PRIORITIZING THE CRITICAL SUCCESS FACTORS THAT INCREASE THE IMPACT OF PROCESS MANAGEMENT

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Anahtar Keywords

Process management, critical success factors, multi-criteria decision making, fuzzy logic, spherical fuzzy numbers

Abstract

There are plenty of criteria that affect the success of process management studies, which are of critical importance in terms of ensuring general efficiency measurement and traceability in enterprises, in reaching their final aims. In this article, a study was conducted to determine the Critical Success Factors (CSFs) that need attention in order to maintain successful process management and to analyze these factors with multiple criteria. During the identification of CSFs, case studies were explored as well as in-depth literature research. In the analysis of the determined CSFs, the Analytical Hierarchy Process (AHP) technique, which is integrated with the spherical fuzzy numbers because it focuses on the hesitancy degree of decision-makers, was employed. According to the results, the human-factor in process management was determined as the most important CSFs, while the appropriate determination of the team was the most important sub-CSFs. It is foreseen that the practical and theoretical information presented as a result of multi-criteria analysis in this study is a guide for companies and professionals who want to carry out their process management studies successfully.

SÜREÇ YÖNETİMİNİN ETKİSİNİ ARTIRAN KRİTİK BAŞARI FAKTÖRLERİNİN ÖNCELİKLENDİRİLMESİ

Kelimeler

Süreç yönetimi, kritik başarı faktörleri, çok kriterli karar verme, bulanık mantık, küresel bulanık sayılar

Öz

İşletmelerde verimlilik ölçümü ve izlenebilirliğinin sağlanması açısından oldukça kritik bir öneme sahip olan süreç yönetimi çalışmalarının nihai hedeflerine ulaşmasındaki başarısını etkileyen çok sayıda kriter bulunmaktadır. Bu makalede başarılı bir süreç yönetimi sürdürebilmek için dikkat edilmesi gerek Kritik Başarı Faktörleri (KBF)'nin belirlenmesi ve bu faktörlerin çok kriterli analizine yönelik bir çalışma yapılmıştır. KBF'lerin belirlenmesi sırasında derin literatür araştırmasının yanı sıra vaka incelemeleri yapılmıştır. Elde edilen KBF'lerin analizinde ise karar vericilerin tereddütlerine odaklanan küresel bulanık sayılarla bütünleştirilmiş edilmiş Analitik Hiyerarşi Prosesi yöntemi kullanılmıştır. Çalışmada elde edilen sonuçlara göre süreç yönetiminde insan faktörü en önemli KBF olarak belirlenirken, süreç yönetimi çalışmalarını sürdürecek ekibin uygun bir şekilde belirlenmesi en önemli alt KBF olarak belirlenmiştir. Bu çalışmada yer alan teorik ve çok kriterli analizin neticesinde sunulan pratik bilgilerin, süreç yönetimi çalışmalarını başarılı bir biçimde yürütmek isteyen işletmeler ve profesyoneller için bir rehber niteliğinde olacağı öngörülmektedir.

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1. Introduction

In its most general definition, process management can be expressed as a set of methods that examines all stages of service and product production activities and incorporates a set of activity/technical/analysis methods that can be applied to make these activities effective (Rezaiea, Ostadib, Tadayoun and Aghdasi, 2009). Process management studies can be examined under two main headings as method study and work measurement. With the method study, unnecessary work elements are eliminated during the execution of duties, and the easiest and fastest way to make the necessary work elements is tried to be found (Kurt and Dağdeviren, 2003). With the method study, it is aimed to establish standard work steps to be followed by all employees. In fact, obtaining a standardized process can also be expressed as one of the outputs of the method study. Studies that allow statistical analyzes to be made with a number of time measurements on standardized work steps and specially to ensure that productivity in production can be measured and traced are called work measurement studies (Dağdeviren, Eraslan and Çelebi, 2011). A basic classification for work measurement studies can be made as follows: a) Indirect work measurement techniques (Predetermined motion time systems), b) Direct work measurement techniques (Time study, Work sampling) (Adem, Kaya, Çakıt and Dağdeviren, 2022a). Therefore, process management studies include different type of methods, and they are ways of analyzing, improving, and controlling processes (Zavareh, 2021).

Process management studies are critical studies that have the capacity to examine all processes in companies and directly contribute to the efficiency of companies. Process management studies have a structure that should be carefully examined from beginning to end, and each step to be followed have a relationship with each other. Two resources that are important for any kind of companies are money and time. Process management studies contribute to companies primarily in terms of these two resources, and then in various aspects such as ergonomics and human resources. Hence, carrying out a process management study successfully plays an important role in gaining these contributions. There are multiple factors that need to be taken into account for the successful execution of process management studies, which are at a critical point in ensuring that the efficiency of all processes in production environments can be measured and monitored (Rezaiea et al, 2009; Zavareh, 2021). These factors can also be called Critical Success Factor (CSFs) affecting process management studies. Knowing the effect of each of the CSFs on the overall success of the process management is important in terms of managing the process in an effective way.

