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An application of fuzzy TOPSIS to improve the process of supply chain management in the food industries: A case study of protein products manufacturing company

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A B S T R A C T

Food industries as one of the most important industries in country, needs appropriate planning at both macro and micro levels. One of the important parts, which need to be discussed is the supply chain management in this industry. In this study, the importance of supply chain in food industries is studied. The proposed study determines different suppliers and using various criteria, the study applies Fuzzy Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) to rank different alternatives. The preliminary results indicate that the proposed model of this paper is capable of determining appropriate suppliers in food industry.

1. Introduction

With an increasing trend on competition in national and global markets, organizations try to use different techniques to survive such as supply chain management (SCM). SCM has the obligation of integrating organizational units along the supply chain (SC) and synchronization of material, information and financial flows in order to meet the customer demands by improving competitiveness (Aissaoui et al., 2007). According to Khosravani (2010) "In order to maintain the company in a sustainable competitive state, we shall keep the relation with supplier chain to expand our performance chain". Since reliable suppliers enable the manufacturers to reduce inventory expenses and improve product quality, any wrong decision can be sufficient to eliminate the financial and technical resources of a supply chain. Therefore, it is understood that the producers are increasingly concerned of supplier selection. On the other hand, by emerging the Just in Time (JIT) philosophy and tendency of the companies to this kind of production, selecting the supplier has got strategic

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aspect and selecting the strategic suppliers in establishing the suitable long-term relation with the best of them and also shortest amount of them are vital. This relationship between the manufacturers and suppliers provides an opportunity to improve operations (Geringer, 1988).

In the current society, with an increasing trend and complexity of information, the primary focus of industrial enterprises is to have continuous improvement. Since there is a close competition in the food industries and the market is highly competitive in this industry, many business owners in this industry have acknowledged that today's competition is the competition in the supply chain and concentrate more on SCM creates the most important sources of competitive advantage. Supply chain contains material, information and financial flows, and it can provide a good condition for increasing competitiveness.

In this study, the researchers try to investigate the SCM issue in food industries and explain that despite the success of this industry, the relationship among different SC parties is very complex and challenging. For food companies, there are many weaknesses in this area and still there is much space for improving the SC in the mentioned companies. On one hand, the platform and modular strategy Build to order (BTO) cause to establish more opportunities with higher profit margin in business and on the other hand, this procedure causes to move towards strengthening more need to pure management and integration of expanded supply chain (on the global scale).

Now, many systems to measure the supply chain performance are not adequate because these measurements strongly rely on the use of cost as a major step, they are by no means comprehensive, they are often in conflict with the organization's strategic objectives and finally do not consider the effects of uncertainty. In this study, in addition to industry analysis, it is trying to design a model for supplier selection using Multi Criteria Decision Making Method and fuzzy approach.

Through providing this model, this study attempts to show that supply chain strategy has better financial yield than the other positive key aspects (each of the other strategies) by the optimal choice of suppliers. This study is intended not only to reduce costs by providing the above model, but also to increase organization profit. In addition, the objective of this study is to show that good design of supplier selection in the food industries supply chain can improve all levels of the food industry and help to increase supply chain performance. In this research, the following questions are proposed for discussion:

- What are the most important criteria of considering the suppliers important in the Pabas protein food industries?
- How could we rank the factors influencing the choice of suppliers in the Pabas protein food industries supply chain?

2. Research literature

2.1. Supply chain

Supply chain management has the obligation of integrating organizational units along the SC and synchronization of material, information and financial flows in order to meet the customer demands with the aim of improving competitiveness (Aissaoui et al., 2007).

2.2 Supply chain in food industries

A comparative study of food supply chain strategic program with other documents helps us use its achievements. On the other hand, it makes this program understandable for people who have seen those documents. In case the inspected document is an official document, a comparative study shows that the program is compatible with the official decisions and their contents or not.

