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Research Article

Hybrid Approach to Supply Chain Project Manager Selection Problem

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Abstract

Supply chain management covers the management of all operations, from determining the material needs of manufacturing companies to delivering value-added products to customers. The success of these operations depends on the success of the supply chain management. Supply chain managers are the planners and implementers of this management process. Therefore, the right supply chain manager is needed. In this research, the supply chain project manager selection problem is discussed. In this context, multi criteria decision making techniques used for project manager selection problem applications were used. According to the literature review and interviews with the manufacturing executive jury, seven criteria were determined. The criterion weights were determined by the fuzzy stepwise weight assessment ratio analysis (F-SWARA) method. The grey operational competitiveness rating method (OCRA-G) method was applied to select the most suitable candidate among the four candidates. According to the research findings, the experience criterion was determined as the most important criterion in the selection of the supply chain project manager. The second candidate was found to be the most suitable candidate. In this research, an alternative hybrid model method for the project selection problem has been presented to the literature by using fuzzy and grey based approaches in a hybrid way. In addition, suggestions have been developed for manufacturing companies, supply chain project manager candidates and researchers.

Keywords: Project Manager Selection Problem, Human Resource Management, Supply Chain Management, F-SWARA, OCRA-G, MCDM.

Tedarik Zinciri Proje Yöneticisi Seçim Probleminde Hibrit Yaklaşım

Öz

Tedarik zinciri yönetimi imalat firmalarının malzeme ihtiyaçlarının belirlenmesinden değer katılarak dönüştürülen ürünlerin müşterilere ulaştırılmasına kadar tüm operasyonların yönetimini kapsamaktadır. Bu operasyonların başarısı, tedarik zinciri yönetiminin başarısına bağlıdır. Tedarik zinciri yöneticileri, bu yönetim sürecinin planlayıcıları ve uygulayıcılarıdır. Bu nedenle, doğru tedarik zinciri yöneticisine ihtiyaç vardır. Bu araştırmada tedarik zinciri proje yöneticisi seçim problemi ele alınmıştır. Bu kapsamda proje yöneticisi seçim problemi uygulamalarına yönelik kullanılan çok kriterli karar verme tekniklerinden faydalanılmıştır. Literatür incelemesi ve imalat firması yönetici jürisi ile yapılan görüşmelere göre yedi kriter belirlenmiştir. Kriter ağırlıkları F-SWARA yöntemiyle belirlenmiştir. Dört aday arasından en uygun adayın seçimi için OCRA-G yöntemi uygulanmıştır. Araştırma bulgularına göre tedarik zinciri proje yöneticisi seçiminde tecrübe kriteri en önemli kriter olarak belirlenmiştir. İkinci aday en uygun aday olarak bulunmuştur. Bu araştırmada bulanık ve grey tabanlı yaklaşımlar hibrit şekilde kullanılarak literatüre proje seçim problemi için alternatif hibrit model yöntemi sunulmuştur. Ayrıca imalat firmalarına, tedarik zinciri proje yönetici adaylarına, araştırmacılara öneriler geliştirilmiştir.

Anahtar Kelimeler: Proje Yöneticisi Seçim Problemi, İnsan Kaynakları Yönetimi, Tedarik Zinciri Yönetimi, F-SWARA, OCRA-G, ÇKKV.

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1. Introduction

One of the most crucial selection that companies must make is choosing a qualified project manager to oversee the full project management process (Jazebi and Rashidi 2013). Selecting a good supply chain project manager is the job of the human resources manager. It is well known that selecting the right project manager is essential to the smooth operation of any project. For human resource manager, finding the ideal project manager is a significant task. The project manager oversees completing the project's goals. Project managers manage projects by identifying project requirements, setting specific, achievable goals, balancing competing demands for quality, scope, time, and cost, adapting plans and strategies to the various concerns and expectations of various stakeholders, and managing projects in the face of uncertainty. The choice of the project manager is one of the two or three most crucial decisions that will affect the project because it is widely acknowledged that the project manager will have the greatest influence on the result (Ahsan et al., 2013).

The selection of project managers typically involves using established techniques like application form completion, interviews, and background checks. The accuracy of the results is in doubt because these traditional techniques frequently base their conclusions on the subjective judgment of decision makers (Zhang and Liu, 2011). Consequently, it is crucial to create efficient selection methods to find the right project manager. An exhaustive review of criteria and a multi-criteria decision making (MCDM) problem may be used to frame the process of choosing the best project manager (Dağdeviren, 2010).

Researchers and practitioners have focused a lot of attention on MCDM techniques for evaluating, assessing, and ranking alternatives in a variety of industries. Numerous studies have recently looked at the use of MCDM modeling techniques in decision-making processes, especially in the construction industry (Torfi and Rashidi, 2011). MCDM has long caught the interest of decision makers since it simply offers a way to get rid of the challenge. It is a method for operational assessment and decision support that works well for dealing with complicated issues that have a range of interests and viewpoints, significant levels of ambiguity, and competing objectives.