This study investigates the critical success factors that will increase the effect of process management studies that can be applied in both product-producing and service-producing systems. İt includes two main steps: a) determining the CSFs of the process management and express them in a hierarchy, b) analyzing them by utilizing one of the fuzzy decision-making techniques. In this analysis spherical fuzzy numbers which focuses on the hesitancy degree of decision-makers (Kutlu Gündoğdu and Kahraman, 2020) was employed. Due to the structure of the decision problem, ie. ranking the CSFs of process management studies, the Analytical Hierarchy Process technique was utilized to gain the relative weights of the determined CSFs and their sub-factors. As seen in the literature survey which is given in Section 3 both for the utilized method and the CSFs details, there is no such study in the literature. This paper is the first study in the related literature in terms of both utilized technique and handled research area.

To accomplish these steps, this paper is structured as follows: Section 2 presents the basic elements and their CSFs of process management studies. Section 3 gives the utilized fuzzy MCDM technique. Section 4 analyzes the determined CFS of process management studies. Section 5 gives the results of this analysis and discuss the gained results with comparing the existing literature. Section 6 presents the conclusion remarks about the paper.

2. Process Management and Determining Critical Success Factors

Process management which has a wide impact area enables the operation of a number of crucial functions such as measuring, monitoring, and improving of the productivity in companies. Process management includes the work measurement and motion study (Adem et al, 2022a; Kurt and Dağdeviren, 2003). In motion study, a number of studies are carried out to standardize the whole production or service process. Existing problems are identified by analyzing the process with recording, analysis and research techniques. Detected problems are tried to be eliminated with motion study techniques. In motion studies, it is aimed to carry out the process by following the same path and following the same steps by all employees. The most economical way of conducting duties is tried to be determined. To do this, activities that do not directly contribute to the process must be eliminated. This requirement is also the cornerstone of lean manufacturing (Alhuraish, Robledo, and Kobi, 2017). Thus, it can be mentioned that there is a direct relationship between motion study and lean manufacturing.

In this study, 4 main and 17 sub-CFS were determined. The main CSFs are Human-related factors, sustainability factors, technical factors, and administrative factors, respectively. The factors were determined by addressing a classical process management study and no sectoral distinction was conducted. Obviously, there is no need to make any sector distinctions because the criteria and sub-criteria determined here are determined to include all sectors.

The specified criteria and their sub-criteria had a hierarchy and they were shown in Figure 1. The explanation of these CSFs were provided as follows:

Human Factors:

- **Relationship between workers and team**

It is important that the blue-collar employee and the foreman present the correct information for the process management team. Even if the measured work is the duty done directly by the blue-collar personnel, the team should not contact the blue-collar personnel directly.

This communication must be provided through the foreman. Thus, the foreman will not doubt his position among the employees in terms of his prestige, and he will both adopt his technical knowledge and process management studies and will share more (Kurt and Dağdeviren, 2003).

- **Team Selection**

The selection of the personnel to take part in the activities to be carried out for process management is a critical factor that triggers success in process management (Zavareh, 2021). It is important that the team that will manage and continue the work on process management includes experts who have the technical knowledge and who have worked in the department, in order to complete the process successfully (Kurt and Dağdeviren 2003).

- **Relationship between workers and managers**

The transparency of the management's relationship with the workers and the reassuring approach of the management cause the employees to approach the applications to be made by the management positively. In process management studies, some activities are directly related to the way of conducting the duties of employees. Thus, taking measurements on the basis of time during the working may cause the employees to manipulate the process by making the work faster or slower. However, if there is effective communication between management and employees, the employee believes that the work is carried out with the aim of improving the process, not for evaluating her/his performance, by trusting the activities on process management. Thus, s/he does not manipulate the process during measurement and everything is conducted as it should and process management studies can be successful (Kurt and Dağdeviren, 2003).

- **Training Activities**

The fact that both the employees who will participate in the process management, the team, and the top management receive basic training that includes what they expect from the process management studies and what the main purpose of the work is, triggers success in process management (Rezaiea et al, 2009; Balzarova, Bamber, McCambridge and Sharp, 2004).

- **The demographic structure of employees**

The educational and economic status of workers and their families may affect the employee's perspective on process management studies. Thus, the demographic structure of employees is one of the CSFs in process management.

Sustainability Factors

- **Documentation style**

That the utilized techniques in process management studies and the obtained results are documented regularly and standardization is achieved during this process, allows comparing the results of the process management studies to be carried out in the following periods with the results of the current studies. These comparisons trigger success by making a positive contribution to the sustainability of the whole process.

- **Standardization in application style**

Each process management study may have a unique set of characteristics within itself. However, it is important to obtain a flow related to the way to be followed in a process management study on the basis of the company's own characteristics, in short, to standardize the implementation steps in order to achieve holistic success.

- **Sustainability of PM application**

It is a necessity for the process to be sustainable so that the information obtained as a result of process management studies can be compared at a later time. A short-term success can be achieved if the process management work is conducted only once. However, the sustainability of the process is closely related to the repetition of studies in certain periods. In this case, a retrospective comparison can be conduct both for the company and in terms of process management studies. Continuous improvement also depends on the sustainability of process management studies, which this situation can be expressed as one of the CSFs (Ittner and Larcher,1997).

Technical factors

- **Methodology selection**

In process management studies, there are multiple and different techniques that can be utilized when analyzing the process, calculating the standard time, or exploring the problem in the process. Employing the most suitable techniques according to the structure of the companies and the handled process directly affects the success of the process.

- **Duration of PM application**

In order to conduct a successful process management study, this study should cover a certain period of time. However, there may be some kind of problems in reaching the main objectives of the study by experiencing a focus shift problem in process management studies that take too long time. On the other hand, if the determined time to conduct a process management study is too short, some problems may be experienced in reaching the solution of the problems throughout the companies. Hence, it may be possible to get one step closer to success in PM studies with an ideal work schedule and time.