There are different rules and regulations on food industry and one of the most important upstream documents in the food products supply chain includes constitution, the prospect of twenty years, general policies and the Fifth Development Program Law. The objectives and strategies of this program are in line with the contents of the upstream documents. This program explains the upstream documents more carefully and attaches to its performance. In other words, executing this program is executing the upstream documents.

General Policies generally contain provisions for food products supply chain, but a policy in relation to the food industry has not been issued clearly. Some provisions of the general policy in revising consumption patterns are devoted to bread. One of the most important strategies to revise the bread consumption pattern is to produce bread at home. Some of the points expressed in this study are relevant to the food products supply chain.

2.2.1 Boundary of food products supply chain

Food supply chain activities can be divided into four sections including 1. Farming, hunting, fishing, 2. Packaging, storage, processing, 3. Distribution and 4. Final preparation for consumption.

The boundary of food products supply chain includes packaging, storage and processing (including activities which are located in code 15 in ISIC prioritizing) and to some extent, distribution and trade (domestic and international) of food products.

2.3. Multi-Criteria Decision Making

These days, most decision making problems are involved optimization of more than one single objective. In many cases, decision makers are faced with various criteria, which are also in conflict with each other. Multi-Attribute Decision Makings, also called Multi-Criteria Evaluation, assume that the decision space is discrete. Although there is no optimal solution for this problem but with a limited set of options, the aim is selecting the best option based on multiple attributes.

2.3.1. TOPSIS Method

Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) method is also one of those useful multi-criteria decision making method for surveying issues in real world raised by Hwang & Yoon (1981) for the first time. This method was also suggested by Jahanshahlo et al. (2006). They described it as:

Let $A_1, A_2 \ldots A_m$ be m alternatives, which are supposed to be ranked by k decision makers based on n criteria (C_1, C_2, …, C_n). Let X_{ij} be the rating score of A_i associated with j^{th} criteria and is defined as follows,

$$x_{ij} \in \left[x_{ij}^{l}, x_{ij}^{u}\right]$$

Weights of criteria are defined as $w_1, w_2 \ldots w_n$ where w_j is the weight of c_j. We can define an MADM problem with interval numbers briefly in a decision making matrix.

Step 1: in TOPSIS method with interval numbers we have to normalize decision making matrix as we show it below:

$$\tilde{a}_{ij}^{l} = \frac{x_{ij}^{l}}{\sqrt{\sum_{j=1}^{m}\left(x_{ij}^{l}\right)^2+\left(x_{ij}^{u}\right)^2}} \qquad i = 1,2,\ldots,n \quad , \quad j = 1,2,\ldots,m$$

$$\tilde{a}_{ij}^{u} = \frac{x_{ij}^{u}}{\sqrt{\sum_{j=1}^{m}\left(x_{ij}^{l}\right)^2+\left(x_{ij}^{u}\right)^2}} \qquad i = 1,2,\ldots,n \quad , \quad j = 1,2,\ldots,m$$

Now $\left[x_{ij}^{l}, x_{ij}^{u}\right]$ are normalized and the calculated domain $\left[a_{ij}^{l}, a_{ij}^{u}\right]$ belongs to$[0,1]$. Because of the differences in importance of each criterion, in the next step we will calculate weighted normalized decision matrix with interval numbers as below:

$$\bar{v}_{ij}^{l} = w_j \tilde{a}_{ij}^{l}, i = 1,2,\dots,n \quad , \quad j = 1,2,\dots,m$$
$$\bar{v}_{ij}^{u} = w_j \tilde{a}_{ij}^{u}, i = 1,2,\dots,n \quad , \quad j = 1,2,\dots,m$$

where w_i is the weight of i_{th} criterion and $\sum_{i=1}^{n} w_i = 1$. Then we describe the ideal positive and negative solutions as:

$$\bar{A}^{+} = \{\bar{v}_1^{+},\dots,\bar{v}_n^{+}\} = \left\{\left(\max_j \bar{v}_{ij}^{u} \middle| i \in I\right), \left(\min_j \bar{v}_{ij}^{l} \middle| i \in J\right)\right\},$$
$$\bar{A}^{-} = \{\bar{v}_1^{-},\dots,\bar{v}_n^{-}\} = \left\{\left(\min_j \bar{v}_{ij}^{l} \middle| i \in I\right), \left(\max_j \bar{v}_{ij}^{u} \middle| i \in J\right)\right\},$$

where “I” is referred to benefit criterion and “J” is referred to cost.