In this research, the project manager selection problem needed to successfully manage a project developed by a manufacturing company to improve supply processes is discussed. In this context, it is aimed to determine the most suitable criteria to be used in the supply chain project by determining the project manager selection criteria used in the literature. It is planned to apply the fuzzy stepwise weight assessment ratio analysis (F-SWARA) method in determining the criterion weights and the grey operational competitiveness rating (OCRA-G) method in ranking the alternative candidates. Thus, applications based on both grey numbers and fuzzy numbers will be possible. At this point, the research questions were formed as follows.

Rquestion 1: Can literature-based criteria be determined for the supply chain project manager selection problem?

Rquestion 2: Can grey and fuzzy-based methods be applied as hybrids?

Rquestion 3: Can a scientifically based solution be produced to the supply chain project manager candidate selection problem of the manufacturing company?

In the second part of this paper for the explanation of the above research questions, the preferred criteria are presented by making a literature review. In the third part, F-SWARA and OCRA-G methods are explained. In the fourth part, the application findings of the manufacturing company's project manager selection problem are presented. In the fifth part, discussion and conclusion are given. In the sixth part, the suggestions and limitations of the research are shown.

2. Literature Review and Criteria Selection

It is well known that one of the most crucial aspects of human resources management is hiring personnel. Selection of employees is related to the input quality of the workforce (Chien and Chen, 2008). The selection of the project manager has been done using MCDM (Kelemenis et al., 2011; Zavadskas et al. 2008). Regarding the selection criteria of project managers, decision makers have their own perspectives. Chen and Cheng (2005) used a fuzzy MCDM method for weighting of criteria and selection of alternatives method to select information system project manager selection. Their selection criteria are analysis and design skills, programming skills, interpersonal skills, business skills, environment skills and application skills. Xing and Zhang (2006) used fuzzy analytic hierarchy process (F-AHP) method for personnel selection problem. Knowledge, capability, character, and body were used as selection criteria in the research. Zavadskas et al. (2008) developed a multi criteria methodology for project manager selection based on grey criteria. The grey based complex proportional assessment (COPRAS-G) method was used for the project manager selection problem in the study. In the selection problem, personal skills, project management skills, business skills, technical skills, quality skills and time of decision making were used as selection criteria. Zhao et al. (2009) adopted a fuzzy comprehensive evaluation method in the selection of a project manager. In this research, among the different selection criteria, site management capacity, technical level, level of leadership and personal qualities were chosen.

Rashidi et al. (2011) combined fuzzy systems (fuzzy logic model), artificial neural network (ANN) and genetic algorithm for choosing a qualified construction project manager. The preferred criteria in this research are technical and professional background, educational background, demographic features, and general management abilities. Zavadskas et al. (2012) used AHP for weighting method and additive ratio assessment (ARAS) for selection method. Education, experience, and personal skills were preferred as selection criteria in the AHP method. Afshari and Yusuff (2013) used fuzzy integral systems for both selecting and weighting. Basic requirements, project management, management skills and interpersonal skills are used as selection criteria. Jazebi and Rashidi (2013) used fuzzy rule system for project manager selection. Technical and professional records, educational background, demographic features, and general management abilities criteria were accepted as the main criteria for the project manager selection problem. Varajao and Cruz-Cunha (2013) applied the AHP-IPMA (international project management association) qualification baseline for the weighting method. Technical competence, behavioral competence and contextual competence are the selection criteria for this research. Dodangeh et al. (2014) applied the fuzzy MCDM method using the criteria of basic requirements, project management skills, management skills and interpersonal skills. Manaan et al. (2014) used fuzzy competency rating method for project manager selection. In the research, the best project manager candidate was determined by using seven criteria. Afshari et al. (2016) used the preference ranking organization method for enrichment evaluation (PROMETHEE) method for project manager selection. Foreign language, computer knowledge, experience, age, gender, labor shift, non-smoker and education were preferred as selection criteria in the study.

Chaghooshi et al. (2016) used fuzzy decision-making trial and evaluation laboratory (F-DEMATEL) method for weighting and fuzzy vlsekriterijumska optimizacija i kompromisno resenje (F-VIKOR) for selection. Site management capacity, technical level, leadership level, personal qualities and contextual competencies are the research criteria. Sadatrasool et al. (2016) used AHP for weighting and the principal component analysis technique for order preference by similarity to ideal solution (PCA-TOPSIS) method for selection. In this research, general management, project management and petroleum project management criteria are the selection criteria. Afshari and Kowal (2017) used PROMETHEE for weighting and fuzzy linguistic evaluation procedure for selection method to select information and communications technology (ICT) project manager. Education, experience, computer knowledge, foreign language, age, gender, labor shift and non-smoker are their criteria for selection. Celikbilek (2018) used grey based AHP for selecting project manager. Basic criteria, character criteria, software criteria, project criteria and energy are the selection criteria for this research. Khodadadi and Aghabeigi (2018) applied F-DEMATEL, analytic network process (ANP) and F-VIKOR methods. Management skills, attitude and insight, personality traits, knowledge and expertise, professional reputation and general criteria were used in this research. The literature review of the project manager selection problem is presented in Table 1.

