained, skill level and team dynamic scores were determined for each project team.

Table 2. Maximin Model 2 Results and Project Team Scores

	P1	P2	P3	P4	P5	P6	P7	P8	P9	Min Value
Z1	1,9113	2,0645	1,9168	1,8615	1,9261	1,8247	1,8804	1,8195	1,8871	1,8195
Z2	2	1,835	2,16	2	2	2,33	2,01	1,84	2	1,835

Table 3. Maximin 1 and Maximin 2 Results and Project Team Scores

		P1	P2	P3	P4	P5	P6	P7	P8	P9
Maximin 1	Z1	1,8155	1,9239	1,9168	1,9307	1,8329	1,9694	1,9278	1,8841	2,1168
	Z2	2,01	2	2,16	2	2,16	2	2	2,01	2
Maximin 2	Z1	1,9113	2,0645	1,9168	1,8615	1,9261	1,8247	1,8804	1,8195	1,8871
	Z2	2	1,835	2,16	2	2	2,33	2,01	1,84	2

Table 4. Maximin 1 and 2 Models' Performance Indicators

		Minimum	Average	Differences among groups	The difference between skill and team dynamics score
Maximin 1	Z1	1,8125	1,9239	0,3043	0,1874
	Z2	2	2,0377	0,16	
Maximin 2	Z1	1,8195	1,8991	0,2450	0,0154
	Z2	2	2,0194	0,495	

Table 5. Comparison Between Models

Models	Objective	Weighting	Pros	Cons
Standard Model	Maximizing total score of project groups	Yes	Maximizing the total utility from groups	It is impractical to use in large problems.
Maximin Model 1	Maximizing the minimum score for both objectives	Yes	Z1 ve Z2 values are higher than Model 2. Additionally, the gap between highest and lowest score is minimum	Difference between minimum skill and team dynamic scores is high
Maximin Model 2	Maximizing the minimum score with minimum resulting objective	No	Difference between minimum skill and team dynamic scores are the lowest	Total group score is the minimum among 3 models.

CONCLUSION

In this study, the team building process, which is one of the most critical stages of project management, is evaluated in terms of proper management of human resources and the success of projects. The skill inventory list was prepared in a way to evaluate the technical and social skills of the personnel who will take part in the projects in the department. A comparison and weighting method were followed between technical and social skills using the Analytical Hierarchy Process. The resulting weights were used in the decision support system.

Models that enable the simultaneous optimization of these two objectives, which are listed as maximizing the technical and social skill level of the team and maximizing team dynamics, were developed and comparisons were made. While the first of the three models that emerged, maximizes the total score of the groups, the second model Maximin 1 tries to achieve a better result by maximizing the minimum values of the skill and team dynamics scores. In Maximin 2 model, it is aimed to maximize the minimum skill and team dynamic scores among the teams. Thus, the difference between the skill score and the team dynamic score is reduced. All 3 models have various advantages and disadvantages. If the size of the problem is not large, the standard model is suitable for use, while the Maximin 1 model should be preferred if the project teams are desired to be balanced and have close scores, and if the skill scores and team dynamics scores are desired to be close to each other, the Maximin 2 model should be preferred.

In this study, a different approach was followed by examining both technical and social skills and team dynamics as a concept that has not yet been studied in the literature, and it was aimed to make team assignment in the most effective way.

REFERENCES

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