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The evaluation of supply chain performance in the Oil Products Distribution Company, using information technology indicators and fuzzy TOPSIS technique

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ABSTRACT

Information Technology (IT) plays an essential role on development of effective supply chain planning and it can improve the supply chain performance, either directly or indirectly. As a national industry, the National Iranian Oil Products Distribution Company involves a large number of organizations within its supply chain. Therefore, this descriptive-survey uses information sharing indicators, fuzzy TOPSIS technique based on managers and expert opinions to evaluate and to rank some oil products distribution companies. Data are analyzed and the results show that Oil Products Distribution Company of Chaharmahal and Bakhtiari received the highest rank and Farsan maintained the lowest rank compared with other regional companies.

1. Introduction

In today's competitive world, the introduction of products with a short longevity and the increasing customer expectations forced the organizations to invest and focus on their logistics systems and reengineering. Among these changes, the creation of new institutions and activities led to uncontrolled irregularities and some activities are required to organize and monitor these irregularities such as identifying the supply chain, managing it, and building a relationship between different components based on IT indicators. On the other hand, organizations always use the methods and techniques of improving the status and appropriate business management and seek to develop new solutions and achieve success. Supply Chain Management (SCM) as an integrated approach for the appropriate management of materials and goods, information and finance owns the ability to face such conditions (Gazanfari et al., 2000). Also, a comparison among various analyzing techniques has been drawn for authenticating the candid method followed by an evaluation using fuzzy TOPSIS (Hwang & Yoon, 1981; Chakraborty et al., 2018) for authenticating the results of comparison (Mittal et al., 2018). Supply chain management, based on two principles of coordination and collaboration coordinates the organizations of a chain through information sharing and invites them to gain competitive advantage. Among all the potential areas for improvement in supply chain management, information sharing is of great importance. Information sharing is the base and the

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pillar of coordination in the supply chain and could be created by establishing the coordination of the benefits promised by the supply chain management (Welker et al., 2008). The Iranian oil product distribution industry has a large number of suppliers and customers as a national industry. By approaching the domestic supply to demand, global trade, import and export of oil products in the country and the increase of product diversity, the need for comprehensive and integrated solutions for the oil product distribution industry and the establishment of necessary infrastructure is felt.

Although the measurement models (including developed BSC and SCOR) have their own limitations to assess the supply chain performance, the first limitation is the large number of individual measurements used in the supply chain. However, these scales providing valuable information for decision-making, selection, exchange of many indicators for effective strategies are difficult to cope for the participants in the supply chain. The effective management of a supply chain was proven to be a very effective mechanism for the rapid and reliable delivery and high quality goods and services at minimum cost (Piotrowicz, & Cuthbertson, 2015). While supply chain models focus on minimizing logistic costs, marketing models focus on maximizing revenues by adjusting products' price and by trying to follow closer demand changes (Díaz-Mateus et al., 2018).

Coordination management in this large collection of organizations based on information sharing is one of the most important management activities that could organize the chain and provide competitive advantages to the oil product distribution industry in the country. Companies help the suppliers by sharing their knowledge, skills and experience and take benefit from improvement in terms of performance, delivery, and quality. In addition, the suppliers improve better performance and lower costs (Lee et al., 2001). In this study, first, the review literature and research on supply chain management and performance based on IT indicators in different fields, prioritization and multi-criteria decision making models with a fuzzy approach are discussed. Then, the fuzzy theory and fuzzy TOPSIS are introduced as the approach used in this research. Finally, by specifying a new model of the Fuzzy TOPSIS Method (FTOPSIS), the prioritization model is established and the results are analyzed.

2. Review of literature

Supply chain management is a collection of approaches attempting to integrate suppliers, producers, warehouses and consumers effectively in order to produce and distribute goods in the correct quantity, place, and time. These approaches seek to minimize the system costs while satisfy a certain level of service (Beamon, 2010). The effective management of a supply chain was proven to be a very effective mechanism for the rapid and reliable delivery and high quality goods and services at minimum cost. Gunasekaran and Ngai (2004) investigated the problems during the development of the supply chain through information technology: The lack of integrity between information technology and business model of the organization, lack of proper strategic planning, poor information technology infrastructure, inadequate use of information technology in virtual enterprises, lack of adequate knowledge about the implementation of information technology. There is a direct relationship between ordering quantity and strategic customer valuation discount factor (Sadjadi et al., 2016).