Table 1. Literature Review of The Project Manager Selection Problem

Research	**Weighting method**	**Selection method**	**Criteria**
Chen and Cheng (2005)	F-MCDM	F-MCDM	“Analysis and design skills, programming skills, interpersonal skills, business skills, environment skills and application skills (6 criteria)”
Xing and Zhang (2006)	F-AHP	F-AHP	“Knowledge, capability, character, and body (4 criteria)”
Zavadskas et al. (2008)	COPRAS-G	COPRAS-G	“Personal skills, project management skills, business skills, technical skills, quality skills, and time of decision making (6 criteria)”
Zhao et al. (2009)	Fuzzy comprehensive evaluation	Fuzzy comprehensive evaluation	“Site management capacity, technical level, level of leadership and personal qualities (4 criteria)”
Rashidi et al. (2011)	Fuzzy logic model	Fuzzy logic model	“Technical and professional background, educational background, demographic features, and general management abilities (4 criteria)”
Zavadskas et al. (2012)	AHP	ARAS	“Education, experience, and personal skills (3 criteria)”
Jazebi and Rashidi (2013)	Fuzzy rule system	Fuzzy rule system	“Technical and professional records, educational background, demographic features, and general management abilities (4 criteria)”
Afshari and Yusuff (2013)	Fuzzy integral	Fuzzy integral	“Basic requirements, project management, management skills and interpersonal skills (4 criteria)”
Varajao and Cruz-Cunha (2013)	AHP	AHP-IPMA	“Technical competence, behavioral competence, and contextual competence (3 criteria)”
Manaan et al. (2014)	Fuzzy competency rating	Fuzzy competency rating	“Knowledge of appropriate site layout techniques for repetitive construction works, dedication in helping works contractors achieve works schedule, knowledge of appropriate technology transfers for repetitive construction works, effective time management practices on all project sites, ability to provide effective solutions to conflicts while maintaining good relationships, ease with which works contractors are able to approach the PM with their problem and volunteering to help works contractors to solve personal problems (6 criteria)”
Dodangeh et al. (2014)	F-MCDM	F-MCDM	“Basic requirements, project management skills, management skills and interpersonal skills (4 criteria)”
Afshari et al. (2016)	PROMETHEE	-	“Foreign language, computer knowledge, experience, age, gender, labor shift, non-smoker, and education (8 criteria)”
Chaghooshi et al. (2016)	F- DEMATEL	F-VIKOR	“Site management capacity, technical level, level of leadership, personal qualities, and contextual competences (5 criteria)”
Sadatrasool et al. (2016)	AHP	PCA-TOPSIS	“General management, project management and petroleum project management (3 criteria)”

Afshari and Kowal (2017)	PROMETHEE	Fuzzy linguistic evaluation procedure	“Education, experience, computer knowledge, foreign language, age, gender, labor shift, and non-smoker (9 criteria)”
Celikbilek (2018)	Grey AHP	Grey AHP	“Basic criteria, character criteria, software criteria, project criteria and energy criteria (5 criteria)”
Khodadadi and Aghabeigi (2018)	F-DEMATEL, ANP	F-VIKOR	“Management skills, attitude and insight, personality traits, knowledge and expertise, professional reputation, and general (6 criteria)”

In this research, the problem of selecting the appropriate project manager for a supply chain improvement project is discussed to improve the supply chain processes of a manufacturing company. In this context, it is necessary to determine the criteria for the supply chain project manager selection problem. Considering the general project manager selection criteria in the literature, interviews were conducted with the management team of the manufacturing company. The opinions of the top managers were used in the criteria determination process by the jury of executive opinion method. Firstly, the criteria obtained from the literature were presented to the managers. Subsequently, criteria were determined for the selection of the supply chain project manager. Explanations and references to the criteria are presented in Table 2.

Table 2. Selected Criteria

Criteria	Explanations	References
Project Management Skills (C1)	Project management skills refer to the management abilities of prospective supply chain project managers in the successful planning, execution, management, and conclusion of the project.	Zavadskas et al. (2008), Afshari and Yusuff (2013), Sadatrasool et al. (2016)
Basic Management Skills (C2)	Basic management skills refer to the ability of project manager candidates to get people to work.	Rashidi et al. (2011), Jazebi and Rashidi (2013), Afshari and Yusuff (2013), Dodangeh et al. (2014), Sadatrasool et al. (2016), Khodadadi and Aghabeigi (2018)
Education (C3)	Education refers the educational level from which the project manager candidate most recently graduated.	Rashidi et al. (2011), Zavadskas et al. (2012), Jazebi and Rashidi (2013), Afshari et al. (2016), Afshari and Kowal (2017)
Experience (C4)	Experience refers to the projects and durations in which project manager candidates serve as project managers.	Zavadskas et al. (2012), Afshari et al. (2016), Afshari and Kowal (2017)
Personality Traits (C5)	Personality traits refers that project manager candidates have the personality traits required for project management. (Endurance, Patience, effective communication, awareness, analytical thinking, perspective etc.)	Zhao et al. (2009), Zavadskas et al. (2012), Chaghooshi et al. (2016), Aghabeigi (2018)
Interpersonal Skills (C6)	Interpersonal skills refer to the skills of the project manager in coordinating different individuals in different tasks within the scope of the project.	Chen and Cheng (2005), Afshari and Yusuff (2013), Dodangeh et al. (2014)
Computer Knowledge (C7)	Computer knowledge refers to the ability to effectively use computers used in the execution of projects.	Afshari et al. (2016), Afshari and Kowal (2017), Celikbilek (2018)

3. Methodology

The application of MCDM methods is based on the project manager selection problem for supply chain management. The F-SWARA method was used to weight the criteria, and the OCRA-G method was used to rank the alternative candidates. Since these methods are not used in project manager selection problem applications, these methods were preferred and applied in a hybrid way. This section describes the F-SWARA and OCRA-G methods.