- **Department and task selection**

A department and task selection are absolutely necessary, as process management studies cannot start at the same time in the entire company. In addition, there are a number of criteria (like economic dimension of the duty, the technical knowledge required by the duty and so on) that should be considered when choosing the department or task where process management studies will be carried out (Kurt and Dağdeviren, 2003). If the task or department that the process management studies will apply are selected in accordance with these selection criteria, there is a potential to positively affect the success of the process management studies.

- **Overall ergonomic status of companies**

In fact, one of the desired results in process management studies is to provide a better working environment in terms of occupational health and safety for employees. However, if the general ergonomic status of the company is serious, this can be expressed as a success criterion as it will affect in a negative direction the motivational status of both the process management team and the employees.

- **Industrialization level of companies**

As the industrialization level of enterprises / the level of approach to Industry 4.0 increases, it can be seen as an obstacle to the successful implementation of classical process management studies. However, at this point, it may be possible to carry out a successful PM work by making utilize of digitalized process management studies (Adem et al, 2022a).

Administrative Factors

- **Management structure of companies**

What is meant by the management structure is actually the attributes which can affect the decision mechanism of the management directly, such as the size of the company, whether the management in the company is a family company or not. If process management studies are carried out in a company with an institutionalized management structure, there may be situations such as the management's positive approach to these studies. Moreover, it is known that in companies with a family business structure, the possible bad relations between family members can spread to all processes carried out through management. Thus, the management structure of the enterprise is a critical success factor in process management in terms of rapid decision-making mechanism and standing behind the decisions. Because process management studies are large-scale studies that may even affect the facility layout in long-term business processes that require direct observation.

- **Management approach of companies**

The fact that companies have an innovative management approach is a phenomenon independent of the structure of management. The innovative approach of the company and its structure that does not resist science and changes will contribute to the progress of process management studies and will definitely affect the total success of it (Balzarova et al, 2004).

- **Available Budget**

Process management studies are a chain of activities that cover a long process and include many cost-intensive activities, including changing even production technology. For this reason, the budget level that the enterprise allocates to process management studies is very important (McNeese and Marks, 2001). Freeing the process management team completely in terms of the budget or giving a budget so low that they cannot carry out their operations undermines the successful result in their work.

- **Utilization style of the data obtained from the PM**

One of the mechanisms that triggers the ultimate success of process management studies is how the obtained data is utilized. For example, the calculated standard time information should be utilized as an input to the policy of equal pay for equal work, which is a very valid principle, as well as to lay the groundwork for the determination of deadlines in production. From another point, integrating the standardized work items with process management into other departments with similar processes will allow the success to be spread throughout the entire enterprise.

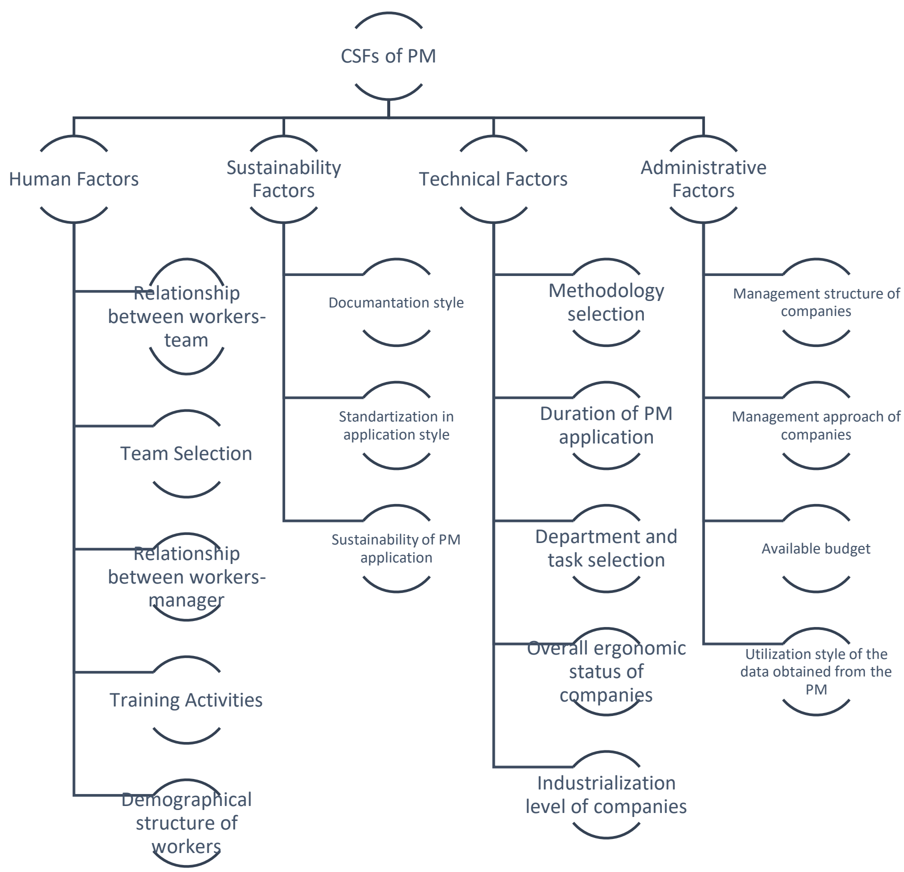

Figure 1. Hierarchical representation of the determined critical success factors of process management

