



Evaluation of ERP software selection criteria with fuzzy AHP approach: an application in the metal production enterprises in the aviation industry

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Abstract Using enterprise resource planning provides benefits and added value regarding enterprise processes' efficiency, integration, and effectiveness. However, while selecting the ERP software, parameters in various categories, such as the enterprise's requests, the services of the consultant firm, and the employee's participation, should be considered. When determining between options, the parameters taken into consideration may differ from one another or be imprecise. This study aims to ascertain the criteria that Small and Medium-Sized Enterprises (SMEs) that intend to invest in ERP software should pay attention to when selecting ERP software. The ERP usage process of the enterprise, the success of ERP within the company, the ERP installation process, the ERP company's support service, and the focus on the parameters of meeting the expectations from the ERP system were made. The obtained information was evaluated with the fuzzy AHP technique. It was decided that the most significant criterion that the enterprise should pay attention to in the selection of ERP is the success of ERP within the company and meeting the expectations of the ERP system, and a suggestion was presented in this direction.

Keywords Multi-criteria decision making · Enterprise resource planning · ERP selection · Analytical hierarchy process · Fuzzy AHP · Decision making

1 Introduction

In the process of evolving from the industrial age to the information age, the importance of knowledge has increased in the globalization and competition environment. Enterprises that intend to maintain their existence and increase their market share in an increasingly competitive environment need faster and more information to make effective decisions about their business processes. Enterprises that reach information quickly and accurately and use it effectively will ensure continuity in the competitive environment by providing high efficiency and profit (Dağci and Ersöz 2018). While enterprises reach information quickly using information technologies, they also use information accurately and effectively with an integrated information management system.

In our current information age, information technologies have become indispensable for enterprises and are constantly evolving. Enterprise Resource Planning (ERP) software is one of the essential information technologies that has emerged in recent years and is widespread worldwide. Enterprise Resource Planning, which has gained importance in the market with the development of the technology and software industry, is a package program that benefits enterprises to plan their resources accurately. Nowadays, many enterprises use ERP software to manage their resources accurately.

ERP software is an advanced software package that enables integrated management of all business processes, from raw material supply to the presentation of the final product to the customer, under enterprises' strategic objectives. ERP software assures enterprises the opportunity to save time and financial benefits by facilitating their business processes. Thus, it contributes to the continuity of the enterprises in the competitive environment. One of the significant advantages

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that enterprises get with ERP software is the contribution to the quality management system.

ERP software, which is more common in large-scale enterprises, is also drawing interest to SME enterprises today to ensure competitiveness by providing accurate and fast information to the decision-maker, thus increasing efficiency. ERP software has a cost to bear to be accessible, and it takes time to integrate it into the operating system correctly. For this reason, when choosing ERP software, businesses should analyze their corporate structure, employee opinion, quality targets and existing work processes well. As there is a prominent ERP software market, it is one of the vital decisions enterprises make to choose ERP software to save time and money (Cruz-Cunha et al. 2021). Choosing the right ERP software package starts with determining and prioritizing the ERP selection criteria. The criteria to be considered when choosing ERP software directly affect the success of ERP software within the company. Prioritizing the criteria that enterprises need to consider also allows them to make a successful and quick choice.

In today's competitive environment, making the right decision quickly is one of the essential goals for enterprises. Enterprises need to adapt quickly to information and technology, which is constantly changing, and to make effective decisions in direct proportion to the change. Enterprises can make the right decision in this decision process by using multi-criteria decision-making techniques (Ersöz and Kabak 2010).

The evaluation of ERP selection criteria is a multi-criteria decision-making problem in which different qualitative and quantitative methods are systematically evaluated. Multi-criteria decision-making (MCDM) problems are the types of problems that we frequently encounter in our daily lives, and these types of problems aim to prioritize the criteria set by the decision-maker.

Enterprises spend a lot of time and pay large sums of money for ERP software. Therefore, it is critical to choose an ERP software that will meet business needs (Sánchez et al. 2009). The common feature of successful businesses in choosing ERP software is that they know their businesses and employees. When choosing ERP, enterprises should first consider the needs and expectations of their employees. In addition, their structures, corporate goals and strategies should also be evaluated.

From the past to the present, many studies have been conducted on CRM techniques and the criteria that play a role in ERP selection.

A study was conducted to determine the commonly used methods by examining the academic studies carried out with MCDM methods in Turkey's defense industry (Ersöz and Kabak 2010). In 2011, literature research was conducted to inform SME enterprises on selecting ERP software (Haddara and Zach 2011). With the AHP method, which is one of the

MCDM techniques, the ERP software to be used in an electronics company (Wei et al. 2005), in Taiwan, an enterprise (Kahraman et al. 2010), operating in the automotive sector, an enterprise operating in the textile sector, (Cebeci 2009), and industrial establishments (Alizadeh et al. 2016) in Iran have been evaluated. In selecting ERP software, enterprises have shown the AHP method they use, and the phase-by-phase application steps (Czekster et al. 2019; Motaki and Kamach 2017). In 2019, the AHP method was used to determine the factors that play a role in selecting ERP software and the successful application of the process (Alkrajji et al. 2020). While ERP software has been mostly decided for the last three years, the AHP method has been applied in an integrated manner with different methods and a hybrid approach has been presented (Hinduja and Pandey 2019; Pereira and Ferreira 2020; Uddin et al. 2021). The factors affecting ERP software choice were analyzed using the fuzzy AHP method in an SME in India (Bhatt et al. 2021).