3.1. The Fuzzy Stepwise Weight Assessment Ratio Analysis (F-SWARA)

The most important feature that distinguishes this criterion weighting method from other methods is that the criteria are sorted according to their priorities and then compared by the decision makers. This method was first developed by Keršuliene et al. (2010). The fuzzy-based SWARA method was developed by Mavi et al. (2017). The SWARA method is preferred in various studies in the literature (Alimardani et al., 2013; Heidary Dahooie et al., 2018; Ijadi Maghsoodi et al. 2019; Toygar et al., 2022). The weighting of the criteria with the F-SWARA method is completed in six steps (Mavi et al., 2017; Zarbakhshnia et al., 2018; Ansari et al., 2020; Mishra et al., 2020). These steps are explained one by one in order:

Step 1-1: Decision makers first rank the available criteria in order of importance.

Step 1-2: The ranked criteria are compared with the previous criteria. Comparison of the first criterion is not made. For example, the third criterion is evaluated by comparing with the second criterion. These assessments are performed based on the linguistic expressions presented in Table 3. The criteria are defined by j.

Step 1-3: The coefficient k_j is calculated by Eq. (1).

$$\tilde{k}_j = \begin{cases} 1, \ j = 1 \\ \tilde{s}_j + 1, \ j > 1 \end{cases} \quad (1)$$

Step 1-4: Recalculated weight $\tilde{q}_j$ is calculated by Eq. (2).

$$\tilde{q}_j = \begin{cases} 1, \ j = 1 \\ \frac{\tilde{q}_{j-1}}{\tilde{k}_j}, \ j > 1 \end{cases} \quad (2)$$

Step 1-5: The fuzzy weight values $(\widetilde{w}_j)$ of the criteria are calculated with Eq. (3).

$$\widetilde{w}_j = \frac{\tilde{q}_j}{\sum_{k\_1}^{n} \tilde{q}_k} \quad (3)$$

Step 1-6: Values (l, m, u) expressing triangular fuzzy numbers are defuzzied with Eq. (4).

$$w_j = \frac{(w^u{}_j - w^l{}_j) + (w^m{}_j - w^l{}_j)}{3} + w^l{}_j \quad (4)$$

Table 3. Linguistic Expressions for Comparison of Criteria

Symbol	**Definition**	**Triangular Fuzzy Number Value**		
		l	**m**	**u**
VL	Very Low	0,00	0,00	0,10
L	Low	0,00	0,10	0,30
ML	Moderately Low	0,10	0,30	0,50
M	Medium	0,30	0,50	0,70
MH	Moderately High	0,50	0,70	0,90
H	High	0,70	0,90	1,00
VH	Very High	0,90	1,00	1,00

3.2. The Grey Operational Competitiveness Rating Method (OCRA-G)

The feature that distinguishes this method from other methods is that the criteria are evaluated separately as beneficial and non-beneficial. The OCRA method was first developed by Parkan (1994). Wu (2002) is among the first to apply the grey based OCRA method. The ranking of the alternatives with the OCRA-G method is completed in seven steps (Madić et al., 2015; Stanujkic et al., 2017; Ulutaş et al., 2020). These steps are explained one by one in order:

Step 2-1 Creating the decision matrix: Using the Grey numbers presented in Table 4, the decision matrix is obtained as in Eq. (5). This process is carried out by evaluating each alternative according to all criteria by each decision maker.

$$\otimes F = \begin{bmatrix} \otimes f_{11} & \cdots & \otimes f_{1j} & \cdots & \otimes f_{1n} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ \otimes f_{i1} & \cdots & \otimes f_{ij} & \cdots & \otimes f_{in} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ \otimes f_{m1} & \cdots & \otimes f_{mj} & \cdots & \otimes f_{mn} \end{bmatrix} \quad (5)$$

Table 4. Grey Numbers for Evaluation of Each Alternative

Symbol	**Linguistic Values**	**Grey Numbers**	
		$\underline{f}_{ij}$	$\bar{f}_{ij}$
VH	Very High	0,800	1
H	High	0,700	0,900
MH	Medium High	0,600	0,800
M	Medium	0,350	0,650
ML	Medium Low	0,200	0,400
L	Low	0,100	0,300
VL	Very Low	0	0,200

Step 2-2 Aggregation of non-beneficial criteria $(\otimes I_i)$: The non-beneficial criteria are aggregated with Eq. (6). $\underline{\widetilde{w}}_j$ represents the lower limit of the fuzzy weight values calculated in Step 1-5, when combined by calculating the geometric mean. and $\overline{w}_j$ represents the upper limit of the fuzzy weight values calculated in Step 1-5, when combined by calculating the geometric mean.