Distances of each alternative from positive and negative solutions have to be calculated by the concepts of n dimensions Euclidean distance method:

$$\bar{d}_j^{+} = \left\{\sum_{i\in I}\left(\bar{v}_{ij}^{l} - \bar{v}_i^{+}\right)^2 + \sum_{i\in J}\left(v_{ij}^{u} - \bar{v}_i^{+}\right)^2\right\}^{1/2}, j = 1,2,\dots,m$$
$$\bar{d}_j^{-} = \left\{\sum_{i\in I}\left(\bar{v}_{ij}^{u} - \bar{v}_i^{-}\right)^2 + \sum_{i\in J}\left(v_{ij}^{l} - \bar{v}_i^{-}\right)^2\right\}^{1/2}, j = 1,2,\dots,m$$

For determining rank of each alternative, we calculate the closeness coefficient as below:

$$\overline{cl} = \frac{\bar{d}_j^{-}}{\bar{d}_j^{-} + \bar{d}_j^{+}} \quad , j = 1,2,\dots,m$$

Based on “closeness coefficient”, we can rank alternatives and select the best one.

2.4. Fuzzy Set

Fuzzy set is an extended form of classic set introduced by Zadeh (Zadeh, 1965). In a classic set, each element has two values. In other words, an element either belongs to a set or not (Liou et al., 2007; Wu & Lee, 2007). If an element becomes a member of set *A*, its related value is equal to 1, and zero, otherwise. However, fuzzy theory is attributing a number between [0 1] to each *x* from *X* (Kaufmann & Gupta, 1991).

A Convex Fuzzy Set: The “A” fuzzy set is convex if and only if for each $x_1, x_2 \in X$ and each $\lambda \epsilon [0, 1]$ we have (Klir & Yuan, 1995):

$$\mu_A[\lambda x_1 + (1-\lambda)x_2] \geq \min[\mu_A(x_1), \mu_A(x_2)]$$

α-cut: The α-cut of fuzzy number $\widetilde{A}$ is defined as:

$$\tilde{A}_\alpha = \{x_i : \mu_{\tilde{A}} \geq \alpha, x_i \in X\}, \alpha \in [0, 1]$$

$\widetilde{A}_\alpha$ is an interval number if it is stated as $\widetilde{A} = [\widetilde{A}_l, \widetilde{A}_u]$ where $\widetilde{A}_l$ and $\widetilde{A}_u$ are lower level and upper level of that interval number (Kaufmann & Gupta, 1991; Zimmermann, 1991). A positive triangular fuzzy number (TFN) $\widetilde{A}$ can be defined as (l, m, u) shown in Fig. 1:

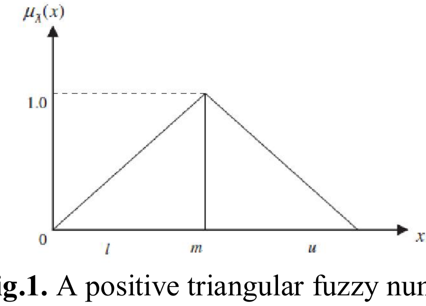

Fig.1. A positive triangular fuzzy number

The membership function $\mu_{\tilde{A}}(x): R \rightarrow [0,1]$ is as follows,

$$\mu_{\tilde{A}}(x) = \begin{cases} (x-l)/(m-l)\,, l \leq x \leq m \\ (u-x)/u-m\,, m \leq x \leq u \\ 0 \qquad\qquad\qquad , \text{otherwise} \end{cases}$$