3. Spherical Fuzzy AHP

In this section, the determined main and sub-criteria are analyzed utilizing the spherical fuzzy extension of the AHP method. First, information about spherical numbers is given, then the Sf-AHP technique is explained. The theoretical information given is mostly adapted from the paper of Kutlu Gündoğdu and Kahraman (2019). By combining Pythagorean and Neutrosophic fuzzy sets, Kutlu Gündoğdu and Kahraman (2019) developed and presented the Spherical fuzzy sets (SFSs) sets to the fuzzy logic literature. By focusing on the degrees of hesitation, these sets really help the decision-maker to assess decision-making difficulties from a broad viewpoint (Kutlu Gündoğdu and Kahraman, 2020). SFS has membership, non-membership, and hesitancy degree criteria, much like Pythagorean fuzzy sets (Doğan, 2021). Let E_1 and E_2 be two universes. Let

$\tilde{A}_s$ and $\tilde{B}_s$ of the universe of discourse E_1 and E_2 be as follows:

$\tilde{A}_s = \{x, (\mu_{\tilde{A}_s}(x), v_{\tilde{A}_s}(x), \pi_{\tilde{A}_s}(x)) \mid x \in E_1\}$ where

$\mu_{\tilde{A}_s}(x): \mathrm{E}_1 \to [0,1], v_{\tilde{A}_s}(x): \mathrm{E}_1 \to [0,1], \pi_{\tilde{A}_s}(x): \mathrm{E}_1 \to [0,1]$ and

$$0 \le \mu^2_{\tilde{A}_s}(x) + v^2_{\tilde{A}_s}(x) + \pi^2_{\tilde{A}_s}(x) \le 1 \qquad \forall x \in E_1$$

While, for each x, $\mu_{\tilde{A}_s}(x)$, $v_{\tilde{A}_s}(x)$ and $\pi_{\tilde{A}_s}(x)$ represent the non-membership function, the membership function and the hesitancy degree, respectively.

Similarly, $\tilde{B}_s = \{y, (\mu_{\tilde{A}_s}(y), v_{\tilde{A}_s}(y), \pi_{\tilde{A}_s}(y)) \mid y \in E_2\}$

where $\mu_{\tilde{B}_s}(y): \mathrm{E}_2 \to [0,1], v_{\tilde{B}_s}(y): \mathrm{E}_2 \to [0,1], \pi_{\tilde{B}_s}(y): \mathrm{E}_2 \to [0,1]$ and

$$0 \le \mu^2_{\tilde{B}_s}(y) + v^2_{\tilde{B}_s}(y) + \pi^2_{\tilde{B}_s}(y) \le 1 \qquad \forall y \in E_2$$

For each y, $\mu_{\tilde{B}_s}(y)$ $v_{\tilde{B}_s}(y)$, $\pi_{\tilde{B}_s}(y)$

represent the non-membership function, the membership function and the hesitancy degree, respectively (Kutlu Gündoğdu and Kahraman, 2020). The basic arithmetical operations of the SFS were shown as follows (Kutlu Gündoğdu and Kahraman, 2019).

Eq. (1) shows the summation of two SFSs:

$$\tilde{A}_s \oplus \tilde{B}_s = \{(\mu^2_{\tilde{A}_s} + \mu^2_{\tilde{B}_s} - \mu^2_{\tilde{A}_s}\mu^2_{\tilde{B}_s})^{1/2}, v_{\tilde{A}_s}v_{\tilde{B}_s}, ((1-\mu^2_{\tilde{B}_s})\pi^2_{\tilde{A}_s} + (1-\mu^2_{\tilde{A}_s})\pi^2_{\tilde{B}_s} - \pi^2_{\tilde{A}_s}\pi^2_{\tilde{B}_s})^{1/2}\} \qquad (1)$$

For multiply the two SFSs, Eq. (2) is utilized:

$$\tilde{A}_s \otimes \tilde{B}_s = \{\mu_{\tilde{A}_s}\mu_{\tilde{B}_s}, (v^2_{\tilde{A}_s} + v^2_{\tilde{B}_s} - v^2_{\tilde{A}_s}v^2_{\tilde{B}_s})^{1/2}, ((1-v^2_{\tilde{B}_s})\pi^2_{\tilde{A}_s} + (1-v^2_{\tilde{A}_s})\pi^2_{\tilde{B}_s} - \pi^2_{\tilde{A}_s}\pi^2_{\tilde{B}_s})^{1/2}\} \qquad (2)$$

Eq. (3) is employed for multiplication by scalar k $(k>0)$ with a SFS;

$$k * \tilde{A}_s = \{(1-(1-\mu^2_{\tilde{A}_s})^k)^{1/2}, v^k_{\tilde{A}_s}, ((1-\mu^2_{\tilde{A}_s})^k - (1-\mu^2_{\tilde{A}_s} - \pi^2_{\tilde{A}_s})^k)^{1/2}\} \qquad (3)$$

On the other hand, the Analytical Hierarchy Process method is utilized quite frequently in the MCDM literature and is based on pairwise comparison logic. Saaty developed the AHP technique with the 1-9 scale (Saaty,1980). Over time, the AHP technique has been used by integrating the number sets developed within the framework of fuzzy logic (Şenol, Adem and Dağdeviren, 2019). Spherical fuzzy sets are one of these sets. The steps of the utilized SF-AHP method are explained as follows: First of all, the elements of decision making problem (i.e. alternatives, criteria, sub-criteria) are determined. After that, by utilizing the provided scale in Table 1, experts or expert group are asked to evaluate the criteria, sub-criteria, and alternatives.

