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Prioritizing and Determining the Optimum Composition of Products using Fuzzy Multi-criteria Decision Making Approach

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Abstract: Today, due to the increasing complexity of the environment and the many variables influencing the decision making process of the managers and furthermore the need for reducing the operating costs of organizations that are considered as one of the major concerns of managers, optimization of production processes of all factories and production institutes have been in the spotlight of the managers. To reduce this complexity, the use of appropriate tools for monitoring and analyzing costs and appropriate policies in this regard, is of particular importance . Objective of this project is to use Fuzzy multiple-criteria decision-making methods to prioritize and optimize product composition of a factory. To achieve this goal, first the factors influencing the prioritization of products through observation, library research and interviews with experts were identified then importance weights of criteria was obtained by analytic hierarchy process method. In latter stage, using Fuzzy TOPSIS method and the obtained weights from the previous step products were prioritized. Then to obtain the optimum composition of production, through placing the similarity index for each product instead of an objective function coefficient a linear program affected by restrictions of production, has been offered and the optimum composition of production is obtained. Eventually the obtained answers have been compared with the current situation through the problem solving model (favorable situation).

Keywords: optimum composition of production, Fuzzy analytic hierarchy process, Fuzzy TOPSIS, a linear programming model

INTRODUCTION

In today's competitive world, organizations need to try aggressively for their growth and sustainability and adopt appropriate strategies for development and survival. In the past an organization's products both goods and services were purchased by the customer and they didn't have any particular concern to create changes in their system or improve it. But gradually by increasing the number of producers and the emergence of more competitors, customers were not forced to choose and the provider organizations were so many that the customers could choose commodities they needed among preferred and appropriate options. In such an era productive firm to survive in this competitive environment, in order to make a profit is inevitable to pay attention to other factors such as customer satisfaction, competitive advantage achievement, customer demand, product quality, the ease of production, sale market and. …

The main problem of this research is to obtain effective criteria on company benefits achievements and prioritizing and determining the optimum composition of production, based on these criteria. As a result first the effective criteria must be identified, and then a suitable method is suggested. Also the suitable limitations are to be considered and finally according to the analysis of the obtained results, the appropriate solutions and suggestions to be presented.

Previously, much research has been done on multi-criteria decision making section. But according to studies, for solving problems related to prioritizing and determining the optimum composition of production, hierarchical and TOPSIS methods in Fuzzy environment have not been used and this research may be one of the first attempts to modulate Fuzzy hierarchy and Fuzzy TOPSIS to prioritize the products. Also identifying effective indicators in the business interests of the company and to quantify them is another aspect of the innovation of this study. Indices initially have been paired compared with verbal variables by decision makers then using the triangular Fuzzy numbers has been quantified. To determine the criteria weight, Matlab software has been used. Prioritizing products is also performed by Fuzzy TOPSIS software (in Excel). Finally linear programming model was written with the constraints of the production and in the software of lingo11 was solved and optimum composition of factory production was obtained. Using exact mathematical methods in the study, making accurate calculations and free from personal judgments to be made .

Literature

In this section a summary of research done in the field of multi-criteria decision-making is described. Extensive research in the field of research method has been done which some of them inside and outside of the country will be pointed out :