$$\otimes I_i = \left[\underline{I_i}, \overline{I_i}\right] = \sum_{j\in\Omega_{min}} \left[\underline{w}''_j, \overline{w}''_j\right] \frac{\left[\max\limits_j \underline{f}_{ij} - \bar{f}_{ij}, \max\limits_j \bar{f}_{ij} - \underline{f}_{ij}\right]}{\left[\max\limits_j \underline{f}_{ij} - \min\limits_j \bar{f}_{ij}, \max\limits_j \bar{f}_{ij} - \min\limits_j \underline{f}_{ij}\right]} \tag{6}$$

Step 2-3 Calculation of linear performance ratings of non-beneficial criteria ($\otimes S_i$): The linear performance ratings of non-beneficial criteria are calculated by Eq. (7).

$$\otimes S_i = \left[\underline{S_i}, \overline{S_i}\right] = \left[\underline{I_i} - \min_i \bar{I}_i, \bar{I}_i - \min_i \underline{I_i}\right] \tag{7}$$

Step 2-4 Aggregation of beneficial criteria ($\otimes O_i$): The beneficial criteria are aggregated with Eq. (8).

$$\otimes O_i = \left[\underline{O_i}, \overline{O_i}\right] = \sum_{j\in\Omega_{max}} \left[\underline{w}''_j, \overline{w}''_j\right] \frac{\left[\underline{f}_{ij} - \min\limits_j \bar{f}_{ij}, \bar{f}_{ij} - \min\limits_j \underline{f}_{ij}\right]}{\left[\max\limits_j \underline{f}_{ij} - \min\limits_j \bar{f}_{ij}, \max\limits_j \bar{f}_{ij} - \min\limits_j \underline{f}_{ij}\right]} \tag{8}$$

Step 2-5 Calculation of linear performance ratings of beneficial criteria ($\otimes R_i$): The linear performance ratings of beneficial criteria are calculated by Eq. (9).

$$\otimes R_i = \left[\underline{R_i}, \overline{R_i}\right] = \left[\underline{O_i} - \min_i \bar{O}_i, \bar{O}_i - \min_i \underline{O_i}\right] \tag{9}$$

tep 2-6 Calculation of alternative values ($\otimes P_i$): The grey values of the alternatives are calculated by Eq. (10).

$$\otimes P_i = \left[\underline{P_i}, \overline{P_i}\right] = \left[\underline{S_i} + \underline{R_i} - \min_i(\bar{S}_i + \bar{R}_i), \bar{S}_i + \bar{R}_i - \min_i(\underline{S_i} + \underline{R_i})\right] \tag{10}$$

Step 2-7 Crisp of alternative values (P_i): Crisp is done by Eq. (11). Thus, the alternatives are ranked.

$$P_i = \frac{\underline{P_i} + \bar{P}_i}{2} \tag{11}$$

4. Application

In this research, the supply chain project manager selection problem is discussed. In the supply chain project manager selection problem for a manufacturing firm, seven criteria (Project management skills (C1), Basic management skills (C2), Education (C3), Experience (C4), Personality traits (C5), Interpersonal skills (C6), Computer knowledge (C7)), four decision makers (DM1, DM2, DM3, DM4) and four project manager candidates (A1, A2, A3, A4) were determined. Firstly, the weights of the criteria were calculated using the F-SWARA method. Then, alternatives were ranked using the OCRA-G method. The steps applied in the application are described below, respectively:

Step 1-1: Each decision maker ranked the criteria among themselves. It is presented in Table 5.

Step 1-2: The criteria are compared against the previous criteria using linguistic expressions. Linguistic expressions of the comparisons are presented in Table 6.

Step 1-3: The coefficients $\tilde{k}_j$ calculated with Eq. (1) are shown in Table 7.

Step 1-4: The $\tilde{q}_j$ values calculated with Eq. (2) are shown in Table 8.

Step 1-5: The $\tilde{w}_j$ values calculated with Eq. (3) are shown in Table 9.

Step 1-6: The values in Table 9 were combined by taking the geometric mean. Then, it was crisped with Eq. (4) and the importance degrees of the criteria were calculated. The importance and order of the criteria are shown in Table 10.

Step 2-1: The decision matrix in Table 11 was created by using the linguistic expressions in Table 4. In Table 12, grey numeric values and geometric mean are shown.

Step 2-2,3,4,5,6,7: Since all criteria are beneficial, only $\otimes O_i$, $\otimes R_i$, $\otimes P_i$, P_i values have been calculated. The values calculated by Eq. (8), Eq. (9), Eq. (10) and Eq. (11) are given in Table 13.

Table 5. Ranking the Criteria in Order of Importance among Themselves

Criteria	DM1	DM2	DM3	DM4
C1	1	2	2	5
C2	3	3	1	4
C3	6	7	4	2
C4	2	1	3	1
C5	5	5	7	5
C6	4	4	5	3
C7	7	6	6	6

Table 6. Comparison of Criteria by Decision Makers

DM1		DM2		DM3		DM4	
C1		***C4***		***C2***		***C4***	
C4	L	***C1***	ML	***C1***	VL	***C3***	ML
C2	MH	***C2***	VL	***C4***	L	***C6***	M
C6	M	***C6***	MH	***C3***	MH	***C2***	L
C5	VL	***C5***	L	***C6***	ML	***C1***	VL
C3	ML	***C7***	M	***C7***	M	***C7***	MH
C7	H	***C3***	L	***C5***	H	***C5***	M