This study aims to determine the ERP selection criteria in an SME operating in the aviation sector in line with the expert opinion, to evaluate the determined criteria by the employees using the pairwise comparison matrix and to prioritize them by using the Fuzzy AHP technique and the pairwise comparison questionnaire.

2 Multi-criteria decision-making techniques

Decisions that individuals, enterprises, or organizations will make in situations they encounter in all areas of life are often multiple and mostly have conflicting criteria. Multi-criteria decision-making (MCDM) evaluates at least two alternatives based on at least two conflicting criteria. MCDM is expressed as the selection process performed by the decision-maker among the available alternatives with a minimum of two criteria (Ersöz and Kabak 2010). Multi-criteria decision-making methods are used in many areas of the literature. Some of those include course selection (Ersöz et al. 2011, 2018), building heat loss rating (Ersöz and Atav 2011), supplier selection (Qazvini et al. 2021), automobile selection (Yavaş et al., 2014), logistics problems (Çakmak and Ersöz 2007), personnel selection (Ozgormus et al. 2019). The solution process steps implemented in MCDM problems are given in Table 1 below (Ersöz and Kabak 2010).

In the MCDM process, first, the problem is defined. The selection criteria are determined, the decision alternatives to be decided are identified, the structure of the decision problem is determined, the MCDM method to be used is specified and the optimum alternative within the decision alternatives is determined as a result of the latest MCDM method applied.

Table 1 Process steps of multi-criteria decision problems

Step 1	Problem is defined
Step 2	Selection criteria are determined
Step 3	Decision alternatives are determined
Step 4	The hierarchical structure of the decision problem is determined
Step 5	Method is determined
Step 6	The best alternative is determined

MCDM methods are divided into two categories: “Multi-Objective Decision Making” (MODM) and “Multi-Attribute Decision Making” (MADM), as shown in Fig. 1 (Ersöz and Kabak 2010).

There are frequently used methods such as “TOPSIS, ANP, AHP, PROMETHEE and ELECTRE” in MCDM techniques, nevertheless, AHP is prioritized among MCDM techniques since it has the potential to blend both quantitative and qualitative approaches in evaluating and ranking decision alternatives (Bhatt et al. 2021).

2.1 AHP and fuzzy AHP

The Analytical Hierarchy Method (AHP), developed by Thomas L. Saaty in 1977 and widely used in the literature, is a technique that facilitates the decision-making process in solving MCDM problems (Avikal et al. 2021). The AHP method allows the evaluation of both qualitative and quantitative criteria (Bakır and Atalık, 2021). It digitizes the abstract values of the decision-maker, such as experience, intuition, and knowledge about the problem, incorporates them into the decision-making process, and ascertains the degree of importance by comparing the evaluation criteria pairwise. Accordingly, it allows evaluation between criteria (Şanlı and Ersöz, 2018). AHP aims to make better choices by allowing the evaluation among the alternatives in line with the criteria it has determined, without stereotyping the decision maker (Bhadu et al. 2022; Saaty 2014).

In the AHP method, there are hierarchical objectives, criteria and options. The objective, namely, deciding on the optimum, is transformed into a model hierarchically, and the criteria are evaluated with their comparative superiority. Linguistic, subjective assessments made by the decision-maker are often based on experience and may not be precise. As a result of the evaluations, a clear decision cannot be made often (Bhatt et al. 2021; Zhou et al. 2011). For such cases, the AHP method was developed using fuzzy logic and the Fuzzy AHP (FAHP) method presented (Şişman and Doğan 2016). In FAHP, while comparing the criteria pairwise, linguistic variables and fuzzy scales are used in order to reduce the undesirable effects, where the criteria in Table 2 are not limited (Ayyıldız and Taskin Gumus 2020; Şanlı and Ersöz, 2018).

Before starting the FAHP, the answers given by the decision-makers to the pairwise comparison matrices are calculated by taking the geometric mean of the fuzzy number equivalents, and the fuzzy decision matrix is created, then the FAHP steps are performed.

Step 1 The fuzzy synthetic amplification value is calculated.

Table 2 Linguistic variables and fuzzy number values are used in the pairwise comparison of criteria

Linguistic variables and fuzzy number equivalent		
Linguistic variables	Fuzzy scale	Corresponding fuzzy scale
Equally important	(1,1,1)	(1,1,1)
Moderately important	(1/2, 1, 3/2)	(2/3, 1, 2)
Important	(3/2, 2, 5/2)	(2/5, 1/2, 2/3)
Very important	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)
Extremely important	(7/2, 4, 9/2)	(2/9, 1/4, 2/7)