Foreign research

Han Park ET al.[1] in 2011 developed TOPSIS for Fuzzy decision-making problems with the distance data under Fuzzy environment, and introduced TOPSIS method to be as one of the best methods to solve Fuzzy problems. Lee et al. [2] in 2008 created a new method based on Fuzzy analytic hierarchy process and balanced scorecard to evaluate the technology in the industry of Taiwan. First, in this study, strategic concepts such as vision, organizational mission, strategy and major success factors are detailed. Then in order to consider the qualitative and quantitative criteria of critical success factors through paired comparisons are weighted with Fuzzy values. In the next stage, indicators related to the selected processes in four areas of balanced scorecard have been categorized to evaluate the performance of various sectors. In the end the results obtained by the model implementation are shown during two consecutive terms. The results show that Fuzzy MADM techniques, using a structured methodology, are practiced successfully in designing balanced scorecard as a performance management system based on strategies. Raj and Kumar [3] 2007 suggested a model with a specific framework for organization to choose the supplier regarding risk factors. In this model verbal phrases, provided by experts have been used to evaluate and determine each supplier performance compared to each criterion and determine criteria weighting. Verbal rankings are expressed using triangular and trapezoidal Fuzzy numbers and finally multi-criteria decision-making approach have been used to choose suppliers a method was used to calculate the weight and ranking of the options in Fuzzy TOPSIS technique. Tolga et al [4] in 2006 developed the TOPSIS to group Fuzzy decision-making. These researchers introduced TOPSIS as a practical and useful methodology for ranking and selection out of a number of options through distance criterion. The model proposed in this paper is actually a unified process and is easily used for many real-world decision-makings without increasing the computational load. Chama and Griss [5] in 2006, began selecting materials for a kind of turbines using a MADM approach. This research led to the selection of the best materials for turbine power using one of the approaches of MADM and Fuzzy verbal variables .

Internal research

Zarrabi and Varesi [6] in 2011 by incorporating two methods of AHP and TOPSIS under Fuzzy environment did the valuation and spatial analysis of indices development in Ardabil province. In this study, 45 of development indicators including cultural, economic, infrastructure development indicators in rural areas and physical indicators in urban areas of Ardabil were evaluated. In this paper first, weight of indices was calculated by AHP method that 15 indices with importance grade of zero were eliminated. Then using TOPSIS, prioritizing areas was discussed. Combining the results indicate that the cities of Nir and Garmi, respectively, with a score of 447.0 and 442.0 are two developed cities and the cities of Ardabil, Pars Abad Bilesavar rated 431.0, 421.0 and 418.0 are developing cities. Khorshid and Ranjbar [7] in 1389, by combining network AHP and Fuzzy TOPSIS did the strategic analysis of SWOT matrix. Researchers were able to combine these two methods to innovate a method to support strategic analysis; strategy formulation and selection. This incorporation could balance the ambiguities and inherent uncertainties in the process of strategic decision-making and determine importance degrees of organization strengths, weaknesses and environmental opportunities and threats. In addition, it could rate edited strategies based on the effects of SWOT strategic factors on the success of the organization and provide sufficient insight and understanding for the strategic management team of the organization compared to competencies and capabilities of their organization in its surrounding operation to achieve competitive advantage. Pourkazemi and Najafi [8] in 1385, rated shahrvand chain stores using multi-criteria decision-making techniques. The main emphasis in this case study is evaluation of appropriate methodologies for modeling and measuring the quality of Shahrvand chain stores. Criteria mentioned in this study are in three categories: financial performance criteria, customer satisfaction criterion and employee satisfaction criterion. In this study, 4 stores were assessed out of the Shahrvand chain stores. Research method was first descaling the soft and linear method and then giving weight or evaluating weights for indices through entropy method and AHP and finally choosing the best store, and average ranks and TOPSIS methods have been used and have achieved the results such as performance measure easy access and adopting major decisions such as expansion of stores, Prioritizing and promoting the staff performance and identifying and removing the troubles. Azimi [9] in 2006 during a research called identification and ranking of barriers or assessment related to Iran Khodro products distribution channels using analytic hierarchy process approach in Tarbiat Modares University, while identifying the marketing barriers of distribution channels (including lacking known relationship between producer and representative, quotas for representatives and inadequate representatives' profit share per each vehicle sale) prioritized them better based on the Fuzzy analytic hierarchy process approach. Hadavi Nejad [10] in 2004 in a research called identification of the effective factors on stock selection in Tehran Stock Exchange using multi-objective decision-making approach in University of Imam Sadiq, first the primary effective criteria on stock selection were detected in Tehran Stock Exchange. Eventually they introduced the profit factors, technology and economic control, respectively as the final result of their research as the most important stock selection in Tehran Stock Exchange.

MATERIALS AND METHODS

One of the important steps prior to the assessment of the problem being studied, is to select appropriate model or models .

