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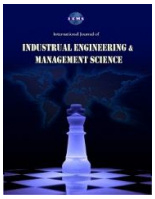

Evaluating The Performance of Chicken Meat Suppliers In The Arak Metropolis Using Fuzzy TOPSIS(FT)

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ABSTRACT

Deciding and selecting a supplier is a multi-criteria problem. This issue is strategically crucial for most organizations. The nature of such decisions is mostly complex and unstructured. Management science techniques can be useful and helpful in making decisions for these issues. The purpose of this article is to apply the Fuzzy Topsis(FTOPSIS) technique to select the best chicken meat supplier company in the Arak metropolis with maximum compliance with the set criteria. These criteria are obtained through interviews with purchasing managers. Managers in practice use these criteria in evaluating and selecting supplier companies. To collect opinions of chicken meat store managers (24 stores), instruments such as questionnaires were employed. Fuzzy Likert Scale (FLS) was utilized to convert verbal data obtained from the questionnaires.
Results: The case study indicates that three suppliers out of six suppliers have been selected as the best suppliers after using the FTOPSIS method, considering all the identified criteria. All the analyses in this study Are performed in MATLAB software. The analysis of the data collected by MATLAB software showed that Supplier No.6 (Dorsa Morgh Company) had the best performance and Supplier No. 2 (Fakhrar Company) had the worst performance in 2023.

1. Introduction

Sustainable supply chain (SSC) involves considering social, economic, and environmental issues in all organizational processes. These processes include the entire life cycle of the supply chain from the purchase of raw materials to the design and development of the product and storage, and distribution and delivery of the final product [1]. In other words, supply chain sustainability is a business issue that affects the organization's supply chain and organizational logistics network according to environmental factors, risk, and production waste management. Considerable growth has emerged in the area of the need for the integration of environmental activities with the supply chain management of the organization. The supply chain sustainability approach is a new approach that has dominated operations management in recent years [2]. Sustainability means focusing on the long-term impacts of the company's activities and the continuation of resources for future use simultaneously with today's profitability [3]. In the organization and management literature, sustainability has become a vital tool that guarantees competitive advantage and social responsibility. Nowadays, sustainability has been added to many organizational topics [4]. The sustainable supply chain is also one of these topics related closely to the concept of green supply chain. These concepts emerged to emphasize the significance of social and environmental concerns, and economic factors in supply chain planning [5]. Supply chains have often been managed traditionally and operationally with a focus on cost reduction in the past. Companies have realized in the last twenty years that they need more effective strategies to increase competitiveness in the supply

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chain, so other attributes are also considered in addition to the cost [6].

The food supply chain is one of the most complex and world's largest industry sectors, so ensuring the safety and quality of food has always been a priority [7]. Many experts argue that the competition has been expanded from the level of companies to the competition between their supply chains in today's competitive world [8]. The supply chain needs continuous improvement to be successful in the business environment. Thus, it is necessary to evaluate the performance of different parts of the supply chain, including suppliers [9]. Neely (2005) stated that performance measurement is much discussed, but fewer definitions have been provided for it. Thus, he describes performance measurement as the process of quantifying activity [10]. The comprehensive assessment and evaluation of the performance of enterprises in the form of terms such as efficiency, effectiveness, empowerment, and accountability within the framework of the scientific principles and concepts of management to fulfill organizational goals and tasks in the form of executive plans are called performance evaluation [11]. Performance evaluation of companies has always been one of the challenging issues in management areas [12]. Performance measurement, especially over the last two decades, has received a lot of attention thanks to its significance in performance evaluation [13]. The use of multi-criteria decision-making methods (MCDM) is one of the most well-known and common performance evaluation methods [14].

One of these techniques is the Fuzzy Topsis (FT) method, which by analyzing quantitative and qualitative data is able to provide clear results of decision options in the decision-making process [15].

2. Literature Review

Mohaghar et al. (2013) investigated the issue of supplier selection. The hybrid approach of data envelopment analysis and VIKOR method was used in this study to calculate the efficiency of suppliers [16].Azizi et al. (2015) identified the most significant criteria and sub-criteria of suppliers in the automotive industry. They used the FTOPSIS technique to identify the best supplier. The results revealed that the score obtained from the FTOPSIS method for the best supplier is significantly far from the scores of other suppliers [17].