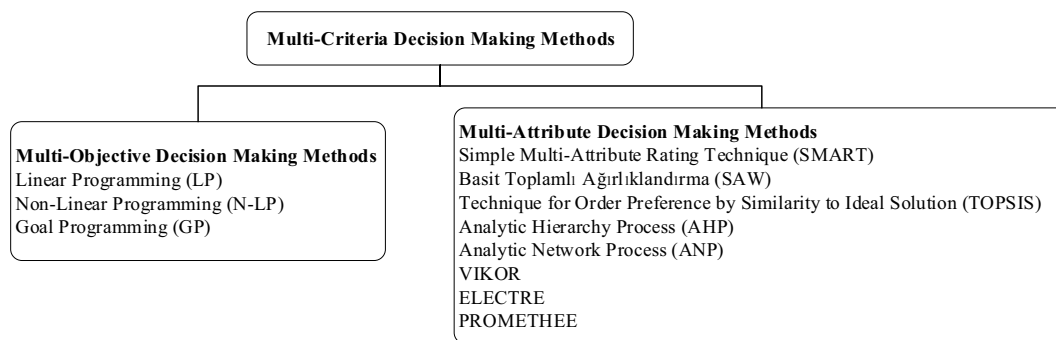


Fig. 1 Classification of MCDM methods

$$s_i = \sum_{j=1}^m M_{gi}^j \left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1}$$

To obtain the value of $\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1}$, the fuzzy sum operation of m extension analysis and vice versa is applied for the pairwise comparison matrix under consideration.

$$\left[\sum_{i=1}^n \sum_{j=1}^m M_{gi}^j \right]^{-1} = \left(\frac{1}{\sum_{i=1}^n m_{3i}}, \frac{1}{\sum_{i=1}^n m_{2i}}, \frac{1}{\sum_{i=1}^n m_{1i}} \right)$$

For the comparison of fuzzy numbers, weight vectors of all elements for each level of the hierarchy are obtained by using fuzzy synthetic values.

Step 2 Obtained fuzzy values are compared and weights are obtained by using these values.

$M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ the two triangular fuzzy numbers and their $M_2 \geq M_1$ probability degrees are as follows:

$$V(M_2 \geq M_1) = \sup_{y \geq x} [\min(\mu_{M_1}(x), \mu_{M_2}(x))]$$

When comparing probabilities,

$$V(M_2 \geq M_1) = \text{hgt}(M_1 \cap M_2) = \mu_{M_2}(d)$$

$$\mu_{M_2}(d) = \begin{cases} 1, & m_2 \geq m_1 \\ 0, & l_1 \geq u_2 \\ \text{etc.}, & \frac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} \end{cases}$$

Step 3 The probability degree to which a convex fuzzy number is greater than k fuzzy number $M_i, (i = 1, 2, 3, \dots, k)$ is like.

$V(M \geq M_1, M_2, \dots, M_k) = \min V[(M \geq M_i)]$. In this case, provided that $i = 1, 2, \dots, n; k \neq i$, it is assumed that; $d(S_1) = \min V[(S_i \geq S_k)]$. The weight vector W' is shown as follows. Here $S_i, (i = 1, 2, \dots, n)$ is n elements. It is found in the equation.

$$W' = (d(S_1), d(S_2), \dots, d(S_n))^T$$

Step 4 The equation finds weight vectors normalized by the normalization of the W value,

$W = (d(S_1), d(S_2), \dots, d(S_n))^T$. (Here, the W value is not a fuzzy number.)

3 Application

Established in 2007 in Ankara, the SME enterprise provides services to leading companies in the defense and aviation industry by machining critical structural parts. The company,

which carries out its manufacturing activities in line with the aviation standard (AS/EN9100:2016) and has an average monthly production capacity of 10,000 parts, provides services to leading companies with a total of 49 employees, including eight white-collar workers, 15 CNC benches, and three CMM benches in an area of 1400 m². This enterprise, which provides services to its customers by machining, also carries out all the stages, from supplying raw materials for the product to be manufactured to the packaging and shipment of the finished product under customer requests.

The enterprise discussed in this study carries out its current business processes in an inactive way by using the accounting package program, Microsoft Excel, and ERP software. Application of the enterprise’s business processes with the current order causes data repetitions and inconsistent information. The enterprise needs easy-to-use and reliable ERP software that can manage all processes in an integrated way to increase its efficiency and profitability. The enterprise currently uses ABAS ERP software developed with 100% German technology. The evaluation criteria to be considered when selecting ERP software were determined by the joint expert opinion of SMEs operating in the same sector. The priorities of the criterion to be considered when making a new ERP investment were prioritized with a survey study. The survey was created using a pairwise comparison matrix. Twenty personnel who have worked in the company for at least five years and are experts in their fields participated in the survey. The data obtained were evaluated according to the “Fuzzy AHP” method. The steps performed in the study are given in Fig. 2 below.

A suggestion was presented to the enterprise in line with the results obtained as a conclusion of the evaluation of the criteria with the fuzzy AHP.