Table 1
Linguistic scale for pairwise comparisons

Linguistic Expressions	μ, v, π	Score Index (SI)
Absolutely more importance (AMI)	(0.90,1.0,0.0)	9
Very high importance(VHI)	(0.8,0.2,0.1)	7
High importance (HI)	(0.7,0.3,0.2)	5
Slightly more importance(SMI)	(0.6,0.4,0.3)	3
Equally importance(EI)	(0.5,0.4,0.4)	1
Slightly low importance (SLI)	(0.4,0.6,0.3)	1/3
Low importance(LI)	(0.3,0.7,0.2)	1/5
Very low importance (VLI)	(0.2,0.8,0.1)	1/7
Absolutely low importance (ALI)	(0.1,0.9,0.0)	1/9

In the traditional AHP technique, the consistency check is an important step, before calculating the weights of the criteria. In the spherical fuzzy extension of the AHP technique, the classical consistency check steps are applied for calculating consistency ratio of decision matrix. To calculate the Consistency Ratio (CR) of decision matrices, the linguistic expressions of SF sets, are need to be convert into the score index.

To calculate the score index of "AMI", "VHI", "HI", and "SMI" Equation (4) is utilized.

$$SI = \sqrt{\left| 100 * \left[(\mu_{\tilde{A}_s} - \pi_{\tilde{A}_s})^2 - (v_{\tilde{A}_s} - \pi_{\tilde{A}_s})^2 \right] \right|} \quad (4)$$

To calculate the score index of "ALI", "VLI", "LI", and "SLI" Equation (5) is employed.

$$\frac{1}{SI} = \frac{1}{\sqrt{\left| 100 * \left[(\mu_{\tilde{A}_s} - \pi_{\tilde{A}_s})^2 - (v_{\tilde{A}_s} - \pi_{\tilde{A}_s})^2 \right] \right|}} \quad (5)$$

The classical consistency calculation stages are applied after calculating the score index of each element in the pairwise comparison matrices. As with the original AHP technique, the permissible consistency ratio limit is 10 % (Dağdeviren, Yavuz and Kılınç, 2009). If the calculated consistency ratios are within acceptable limits, the next step can be taken. Otherwise, decision matrices need to be resubmitted to experts and updated. After checking the consistency ratios of decision matrices, the fuzzy weights of criteria are computed using the Spherical Weighted Arithmetic Mean (SWAM). (Eq. 6):

$$SWAM_w(A_{S1},....,A_{Sn}) = w_1 A_{S1} + w_2 A_{S2} + ... + w_n A_{Sn}$$
$$= \left\langle \left[1-\prod_{i=1}^{n}(1-\mu_{\tilde{A}_{si}}^2)^{w_i}\right]^{1/2}, \prod_{i=1}^{n} v_{\tilde{A}_{si}}^{w_i}, \left[\prod_{i=1}^{n}(1-\mu_{\tilde{A}_{si}}^2)^{w_i} - \prod_{i=1}^{n}(1-\mu_{\tilde{A}_{si}}^2 - \pi_{\tilde{A}_{si}}^2)^{w_i}\right]^{1/2} \right\rangle \quad (6)$$

Where w=1/n.

Because the weights of the criteria are in fuzzy forms, they must be defuzzified with the help of Equation (7).

$$S(\tilde{w}_j^s) = \sqrt{\left| 100 * \left[(3\mu_{\tilde{A}_s} - \frac{\pi_{\tilde{A}_s}}{2})^2 - (\frac{v_{\tilde{A}_s}}{2} - \pi_{\tilde{A}_s})^2 \right] \right|} \quad (7)$$

Using Equation (8), the calculated crisp weights are normalized to rank the final weights of the criteria.

$$\tilde{w}_j^s = \frac{S(\tilde{w}_j^s)}{\sum_{j=1}^{n} S(\tilde{w}_j^s)} \quad (8)$$

SF sets, while being a recently formed set, have swiftly established themselves in the literature and have been included in a variety of multi-criteria decision-making (MCDM) approaches. Table 2 shows the summary of the spherical fuzzy AHP literature.

Table 2
Summary of the spherical fuzzy AHP literature

Author and year	Applied area / MCDM problem
Adem, Çakıt and Dağdeviren, (2022b)	Distance learning system assessment
Onar and Ibil, (2021)	Personalized medical
Buran and Erçek, (2022)	Public transportation business model assessment
Demir and Turan, (2021)	Covid-19 crises management
Singer and Özşahin, (2021)	Laminate flooring selection
Jaller and Otay, (2020)	Evaluating sustainable vehicle technologies
Unal and Temur, (2020)	Sustainable supplier selection
Ashraf and Abdullah, (2020)	Emergency decision support modeling for Covid-19
Oztaysi, Onar and Kahraman, (2020)	Dynamic pricing model for location-based advertisements
Kutlu Gündogdu and Kahraman (2019)	Industrial robot selection
Doğan, (2021)	Process mining technology selection
Kieu, Nguyen, Nguyen and Ho, (2021)	Distribution center location selection
Mathew Chakrabortty and Ryan, (2020)	Advanced manufacturing system selection
Ayyıldız and Gumus, (2020)	Petrol station location selection
Kutlu Gündogdu and Kahraman (2020)	Renewable energy location selection

Moreover, because the classical type and the other fuzzy extensions of the AHP approach is one of the most widely used MCDM techniques, it has been employed to solve almost all types of multi-criteria decision problems (Adem, Çakıt and Dağdeviren, 2021; Yücesan and Gül, 2020; Gül 2020; Oktal and Onrat, 2020; Çolak, Adem and Dağdeviren, 2019; Adem, Çolak and Dağdeviren, 2018; Dağdeviren et al, 2009).