where l and u mean the lower and upper bounds of the fuzzy number$\tilde{A}$, and m is the modal value for $\tilde{A}$ (as Fig. 1). The operational laws of TFN $\tilde{A}_1 = (l_1, m_1, u_1)$ and $\tilde{A}_2 = (l_2, m_2, u_2)$ are displayed as following Equations:

$$\tilde{A}_1 \oplus \tilde{A}_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$
$$\tilde{A}_1 \ominus \tilde{A}_2 = (l_1, m_1, u_1) \ominus (l_2, m_2, u_2) = (l_1 - l_2, m_1 - m_2, u_1 - u_2)$$
$$\tilde{A}_1 \otimes \tilde{A}_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) = (l_1.l_2, m_1.m_2, u_1.u_2),$$
$$l_1, l_2 > 0, m_1, m_2 > 0, u_1, u_2 > 0$$
$$\tilde{A}_1 \oslash \tilde{A}_2 = (l_1, m_1, u_1) \oslash (l_2, m_2, u_2) = (l_1/u_2\,, m_1/m_2\,, u_1/l_2),$$
$$l_1, l_2 > 0, m_1, m_2 > 0, u_1, u_2 > 0$$
$$\tilde{A}^{-1} = (l_1, m_1, u_1)^{-1} = (1/u_1\,, 1/m_1\,, 1/l_1), l_1, m_1, u_1 > 0$$
$$\tilde{A}_1 \otimes r = (l_1 r, m_1 r, u_1 r)$$

For real-world applications, we utilize some fuzzy and vague statements rather than some crisp terms (Zimmermann, 1991). Very low, low, middle, high and very high are some examples of linguistic terms. Fuzzy numbers can stand for these linguistic terms in a mathematical model.

In this paper, the importance weights of the ratings of qualitative criteria are considered as linguistic variables. In this paper, the decision-makers use the linguistic variables shown in Table 1 to evaluate the ratings of alternatives with respect to qualitative criteria.

Table 1
Basic linguistics terms

VG	G	MG	F	MP	P	VP
(9,10,10)	(7,9,10)	(5,7,9)	(3,5,7)	(1,3,5)	(0,1,3)	(0,0,1)

In this article, we select a supplier that has the lowest amount of risk in relationship with the company. This problem can be defined as a group MADM (GMADM) problem. We consider some steps for modeling these cases as below:

a) A set of k decision maker that is defined by $D= \{D_1, D_2 \ldots D_k\}$

b) A set of m supplier (alternative) that we call it $A= \{A_1, A_2 \ldots A_m\}$

c) A set of n criteria that we evaluate suppliers by those criteria and call it $C= \{C_1, C_2 \ldots C_n\}$

d) A set of performance rate of supplier , A_i (i= 1, 2 … m) in association with criteria (c_j, $j= 1, 2 \ldots n$) that we show it as below:

$$X = \{x_{ij}, i = 1,2, \ldots, m \text{ و } j = 1,2, \ldots, n\}$$

Consider a situation where there are k decision makers in a group and each decision maker D_k and $k = 1,2,..,k$ evaluates suppliers based on fuzzy numbers $\mu_{\tilde{A}}(x)$ that has a membership degree$\mu_{\tilde{A}}(x)$. Decision makers' assessments can be depicted by Triangular Fuzzy Numbers (TFN)$\tilde{A}_k(l_k, m_k, u_k)$, $k = 1,2, \ldots, k$ and after collecting all of decision makers' assessments, fuzzy numbers could be defined as below:

$\tilde{A} = (l, m, u), k = 1,2, \dots, k$

where

$l = \frac{1}{k}\sum_{k=1}^{k} l_k, \qquad m = \frac{1}{k}\sum_{k=1}^{k} m_k, \qquad u = \frac{1}{k}\sum_{k=1}^{k} u_k$