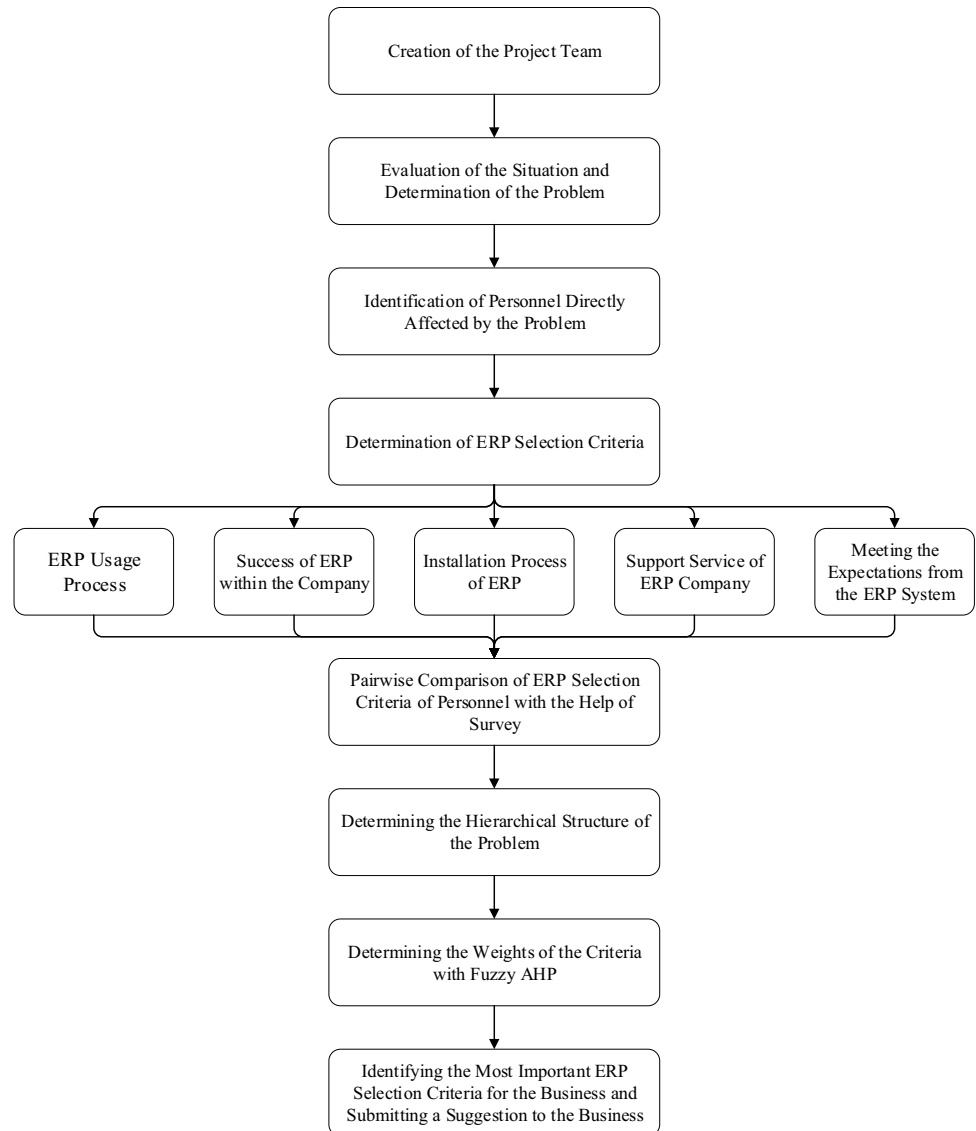
3.1 ERP software evaluation criteria

A company in the aviation industry evaluated the ERP software packages in line with five main criteria and 35 sub-criteria through a survey so that paired comparisons could be made. In Table 3, there are five main criteria, which are the ERP usage process, the success of ERP within the company, the ERP installation process, the ERP company’s support service, and meeting expectations from the ERP system.

ERP installation process criteria comprised testability, performance measurement, usability in different environments, flexibility, reporting ability, the accessibility of the system to development, data import-data transfer capabilities, graphic design capabilities, information confidentiality, and software reliability.

The criteria for the success of ERP within the company consist of ERP consultancy company support, business process restructuring, project management, employee

Fig. 2 Flow chart for evaluation of criteria with Fuzzy AHP



participation and support, software/hardware suitability, and senior management support sub-criteria.

The ERP installation criteria comprise technical support, training program, obeying the deadline, and installation time sub-criteria.

The support service criteria of the ERP company consist of the speed of reaching the right person, the speed of problem-solving, the supporters' communication skills, the supporters' adequacy, the promotion of package updates, continuous improvement, training services, and 7–24 service sub-criteria.

The criteria for meeting the expectations from the ERP system are composed of the adaptation of the workers to the new business processes, the integrated operation of the business units, the increase in customer service quality and satisfaction, the increase in the efficiency of the business, the increase in the performance of the employees,

the increase in the competitiveness of the enterprise, the decrease in the expenses and the increase in the income, and the strengthening of the decision mechanism of the management sub-criteria.

4 Results

In the decision-making process to be carried out with Fuzzy AHP, the criteria are coded as C1, C2, C3, C4, and C5. This criterion and corresponding codes are shown below.

- C1: ERP Usage Process
- C2: Success of ERP within the Company
- C3: Installation Process of ERP
- C4: Support Service of ERP Company
- C5: Meeting the Expectations from the ERP System