Some researchers evaluated the performance of independent units in a supply chain, such as: the evaluation of distribution centers performance (DC) (Ross & Droge, 2007), Sales Performance Evaluation (Estampe et al., 2013), Supplier Performance Evaluation (Talluri et al., 2006), etc. However, these independent units in the supply chain have their own specific goals which are often contradictory. Therefore, there is a need for a performance evaluation framework in which the performance of these independent units is merged and evaluated, simultaneously. These approaches seek to minimize the costs of the system while satisfying a certain level of service. Analytical Networking Process (ANP) (Saaty, 2004) is one of several multi-criteria decision-making techniques in order to solve a multi-criteria decision-making problem (Tsai & Chou, 2009).

Supply chain management, which is constantly evolving, means integrating the organizational units within the chain and creating coordination in the flow of materials, information and financial resources to meet the customers' needs and achieve a reliable and long-term competitive advantage. An important point in this definition is that all activities required during a supply chain should be designed and implemented in accordance with the needs of the final customers. Two main elements in supply chain management are the synchronization of product flow and information flow, hence the components of the supply chain focus on the movement of goods within the chain and aim at cost reduction, quality improvement, timely delivery, flexibility against environmental change, and innovation in goods and services delivery. The managers of most successful companies acknowledge that efficient supply chain management is a key to establish and consolidate the competitive advantage in delivering products and services which is not possible without the deployment and effective use of information technology. In order to facilitate the flow of information and access to information and accurate management, supply chain became an appropriate platform for integrated information systems, the speed of globalization, and the growing trend of expanding economic activities around the world and led to an increase in the competitiveness of companies.

Thus, in today's economy, the field of competition and conflict has shifted from the performance of individual companies to supply chain performance. Performance measurement plays a decisive role in the development of each collection. Supply chain (SC) approach seems to become a combination of build to order (BTO)-SC (Black, 2002). The use of a BTO supply chain is a non-critical decision to manage production, supply chain accountability, suppliers, and cost of products, requiring the strong coordination of information by measuring the good performance of the supply chain (Gunasekaran & Ngai, 2004 2009). Sharing the existing information and inventory control are two important factors in supply chain improvement, Simulation method is used to show the relationship between information scoring indices and their impacts on supply chain performance (Costantino et al., 2015). Sharing the information between the inventory order of producer and retailer in closed loop supply chain is very important (Hosoda et al., 2015).

Rached et al. (2015) studied the value of information sharing and its impact on the performance of different partners in the supply chain. They developed information and communication technology and real time of information sharing precisely in the entire single-product supply chain and considered two main objectives in this study. One was to estimate the benefits of partners at the initial cost of using different parts of the supply chain information supply with details, and the other was to determine the cumulative effect of information sharing simultaneously in the entire supply chain. They provided a mathematical model for developing and evaluating the value of information sharing in the context of logistic costs for different combinations with and without information sharing with three indicators of upstream and downstream information. However, for the better efficiency of information and motivation of each part, it was proposed to create the commitments of common interests among the supply chain loops.

In general, the supply chain management philosophy is that the overall performance of a set of supply chain increases when the performance of all organizations associated with this process is optimized in comparison to the performance of all organizations. Supply and demand planning and management, materials supply, production, product or service scheduling, warehousing, inventory control and distribution, delivery and customer service are among the issues coordinated by supply chain management so that customers can obtain high-quality and reliable products and services at a minimum cost; an event that can provide a competitive advantage to the company (Breen & Crawford, 2005).

In today's world, information is considered as a decisive factor in increasing the efficiency of complex organizations, so that today's organizations' ability to process information and their speed is summed up in decision making; Accordingly, predicting and estimating the supply and demand of raw materials to the supply and demand of products at the position of sales and reorganization of organizations in order to achieve such a situation is necessary. In order to achieve such an objective, an organizational system must coordinate the flow of information needed to produce and deliver products leading to the facilitation of decision making and the implementation of the supply chain process (Slone et al., 2007). Generally, in a supply chain, the performance or accountability of companies depends on the amount of information that the companies intend to share. As the amount of information associated with product supply, customer demand, market forecasts, and the timing of production shared by the companies are higher, the accountability and response of these companies will be greater. However, this sharing should be balanced and measured, because the use of competitors from this information is one of the concerns of companies in this field (Samizadeh & Hosaini, 2010). A study classified the goals that companies pursue by using information technology in supply chain management. The first category of information technology application implies the use of information technology for information sharing and the coherence of information in the business which aims at increasing the efficiency of the exchange of information among supply chain partners. The second type of information technology application reflects the use of information technology for information sharing related to planning such as demand forecast and other information related to demand, inventory information and information related to production capacity, which aims to increase the efficiency of the supply chain. Finally, the third type of information technology application refers to the personal or transportation orders, which may include end product or product components. The objective of the third group is to coordinate the delivery of these components or end products or provide timely delivery of their location information (Vishal, 2015).