Pitchipoo et al. (2018) investigated the issue of supplier selection. They employed a hybrid approach including Data Envelopment Analysis (DEA), Shannon Entropy, and Analytic Hierarchy Method (AHP) to evaluate suppliers of a chemical company. They finally identified the best option [18].

In 2018 KhanMohammadi et al. proposed a Multi-Criteria Decision Making (MCDM) model for supplier evaluation and selection in oil production projects. This model considers both qualitative and quantitative factors to assess potential suppliers. The SCOR model is used to identify relevant criteria, the AHP model is used to determine the weights of these criteria, and DEA is used to rank suppliers. The authors evaluated the model using data from an oil production company and found that it is effective in selecting the best suppliers [19].

Jafari et al. (2019) evaluated the performance of sub-units of Isfahan Water and Sewerage Company using data envelopment analysis (DEA). The purpose of the mentioned study was to provide a clear picture of the relative efficiency of decision-making units in 2019. The library method was for data collection in this study. All the analyses were performed through mathematical modeling. The results revealed that 11 of the 30 studied units are efficient and the rest of the units are inefficient [20].

In 2020 Wang et al. present a Multi-Criteria Decision Making (MCDM) model for supplier evaluation and selection in the oil production industry in Vietnam. The study uses the Supply Chain Operation Reference (SCOR) model to identify the best applications, performance metrics, and functional requirements of each core process, subprocess, and supply chain operations. The Analytic Hierarchy Process (AHP) is used to evaluate the weight of criteria, and the Data Envelopment Analysis (DEA) is used to rank the suppliers. The study concludes that the proposed MCDM model can help decision-makers to have a stronger and more accurate outcome in selecting the optimal supplier, reducing product costs, and improving competitiveness in the oil production industry. The study also provides a useful guideline for supplier selection in other industries [21].

Jafari and Ehsanifar (2020) investigated an extensively-used technique in multi-attribute decision-making (MADM). These researchers developed the VIKOR method in non-crisp (gray) conditions. The proposed method in this study could evaluate decision options in gray (interval) conditions. This capability was shown with a numerical example at the end of the study [22].

Kamalkhani et al. in a 2022 study suggest using TOPSIS, a multi-criteria decision-making (MCDM) technique, to assess suppliers according to their operational performance. The approach is used in Iran's e-commerce sector, where suppliers are essential to companies' success. The analytic hierarchy process (AHP) is used to establish the weights of the five operational criteria that are identified using the Delphi technique. Next, suppliers are ranked according to their performance using TOPSIS. The authors advise businesses to share the score with their suppliers in order to help them pinpoint areas that need work and to foster a competitive atmosphere that will reward higher performance. The case study illustrates how successful the suggested approach is [23].

Wei et al. in 2022 published a paper that offers a thorough analysis of the application of entropy-based mixed compromise solution technique and Fermatean fuzzy operators to the crucial field of green supplier selection. Through the integration of several criteria and professional perspectives, the study seeks to solve the difficulties and uncertainties associated with the decision-making process for the selection of green suppliers. The efficacy and practicability of the suggested method are demonstrated by applying it to the real-world issue of choosing environmentally friendly suppliers. The study offers a thorough decision-making technique that takes into account the uncertainties and complexities inherent in the process, which makes significant contributions to the field of green supplier selection. The article's conclusions and methods have ramifications for solid waste management, emergency plan evaluation, and sustainable supply chain management [24].

In 2023 Zhong et al. suggested an improved CRITIC (Criteria Importance Through Intercriteria Correlation) method to evaluate and select coal suppliers for a large vertically integrated coal and electricity company in China. The company needs to assess suppliers' performance during a period of coal shortage when market prices rose and some suppliers breached contracts. The traditional CRITIC method can have issues calculating weights when criteria have conflicting value ranges. The improved method

limits the conflict value range to [0,1] to avoid this issue. Using short-term shipment data, the company evaluated 36 suppliers with the original, CRITIC, and improved CRITIC methods. Results show that the improved method better reflects supplier performance during the coal shortage period and avoids unreasonable weights. The improved CRITIC method provides an objective data-driven way to rapidly evaluate suppliers based on dynamic operational data in an information system, meeting the company's supply chain optimization needs [25].