Imagine that fuzzy ranking of k^{th} decision maker about i^{th} alternative related to j^{th} criteria be stated as $\tilde{x}_{ijk} = (l_{ijk}, m_{ijk}, u_{ijk})$ that after gathering experts' opinion, fuzzy number $\tilde{x}_{ij}$ is defined for i^{th} alternative related to j^{th} criteria as follows,

$\tilde{x}_{ij} = (l_{ij}, m_{ij}, u_{ij})$

where

$l_{ij} = \frac{1}{k}\sum_{k=1}^{k} l_{ij}, \ m_{ij} = \frac{1}{k}\sum_{k=1}^{k} m_{ij}, \ u_{ij} = \frac{1}{k}\sum_{k=1}^{k} u_{ij}.$

After choosing adequate linguistic terms for ranking suppliers and translating them to fuzzy numbers, we utilized α-cut method to alternate these fuzzy numbers by interval numbers instead of defuzzification for prioritizing alternatives and then we used a TOPSIS method to rank interval numbers for ranking suppliers.

2.5. Literature Review

Now we review articles and studies, which have performed in the field of food products supply chain. Sharifi et al. (2007) studied establishing the holistic modeling, which include the developed supply chain enterprise in a strategic. Holistic modeling was recognized first by the industry and more recently by the scientific communities. Decision making strategy needs comprehensive models to guide them in effective decision makings that increase the profitability of entire chain.

Determination of the optimal network configuration, inventory management policies, supply contracts, distribution strategies, supply chain integration, provision strategies and finding supply sources out of the company (using another company to supply), product design and information technology are primary examples of strategic decision makings that affects the ability of long-term profitability of the entire supply chain. Sharifi et al. (2007) used a methodology of system dynamics (dynamic systems) as a tool for modeling and analyzing with regard to strategic issues for food of supply chains. They provided a strategy for methodology and then examined its improvement for strategic modeling of one or more columns supply chains. Finally, they analyzed the key issue of strategic supply chain management in-depth where one of them is long-term capacity planning and in particular. They studied the capacity planning strategy for the management of food chains with the unstable limitations of deadline and with market parameters and finally, they showed the executive feasibility of the developed methodology on a network of several major chain of fast food.

Fatahi et al. (2010) evaluated the performance in food supply chain in a case study from meat industry. Performance evaluation was an activity in which help them achieve the strategic goals of the chain. In order to execute a system of evaluation performance, defining appropriate attributes was essential at various levels of the chain. Among the important supply chains, food supply chain requires special attention due to the specific characteristics. Due to the lack of adequate research in this area, in the present research, the attributes in two strategic and organizational levels are organized in order to evaluate the performance of meat products chain and a method is introduced to prioritize them. Many people believe that holistic optimization by vendor managed inventory (VMI) can reduce the overall system cost, significantly. We considered an industrial unit of making cookies in order to be aware of how to divide the cost between retailer and supplier in the food industries. Using suitable data, we compared the total cost of the status quo (ordering traditional model without the VMI) and the ideal situation (synchronized VMI order model). Despite all the problems in the related industry, the results have shown the high performance of VMI, as well as how to divide the profit between the retailer and the supplier clearly.

3. Research Methodology

To analyze the obtained data and select the best supplier among the available suppliers, the TOPSIS method is used. TOPSIS model was introduced by Hwang & Yoon (1981). This model is one of the best models of multi-attribute decision making models and it is used a lot. In this method, *m* options are evaluated by *n* attributes, too. This technique is based on this concept that the selected option shall have the minimum distance from the positive ideal solution (the best possible) and the maximum distance from the negative ideal solution (the worst possible). It is assumed that the utility of each attribute is steadily increasing or decreasing (Hosseini, 2002)

4. Research results

The following tables are showing the calculated results from solving the model based on mentioned steps in TOPSIS Method.