Benton and Melon (2002) conducted extensive research on information sharing in the supply chain, and focused on the dimensions of communication between suppliers and manufacturers as the main factors in communication. After examining the various factors, they announced three factors of commitment, trust and cooperation as the main factors considered by suppliers in communicating with main producers as their customers which should be considered in establishing a successful relationship. Raghunathan (2003) stated that information sharing between chain members is at the top of the key to the success of supply chain management and believed that information sharing is the result of a combination of four factors of cost, security, risk and trust. He argued that when a number of suppliers may be in contact with the manufacturer's competitors, it is necessary to adopt the correct combination of these four factors.

Production decision-making is a complex decision of the retail channel approach. In the early 1990s, Dell started BTO in its computer manufacturing industry strategy that directly ordered customer information through the customer electronic commerce channel to Dell before supplying information to suppliers about the inventory of goods (Li et al., 2015). The power of retailers in the supply chain is known with vendors' interests and has a larger share of profits in the chain. The information sharing security policy reduced the cost of high-level supply chain and the impact of Bullwhip effect playing a significant role in supply chain sustainability and improvement (Qin et al., 2016). In a study, a fuzzy TOPSIS model was used to evaluate the performance and classification of suppliers in four different groups (Lima-Junior & Carpinetti, 2016). In order to manage the supply chain in another study, Lee et al (2000) examined the factors affecting information sharing and information quality in the three dimensions of environmental uncertainty, inter-organizational facilities, and intra-organizational relationships. Environmental uncertainty is the result of four factors of global competitiveness, the continued technological advancement, the changing needs of customers, and the increased need for engagement with external organizations such as suppliers and customers. Inter-organizational facilities are due to two factors of support for senior management and IT empowerment. In the dimension of intra -organizational relations, the degree of trust, commitment, and shared vision are raised among supply chain partners.

In a research, group purchasing organizations (GPO) were explored in facilitating information sharing and horizontal competition synchronization and each source had specific information about the unknown request and could choose to share it with the GPO (Zhou et al., 2016). Perçin (2008) used the fuzzy hierarchy process analysis technique to evaluate the benefits of information sharing in the supply chain. In this research, four choices for decision making, namely, internal processes, growth and learning, customer and financial needs were selected to evaluate the benefits of information sharing.

The approach used in this study for ranking the oil products distribution companies was based on the combination of concepts of fuzzy theory and multi-criteria decision-making. The theory of fuzzy sets was presented by Zadeh (1965) presenting an issue of data uncertainty and inaccuracy (Zadeh, 1965). In the classical TOPSIS method (similar to the classic ideal option), precise values are used to determine the weight of the criteria and the ranking of the options. In many cases, human thoughts are associated with uncertainty and this uncertainty affects decision making. In this situation, fuzzy decision-making methods are used that the fuzzy tops approach (similar to the fuzzy ideal option) is one of these methods. This method was first used by Chen and Huang in 1992. In this case, the elements of the decision matrix or the weight of the criteria, or both, are evaluated by the verbal variables represented by the fuzzy numbers, thus he problems of the method similar to the ideal classical option were overcame. The difference of various models of this method was in the type of fuzzy number, the normalization method and ranking method.

3. Research methodology

The main objective of the research is to evaluate the supply chain performance of oil products distribution companies in Chaharmahal and Bakhtiari province in Iran by using information sharing indicators, the present study was applied in terms of purpose and descriptive-survey in terms of data collection method.

In order to collect information in this research, the views of 15 knowledgeable managers and experts on the supply chain and information sharing in each section were used separately in oil products distribution companies (Headquarters of Shahrekord, Central Shahrekord, Boroujen, Lordegan, Farsan). The method of data collection in this study included library studies and field studies of interview and questionnaire type. In order to make the questionnaire valid, in the initial design of questions the items such as the structure of the questionnaire, the use of understandable and unambiguous sentences were considered. After the initial design of the questionnaires, the opinions of the supervisors, consultants and experts were used to increase the validity. Cronbach's alpha coefficient test was used to test the reliability of the questionnaire. The obtained alpha was 0.754 which showed the reliability of the questionnaire.

3.1. Identifying the information sharing indicators in the supply chain and selecting their most important ones

Table 1 lists the IT indicators in terms of financial, customer, internal processes, growth and learning in a supply chain.