In 2023 Dehghani Sadrabadi et al, present a robust-stochastic data envelopment analysis (DEA) model for evaluating supplier performance in the telecommunications industry under uncertainty. DEA measures efficiency of decision-making units using multiple inputs and outputs. The proposed model uses a hybrid approach calculating efficiency based on distance from the efficient frontier and anti-efficient frontier. It applies robust optimization to address uncertainty in parameters. The model is tested on 90 supplier units for an Iranian telecom company considering inputs like human resources and outputs like adaptability. Results show human resources and cash assets are important inputs while adaptability, reliability, visibility and coordination are key outputs. Using robust optimization helped control fluctuations and maintain optimal efficiency levels under different scenarios. Overall the model provides a valid way to evaluate and rank telecom suppliers on resilience and agility, addressing uncertainty [26].

3. Methods

The statistical population in this study included 24 people including the managers of 24 different chicken meat stores in Arak city. Field and library methods were used to collect data. The field method is appropriate for determining the attributes of the evaluation model, and the library method is appropriate for collecting data related to the suppliers' performance (6 cases in total) in the attributes approved in the previous stage. The data collection tool also includes a questionnaire, which will be discussed later. In the implementation phase, the FTOPSIS method is used to determine the score of each supplier.

4. FTOPSIS Algorithm

This method includes the following steps [27]:

Step 1: Quantifying and descaling the decision matrix ($\tilde{D}$). In this step, fuzzy numbers are assigned to the verbal variables in the decision matrix to quantify all the elements in this matrix. Now, if set B represents the set of criteria with a positive aspect (profit) and set C represents the set of criteria with a negative aspect, to descale the decision matrix $\tilde{D}$ and form the descaled matrix $\tilde{R} = \left[\tilde{r}_{ij}\right]_{m\times n}$, we use the following equations:

$$\tilde{r}_{ij} = \left(\frac{a_{ij}}{c_j^+}, \frac{b_{ij}}{c_j^+}, \frac{c_{ij}}{c_j^+}\right); \quad j \in B \tag{1}$$

$$\tilde{r}_{ij} = \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right); \quad j \in C \tag{2}$$

In these equations, we have

$$c_j^+ = max_i c_{i,j}\,; \quad j \in B \tag{3}$$

$$a_j^- = min_i a_{i,j}\,; \quad j \in C \tag{4}$$

Step 2: Obtaining the weighted descaled matrix ($\tilde{V}$). We multiply the descaled matrix $\tilde{D}$ by the weight column matrix of criteria ($\tilde{W}_{n\times 1}$), that is:

$$\tilde{V} = \left[\tilde{v}_{i,j}\right]_{m\times n}; \quad i = 1,2,\dots,m \;\; and \;\; j = 1,2,\dots,n \tag{5}$$

Where,

$$\tilde{v}_{i,j} = \tilde{w}_j \times \tilde{r}_{i,j} \tag{6}$$

So that $\tilde{w}_j$ is the weight of the jth criterion.

Step 3: Determining the positive ideal solution and the negative ideal solution using the following two equations:

$$A^+ = (\tilde{v}_1^+, \tilde{v}_2^+, \quad \dots, \tilde{v}_n^+) \tag{7}$$

$$A^- = (\tilde{v}_1^-, \tilde{v}_2^-, \quad \dots, \tilde{v}_n^-) \tag{8}$$

Where,

$$\tilde{v}_j^+ = max_i\{v_{i,j}^u\}; \quad j = 1,2,\dots,n \tag{9}$$

$$\tilde{v}_j^- = min_i\{v_{i,j}^l\}; \quad j = 1,2,\dots,n \tag{10}$$

Step 4: Obtaining the distance of each option from positive and negative ideals.