Based on the studies presented in this study, the preliminary conceptual model is shown in Figure 1. The model consists of three Fuzzys. During the first Fuzzy, using the paired comparisons matrix and Fuzzy AHP method the weight of each factor has been determined. In the second Fuzzy using Fuzzy TOPSIS technique products have been prioritized and finally in the third Fuzzy using linear programming and using the weights obtained in the first Fuzzy as linear composition coefficients, the optimum composition of production is achieved.

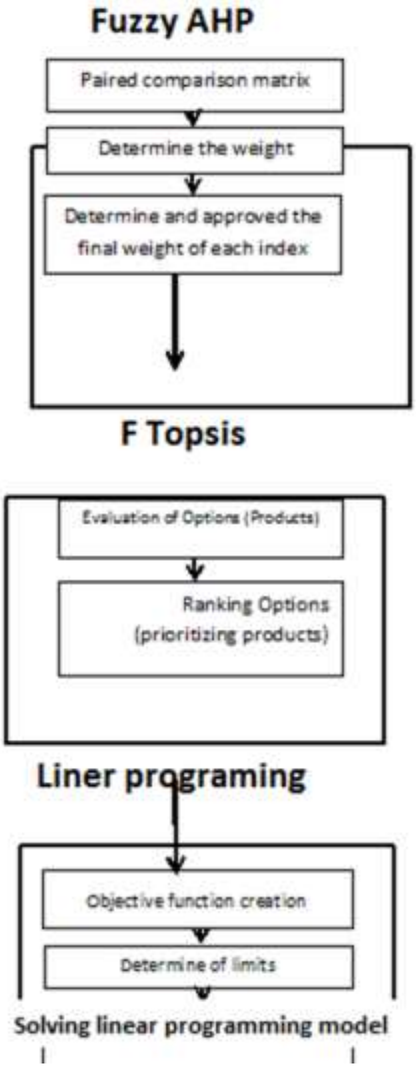

Figure 1.shows the research process

Fuzzy I: FAHP

Step 1: Drawing the hierarchy chart

Step 2: Defining the Fuzzy numbers in order to perform paired comparisons

In this study, verbal phrases have been used instead of absolute values to do paired comparisons and to determine the indices weight. Verbal phrases are presented in Table 1 to describe the importance of the criteria with each other[11].

Table 1. Verbal phrases to describe the importance of the criteria

Fuzzy number	verbal variable	Scale of Fuzzy number
1	Equal	(1, 1, 1)
2	Infinitely less important	(1,2,3)
3	much less important	(2,3,4)
4	less important	(3,4,5)
5	Average	(4,5,6)
6	Important	(5,6,7)
7	Very important	(6,7,8)
8	Extremely important	(7,8,9)
9	The absolute importance	(8,9,10)

To describe Fuzzy kind of the problem and change verbal variables into the Fuzzy numbers, triangular Fuzzy numbers have been used as $\tilde{A}$ = (L, m, n). In this study, the selected membership function for Fuzzy numbers is as follows [12]:

$$(x) = \begin{cases} 0 & x < l \\ x - l/m - l & l \leq x \leq m \\ u - x/u - m & m \leq x \leq u \\ 0 & x > u \end{cases} \quad (1)$$

Step 3: the paired comparison matrix ($\tilde{A}$) using Fuzzy numbers[13].

$$\widetilde{A} = \begin{bmatrix} \tilde{1} & \cdots & \widetilde{a_{1n}} \\ \vdots & \ddots & \vdots \\ \widetilde{a_{n1}} & \cdots & \tilde{1} \end{bmatrix} \qquad \text{s.t} \quad \widetilde{a_{ij}} = \begin{cases} 1 & i = j \\ \tilde{2}, \tilde{3}, \ldots, \tilde{9}, \tilde{2}^{-1}, \tilde{3}^{-1}, \ldots, \tilde{9}^{-1} & i \neq j \end{cases} \quad (2)$$

Step 4: Calculating S_k for each of the rows .