Table 2
Judgments of Experts about Criteria

Criteria		D_1		D_2		D_3		D_4		D_5
C_1	(0.9,0.9,1,1)	VH	(0.7,0.8,0.8,0.9)	H	(0.7,0.8,0.8,0.9)	H	(0.7,0.8,0.8,0.9)	H	(0.7,0.8,0.8,0.9)	H
C_2	(0.9,0.9,1,1)	M	(0.9,0.9,1,1)	VH	(0.9,0.9,1,1)	VH	(0.7,0.8,0.8,0.9)	H	(0.9,0.9,1,1)	VH
C_3	(0.9,0.9,1,1)	VH	(0.9,0.9,1,1)	VH	(0.9,0.9,1,1)	VH	(0.7,0.8,0.8,0.9)	H	(0.9,0.9,1,1)	VH
C_4	(0.1,0.2,0.2,0.3)	L	(0.4,0.5,0.5,0.6)	M	(0.7,0.8,0.8,0.9)	H	(0.7,0.8,0.8,0.9)	H	(0.7,0.8,0.8,0.9)	H
C_5	(0.7,0.8,0.8,0.9)	H	(0,0,0.1,0.2)	VL	(0.1,0.2,0.2,0.3)	L	(0.7,0.8,0.8,0.9)	H	(0.4,0.5,0.5,0.6)	M
C_6	(0.4,0.5,0.5,0.6)	M	(0.7,0.8,0.8,0.9)	H	(0.7,0.8,0.8,0.9)	H	(0.1,0.2,0.2,0.3)	L	(0.4,0.5,0.5,0.6)	M

Judgments of Experts about Alternatives and Decision matrix gained from experts' judgments are summarized in Table 3 and Table 4.

Table 3
Judgments of Experts about Alternatives

	A_1					A_2					A_3					A_4					A_5				
	D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5
c_1	F	F	F	F	F	MP	MP	P	MP	P	MP	F	F	F	P	F	F	F	MG	F	F	MG	F	MG	F
c_2	F	MP	F	P	F	MG	MP	F	MP	F	MG	F	F	MP	F	MG	F	F	F	F	G	F	MG	F	F
c_3	F	MP	F	F	F	F	MP	F	F	F	F	F	F	MP	F	G	F	MG	F	MG	G	MG	MG	F	MG
c_4	MG	P	F	F	F	MG	MG	F	F	MP	MP	F	F	F	MP	F	F	MG	MG	MP	F	MG	F	F	MP
c_5	MG	F	F	MG	MG	MG	F	MG	F	MG	F	F	MG	F	F	MG	F	F	MG	G	F	MP	MP	MG	G
c_6	G	F	F	MG	F	G	MG	MG	MP	F	MP	MG	F	F	MP	F	F	G	F	MG	F	MP	G	G	G