The Euclidean distance of each option from the positive ideal (A^+) and the distance of each option from the negative ideal (A^-) are calculated based on the following equations.

$$d_i^+ = \sum_{j=1}^{n} d_v\left(\tilde{v}_{i,j}, \tilde{v}_j^+\right); \quad i = 1,2,\dots,m \tag{11}$$

$$d_i^- = \sum_{j=1}^{n} d_v\left(\tilde{v}_{i,j}, \tilde{v}_j^-\right); \quad i = 1,2,\dots,m \tag{12}$$

Where, d_v is the distance between two triangular fuzzy numbers ($d_v(\tilde{x},\tilde{y}) = \sqrt{\frac{(x^l-y^l)^2+(x^m-y^m)^2+(x^u-y^u)^2}{3}}$).

Step 5: Determining the relative closeness (CL) of an option to the ideal solution.

$$CL_i = \frac{d_i^-}{d_i^- + d_i^+}; \quad i = 1,2,\dots,m \tag{13}$$

Step 6: Ranking the options. Based on the calculated relative closeness of each option, the option that has a greater relative closeness is placed at a higher level of the ranking of options.

5. Case Study

As stated before, the purpose of this study is to evaluate the performance of chicken meat suppliers from the customers' viewpoint (i.e. managers of chicken meat stores). In this regard, 6 chicken meat suppliers and 24 chicken meat stores were identified in Arak City. Important and influential attributes or criteria in selecting a chicken meat supplier were identified by conducting face-to-face interviews with the managers of these stores and a group of academic professors based on previous studies [28,29,30,31,32]. These attributes are 1-price of chicken meat 2-quality of chicken meat 3-timely delivery 4-packaging method 5-observing the hygiene.

As mentioned earlier, the statistical population of this research included 24 people, eleven of whom had a diploma, seven of them had a post-graduate degree, and the rest had a bachelor's degree.

The chicken meat supplier companies are: 1- Sabin Tejarat Company 2- Fakhrar Company 3- Makian Behsa Morgh Company 4- Arak Tihoo Company 5- Amiran Star Company 6- Dorsa Morgh Company.

Each store manager was asked to complete the researcher-designed questionnaire using verbal variables (very low (VL), low (L), medium (M), high (H), and very high (VH). The stated questionnaire includes 35 different questions, the first 5 of which are about the importance of attributes, and the next 30 questions are about the performance of each of the suppliers in the 5 identified attributes. After collecting all the questionnaires using the Fuzzy Likert Scale (FLS), shown in Table 1, all the verbal variables were converted into Triangular Fuzzy Numbers (TFN). This fuzzy system is shown in Figure 1 for more clarification.

Table 1. Fuzzy membership functions [33]

Verbal variable	Fuzzy number	Membership function
very low (VL)	$\tilde{1}$	(1,1,2)
low (L)	$\tilde{2}$	(1,2,3)
Medium (M)	$\tilde{3}$	(2,3,4)
high (H)	$\tilde{4}$	(3,4,5)
very much (VH)	$\tilde{5}$	(4,5,5)

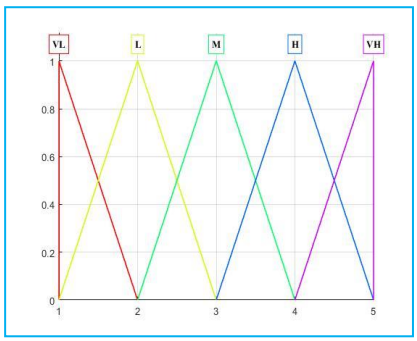

Figure 1. The verbal fuzzy system used [33]

The Cronbach's alpha value obtained from the previous questionnaire is 0.78. Since the alpha value is greater than 0.7, it can be concluded that the used questionnaire is confirmed (defuzzified data were used to calculate Cronbach's alpha). Finally, Table 2 shows the opinions of store managers.