S_k is a triangular Fuzzy number itself. Is calculated from the following equation[14]:

$$S_k == \sum_{j=1}^{n} M_{kj} \times \left[\sum_{i=1}^{m} \sum_{j=1}^{n} M_{ij}\right]^{-1} \quad (3)$$

That k represents the number of row and i And j show options and indicators, respectively .

Step 5: Calculating largeness degree of S_k s compared to each other .

If we assume M_(1) and M_2are two triangular Fuzzy numbers as follows[15]:

$M_1 = (L_1, M_1, U_1), M_2 = (L_2, M_2, U_2)$

Then their largeness degree will be calculated like as follows[16]:

$$V(M_1 \geq M_2) = \begin{cases} 1 \quad if & m_1 \geq m_2 \\ 0 \quad if & l_2 \geq l_1 \\ \frac{u_1 - l_2}{(u_1 - l_2) + (m_2 - m_1)} & otherwise \end{cases} \quad (4)$$

Step 6: Calculating the criteria weight in paired comparison matrices. Therefore following equation is used:

$$\acute{w}(i) = \text{Min}\{V(S_i \geq S_k)\} \qquad k = 1,2,3,\ldots,n \quad k \neq I \; (5)$$

By normalizing the values obtained above, by the formula below, the weight of each criterion is obtained:

$$W_{(i)} = \acute{W}(i) / \sum_{j=1}^{n} \acute{W}(i) \; (6)$$

Fuzzy II: Ptosis

Step 1: the paired comparison matrix associated with the products prioritization compared to each of the criteria: at this point to change verbal variables into Fuzzy triangular numbers, the table below is used :

Table 2. shows changing verbal variables into triangular Fuzzy numbers[17]

Fuzzy numbers	verbal variables
(1,1,3)	Very poor

(1,3,5)	Weak
(3,5,7)	Average
(5,7,9)	Good
(7,9,10)	Very good

Decision-making matrix of D includes m rows and n columns. Each row shows a measuring indicator and each column represents a product. This matrix of paired comparisons will be completed using the verbal variables in Table 2-3 and will be displayed as follows[18].

$$D = \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix}$$

In which xij s are triangular Fuzzy numbers. These numbers are obtained by aggregating the opinions of decision makers which are calculated using the following equation[19]:

Xij=(lij,mij,uij) s.t lij=min{aijk} , mij=(∑_(k=1)^N▒b_ijk)/k , uijk=max{dijk} (7)

In the equation above (an ijk , b ijk , c ijk) are decision-making matrix elements .

Also, since all decision-makers are considered to have equal weight, the formula has become as said before[20] .

Step 2: normalizing matrix of decision-making. In this regard, index values that range from an interval different from (1, 0) are de-scaled 21. De-scaling, method is like the function below:

$$\tilde{r_{ij}}=\left(\frac{a_{ij}}{c_j},\frac{b_{ij}}{c_j},\frac{c_{ij}}{c_j}\right) \quad \text{s.t } c_j= \max c_{ij} \quad (8)$$

In this method, to de-scale decision-making matrix, the data in each column of the matrix are divided by the maximum of the column. Based on this, after normalizing, the data are located between zero and one that number one is the maximum data[21 ,22] .

Step 3: A weighty normalized matrix. for this purpose two following equations are used[23]:

$$\bar{V}=\tilde{r_{ij}}.\tilde{w_j} \quad (9)$$

$$V=\begin{bmatrix} \widetilde{v_{11}} & \cdots & \widetilde{v_{1n}} \\ \vdots & \ddots & \vdots \\ \widetilde{v_{m1}} & \cdots & \widetilde{v_{mn}} \end{bmatrix}$$

Step 4: Defining the positive and negative ideal[24]:

$$V_i^-=\begin{cases} \max\{v_{ij}\} & s.t \quad c_i \ \ is\ associated\ with\ cost \\ \min\{v_{ij}\} & s.t \quad c_i \ \ is\ associated\ with\ benefit \end{cases} \quad (10)$$

$$V_i^+=\begin{cases} \max\{v_{ij}\} & s.t \quad c_i \ \ is\ associated\ by\ benefit \\ \min\{v_{ij}\} & s.t \quad ci \ \ is\ associated\ by\ cost \end{cases} \quad (11)$$

As shown in the above functions. Ideals can be calculated using indicated number one maximum and indicated number one minimum[25].