Table 7. The $\tilde{k}_j$ Coefficients

	DM1				DM2				DM3				DM4		
	l	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**
C1	1.00	1.00	1.00	***C4***	1.00	1.00	1.00	***C2***	1.00	1.00	1.00	***C4***	1.00	1.00	1.00
C4	1.00	1.10	1.30	***C1***	1.10	1.30	1.50	***C1***	1.00	1.00	1.10	***C3***	1.10	1.30	1.50
C2	1.50	1.70	1.90	***C2***	1.00	1.00	1.10	***C4***	1.00	1.10	1.30	***C6***	1.30	1.50	1.70
C6	1.30	1.50	1.70	***C6***	1.50	1.70	1.90	***C3***	1.50	1.70	1.90	***C2***	1.00	1.10	1.30
C5	1.00	1.00	1.10	***C5***	1.00	1.10	1.30	***C6***	1.10	1.30	1.50	***C1***	1.00	1.00	1.10
C3	1.10	1.30	1.50	***C7***	1.30	1.50	1.70	***C7***	1.30	1.50	1.70	***C7***	1.50	1.70	1.90
C7	1.70	1.90	2.00	***C3***	1.00	1.10	1.30	***C5***	1.70	1.90	2.00	***C5***	1.30	1.50	1.70

Table 8. The $\tilde{q}_j$ Values

	DM1				DM2				DM3				DM4		
	l	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**
C1	1.0000	1.0000	1.0000	***C4***	1.0000	1.0000	1.0000	***C2***	1.0000	1.0000	1.0000	***C4***	1.0000	1.0000	1.0000
C4	1.0000	0.9091	0.7692	***C1***	0.9091	0.7692	0.6667	***C1***	1.0000	1.0000	0.9091	***C3***	0.9091	0.7692	0.6667
C2	0.6667	0.5348	0.4049	***C2***	0.9091	0.7692	0.6061	***C4***	1.0000	0.9091	0.6993	***C6***	0.6993	0.5128	0.3922
C6	0.5128	0.3565	0.2382	***C6***	0.6061	0.4525	0.3190	***C3***	0.6667	0.5348	0.3681	***C2***	0.6993	0.4662	0.3017
C5	0.5128	0.3565	0.2165	***C5***	0.6061	0.4114	0.2454	***C6***	0.6061	0.4114	0.2454	***C1***	0.6993	0.4662	0.2742
C3	0.4662	0.2742	0.1443	***C7***	0.4662	0.2742	0.1443	***C7***	0.4662	0.2742	0.1443	***C7***	0.4662	0.2742	0.1443
C7	0.2742	0.1443	0.0722	***C3***	0.4662	0.2493	0.1110	***C5***	0.2742	0.1443	0.0722	***C5***	0.3586	0.1828	0.0849

Table 9. The $\widetilde{w}_j$ Values

	DM1				DM2				DM3				DM4		
	l	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**		**l**	**m**	**u**
C1	0.2256	0.2797	0.3515	***C4***	0.2015	0.2547	0.3234	***C2***	0.1995	0.2340	0.2908	***C4***	0.2070	0.2724	0.3492
C4	0.2256	0.2543	0.2704	***C1***	0.1832	0.1959	0.2156	***C1***	0.1995	0.2340	0.2644	***C3***	0.1881	0.2095	0.2328
C2	0.1504	0.1496	0.1423	***C2***	0.1832	0.1959	0.1960	***C4***	0.1995	0.2127	0.2034	***C6***	0.1447	0.1397	0.1369
C6	0.1157	0.0997	0.0837	***C6***	0.1221	0.1153	0.1031	***C3***	0.1330	0.1251	0.1070	***C2***	0.1447	0.1270	0.1053
C5	0.1157	0.0997	0.0761	***C5***	0.1221	0.1048	0.0793	***C6***	0.1209	0.0963	0.0714	***C1***	0.1447	0.1270	0.0958
C3	0.1052	0.0767	0.0507	***C7***	0.0939	0.0699	0.0467	***C7***	0.0930	0.0642	0.0420	***C7***	0.0965	0.0747	0.0504
C7	0.0619	0.0404	0.0254	***C3***	0.0939	0.0635	0.0359	***C5***	0.0547	0.0338	0.0210	***C5***	0.0742	0.0498	0.0296

Table 10. The weighted and ranked of the criteria

Criteria	$\widetilde{w}_j$			w_j	**Rankings**
	l	**m**	**u**		
C4	0.2081	0.2475	0.2807	0.2454	1
C1	0.1859	0.2009	0.2093	0.1987	2
C2	0.1679	0.1718	0.1710	0.1702	3
C6	0.1254	0.1115	0.0958	0.1109	4
C3	0.1235	0.1022	0.0751	0.1003	5
C5	0.0870	0.0647	0.0440	0.0653	6
C7	0.0850	0.0606	0.0398	0.0618	7