Table 4
Decision matrix gained from experts' judgments

	A_1					A_2					A_3					A_4					A_5				
	D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5	D_1	D_2	D_3	D_4	D_5
c_1	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(2,3,4,5)	(2,3,4,5)	(1,2,2,3)	(2,3,4,5)	(1,2,2,3)	(2,3,4,5)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(1,2,2,3)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)
c_2	(4,5,5,6)	(2,3,4,5)	(4,5,5,6)	(1,2,2,3)	(4,5,5,6)	(5,6,7,8)	(2,3,4,5)	(4,5,5,6)	(2,3,4,5)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(4,5,5,6)	(2,3,4,5)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(7,8,8,9)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(4,5,5,6)
c_3	(4,5,5,6)	(2,3,4,5)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(2,3,4,5)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(2,3,4,5)	(4,5,5,6)	(7,8,8,9)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(5,6,7,8)	(7,8,8,9)	(5,6,7,8)	(5,6,7,8)	(4,5,5,6)	(5,6,7,8)
c_4	(5,6,7,8)	(1,2,2,3)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(5,6,7,8)	(5,6,7,8)	(4,5,5,6)	(4,5,5,6)	(2,3,4,5)	(2,3,4,5)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(2,3,4,5)	(4,5,5,6)	(4,5,5,6)	(5,6,7,8)	(5,6,7,8)	(2,3,4,5)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(4,5,5,6)	(2,3,4,5)
c_5	(5,6,7,8)	(4,5,5,6)	(4,5,5,6)	(5,6,7,8)	(5,6,7,8)	(5,6,7,8)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(4,5,5,6)	(5,6,7,8)	(7,8,8,9)	(4,5,5,6)	(2,3,4,5)	(2,3,4,5)	(5,6,7,8)	(7,8,8,9)
c_6	(7,8,8,9)	(4,5,5,6)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(7,8,8,9)	(5,6,7,8)	(5,6,7,8)	(2,3,4,5)	(4,5,5,6)	(2,3,4,5)	(5,6,7,8)	(4,5,5,6)	(4,5,5,6)	(2,3,4,5)	(4,5,5,6)	(4,5,5,6)	(7,8,8,9)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(2,3,4,5)	(7,8,8,9)	(7,8,8,9)	(7,8,8,9)

Table 5
Decision matrix gained from the average of experts' judgments

	A_1	A_2	A_3	A_4	A_5
c_1	(4,5,5,6)	(2,3,4,5)	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)
c_2	(4,5,5,6)	(2,3,4,5)	(4,5,5,6)	(4,5,5,6)	(5,6,7,8)
c_3	(4,5,5,6)	(4,5,5,6)	(4,5,5,6)	(5,6,7,8)	(5,6,7,8)
c_4	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)
c_5	(5,6,7,8)	(5,6,7,8)	(4,5,5,6)	(5,6,7,8)	(4,5,5,6)
c_6	(5,6,7,8)	(4,5,5,6)	(2,3,4,5)	(5,6,7,8)	(7,8,8,9)

Table 6
Fuzzy decision matrix

	C1	**C2**	**C3**	**C4**	**C5**	**C6**
Weights	(0.7,0.8,0.8,0.9)	(0.8,0.9,1,1)	(0.7,0.87,0.93,1)	(0.7,0.8,0.8,0.9)	(0.7,0.8,0.8,0.9)	(0.7,0.8,0.8,0.9)
A1	(5,6,7,8)	(5,7,8,10)	(7,8,8,9)	(7,8,8,9)	(7,8,8,9)	(7,8,8,9)
A2	(7,8,8,9)	(8,9,10,10)	(8,9,10,10)	(7,8.67,9.33,10)	(8,9,10,10)	(7,8.67,9.33,10)
A3	(7,8.67,9.33,10)	(7,8.33,8.67,10)	(7,8.67,9.33,10)	(8,9,10,10)	(7,8.33,8.67,10)	(7,8.67,9.33,10)
A4	(7,8,8,9)	(5,7.33,7.67,9)	(5,6.67,7.33,9)	(7,8,8,9)	(7,8.33,8.67,10)	(7,8,8,9)
A5	(5,6,7,8)	(5,7.33,7.67,9)	(5,6,7,8)	(5,6.67,7.33,9)	(5,6,7,8)	(5,6,7,8)