Table 3 ERP software evaluation criteria

Criteria code	Main criteria	Sub-criteria	Criteria code
C1	ERP usage process	Testability	C1.1
		Performance measurement	C1.2
		Ability to use in different environments	C1.3
		Flexibility	C1.4
		Reporting ability	C1.5
		The system’s openness to development	C1.6
		Data import-data transfer capabilities	C1.7
		Graphic design capabilities	C1.8
		Ensuring information confidentiality and software reliability	C1.9
C2	Success of ERP within the company	ERP consulting company support	C2.1
		Restructuring business processes	C2.2
		Project management (setup plan, creating a project team)	C2.3
		Employee participation and support	C2.4
		Software/hardware availability	C2.5
		Executive management support	C2.6
C3	Installation process of ERP	Technical support	C3.1
		Educational program	C3.2
		Complying with deadline	C3.3
		Setup time	C3.4
C4	Support service of ERP company	Speed of reaching the right person	C4.1
		Speed of problem solving	C4.2
		Communication skills of supporters	C4.3
		Qualification of supporters	C4.4
		Introducing updates to the package	C4.5
		Ensuring continuous improvement	C4.6
		Education services	C4.7
		7/24 Service	C4.8
C5	Meeting the expectations from the ERP system	Adaptation of personnel to new business processes	C5.1
		Integrated operation of business units	C5.2
		Increasing customer service quality and satisfaction	C5.3
		Increasing the efficiency of the enterprise	C5.4
		Increasing employee performance	C5.5
		Increasing the competitiveness of the enterprise	C5.6
		Decrease in expenses and increase in income	C5.7
		Strengthening the decision mechanism of management	C5.8

Table 4 The main criterion is a fuzzy decision matrix

	C1			C2			C3			C4			C5		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C1	1.000	1.000	1.000	0.505	0.608	0.783	0.830	0.947	1.074	0.662	0.762	0.908	0.461	0.530	0.640
C2	1.276	1.644	1.981	1.000	1.000	1.000	1.903	2.352	2.805	1.316	1.538	1.806	0.893	0.986	1.103
C3	0.931	1.056	1.204	0.357	0.425	0.526	1.000	1.000	1.000	0.728	0.878	1.097	0.422	0.512	0.658
C4	1.101	1.312	1.512	0.554	0.650	0.760	0.911	1.139	1.374	1.000	1.000	1.000	0.503	0.600	0.718
C5	1.561	1.888	2.171	0.906	1.014	1.120	1.519	1.955	2.370	1.393	1.668	1.986	1.000	1.000	1.000

Table 5 Fuzzy synthetic extent value of the main criterion

	Σl	Σm	Σu	$1/\Sigma u$	$1/\Sigma m$	$1/\Sigma l$	S matrix		
							l	m	u
C1	3.457	3.847	4.406	0.032	0.036	0.042	0.109	0.140	0.186
C2	6.388	7.519	8.695	0.032	0.036	0.042	0.202	0.274	0.366
C3	3.437	3.871	4.485	0.032	0.036	0.042	0.109	0.141	0.189
C4	4.070	4.701	5.364	0.032	0.036	0.042	0.129	0.171	0.226
C5	6.380	7.525	8.648	0.032	0.036	0.042	0.202	0.274	0.364
Sum	23.732	27.463	31.597						

Table 6 Main criteria importance weight

	C1	C2	C3	C4	C5	min	w
C1	X	0.000	1.000	0.647	0.000	0.000	0.0000
C2	1.000	X	1.000	1.000	1.000	1.000	0.4569
C3	1.000	0.000	X	0.666	0.000	0.000	0.0000
C4	1.000	0.189	1.000	X	0.190	0.189	0.0862
C5	1.000	1.000	1.000	1.000	X	1.000	0.4569
					Sum	2.189	

The geometric mean of the opinions collected from the decision-makers with the help of a survey was calculated and a pairwise comparison fuzzy decision matrix was obtained as in Table 4.

The fuzzy AHP solution steps were applied sequentially to the pairwise comparison fuzzy decision matrix. First, the formula in “Step 1” was applied. The l, m and u values of the main criteria in each row in the pairwise comparison fuzzy decision matrix were added separately and fuzzy addition calculation was made according to the given operations. As a result of the fuzzy addition process, for each main criterion, “ Σl , Σm and Σu ” values have been obtained. Then, the fuzzy numbers “ Σl , Σm , Σu ” in Table 5 and the inverses of the column sums of these numbers were multiplied and the fuzzy synthetic extent value called S matrix was found.

Secondly, for each criterion whose fuzzy synthetic extent values were calculated, the formulas in Step 2 were applied and checked whether the criteria values were more extensive than each other. Table 6 demonstrates the results of the calculations. The “min” column in the table shows the smallest value of the relevant criterion. While calculating the “W” value, the smallest value of each criterion was obtained by dividing the sum of the “min” values.

As a result of the calculations, the importance weights of the criteria are given in Table 7. In the enterprise that wants to invest in ERP software, as a result of the pairwise comparison survey made to the workers using ERP, it is deduced that 45.69% of ERP’s success in the company, 45.69% of the ERP system’s expectations are met and 8.62% of the support service criteria of the ERP company are met, are important.

As a result of Fuzzy AHP calculations, it was concluded that the ERP usage process and the installation process of

Table 7 Importance weights of ERP selection criteria

Sorting	Criteria	Importance weights
1	C2: Success of ERP within the company	0.4569
2	C5: Meeting the expectations from the ERP system	0.4569
3	C4: Support service of ERP company	0.0862
4	C1: ERP usage process	0.0000
5	C3: Installation process of ERP	0.0000

the ERP did not have any decisive effect on the decision-makers when choosing the ERP software.

The sub-criteria of ERP’s success within the company are coded as C2.1, C2.2, C2.3, C2.4, C2.5, and C2.6.