Table 11. The Grey Decision Matrix

		C1	C2	C3	C4	C5	C6	C7
DM1	***A1***	H	H	MH	L	M	ML	H
	A2	MH	H	M	M	MH	L	MH
	A3	M	MH	MH	MH	M	H	M
	A4	M	H	H	ML	ML	H	MH
DM2	***A1***	VH	H	M	ML	ML	M	MH
	A2	M	MH	ML	MH	M	MH	M
	A3	MH	MH	M	M	MH	M	M
	A4	ML	MH	MH	M	ML	MH	H
DM3	***A1***	MH	MH	MH	M	L	ML	H
	A2	MH	MH	M	MH	MH	MH	MH
	A3	M	M	M	M	MH	MH	MH
	A4	L	MH	H	ML	M	H	M
DM4	***A1***	H	MH	MH	ML	M	M	MH
	A2	M	H	M	M	MH	L	M
	A3	MH	H	MH	MH	MH	M	MH
	A4	L	M	M	ML	M	M	MH

Table 12. Alternatives Evaluation Results with the OCRA-G method (Grey Numbers)

		C1	C2	C3	C4	C5	C6	C7
DM1	***A1***	[0.700; 0.900]	[0.700; 0.900]	[0.600; 0.800]	[0.100; 0.300]	[0.350; 0.650]	[0.200; 0.400]	[0.700; 0.900]
	A2	[0.600; 0.800]	[0.700; 0.900]	[0.350; 0.650]	[0.350; 0.650]	[0.600; 0.800]	[0.100; 0.300]	[0.600; 0.800]
	A3	[0.350; 0.650]	[0.600; 0.800]	[0.600; 0.800]	[0.600; 0.800]	[0.350; 0.650]	[0.700; 0.900]	[0.350; 0.650]
	A4	[0.350; 0.650]	[0.700; 0.900]	[0.700; 0.900]	[0.200; 0.400]	[0.200; 0.400]	[0.700; 0.900]	[0.600; 0.800]
DM2	***A1***	[0.800; 1.000]	[0.700; 0.900]	[0.350; 0.650]	[0.200; 0.400]	[0.200; 0.400]	[0.350; 0.650]	[0.600; 0.800]
	A2	[0.350; 0.650]	[0.600; 0.800]	[0.200; 0.400]	[0.600; 0.800]	[0.350; 0.650]	[0.600; 0.800]	[0.350; 0.650]
	A3	[0.600; 0.800]	[0.600; 0.800]	[0.350; 0.650]	[0.350; 0.650]	[0.600; 0.800]	[0.350; 0.650]	[0.350; 0.650]
	A4	[0.200; 0.400]	[0.600; 0.800]	[0.600; 0.800]	[0.350; 0.650]	[0.200; 0.400]	[0.600; 0.800]	[0.700; 0.900]
DM3	***A1***	[0.600; 0.800]	[0.600; 0.800]	[0.600; 0.800]	[0.350; 0.650]	[0.100; 0.300]	[0.200; 0.400]	[0.700; 0.900]
	A2	[0.600; 0.800]	[0.600; 0.800]	[0.350; 0.650]	[0.600; 0.800]	[0.600; 0.800]	[0.600; 0.800]	[0.600; 0.800]
	A3	[0.350; 0.650]	[0.350; 0.650]	[0.350; 0.650]	[0.350; 0.650]	[0.600; 0.800]	[0.600; 0.800]	[0.600; 0.800]
	A4	[0.100; 0.300]	[0.600; 0.800]	[0.700; 0.900]	[0.200; 0.400]	[0.350; 0.650]	[0.700; 0.900]	[0.350; 0.650]
DM4	***A1***	[0.700; 0.900]	[0.600; 0.800]	[0.600; 0.800]	[0.200; 0.400]	[0.350; 0.650]	[0.350; 0.650]	[0.600; 0.800]
	A2	[0.350; 0.650]	[0.700; 0.900]	[0.350; 0.650]	[0.350; 0.650]	[0.600; 0.800]	[0.100; 0.300]	[0.350; 0.650]
	A3	[0.600; 0.800]	[0.700; 0.900]	[0.600; 0.800]	[0.600; 0.800]	[0.600; 0.800]	[0.350; 0.650]	[0.600; 0.800]
	A4	[0.100; 0.300]	[0.350; 0.650]	[0.350; 0.650]	[0.200; 0.400]	[0.350; 0.650]	[0.350; 0.650]	[0.600; 0.800]
Geo. Mean	***A1***	[0.696; 0.897]	[0.648; 0.849]	[0.524; 0.760]	[0.193; 0.42]	[0.222; 0.475]	[0.265; 0.510]	[0.648; 0.849]
	A2	[0.458; 0.721]	[0.648; 0.849]	[0.304; 0.576]	[0.458; 0.721]	[0.524; 0.760]	[0.245; 0.490]	[0.458; 0.721]
	A3	[0.458; 0.721]	[0.545; 0.782]	[0.458; 0.721]	[0.458; 0.721]	[0.524; 0.760]	[0.476; 0.743]	[0.458; 0.721]
	A4	[0.163; 0.391]	[0.545; 0.782]	[0.566; 0.806]	[0.230; 0.452]	[0.265; 0.510]	[0.566; 0.806]	[0.545; 0.782]

Table 13. The $\otimes O_i$, $\otimes R_i$, $\otimes P_i$, P_i Values and Ranking of Alternatives