Table 3
Summary of the papers ranking CSFs by utilizing MCDM techniques

Author And Year	Main Topic	Utilized MCDM Technique
Mathiyazhagan, Gnanavelbabu and Agarwal, (2021)	CSFs of lean manufacturing	COPRAS and BWM
Naveed, Islam, Qureshi, Aseere, Rasheed, and Fatima, (2021)	CSFs of cloud enterprise recourse planning	Fuzzy AHP
Dehdasht, Ferwati, Zin, and Abidin (2020)	key drivers of lean construction implementation	Using Entropy And TOPSİS
Sumrit (2019)	CSFs of vendor managed inventory in healthcare industries	Fuzzy Delphi and Grey DEMATEL
Jusoh, Mardani, Omar, Štreimikienė, Khalifah, and Sharifara (2018)	Analyzing The CSFs of TQM in hospitality	Fuzzy AHP
Belhadi, Touriki, and Elfezazi, (2019)	CSFs of lean manufacturing	AHP
Sadeghi (2018)	CSFs of high-tech SMEs	Fuzzy ANP And Fuzzy TOPSIS
Han and Dang (2018)	CSFs of high-risk emergency systems	DEMATEL
Sun, (2015)	CSFs in electronic design automation	DEMATEL
Nilashi, Zakaria, Ibrahim, Majid, Zin, and Farahmand (2015)	CSFs on construction projects	DEMATEL and ANP
Fu, Chang, Kao, Chiu, and Luet (2015)	CSFs of the performance training course project	VIKOR and Fuzzy AHP
Çelik, Gumuş and Alegoz (2014)	The CSFs of humanitarian relief logistic management	Fuzzy AHP
Yeh, Pai, and Liao, (2014)	CSFs in new product development	Fuzzy AHP
Rezazadeh, Najafi, Hatami-Shirkouhi and Miri-Nargesi (2012)	CSFs of TQM applications	Fuzzy AHP

Table 3 shows the summary of the papers ranking or analyzing the CSFs of different research area by utilizing MCDM techniques. As seen in Table 2 and Table 3, as far as we know, there is no published paper in the literature that analyzes the CSFs of process management studies by utilizing the Spherical fuzzy extension of the AHP technique. This study aimed to fill this gap in the literature. The study differs from other studies in the literature both with the method it utilizes and the CSFs it deals with.

In this study, research and publication ethics were followed.

4. Prioritization calculations

In this part of the paper, the determined CSFs were prioritized by utilizing the Spherical Fuzzy AHP. All decision matrices are the compromised matrices by the decision-making group. Moreover, all matrices' consistency ratios were checked, and no matrix was detected as non-consistent.

By applying the formulas between Eq. (4)- Eq. (8) to all decision matrices, the weights of the CSFs and their sub-CSFs presented in Fig. 1 were calculated.

Table 4
Decision matrix, spherical fuzzy weights and crisp weights for main CSFs

Main	C1	C2	C3	C4	Spherical Fuzzy Weights	Crisp Weights
C1	EI	VHI	HI	HI	(0.70,0.29,0.23)	0.348
C2	VLI	EI	SLI	SLI	(0.39,0.58,0.31)	0.182
C3	LI	SMI	EI	SMI	(0.52,0.46,0.32)	0.248
C4	LI	SMI	SLI	EI	(0.47,0.51,0.32)	0.221

CR=0.087

Table 4 shows the decision matrix, spherical fuzzy weights and crisp weights for main CSFs. In order to check the CR of this matrix, first of all, Eq. (4) and Eq. (5) were applied to calculate the Score Index of the elements of decision matrix. After that, the consistency ratio of this matrix was calculated by following the traditional consistency ratio computing steps, and the matrix was determined as consistent. After checking the CR of decision matrix, SWAM operator (Eq. (6)) was utilized to find the spherical fuzzy weights. Finally, Eq. (7) and Eq. (8) were employed for finding the crisp weights of main CSFs. The crisp weights of the main CSFs and their sub-factors which were shown in the decision hierarchy in Fig.1 were calculated by repeating the same steps. The decision matrices of the sub-factors are shown in Appendix 1.