Table 1
Information technology indicators in organizations

dimensions	indicator
financial	Return on investment and current net worth
	measuring the economic value added
	Cost Control (IT, Communications, Network)
customer	The degree of satisfaction of IT staff
	Satisfaction of users of other units of the organization
	Average response time and access to services (for the development and support of
	The rate of optimization and development of hardware and software systems
	Accuracy and timeliness of information
internal processes	Errors and rework in systems
	Number and quality of internal processes simplification
	Reducing the time cycle of performing processes
	Improving the cost / return ratio in processes
	Percentage and timeliness of issues solved
	Timely completion rate of projects
growth and learning	Innovation in old systems
	New system development
	Training of IT staff, continuous training of system users

In order to determine the information sharing indicators in the supply chain of the country's oil products distribution company, high-importance indicators were specified in the following table by reviewing and studying specialized articles and books as well as interviewing experts and oil experts who were familiar with the issue of information sharing in the supply chain.

Table 2
Selected indicators of information technology in the supply chain of oil products distribution

row	indicator
1	Costs (IT purchase, communications, network)
2	Optimization and development of hardware and software systems (including communication bandwidth, computer power, etc.)
3	Average response time and access to services (for the development and support of hardware and software, websites, networks)
4	Training of IT staff, continuous training of system users
5	Accuracy and timeliness of information

Indicators C_1, C_2 and C4 were considered quantitatively and other indicators were qualitatively as follows:

C_1= Costs (IT purchase, communications, network)

C_2= Optimization and development of hardware and software systems including communication bandwidth, computer power, etc.

C_3= Average response time and access to services for the development and support of hardware and software, websites, networks

C_4= Training of IT staff, continuous training of system users

C_5= Accuracy and timeliness of information

The studied oil products distribution companies in Chaharmahal and Bakhtiari province were considered as follows.

A_1= Broujen A_2= Farsan A_3= Lordegan A_4= Headquarters of the province A_5= Shahrekord

Problem solving steps

Generally, in this study the fuzzy TOPSIS method was conducted in 8 steps (Tsai & Chou, 2009):

Step 1: Creating a decision matrix

In order to form the decision matrix according to the number of criteria, the number of options, and the evaluation of all options for different criteria and the application of the method in question, first the mathematical symbols were used for the criteria, options and evaluation results as follows:

$$\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij}) \quad \tilde{D} = \begin{bmatrix} \tilde{x}_{11} & \cdots & \tilde{x}_{1n} \\ \cdots & \ddots & \cdots \\ \tilde{x}_{m1} & \cdots & \tilde{x}_{mn} \end{bmatrix}$$

$\tilde{D}$: decision-making matrix

$\tilde{x}_{ij}$; The function of option i (i=1,2,…,m) in relation to criterion j (j=1,2,…,n) as fuzzy numbers with triangular membership function.

Thus, for forming the decision matrix, the fuzzy verbal variables, which were one of the fuzzy theory tools for displaying the uncertainty, were determined by the membership functions μ (x). The fuzzy number with the triangular membership function used in this study as the fuzzification of weights and evaluations was shown in Fig. 1 represented by S = (a, b, c).

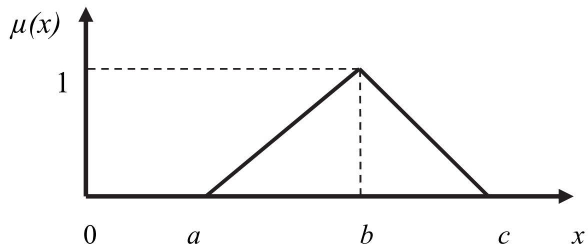

Fig. 1. Triangular membership function

Since there are no numerical values for qualitative criteria, their evaluation was based on verbal values of decision makers. The verbal values used in this study were for the weights of the criteria and the evaluation of the options, and their fuzzy functions were given in Table 3 and Table 4.

Table 3
Verbal variables for ranking the options and equivalent fuzzy functions

Verbal value	Triangular fuzzy function corresponding to the evaluation rating variable
very low	(0,0,1)
low	(0,1,3)
relatively low	(1,3,5)
appropriate	(3,5,7)
relatively high	(5,7,9)
high	(7,9,10)
very high	(9,10,10)

Table 4
Verbal variables to evaluate the importance of criteria and model fuzzy criteria

verbal value	A triangular fuzzy function corresponding to the importance of the criteria
very insignificant	(0,0,0.1)
insignificant	(0,0.1,0.3)
relatively insignificant	(0.1,0.3,0.5)
indifferent	(0.3,0.5,0.7)
relatively significant	(0.5,0.7,0.9)
significant	(0.7,0.9,1)
very significant	(0.9,1,1)