Step 5: Calculating positive and negative distance between options (products). To calculate the distance between two triangular Fuzzy numbers, the equation below is used. If A and B is two triangular Fuzzy numbers, so the distance between them can be obtained by [26]:

$\tilde{A}=(a_1,b_1,c_1)$ & $\tilde{B}=(a_2,b_2,c_2)$

$$D(\tilde{A},\tilde{B})=\sqrt{\frac{1}{3}[(a_2-a_1)^2+(b_2-b_1)^2+(c_2-c_1)^2} \quad (12)$$

Therefore each of the options' distances from the positive and negative ideal is calculated as follows[27]:

$$D^{+}_{xij}=\sqrt{\sum_{i=1}^{m}(v_{ij}-v_i^{+})^2} \quad \textbf{(13)}$$

$$D^{-}_{xij}=\sqrt{\sum_{i=1}^{\square}(v_{ij}-v_i^{-})^2} \quad (14)$$

Step 6: Calculating similarity index. This is done through the following equation [28]:

$$CC_j=\frac{D_j^-}{D_j^+ + D_j^-} \qquad j=1,2,\dots,n \quad (15)$$

Step 7: Ranking the options. During this stage options have better situations with more similarity index[29].

Fuzzy III: Determining the optimum composition of production using a linear composition

At this stage of research this linear composition model has been presented by replacing products weight (effectiveness of each product to make profits)[30], in objective function coefficients and taking production constraints into account[31].

Max p = $\sum_{i=1}^{n} w_i\, x_i$ (16)

s.t $\sum_{j=1}^{n} a_{ij}x_j \le b_i$ i=1,2,...,m & j=1,2,...,n (17)

$x_j \ge 0$ (18)

Implementation of the proposed model (case study)

In this study, in order to prioritize and obtain the optimum composition of products in a factory, the criteria through library studies and interviews with experts involved in the manufacturing sector, which includes four people have been chosen and have been weighted using a Fuzzy analytic hierarchical process. Then using a Fuzzy TOPSIS method, products have been prioritized and finally with the help of a linear composition, the optimum production composition has been calculated.

Indicators information collecting results:

In this section the way indices weight is calculated has been presented by a Fuzzy analytic hierarchy process as well as the table related to integrate the views of decision makers which has been the result of geometric mean of experts' opinions in paired comparison of criteria. In this research, through library studies and interviews with experts, 10 effective criteria on business interests of a company, were identified. These criteria include: Profitability (c1), Ease of production (C2), Customer demand (C3), Production safety (C 4), The time consumed for production (C 5), Sale Market access (C 6), Production effects on the environment (C 7), Aligning with IT developments (C 8), Product quality (C9) Transportation facilities (C10)