Table 2. Mean opinions of store managers

	The level of satisfaction with the chicken price (+)	The level of satisfaction with the chicken meat quality (+)	The level of satisfaction with timely delivery (+)	The level of satisfaction with packaging (+)	The level of satisfaction with observing hygiene (+)
Weight	(2.96,3.96,4.71)	(3.63,4.63,5)	(3,4,5)	(1.63,2.29,3.29)	(2.63,3.63,4.33)
Sabin Tejarat Company	(2.54,3.5,4.21)	(1.96,2.83,3.71)	(2.13,2.92,3.75)	(2.17,2.92,3.79)	(2.29,3.17,3.96)
Fakhrar Company	(2.08,3.04,3.83)	(2.21,3.04,3.83)	(2,2.88,3.79)	(2.29,3.21,4.08)	(2.25,3.04,3.88)
Makian Behsa Morgh Company	(2.17,3,3.83)	(2.58,3.46,4.13)	(2.38,3.25,4.04)	(2.08,2.88,3.71)	(2.25,3.17,4.04)
Arak Tihoo Company	(2.46,3.42,4.21)	(2.46,3.25,4)	(2.29,3.17,4)	(2.25,3.21,4)	(2.13,3.04,3.96)
Amiran Star Company	(2.5,3.46,4.17)	(2.58,3.42,4.13)	(2.08,2.92,3.75)	(1.83,2.58,3.46)	(1.92,2.75,3.58)
Dorsa Morgh Company	(2.29,3.25,4.13)	(2.25,3.08,3.96)	(2.38,3.17,3.96)	(2.46,3.46,4.29)	(2.38,3.25,4.04)

Figure 2 displays a better comparison of the weights of the attributes, the importance of each of the attributes is displayed in the form of a fuzzy and definite bar chart.

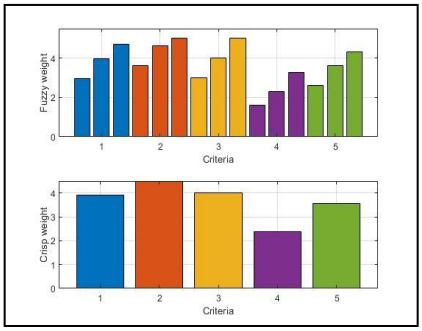

Figure 2. The importance of each attribute in the form of fuzzy and definite bar charts

According to the Chart in Figure 2, it can be stated that the second and fourth attributes have the highest and lowest importance, respectively. Table 3 shows the normalized matrix by the FTOPSIS method.

Table 3. Normalized matrix by the FTOPSIS method

	The level of satisfaction with the chicken price	The level of satisfaction with the chicken meat quality	The level of satisfaction with timely delivery	The level of satisfaction with packaging	The level of satisfaction with observing hygiene
Sabin Tejarat Company	(0.6,0.83,1)	(0.47,0.69,0.9)	(0.53,0.72,0.93)	(0.51,0.68,0.88)	(0.57,0.78,0.98)
Fakhrar Company	(0.49,0.72,0.91)	(0.54,0.74,0.93)	(0.5,0.71,0.94)	(0.53,0.75,0.95)	(0.56,0.75,0.96)
Makian Behsa Morgh Company	(0.52,0.71,0.91)	(0.62,0.84,1)	(0.59,0.8,1)	(0.48,0.67,0.86)	(0.56,0.78,1)
Arak Tihoo Company	(0.58,0.81,1)	(0.6,0.79,0.97)	(0.57,0.78,0.99)	(0.52,0.75,0.93)	(0.53,0.75,0.98)
Amiran Star Company	(0.59,0.82,0.99)	(0.62,0.83,1)	(0.51,0.72,0.93)	(0.43,0.6,0.81)	(0.48,0.68,0.89)
Dorsa Morgh Company	(0.54,0.77,0.98)	(0.54,0.75,0.96)	(0.59,0.78,0.98)	(0.57,0.81,1)	(0.59,0.8,1)

Table 4 shows the weighted normalized matrix using the FTOPSIS method.