	$\otimes \boldsymbol{O_i}$	$\otimes \boldsymbol{R_i}$	$\otimes \boldsymbol{P_i}$	$\boldsymbol{P_i}$	**Rank**
A1	[0.614; 0.601]	[0.084; -0.013]	[0.168; -0.097]	0.0357	4
A2	[5.301; 0.799]	[4.772; 0.186]	[4.856; 0.101]	2.4787	1
A3	[4.335; 0.825]	[3.806; 0.211]	[3.890; 0.127]	2.0085	2
A4	[0.989; 0.530]	[0.460; -0.084]	[0.544; -0.168]	0.1879	3

5. Discussion and Conclusion

In project management, which is based on the improvement of supply chain processes, the selection of the project manager is critical for the successful completion of the project. In this research, the project manager selection problem is discussed to manage the supply chain project of a manufacturing company. The criteria obtained as a result of the literature review were presented to the executive jury of the manufacturing company. Seven criteria were determined as a result of the discussions with the jury. According to these criteria, four project manager candidates were evaluated. F-SWARA method was used to weight the criteria. According to the criteria weights obtained, the ranking of the candidates was carried out with the OCRA-G method. F-SWARA findings showed that the experience criterion is the criterion with the highest level of importance. The OCRA-G findings presented that the most suitable candidate among the project manager candidates was the second candidate.

This finding obtained by examining the studies in the literature was compared with the literature findings. The literature findings are as follows: Xing and Zhang (2006) determined that the decision-making ability criterion, which is included in the capacity of the candidates, is the most important selection criterion in the project manager selection problem. Zavadskas et al. (2008) points out that personnel skills, project managers skills, business skills and experience criteria are among the most preferred criteria in the literature of project manager selection problem. Zhao et al. (2009) evaluated the existing criteria by considering the work experience and job performance of the candidates in the evaluation index they put forward for the project manager selection problem. As a result of the evaluation, they emphasized the site management capacity criterion as the criterion with the highest level of importance. Among the twenty-three criteria in the construction project manager selection problem, Rashidi et al (2011) identified the criterion of experience as the criterion with the highest importance level. Zavadskas et al. (2012) showed the three most important selection criteria in the list of project manager selection criteria as education, project design experience and project management experience. Jazebi and Rashidi (2013) determined the project managers' experience working with existing employees, English communication ability and general experience as highest criteria weight among the selection criteria. Afshari and Yusuff (2013) included the experience criterion among the basic requirement criteria in the project manager selection and calculated it as the best criterion. Dodangeh et al. (2014) emphasizes that there are four basic project manager selection criteria and points to the basic requirements criterion as the most important criterion. Experience sub-criteria is among the basic requirement criteria. Afshari et al. (2016) among the eight project manager criteria, the experience criterion is shown as the criterion with the highest importance. Afshari et al. (2016) among the five ICT project manager criteria, the experience criterion is also shown as the best criterion. Celikbilek (2018) found that among the sub-criteria of software and project criteria used in the project manager selection problem, the most important criteria are software experience and project experience. According to the literature findings, it can be mentioned that this study is in parallel with the findings (Zavadskas et al., 2008; Zhao et al., 2009; Rashidi et al., 2011; Zavadskas et al., 2012; Jazebi and Rashidi, 2013; Afshari and Yusuff, 2013; Dodangeh et al., 2014; Afshari et al., 2016; Afshari and Kowal, 2017; Celikbilek, 2018).

6. Suggestions and Limitation

In the research, which deals with the supply chain project manager selection problem, suggestions were developed for manufacturing companies, project manager candidates and researchers. Suggestions for manufacturing companies are as follows: (i) They should take a project-based approach to improving supply chain processes. (ii) They should prefer to apply multi criteria decision making methods instead of intuitive approaches in the selection of project managers. (iii) In the project manager selection process, criteria should be determined, and the importance levels of the criteria should be also determined. (iv) By creating a project manager candidate pool, it should be aimed to determine the best candidate according to the importance levels of the criteria. (v) They should seek expert support in their project manager selection process. The suggestions for project manager candidates are as follows: (i) The project manager should develop their skills and abilities, considering the importance of the selection criteria. (ii) Considering the importance of the experience criterion, they should take steps towards gaining project manager experience. (iii) The project manager should develop criteria for preference over other candidates during the selection process. Suggestions for researchers are as follows: i) They can compare the findings of this research with the findings obtained by applying the project manager selection problem with different fuzzy and grey-based methods. (ii) They can revisit the supply chain project manager problem by differentiating the project manager identification criteria. (iii) They can contribute to the literature by identifying different project manager topics as research topics.

There are four main limitations of this research. First limitation; this research is the project manager selection that addresses the improvement of supply chain processes of manufacturing companies. For this reason, the determined criteria were created in this way. Second limitation; in this study, a fuzzy-based approach was adopted for weighting the criteria and a grey-based approach for ranking the alternatives. Different results can be obtained if different MCDM methods are applied. Third limitation; evaluations of the criteria and alternatives were obtained from the managers of the manufacturing company. Different results can be reached according to the evaluations obtained by different decision makers. The fourth limitation; the manufacturing firm has four project manager candidates. As the candidate pool increases, different results can be obtained. Finally, with this research, the supply chain process improvement project selection problem was handled, and the most suitable candidate was determined by fuzzy and grey-based MCDM methods and presented to the literature.

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