- C2.1: ERP Consulting Company Support
- C2.2: Restructuring Business Processes
- C2.3: Project Management (Setup plan, Creating a project team)
- C2.4: Employee Participation and Support
- C2.5: Software/Hardware Availability
- C2.6: Executive Management Support

The sub-criteria of the main criterion of “The Success of ERP within the Company”, which is the important criterion, were also evaluated. The pairwise comparison fuzzy decision matrix in Table 8 was obtained.

Fuzzy AHP solution steps were applied sequentially to the pairwise comparison fuzzy decision matrix of all sub-criteria for ERP’s success within the company. First, the

formulas in “Step 1” were applied. The l, m and u values of the main criteria in each row in the pairwise comparison fuzzy decision matrix were added separately and fuzzy addition calculation was made according to the given operations. As a result of the fuzzy addition process, “ Σl , Σm and Σu ” values were obtained for each main criterion. Then, the fuzzy numbers “ Σl , Σm , Σu ” in Table 9 were multiplied with the inverses of the column sums of these numbers, and the fuzzy synthetic extent value called the S matrix was found.

Secondly, for each criterion whose fuzzy synthetic extent values were calculated, the formulas in Step 2 were applied and checked whether the criteria values were more extensive than each other. Table 10 demonstrates the results of the calculations. The “min” column in the table shows the smallest value of the relevant criterion. While calculating the “W” value, the smallest value of each criterion was obtained by dividing the sum of the “min” values.

As a result of the pairwise comparison survey of employees who use ERP in the enterprise that wants to invest in ERP software, it was identified that the most crucial sub-criterion for ERP’s success within the company is employee participation and support. As a result of the calculations, the importance weights of the criteria are given in Fig. 3.

According to Fig. 3, it has been determined that the most significant factor affecting the success of ERP within the company is the top management support with 35.72%. The sub-criterion that most affect the criteria for success of ERP within the company in the second place is participation and support of the employees with 20.44%. Software/hardware availability is in third place with 17.78%. Project management is in fourth place with 10.34%, business processes restructuring is in fifth place with 8.38%, and lastly, sixth place with 7.34% ERP consultancy company support. The sub-criteria are the criteria that affect the success of ERP

Table 8 Pairwise comparison fuzzy decision matrix of the sub-criteria of ERP’s success within the company

	C2.1			C2.2			C2.3			C2.4			C2.5			C2.6		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
C2.1	1.000	1.000	1.000	0.816	0.933	1.121	0.883	1.041	1.269	0.611	0.841	1.157	0.653	0.738	0.852	0.490	0.581	0.675
C2.2	0.892	1.072	1.226	1.000	1.000	1.000	0.783	0.914	1.136	0.620	0.780	0.991	0.718	0.947	1.139	0.443	0.544	0.692
C2.3	0.788	0.960	1.133	0.880	1.094	1.277	1.000	1.000	1.000	0.750	0.933	1.220	0.682	0.853	1.064	0.524	0.600	0.716
C2.4	0.865	1.189	1.637	1.009	1.282	1.613	0.820	1.072	1.334	1.000	1.000	1.000	0.813	1.050	1.307	0.720	0.807	0.947
C2.5	1.089	1.231	1.350	0.878	1.056	1.392	0.940	1.172	1.467	0.781	0.952	1.188	1.000	1.000	1.000	0.739	0.829	0.920
C2.6	1.438	1.677	1.989	1.444	1.839	2.258	1.396	1.668	1.909	1.056	1.238	1.389	1.086	1.206	1.353	1.000	1.000	1.000

As a result of the formulation, the intersections in the matrix must always be 1. It is made in bold color for attention

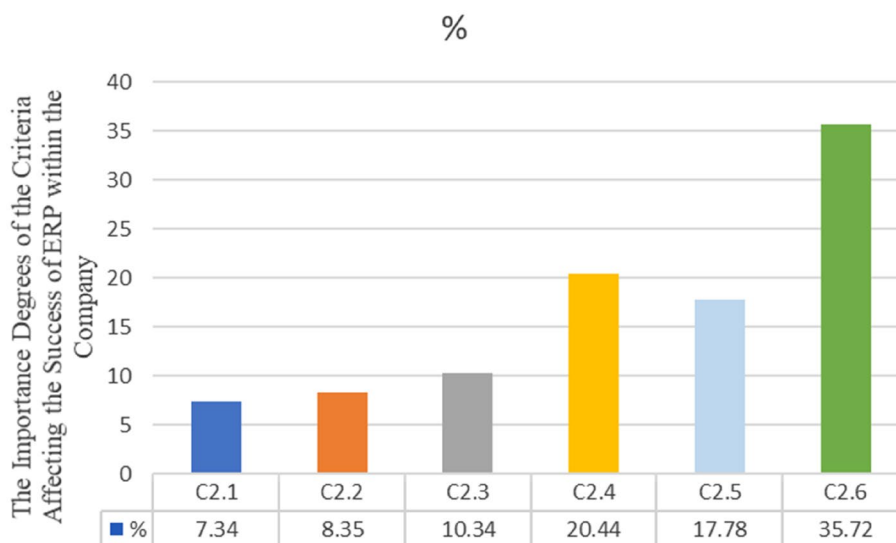
Table 9 Fuzzy synthetic extent values of the sub-criteria of ERP’s success within the company