Table 4. weighted matrix by FTOPSIS method

	The level of satisfaction with the chicken price	The level of satisfaction with the chicken meat quality	The level of satisfaction with timely delivery	The level of satisfaction with packaging	The level of satisfaction with observing hygiene
Sabin Tejarat Company	(1.79,3.29,4.71)	(1.72,3.17,4.49)	(1.58,2.89,4.64)	(0.82,1.56,2.91)	(1.49,2.85,4.24)
Fakhrar Company	(1.46,2.86,4.28)	(1.94,3.41,4.64)	(1.49,2.85,4.69)	(0.87,1.71,3.13)	(1.46,2.73,4.16)
Makian Behsa Morgh Company	(1.53,2.82,4.28)	(2.27,3.88,5)	(1.77,3.22,5)	(0.79,1.54,2.85)	(1.46,2.85,4.33)
Arak Tihoo Company	(1.73,3.22,4.71)	(2.16,3.64,4.84)	(1.7,3.14,4.95)	(0.85,1.71,3.07)	(1.39,2.73,4.24)
Amiran Star Company	(1.76,3.25,4.67)	(2.27,3.83,5)	(1.54,2.89,4.64)	(0.7,1.38,2.65)	(1.25,2.47,3.84)
Dorsa Morgh Company	(1.61,3.06,4.62)	(1.98,3.45,4.79)	(1.77,3.14,4.9)	(0.93,1.85,3.29)	(1.55,2.92,4.33)

Table 5 shows positive and negative ideal options by FTOPSIS method.

Table 5. positive and negative ideal options are displayed by FTOPSIS method

	The level of satisfaction with the chicken price	The level of satisfaction with the chicken meat quality	The level of satisfaction with timely delivery	The level of satisfaction with packaging	The level of satisfaction with observing hygiene
A^+	4.71	5	5	3.29	4.33
A^-	1.46	1.72	1.49	0.70	1.25

Table 6 shows the distance of each of the options from the ideal options, the final score of each of the options, and the obtained rank.

Table 6. Distance of the options from the positive and negative ideal and the final score of each option

	d^-	d^+	Score	Rank	Accept or Reject
Sabin Tejarat Company	9.30	9.99	0.482	4	reject
Fakhrar Company	9.19	10.13	0.476	6	reject
Makian Behsa Morgh Company	9.71	9.63	0.502	3	accept
Arak Tihoo Company	9.91	9.54	0.509	2	accept
Amiran Star Company	9.24	9.96	0.481	5	reject
Dorsa Morgh Company	9.96	9.54	0.511	1	accept

For a better comparison of chicken meat suppliers, Figure 3 displays the score of each of these suppliers in the form of a stem chart.

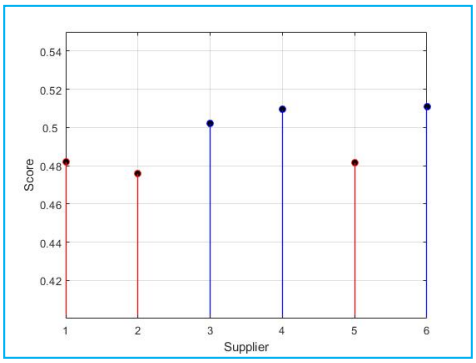

Figure 3. Scores obtained from the FTOPSIS method

Considering fifty percent of the best suppliers, the list of selected cold chicken supplier companies will be as follows:

1- Makian Behsa Morgh Company
2- Arak Tihoo Company
3- Dorsa Morgh Company

6. Conclusion

The food industry is one of the oldest and most important industries in the world. This industry consists of a complex network of industries that includes all the processes of agricultural and crop cultivation, animal husbandry and fishing, processing, production, and distribution. The logistics and supply chain of the food industry includes all types of food such as meat, vegetables, and processed materials. The performance evaluation attributes of chicken meat suppliers in Arak City were identified in this article. Then, the performance of 6 chicken meat suppliers in 2023 was discussed using fuzzy set theory and the FTOPSIS model. The identified attributes include 5 items, and chicken meat supplier companies also include 6 items. The analysis of the data collected by MATLAB software showed that Supplier No.6 (Dorsa Morgh Company) had the best performance and Supplier No. 2 (Fakhrar Company) had the worst performance in 2023.

Next researchers are suggested to evaluate the performance of private and public organizations by using fuzzy non-parametric models such as data envelopment analysis (DEA).

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