Table 3*. Geometric mean of paired comparisons matrices of experts'* opinions

	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10
C1	(1,1,1)	(6.4,7.4,8.4)	(3.6,4.6,5.6)	(4.5,5.5,6.5)	(6.6,7.6,8.6)	(2.9,3.9,4.9)	(3.1,4.1,5.1)	(4.9,5.9,6.9)	(4.6,5.6,6.6)	**(6.9,7.9,8.9)**
C2	(.12,.14,.16)	(1,1,1)	(4.1,5.1,6.1)	(2.4,3.4,4.4)	(3.6,4.6,5.6)	(2,3,4)	(4,5,6)	(3.8,4.8,5.8)	(1.1,2.1,3.1)	**(4.9,5.9,6.9)**
C3	(.18,.22,.28)	(.16,.2,.24)	(1,1,1)	(4,5,6)	(5.1,6.1,7.1)	(2.6,3.6,4.6)	(4.5,5.5,6.5)	(3.2,4.2,5.2)	(2.1,3.1,4.1)	**(4.9,5.9,6.9)**
C4	(.15,.18,.22)	(.23,.29,.42)	(.17,.2,.25)	(1,1,1)	(4.9,5.9,6.9)	(4.9,5.9,6.9)	(3.2,4.2,5.2)	(5.7,6.7,7.7)	(4.7,5.7,6.7)	**(7,8,9)**
C5	(.12,.13,.15)	(.18,.22,.28)	(.14,.16,.2)	(.14,.17,.2)	(1,1,1)	(2.9,3.9,4.9)	(3.5,4.5,5.5)	(4.2,5.2,6.2)	(2.9,3.9,4.9)	**(3.9,4.9,5.9)**
C6	(.2,.26,.34)	(.25,.33,.5)	(.22,.28,.38)	(.14,.17,.2)	(.2,.26,.34)	(1,1,1)	(5.4,6.4,7.4)	(5.1,6.1,7.1)	(3.9,4.9,5.9)	**(6,7,8)**
C7	(.2,.24,.32)	(.17,.2,.25)	(.15,.18,.22)	(.19,.24,.31)	(.18,.22,.29)	(.14,.16,.19)	(1,1,1)	(5.4,6.4,7.4)	(4.7,5.7,6.7)	**(7.2,8.2,9.2)**
C8	(.14,.17,.2)	(.17,.21,.26)	(.19,.24,.31)	(.13,.15,.18)	(.16,.19,.24)	.14,.16,.2)	(.14,.16,.19)	(1,1,1)	(2.9,3.9,4.9)	**(4.9,5.9,6.9)**
C9	(.15,.18,.22)	(.32,.48,.91)	(.24,.32,.48)	(.15,.18,.21)	(.2,.26,.34)	(.17,.2,.26)	(.15,.18,.21)	(.2,.26,.34)	(1,1,1)	**(7,8,9)**
C10	(.11,.13,.14)	(.11,.13,.14)	(.14,.17,.2)	(.11,.13,.14)	(.17,.2,.26)	(.13,.14,.17)	(.11,.12,.14)	(.14,.17,.2)	(.11,.13,.14)	**(1,1,1)**

Now, we calculated Sk : According to Equation 3, we have:

S_1=(44.50,53.50,62.50). $(\frac{1}{307.83},\frac{1}{260.21},\frac{1}{211.59})$=(0.145,0.206,and 0.295)

S_2=(27.02,35.04,43.06). $(\frac{1}{307.83},\frac{1}{260.21},\frac{1}{211.59})$=(0.088,0.135,0.203)

S_3=(27.74,34.82,41.92). $(\frac{1}{307.83},\frac{1}{260.21},\frac{1}{211.59})$=(0.09,0.135,0.198)

S_4=(31.95,38.07,44.29). $(\frac{1}{307.83},\frac{1}{260.21},\frac{1}{211.59})$=(0.104,0.146,0.209)

S_5=(18.98,24.08,29.23). $(\frac{1}{307.83},\frac{1}{260.21},\frac{1}{211.59})$=(0.062,0.093,0.138)

S_6=(20.40,26.70,31.16). $(\frac{1}{307.83},\frac{1}{260.21},\frac{1}{211.59})$=(0.066,0.103,0.147)

S_7=(19.33,22.54,25.88). $(\frac{1}{307.83},\frac{1}{260.21},\frac{1}{211.59})$=(0.063,0.087,0.067)

S_8=(9.96,12.08,14.29). $(\frac{1}{307.83},\frac{1}{260.21},\frac{1}{211.59})$=(0.032,0.046,0.061)
S_9=(9.58,11.06,12.97). $(\frac{1}{307.83},\frac{1}{260.21},\frac{1}{211.59})$=(0.031,0.042,0.061)
S_{10}=(2.13,2.32,2.53). $(\frac{1}{307.83},\frac{1}{260.21},\frac{1}{211.59})$=(0.007,0.009,0.012)

Table 4. After calculating largeness of Sks criteria weights

Transport	raw materials	Technology Developments	Environment	Market	Time-consumed	Safety	Production capacity	Ease of production	Profit	Criterion
0	0.88	0.01	0.23	0.02	0.39	0.52	0.43	0.45	1	Not normalized weight
0	0.22	0.01	0.06	0.01	0.1	0.13	0.11	0.12	0.25	normalized weight

Table 4 shows the normalized and not normalized criterion weights. According to what has been mentioned so far, it is conceivable that profitability criterion has the highest importance coefficient and the ease of transport with an importance coefficient of zero takes the lowest importance coefficient, so this criterion is removed according to the views of experts in manufacturing sector and by FAHP method.