Table 5
Local and global weights of sub-criteria

Main CSFs	Sub-CSFs	Local weights of Sub-criteria	Global weights of Sub-criteria
Human Factors (0.348)			
	Relationship between worker-team	0.235	0.082
	Team selection	0.251	0.088
	Relationship between worker-manager	0.209	0.073
	Training activities	0.172	0.060
	Demographical structure of workers	0.133	0.046
Sustainability Factors(0.182)			
	Documentation style	0.331	0.060
	Standardization in application style	0.261	0.047
	Sustainability of PM application	0.409	0.074
Technical Factors(0.248)			
	Methodology selection	0.201	0.050
	Duration of PM application	0.217	0.054
	Department and task selection	0.244	0.061
	Overall ergonomic status of companies	0.183	0.045
	Industrialization level of companies	0.156	0.039
Administrative Factors (0.221)			
	Management structure of companies	0.264	0.058
	Management approach of companies	0.367	0.081
	Available budget	0.204	0.045
	Utilization style of the obtained data	0.165	0.036

After calculating the local weights of the sub-CSFs, the weights of the main CSFs and the local weights of the sub-CSFs are multiplied to obtain the global weights of the sub-criteria. Table 5 shows the calculated local and global weights of Sub-CSFs.

5. Results and Discussion

It is the first obtained result that the most critical success factors in process management studies, which engineers frequently employ to control and increase the efficiency of all types of processes and systems, are the human-related factors (see Fig. 2). Essentially, human factors and technical factors including the sub-factors to be considered during the application of the method were calculated as the first two most critical success factors.

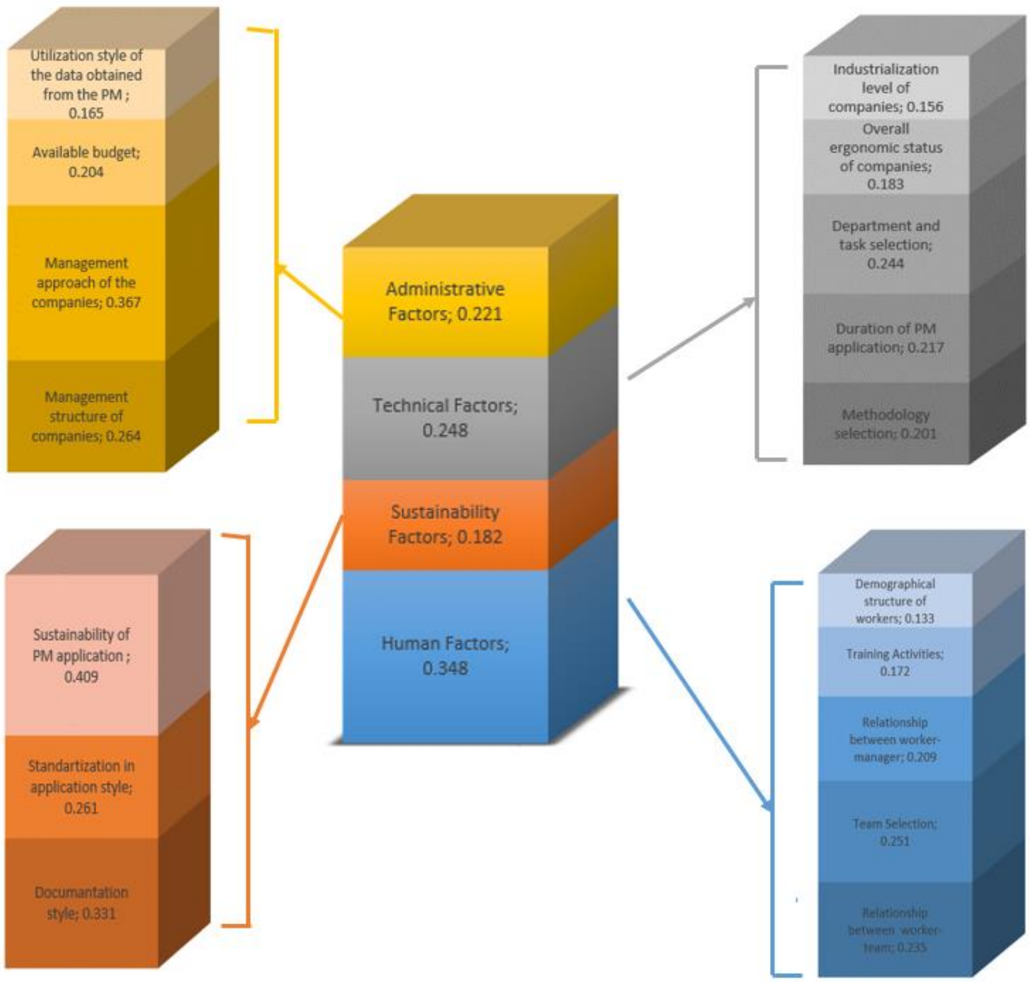

Figure 2. The weights of main CSFs and the local weights of sub-CSFs

In other words, it would not be wrong to say that when these two factors are applied successfully, the majority of the process can be continued successfully. On the other hand, it is clear that the ultimate goal cannot be achieved unless the success of the whole process is achieved in process management studies. Obviously, administrative factors and the sustainability-related factors of the process must also be taken into account for holistic success of process management studies.

According to the local weights of sub-CSFs, in human-factors related CSFs, the most critical one is determined as team selection. In this group, the least critical Sub-CSF is the demographical structure of workers. In the second CSF, i.e. sustainability factors, sustainability of PM applications is determined as the most critical sub-CSF. Department and task selection, and management approach of companies are the most important sub-CSFs in their main CSFs groups technical and administrative factors, respectively.