After collecting the evaluation results of each decision maker to combine the results and obtain the final decision matrix, since the fuzzy ranking of the k-th decision maker is $\tilde{x}_{ijK} = (a_{ijk}, b_{ijk}, c_{ijk})$ (Triangular fuzzy number), thus according to the criteria, the fuzzy combined ranking $\tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij})$ of options are obtained based on the mentioned relations:

$$a_{ij} = \min_{K}\{a_{ijk}\} \quad (1)$$

$$b_{ij} = \frac{\sum_{k=1}^{K} b_{ijk}}{K} \quad (2)$$

$$c_{ij} = \max_{K}\{c_{ijk}\} \quad (3)$$

where, $\boldsymbol{a_{ijk}}$, $\boldsymbol{b_{ijk}}$, and $\boldsymbol{c_{ijk}}$ are the fuzzy number parameters of the k-th decision maker. At this stage, a group of directors and relevant experts from oil products distribution companies of Chaharmahal and Bakhtiari province determine the weights of the criteria and evaluate the options based on the decision making. In order to complete the decision matrix the documentary method was used to obtain available information in case of little information about the existing criteria.

At this stage, the definitive data from quantitative criteria were written as triangular fuzzy numbers to use in the fuzzy decision matrix. Regarding the criteria for which the necessary information is not available and criteria of a qualitative nature, the opinions of the decision makers and a questionnaire were used to collect experts' opinions based on verbal variables in Eq. (3) and Eq. (4).

Costs (purchase of information technology, communications, network), optimization and development of hardware and software systems (including communication bandwidth, computer power, etc.) and the cost of continuous training of IT staff, continuous training of system users as quantitative and average metrics of response time and access to services (for the development and support of hardware and software, website, network), and the accuracy and timeliness of information were considered as qualitative criteria.

Thus, the whole statistical work was divided into two groups:

1. Using the time series data for the years 2006 to 2016 to examine quantitative criteria for which some statistical data exists.
2. Using the experts' opinions by using fuzzy logic for qualitative criteria.

It should be noted that due to the need to maintain economic information for the oil product distribution company, the full release of information as avoided and the results of step 1 were presented in Table 5.

Table 5
Decision making matrix

option	C_1	C_2	C_3	C_4	C_5
A1	(10,9,7))	(5,8,10))	(5,8.7,10)	(3,7,10)	(7,9,10)
A2	(7,5.10,7)	(3,7,10)	(7.9.7,10)	(1,5.7,10)	(7,9.4,10)
A3	(7,5.7,10)	(0,6.4,10)	(7,9.4,10)	(3,6.4,9)	(5,8.4,10)
A4	(9,7.10,4)	(7,9,10)	(9,10,10)	(7,3.10,4)	(5,9,10)
A5	(7,9,10)	(3,7.7,10)	(7,9.4,10)	(3,7,10)	(8,5.7,10)

(Ai) indicates the options and (Cj) represents the criteria.

$A_{i: \text{ option } i,}$ i = 1,2,…,m

$C_{j: \text{ criterion } j,}$ j = 1,2,…,n

Step 2: Determining the weight matrix of the criteria

At this stage, the importance factor of decision-making criteria was determined, which can be defined as follows:

$$\tilde{\boldsymbol{w}} = [\tilde{\boldsymbol{w}}_1, \tilde{\boldsymbol{w}}_2, \ldots, \tilde{\boldsymbol{w}}_5] \tag{4}$$

$\tilde{\boldsymbol{w}}_j$: The importance factor of the j-th criterion, j = 1,2, ..., 5

In such a way that triangular fuzzy numbers are used in it, each criterion of $\tilde{\boldsymbol{w}}_j$ (the weight of each criterion), will be defined as $\tilde{\boldsymbol{w}}_j = (\tilde{\boldsymbol{w}}_{j1}, \tilde{\boldsymbol{w}}_{j2}, \tilde{\boldsymbol{w}}_{j3})$.

At this step, a combination of the following relations was used for the fuzzy ranking:

$$\tilde{w}_{j1} = \min_{K}\{w_{jk1}\} \quad (5)$$

$$\tilde{w}_{j2} = \frac{\sum_{k=1}^{K} w_{jk2}}{K} \quad (6)$$

$$\tilde{w}_{j3} = \max_{K}\{w_{jk3}\} \quad (7)$$

$\tilde{w}_{jk}$: The importance factor of the k-th decision maker.

At this stage, the fuzzy weights derived from Eq. (4) were based on the opinions of the decision makers regarding the importance of the criteria using the verbal values of Table 4, and the results were calculated according to Table 6.