	Σl	Σm	Σu	$1/\Sigma u$	$1/\Sigma m$	$1/\Sigma l$	S matrix		
							l	m	u
C2.1	4.452	5.134	6.074	0.030	0.035	0.041	0.132	0.180	0.251
C2.2	4.456	5.256	6.184	0.030	0.035	0.041	0.132	0.185	0.256
C2.3	4.624	5.440	6.410	0.030	0.035	0.041	0.137	0.191	0.265
C2.4	5.226	6.401	7.837	0.030	0.035	0.041	0.155	0.225	0.324
C2.5	5.426	6.241	7.316	0.030	0.035	0.041	0.160	0.219	0.303
C2.6	7.421	8.629	9.899	0.030	0.035	0.041	0.219	0.303	0.409
Sum	24.185	28.472	33.822						

Table 10 Calculation of importance weights for the sub-criteria of success of ERP within the company

	C2.1	C2.2	C2.3	C2.4	C2.5	C2.6	min	w
C2.1	X	0.965	0.914	0.685	0.700	0.205	0.205	0.0734
C2.2	1.000	X	0.949	0.716	0.734	0.235	0.235	0.0838
C2.3	1.000	1.000	X	0.766	0.788	0.289	0.289	0.1034
C2.4	1.000	1.000	1.000	X	1.000	0.572	0.572	0.2044
C2.5	1.000	1.000	1.000	0.963	X	0.498	0.498	0.1778
C2.6	1.000	1.000	1.000	1.000	1.000	X	1.000	0.3572
						Sum	2.799	

Fig. 3 The importance degrees of the criteria affect ERP’s success within the company



within the company. In this context, while investing in ERP software, the enterprise must first prepare the necessary infrastructure for the success of ERP within the company. For this, it should first create the infrastructure that will ensure top management support.

The sub-criteria of the main criterion of “Meeting the Expectations from the ERP System”, which is the important criterion, were also evaluated. Fuzzy AHP solution steps were applied sequentially to the pairwise comparison fuzzy decision matrix of all sub-criteria for Meeting the Expectations from the ERP System. First, the formulas in “Step 1” were applied. Secondly, for each criterion whose fuzzy synthetic extent values were calculated, the formulas in Step 2 were applied and checked whether the criteria values were more extensive than each other. Table 11 demonstrates the results of the calculations. The “min” column in the table shows the smallest value of the relevant criterion. While calculating the “W” value, the smallest value of each criterion was obtained by dividing the sum of the “min” values. As a result of the pairwise comparison survey of employees who use ERP in the enterprise that wants to invest in ERP software, it was identified that the most crucial sub-criterion for meeting the ERP system’s expectations is decreased expenses and increased income. As a result of the calculations, the importance weights of the criteria are given in Fig. 4.

According to Fig. 4, it has been determined that the most significant factor affecting the meeting of the expectations from the ERP system is the decrease in expenses and increase in income by 25.48%. The sub-criterion that most affect the criteria for meeting expectations from the ERP system in the second place is increasing the competitiveness of the business with 17.62%. Increasing employee performance is in third place with 16.11%, increasing customer service quality and satisfaction is in fourth place with

15.62%, strengthening the decision-making mechanism of the management is in fifth place with 11.53%, increasing operational efficiency is sixth with 9.02%, the adaptation of the personnel to new business processes is the seventh with 4.63%, and lastly eight place with 0% is integrated operation of business units. The sub-criteria are the criteria that affect the meeting the expectations from the ERP system.

As a result of the calculations, all criteria are given in Table 11 in order of importance.

In order to test the consistency of the significance levels, the consistency ratio of the fuzzy decision matrix is calculated. While calculating the consistency ratio, firstly, the An matrix, which is formed by the middle numbers of the triangular fuzzy matrix (m), and the Ag matrix, which is formed by taking the geometric mean of the lower and upper limits of the triangular matrix (l, u). The data obtained from these matrices and the CI and CR values were calculated separately for both matrices. The consistency ratios obtained from the calculations are given in Table 12.

The fact that the CRm and CRg consistency ratios calculated according to the fuzzy AHP method are less than 0.10 indicates that the matrix is consistent. As a result of the calculations, it is seen that the fuzzy decision matrices, in which the importance weights of the main criteria and the sub-criteria related to the main criteria are calculated, are consistent.

5 Conclusion

This study, carried out in a production company, aimed to determine the relative importance of the ERP selection criteria by using the fuzzy AHP method and the answers given by the company workers to the pairwise comparison survey. In this study, the sub-criteria of the evaluation criteria of