Figure 3 shows the treemap representation of the global weights of sub-CSFs. In Figure 3, the size of the fields is proportional to the weights of the sub-CSFs. That is, the larger the area, the greater the weight of the sub-CSFs. When the results related to the sub-factors are evaluated, it is seen that the selection of the team that implements the process management studies is in the first order. Frankly, it is not surprising that the factor related to the team selection is determined as the most effective sub-factor in the successful continuation of the process management studies, because the team that implements it in process management studies plays an active role from the beginning to the end of the process (Rezaiea et al, 2009). Moreover, the relationship between the employees and the process management team, which is also one of the human factors, was determined as the second most critical sub-factor. The third most critical sub-factor is the management approach of companies which is one of the administrative factors.

Figure 3. Treemap representation of the global weights of Sub-CSFs

Even if the techniques that are chosen correctly from the beginning to the end of the process are applied with a good team, it is highly likely that the success of the process management studies that are not supported by the top management will be adversely affected (Juran, and Godfery, 2000) From another point of view, it is seen that the three critical success factors that contribute the least to the process are the use of the obtained data, the level of industrialization of the companies, and the level of the allocated budget.

When the results of the study are evaluated from a broader framework, it can be concluded that human relations constitute a very critical turning point in the processes involving human beings. It is noteworthy that the concept of Industry 4.0 is integrated into our daily lives and businesses, and the increase in the use of Industry 4.0 and its practical benefits will reduce the need for manpower in production. Obviously, the effect of change that comes with Industry 4.0 should also be taken into account in process management studies. Ignoring this effect would be unrealistic (Adem et al, 2022a).

6. Conclusion

It can be said that the concepts of productivity measurement and leanness in production are in a two-way interaction with each other. In fact, finding the most economical way to produce, eliminating activities that do not directly contribute to production, determining the standard time of production, and making this process sustainable are the basic steps followed in process management studies (Kurt and Dağdeviren, 2003). Efficiency measurements are conducted to determine whether these activities affect productivity. Depending on the results of the efficiency measurements, it may be necessary to continue the process management work again. This process, which has the potential to directly affect the profitability of companies and is so critical for companies, must be carried out successfully. Determining the success factors that affect the successful execution of this process and revealing which factor contributes to this success and how much be a guide for companies that will carry out process management studies. Considering the importance weights of the CSFs calculated in this study, it can shed light on the process management studies to be carried out regardless of the sector.

Utilizing analytical calculation methods to calculate these relative contribution values allows for a more comprehensive and unbiased evaluation. Within the scope of this study, multi-criteria decision making techniques were utilized to prioritize the critical factors that need to be considered in order to successfully continue a process management study. Since the determined critical factors have sub-factors and this situation can be expressed with a hierarchy, the AHP technique, one of the MCDM techniques, was employed.

The spherical fuzzy extension of this method was employed, which allows decision makers to focus on the hesitancy situation and provide solutions. By obtaining the weights for the determined critical success factors and their sub-factors, it is aimed to determine the factors to be considered in order of importance in order to achieve success in the process management studies that every companies must implement in order to increase the process efficiency. The results showed that human-related factors were the most critical factors.

Obviously, this study also has some limitations. The first of these constraints is that the specified criteria were determined by consulting experts through literature research and brainstorming techniques. Another limitation is to make calculations over compromised decision matrices. In future studies, group decision can be applied or the results obtained by performing the same analysis with different MCDM techniques can be compared. The CSFs given in this study were developed to be used by companies from all sectors. However, in future studies, specific sector-based studies can be conducted in determining the CSFs.

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Appendix 1: Decision matrices spherical fuzzy weights and crisp weights of sub-CSFS,

C1	C11	C12	C13	C14	C15	Spherical Fuzzy Weights	Crisp Weights
C11	EI	SMI	SMI	SMI	HI	(0.61,0.38,0.30)	0.235
C12	SLI	EI	SMI	HI	VHI	(0.64,0.36,0.26)	0.251
C13	SLI	SLI	EI	SMI	HI	(0.54,0.44,0.30)	0.209
C14	SLI	LI	SLI	EI	SMI	(0.46,0.53,0.31)	0.172
C15	LI	VLI	LI	SLI	EI	(0.36,0.62,0.27)	0.133

CR=0.097

C2	C21	C22	C23	Spherical Fuzzy Weights	Crisp Weights
C21	EI	SMI	SLI	(0.51,0.46,0.34)	0.331
C22	SLI	EI	LI	(0.41,0.55,0.32)	0.261
C23	SMI	HI	EI	(0.61,0.36,0.30)	0.409

CR=0.033

C3	C31	C32	C33	C34	C35	Spherical Fuzzy Weights	Crisp Weights
C31	EI	SLI	SLI	SMI	SMI	(0.51,0.47,0.32)	0.201
C32	SMI	EI	SLI	SMI	SMI	(0.55,0.43,0.32)	0.217
C33	SMI	SMI	EI	SMI	HI	(0.61,0.38,0.30)	0.244
C34	SLI	SLI	SLI	EI	SMI	(0.47,0.51,0.33)	0,183
C35	SLI	SLI	LI	SLI	EI	(0.41,0.57,0.31)	0.156

CR=0.089

C4	C41	C42	C43	C44	Spherical Fuzzy Weights	Crisp Weights
C41	EI	SLI	SMI	HI	(0.57,0.41,0.30)	0,264
C42	SMI	EI	AMI	VHI	(0.76,0.24,0.21)	0,367
C43	SLI	ALI	EI	SMI	(0.45,0.54,0.31)	0,204
C44	LI	VLI	SLI	EI	(0.37,0.61,0.29)	0,165

CR=0.067