Prioritizing products by F Topsis method

In this section through interviews with four decision makers, the options are compared against each criterion. (Table 5) is the result of aggregating expert opinions which have been obtained using equation 7. Table 5 comparing the products of each of the criteria

Table 5. compare the products of each of the criteria

	C1	C2	C3	C4	C5	C6	C7	C8	C9
A1	(1,3.5,7)	(1,4,7)	(3,7,10)	(5,7,10)	(1,5,9)	(1,5,9)	(1,5,10)	(1,5,9)	**(1,5.5,9)**
A2	(3,6.5,10)	(3,7.5,10)	(1,5,9)	(1,4.5,9)	(3,5.5,9)	(3,6.5,9)	(3,6,9)	(1,5,9)	**(1,5,9)**
A3	(1,5,9)	(1,4,9)	(3,8,10)	(3,6.5,10)	(1,4,9)	(1,3.5,7)	(1,6,10)	(1,4,9)	**(1,5.5,9)**
A4	(1,5.5,9)	(1,3.5,7)	(3,7,10)	(5,8.5,10)	(1,4,9)	(1,6,10)	(1,4,9)	(1,4.5,7)	**(3,7.5,10)**
A5	(1,4.5,9)	(1,6,10)	(1,5,9)	(3,6.5,10)	(3,4,9)	(1,6,9)	(1,4.5,7)	(1,3,7)	**(1,3,7)**
A6	(3,7,10)	(1,2.5,7)	(1,5.5,9)	(3,6.5,10)	(1,4,9)	(1,4.5,10)	(1,6,10)	(3,6,9)	**(1,4.5,9)**
A7	(5,8,10)	(1,3,7)	(5,8.5,10)	(1,5.5,9)	(1,4.5,9)	(5,8,10)	(1,4,9)	(1,5,9)	**(1,4.5,9)**

A8	(1,5.5,9)	(3,6.5,10)	(1,4.5,9)	(3,6.5,10)	(1,6.5,10)	(3,6,9)	(1,5.5,9)	(1,4,9)	**(1,5.5,9)**
A9	(1,5,9)	(1,5.5,9)	(1,5,9)	(1,6.5,10)	(1,5.5,9)	(3,7,10)	(1,5,9)	(1,4,9)	**(1,4,9)**
A10	(1,5,10)	(1,6.5,10)	(3,7,9)	(3,6,10)	(1,5,9)	(1,3.5,7)	(1,5.5,10)	(1,4,7)	**(3,5.5,9)**
A11	(1,3.5,7)	(1,5,9)	(3,7.5,10)	(1,5.5,10)	(1,6,9)	(1,4.5,7)	(1,4.5,9)	(1,5.5,9)	**(1,3,5)**
A12	(1,6,10)	(1,3.5,7)	(5,7.5,10)	(3,6,9)	(1,3.5,7)	(1,5.5,10)	(3,5.5,9)	(3,5,7)	**(3,6.5,9)**
A13	(1,5,9)	(1,2,5)	(1,5,10)	(1,6,9)	(1,5.5,9)	(3,6.5,7)	(1,6,9)	(1,5.5,10)	**(1,4,7)**
A14	(3,7,10)	(1,3,7)	(1,5,9)	(3,6,10)	(1,5,9)	(1,7,10)	(3,8,10)	(1,6,10)	**(1,3.5,7)**
A15	(0,3.5,7)	(3,7,10)	(1,4.5,9)	(1,6.5,10)	(1,5.5,10)	(3,6,9)	(1,4.5,9)	(3,5.5,9)	**(5,6.5,9)**
A16	(3,7.5,10)	(3,6.5,10)	(1,5,9)	(3,7.5,10)	(3,7,10)	(1,4.5,9)	(3,4.5,9)	(1,4.5,9)	**(1,5,7)**
A17	(1,5,9)	(0,3.5,9)	(1,6,9)	(3,7.5,10)	(5,7.5,10)	(1,5.5,9)	(1,6.5,10)	(1,4.5,9)	**(1,4,7)**
A18	(3,6,10)	(1,2,5)	(1,5.5,9)	(1,5,9)	(3,5.5,9)	(1,4.5,9)	(3,5.5,9)	(3,7,10)	**(1,4.5,9)**