Table 6
Results of general weights of criteria $\tilde{w}$

criterion	C1	C2	C3	C4	C5
weights of criterion	(0.65,0.87,1)	(5, 0.75,1)	(0.65,0.93,1)	(0.35,0.55,0.8)	(0.5,0.77,1)

Step 3: Descaling the fuzzy decision matrix

In order to descale the fuzzy decision matrix, a linear scale change was used to convert the scale of different criteria into comparable scale rather than the complex calculation.

When the decision making entries ($\tilde{x}_{ij}$) are fuzzy, the descaled decision matrix entries will be fuzzy too. For the positive and negative criteria, the following relations were used:

For positive criteria:

$$\tilde{r}_{ij} = (\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}) \quad (8)$$

For negative criteria:

$$\tilde{r}_{ij} = (\frac{a_{\bar{j}}}{c_{ij}}, \frac{a_{\bar{j}}}{b_{ij}}, \frac{a_{\bar{j}}}{a_{ij}}) \quad (9)$$

In these relations:

$$c_j^* = \max_{i}\{c_{ij}\} \qquad i=1,2,\dots,m\ ;\ j=1,2,\dots,n \quad (10)$$

$$a_{\bar{j}} = \min_{i}\{a_{ij}\} \qquad i=1,2,\dots,m\ ;\ j=1,2,\dots,n \quad (11)$$

Thus, the descaled fuzzy decision matrix ($\tilde{R}$) was obtained as follows:

$$\tilde{R} = [\tilde{r}_{ij}]_{m\times n} i = 1, 2, \dots, 5; j = 1, 2, \dots, 5 \quad (12)$$

where m denotes the number of options and n denotes the number of criteria. In this situation, the crude decision matrix, whose elements are triangular fuzzy numbers was converted to the fuzzy normal matrix by Eq. (8) and Eq. (9), part of which was given in Table 7.

Table 7
Results of descaled decision-making matrix

option	C_1	C_2	C_3	C_4	C_5
A_1	(0,455.1,78)	(0,25,6.95)	(0,325.1,81)	(0,105,385.8)	(25,0,426.7)
A_2	(0,325.1,66)	(0,15,525.95)	(0,455.1,91)	(0,35,312.7)	(0,25,41.71)
A_3	(0,325.1,67)	(0,0,475.95)	(0,455.1,87)	(0,11,348.72)	(0,25.1,46)
A_4	(0,455.1,81)	(0,35,675.95)	(0,585.1,93)	(0,105,41.8)	(0,25.1,43)
A_5	(0,455.1,78)	(0,15,575.95)	(0,455.1,87)	(0,105,385.8)	(0,25.1,44)

Step 4: Determining the weighted fuzzy matrix

In step 2, the weight of the criteria was obtained. Now, considering the weights of different criteria, the weighted fuzzy decision matrix was obtained by multiplying the importance factor related to each criterion by the descaled matrix entries related to that criterion as follows,

In these relations, $\tilde{\boldsymbol{w}}_{\boldsymbol{j}}$ indicates the importance factor of criterion C_j $\tilde{\boldsymbol{r}}_{\boldsymbol{ij}}$ is the entries of weighted fuzzy matrix.

$$\tilde{\boldsymbol{v}}_{\boldsymbol{ij}} = \tilde{\boldsymbol{r}}_{\boldsymbol{ij}}.\tilde{\boldsymbol{w}}_{\boldsymbol{j}} \tag{13}$$

Therefore, the weighted fuzzy decision matrix $(\tilde{\boldsymbol{V}})$ will be as follows:

$$\tilde{\boldsymbol{V}} = [\tilde{\boldsymbol{v}}_{\boldsymbol{ij}}]_{\boldsymbol{m\times n}} \qquad i= 1,2,\ldots,m\ ; j=1,2,\ldots,n \tag{14}$$

Table 8
Results of the descaled weighted decision matrix

option	C_1	C_2	C_3	C_4	C_5
A_1	(0.7,0.9,1)	(0.5,0.8,1)	(0.5,0.87,1)	(0.3,0.7,1)	(0.5,0.55,0.71)
A_2	(0.5, 0.77, ,1)	(0.3,0.7,1)	(0.7,0.97,1)	(0.1,0.57,1)	(0.5,0.53,0.71)
A_3	(0.5,0.77,1)	(0,0.64,1)	(0.7,0.94,1)	(0.3,0.64,0.9)	(0.5,0.6,1)
A_4	(0.7,0.94,1)	(0,0.79,1)	(0.9,1,1)	(0.3,0.74,1)	(0.5,0.55,1)
A_5	(0.7,0.9,1)	(0.3,0.1,0.77)	(0.7,0.94,1)	(0.3,0.7,1)	(0.5,0.57,1)

By multiplying the total weights of the criteria based on the corresponding entries in the fuzzy normal matrix, the normal fuzzy normal decision matrix will be obtained from Eq. (13), part of which was given in Table 8.