Table 7
Normalized decision matrix

	C1	C2	C3	C4	C5	C6
A1	(0.35,0.48,0.56,0.72)	(0.4,0.63,0.8,1)	(0.49,0.7,0.74,0.9)	(0.49,0.64,0.64,0.81)	(0.49,0.64,0.64,0.81)	(0.49,0.64,0.64,0.81)
A2	(0.49,0.64,0.64,0.81)	(0.64,0.81,1,1)	(0.56,0.78,0.93,1)	(0.49,0.69,0.75,0.9)	(0.56,0.72,0.8,0.9)	(0.49,0.69,0.75,0.9)
A3	(0.49,0.69,0.75,0.9)	(0.56,0.75,0.87,1)	(0.49,0.75,0.87,1)	(0.56,0.72,0.8,0.9)	(0.49,0.67,0.69,0.9)	(0.49,0.75,0.87,1)
A4	(0.49,0.64,0.64,0.81)	(0.4,0.66,0.77,0.9)	(0.35,0.58,0.68,0.9)	(0.49,0.64,0.64,0.81)	(0.49,0.67,0.69,0.9)	(0.49,0.64,0.64,0.81)
A5	(0.35,0.48,0.56,0.72)	(0.4,0.66,0.77,0.9)	(0.35,0.52,0.65,0.8)	(0.35,0.53,0.59,0.81)	(0.35,0.48,0.56,0.72)	(0.35,0.48,0.56,0.72)

Positive ideal solutions**:**

Table 8
Positive ideal solutions

A^+	(0.9,0.9,0.9,0.9)	(1,1,1,1)	(1,1,1,1)	(0.9,0.9,0.9,0.9)	(0.9,0.9,0.9,0.9)

Negative ideal solutions:

Table 9
Negative ideal solutions

A^-	(0.35,0.35,0.35,0.35)	(0.4,0.4,0.4,0.4)	(0.35,0.35,0.35,0.35)	(0.35,0.35,0.35,0.35)	(0.35,0.35,0.35,0.35)

Alternative distances from positive ideal solutions:

Table 10
Alternative distances from positive ideal solutions

S_1^+	S_2^+	S_3^+	S_4^+	S_5^+
1.660	1.170	1.250	1.610	1.990

Alternative distances from negative ideal solutions:

Table 11
Alternative distances from negative ideal solutions

S_1^-	S_2^-	S_3^-	S_4^-	S_5^-
1.630	2.110	2.070	1.690	1.330

Calculating CCI of suppliers:

Table 12
Calculating CCI of suppliers

CC_1	CC_2	CC_3	CC_4	CC_5
0.495	0.643	0.623	0.512	0.401

Final Rank of suppliers:

Table 13
Final Rank of suppliers

Karimi meat and poultry meat production	A_2	0.643
Fakharan meat and poultry distribution company	A_3	0.623
Baharan meat and poultry distribution company	A_4	0.512
Goushtiran meat and poultry distribution company	A_1	0.495
The meat and poultry distribution of province	A_5	0.401

5. Discussion and conclusion

As can be seen, Karimi meat and poultry meat production, packaging and distribution company that is the oldest producer of meat and poultry meat in Iran, has the highest weight and rank. This indicates that from the decision makers' point of view, long-term cooperation and collaboration with this supplier can make a better future for the factory. The second supplier, Fakharan meat and poultry distribution company, has a good share in the market. The last level is also associated with the meat and poultry cooperative of the province. Factory managers are not willing to be dependent to the state suppliers and prefer to deal with private suppliers. According to the results, it is recommended to plant managers and decision makers, to have interaction with suppliers based on a prioritized list of suppliers and this could guarantee the long-term interaction and profitability for the company. Supplier is one of the essential elements of supply chain and its selection needs comprehensive assessment. The current method used in this company is not an accurate and documented method and sometimes causes personal opinions involve in the selection of suppliers and cause to appear a problem in the supply chain targets. Therefore, the evaluation and selection of suppliers in this company needs a system that has a pre-determined criteria and follows certain principles of selection and decision making. In the proposed method, it is tried to apply the criteria and opinions of the managers in order to draw a secure pattern to select the supplier.

At the end, in addition to the above matters that can be suggested for future research, there is an issue that many companies deal with it and this issue is having a managerial approach towards the supplier selection. In fact, it is important that we cannot have a quantitative approach towards the issue and the quantitative approach cannot fulfill the needs of the managers, solely, is an issue that is seen in the current position of the industry clearly. Therefore we recommend to discuss other issues, such as how to interact with partners and suppliers, how to form relationships with suppliers based on supply chain.

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