Table 11 Main criteria, sub-criteria and importance degrees

Main criteria	Importance degrees	Sub-criteria	Importance degrees
C2 Success of ERP within the company	0.4569	C2.6 Executive management support	0.3572
		C2.4 Employee participation and support	0.2044
		C2.5 Software/hardware availability	0.1778
		C2.3 Project management (setup plan, creating a project team)	0.1034
		C2.2 Restructuring business processes	0.0838
		C2.1 ERP consulting company support	0.0734
C5 Meeting the expectations from the ERP system	0.4569	C5.7 Decrease in expenses and increase in income	0.2548
		C5.6 Increasing the competitiveness of the enterprise	0.1762
		C5.5 Increasing employee performance	0.1611
		C5.3 Increasing customer service quality and satisfaction	0.1562
		C5.8 Strengthening the decision mechanism of management	0.1153
		C5.4 Increasing the efficiency of the enterprise	0.0902
		C5.1 Adaptation of personnel to new business processes	0.0463
		C5.2 Integrated operation of business units	–
		C4.7 Education services	0.1801
C4 Support service of ERP company	0.0862	C4.4 Qualification of supporters	0.1692
		C4.8 7/24 Service	0.1523
		C4.6 Ensuring continuous improvement	0.1405
		C4.2 Speed of problem solving	0.1169
		C4.3 Communication skills of supporters	0.1130
		C4.5 Introducing updates to the package	0.0718
		C4.1 Speed of reaching the right person	0.0562
		C1.1 Testability	–
C1 ERP usage process	0.00	C1.2 Performance measurement	–
		C1.3 Ability to use in different environments	–
		C1.4 Flexibility	–
		C1.5 Reporting ability	–
		C1.6 The system's openness to development	–
		C1.7 Data import-data transfer capabilities	–
		C1.8 Graphic design capabilities	–
		C1.9 Ensuring information confidentiality and software reliability	–
		C3.1 Technical support	–
C3 Installation process of ERP	0.00	C3.2 Educational program	–
		C3.3 Complying with deadline	–
		C3.4 Setup time	–
			–

“ERP usage process, the success of ERP within the company, the installation process of ERP, support service of the ERP company and meeting the expectations from the ERP system” were prioritized according to the pairwise comparison matrix.

In this study, it is concluded that the ERP usage process criterion has no effect on ERP selection, the effect of ERP's success criterion within the company on ERP selection is 45.69%, ERP's installation process criteria have no effect on ERP selection, the effect of the support service of the ERP company on the ERP selection is 8.62% and

finally, the criterion of meeting the expectations from the ERP system has a 45.69% effect on the ERP selection.

The sub-criteria of the criteria for ERP's success within the company and the degree of importance among themselves: ERP consulting company support 7.34%; restructuring business processes 8.38%; project management (setup plan, project team creation) 10.34%; employee participation and support 20.44%; software/hardware availability is 17.78% and executive management support is 35.72%, respectively.

Fig. 4 The importance degrees of the criteria affect the meeting the expectations from the ERP system

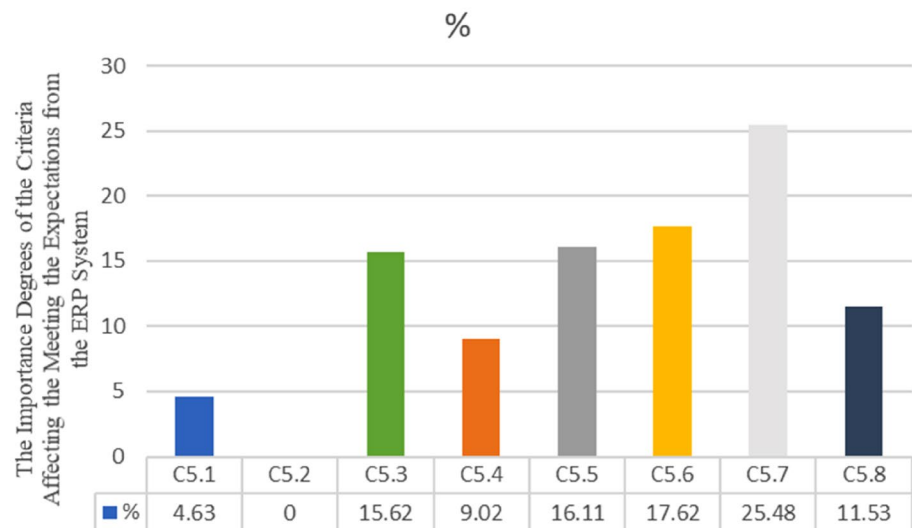


Table 12 Consistency rates

	Main criteria	C1	C2	C3	C4	C5
CRm	0.01	–	0.00	–	0.01	0.01
CRg	0.01	–	0.00	–	0.05	0.01

The sub-criteria of the criteria for meeting the expectations from the ERP system and the degree of importance among themselves: adaptation of personnel to new business processes 4.63%; integrated operation of business units 0%; increasing customer service quality and satisfaction 15.62%; increasing the efficiency of the enterprise 9.02%; increasing employee performance 16.11%; increasing the competitiveness of the enterprise 17.62%; decrease in expenses and increase in income is 25.48% and strengthening the decision mechanism of management is 11.53%, respectively.

In line with the results obtained from this study, it has been observed that the most important criterion to be considered when choosing ERP for SMEs engaged in machining in the aviation sector in Ankara is whether the ERP has been successful within the company and meets the expectations from the ERP system.

It should not be forgotten that the most important factor in the selection of ERP in the company where the study is carried out and in the companies with the same status is the top management, and if success is desired due to the ERP selection, the necessary infrastructure must be established. Top management should show all material and moral support for the successful execution of the selection, installation and use of ERP. For example, Motivating awareness training should be given to employees so they can carry out their business processes in an integrated manner with ERP, and their ERP usage performance should be evaluated and encouraged with awards.

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Declarations

Conflict of interest There are no conflicts of interest declared by the authors.

Informed consent All individual participants in the study gave their informed consent.

Human and animal rights All individuals in the study were included with their consent.

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