Step 5: Finding the ideal fuzzy solution (FPIS, A*) and counter - ideal fuzzy solution (FNIS, $\overline{\boldsymbol{A}}$)

The goal of this stage was based on the best option according to the desired criteria. Therefore, the logic was defining the ideal and counter -ideal solution because the ideal solution maximized the benefit criteria and minimized the cost criteria. In short, the ideal solution included all the best values in the available metrics; while the counter -ideal was a combination of the worst values of available metrics and the optimal option was the best option having the shortest distance from the ideal solution and the greatest distance from the counter -ideal. Fuzzy ideal solution and fuzzy counter-ideal solution were defined as follows:

$$\boldsymbol{A}^{*} = \{\tilde{\boldsymbol{v}}_{\boldsymbol{1}}^{*}, \tilde{\boldsymbol{v}}_{\boldsymbol{2}}^{*}, \ldots, \tilde{\boldsymbol{v}}_{\boldsymbol{n}}^{*}\} \tag{15}$$

$$\boldsymbol{A}^{-} = \{\tilde{\boldsymbol{v}}_{\boldsymbol{1}}^{-}, \tilde{\boldsymbol{v}}_{\boldsymbol{2}}^{-}, \ldots, \tilde{\boldsymbol{v}}_{\boldsymbol{n}}^{-}\} \tag{16}$$

where $\tilde{\boldsymbol{v}}_{\boldsymbol{j}}^{*}$ is the best criterion value *j* among all options, and $\tilde{\boldsymbol{v}}_{\boldsymbol{j}}^{-}$ is the worst value of criterion *j* among all options in the weighted fuzzy decision matrix; These values were obtained from the following relations:

$$\tilde{v}_j^* = \max_i\{\tilde{v}_{ij}\} \qquad i=1,2,\dots,m\ ;\ j=1,2,\dots,n \tag{17}$$

$$\tilde{v}_j^- = \min_i\{\tilde{v}_{ij}\} \qquad i=1,2,\dots,m\ ;\ j=1,2,\dots,n \tag{18}$$

The options in A^* and A^- respectively represent better and worse options. Therefore, after forming a normal fuzzy matrix, according to the TOPSIS method ranking mechanism, to determine the positive and negative ideal options, the best and worst values for each criterion were determined by comparing the values of the normal fuzzy matrix based on Eq. (15) to Eq. (18). The results of step 5 were shown below.

$$\boldsymbol{A^* = [(1,1,1),(0.95,0.95,0.95),(1,1,1),(0.8,0.8,0.8),(1,1,1)]}$$

$$\boldsymbol{A^- = [(0.325,0.325,0.325),(0,0,0),(0.325,0.325,0.325),(0.325,0.325,0.325),(0.25,0.25,0.25)}$$

Step 6: Calculating the distance from the fuzzy ideal and counter ideal solution

In the previous step, the best and the worst possible option were identified. At this point, the distance between each option from fuzzy ideal solution and counter-ideal solution can be calculated from the following relations:

$$\boldsymbol{S_i^* = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^*\right), \qquad i = 1,2,\dots,m} \tag{19}$$

$$\boldsymbol{S_i^- = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right), \qquad i = 1,2,\dots,m} \tag{20}$$

To calculate the distance from the ideal and counter-ideal solution, the most important algebraic operations for two triangular fuzzy numbers were given in Table 9. If $\boldsymbol{\tilde{M}_1 = (a_1, b_1, c_1)}$ and $\boldsymbol{\tilde{M}_2 = (a_2, b_2, c_2)}$ are two Triangular fuzzy numbers, then:

Table 9
The most important algebraic operation for two triangular fuzzy numbers

operator	procedure
addition	$\tilde{M}_1 + \tilde{M}_2 = (a_1 + a_2, b_1 + b_2, c_1 + c_2)$
Subtraction	$\tilde{M}_1 - \tilde{M}_2 = (a_1 - a_2, b_1 - b_2, c_1 - c_2)$
Average	$\bar{X}(\tilde{M})_1 = \frac{a_1 + b_1 + c_1}{3}$
distance	$d(\tilde{M}_1, \tilde{M}_2) = \sqrt{\frac{1}{3}[(a_1 - a_2)^2 + (b_1 - b_2)^2 + (c_1 - c_2)^2]}$

$d(\tilde{v}_{ij}, \tilde{v}_j^-)$ *and* $d(\tilde{v}_{ij}, \tilde{v}_j^*)$ show the distance between two fuzzy numbers and the distance between two numbers is definite numbers. In step 6, by using the equations 19 and 20, the distance of each option from the best value in each criterion was shown as S * and its distance from the worst value in each criterion was shown as S^- and the results of this step were shown in Table 10 and Table 11. As shown in Table 10, the first rank closely related to the ideal solution was related to the option (headquarter), because this sectors is of greater advantages than other sectors in terms of optimization cost and development of hardware and software systems (including communication bandwidth, The ability of computers, etc.) and the average response time and access to services (for the development and support of hardware and software, website, network) causing more proximity to the ideal solution.

Table 10
The distance between each option from the ideal solution

option	C_1	C_2	C_3	C_4	C_5	The distance between each option from the ideal solution
$d(A_1,A^*)$	0.34	0.45	0.41	0.47	0.57	2.24
$d(A_2,A^*)$	0.44	0.52	0.32	0.52	0.57	2.37
$d(A_3,A^*)$	0.44	0.61	0.32	0.48	0.53	2.38
$d(A_4,A^*)$	0.33	0.38	0.24	0.46	0.54	1.95
$d(A_5,A^*)$	0.34	0.51	0.32	0.47	0.54	2.18

Table 11
The distance from each option and counter-ideal solution

option	C_1	C_2	C_3	C_4	C_5	The distance from each option and counter-ideal solution
$d(A_1,A^-)$	0.48	0.66	0.48	0.49	0.29	2.4
$d(A_2,A^-)$	0.44	0.63	0.52	0.47	0.28	2.34
$d(A_3,A^-)$	0.44	0.61	0.51	0.44	0.45	2.45
$d(A_4,A^-)$	0.49	0.7	0.55	0.49	0.44	2. 67
$d(A_5,A^-)$	0.48	0.65	0.51	0.49	0.45	2.58

The results in Table 11 also indicated that the headquarters have the greatest distance from counter-ideal solution with a distance of 2.67.

Step 7: Calculating the similarity index

The similarity index was calculated from the following equation:

$$CC_i = \frac{S_i^-}{S_i^* + S_i^-} \quad i=1,2,\ldots,m \tag{21}$$

For the final ranking of options in Step 7, the distance from the positive ideal was calculated as the total distance of options from the best value in the criteria and the distance from the negative ideal was calculated as the total distance of options from the worst value in the criteria. Accordingly, the similarity index for each option was obtained through the Eq. (21). The results of this step were shown in Table 12.

Table 12
The final ranking of options

option	A_1	A_2	A_3	A_4	A_5
The distance from the ideal solution	2.24	2.37	2.38	1.95	2.18
The distance from the counter ideal solution	2.4	2.34	2.45	2.67	2.58
similarity index	0.517	0.496	0.507	0.578	0.541

Step 8 :Ranking the options

At this stage, the options were ranked depending on the degree of similarity index, so that options with more similarity index were prioritized. In the final step, the options were ranked from the largest to the nearest similarity index, respectively.

A4> A5> A1> A3> A2

3. Conclusion

In this study, a model was presented for ranking the oil products company in Chaharmahal and Bakhtiari province by using the information technology indicators. Considering the features of the problem, the used decision-making approach was an improved version of Fuzzy TOPSIS having the ability to consider quantitative and qualitative criteria. Furthermore, due to the uncertainty and ambiguity in some of the criteria, the fuzzy approach was used in the method. The final results obtained from the model provided a high utility in terms of criteria and indices defined for oil products distribution companies. Accordingly, the ranking of oil products distribution companies in Chaharmahal and Bakhtiari province was based on the information technology index as follows:

1- Headquarters of the province 2- Shahrekord 3- Boroujen 4. Lordejan 5- Farsan

The results of using fuzzy TOPSIS method have indicated that the oil products distribution company in the Headquarters of the province had the highest index of similarity with the value of 0.578 and the oil products distribution company of Farsan had the lowest similarity index with the value of 0.496 among other distribution companies. Finally, the Headquarter could obtain accurate and timely information by relying on the continuous training of information technology employees and the use of hardware and software tools and systems optimization in the supply chain. As a result, the supply chain accountability could grow to a high level. The use of IT indicators improved the supply chain at a high level and this model can be implemented at the level of oil products distribution throughout the country.

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