At this stage the weights of the criteria by FAHP method as well as Fuzzy numbers obtained from aggregation of decision makers' opinions about comparison of products with each of the criteria were put in Fuzzy Topsis solver software and the similarity index of each product and as a result product prioritization is obtained as follows.

Table 6. Priority of products and similarity index of products

Row	*Products in priority*	*Similarity index*
1	A6	*0.4112*
2	A13	*0.4035*
3	A14	*0.4016*
4	A9	*0.4002*
5	A8	*0.3975*
6	A11	*0.3846*
7	A3	*0.3769*
8	A1	*0.3570*
9	A10	*0.3523*
10	A5	*0.3521*
11	A17	*0.3474*
12	A18	*0.3412*
13	A7	*0.3393*
14	A12	*0.3342*
15	A4	*0.3133*
16	A15	*0.2985*

17	A2	*0.2979*
18	A16	*0.2780*

Determining the optimum production composition of a factory products

At this stage, with the help of quantitative data coming from documents and reports obtained from the factory and putting the similarity index (effectiveness of each product in profitability), in the coefficient of the objective function instead of profitability, Linear programming model is presented as follows. After solving this model in Lingo software The optimum composition of products is obtained.

$$Maxp=0.357X1+.2979X2+0.3769X3+0.3133X4+0.3521X5+0.4112X6+0.3393X7+0.3975X8+0.4002X9+0.3523X10+0.3841X11+0.3342X12+0.4035X13+0.4016X14+0.2985X15+0.278X16+0.3474X17+0.3412X18 \quad (19)$$

$$0.6X1+0.7X4+0.69X5+0.11X7+0.22X11+0.88X15\leq 11800 \quad (20)$$

$$0.95X3+1.01X6+0.1X8+0.786X9+059X10+0.688X13+0.08X16+0.69X17\leq 39000 \quad (21)$$

$$3.5X1+279X2+124X3+139X4+251X5+169X6+279X7+250X8+152X9+111X10+128X11+201X12+191X13+149X14+71X15+125X16+210X17+38X18\leq 172800000 \quad (22)$$

$$0.006X1+0.71X2+0.21X3+0.25X4+0.81X5+0.52X6+0.91X7+0.89X8+0.45X9+0.28X10+0.12X11+0.17X12+0.19X13+0.49X14+0.17X15+0.61X16+0.9X17+0.15X18\leq 9480000 \quad (23)$$

$$0.44X1+2.9X2+1.8X3+2.08X4+1.82X5+0.97X6+2.01X7+0.7X8+1.23X9+2X10+0.82X11+0.71X12+1.85X13+0.38X14+0.15X15+0.48X16+1.9X17+0.48X18\leq 8484000 \quad (24)$$

$X1\leq 102000$; $X2\leq 95000$; $X3\leq 121000$; $X4\leq 25000$; $X5\leq 98000$; $X6\leq 135000$; $X7\leq 50000$; $X8\leq 32000$; $X9\leq 101000$; $X11\leq 105000$; $X12\leq 92000$; $X13\leq 89000$; $X14\leq 75000$; $X15\leq 210000$; $X16\leq 45000$; $X17\leq 67000$; $X18\leq 21000$;

In the above model equation (19) maximizes the objective function, the constraint (20) is the amount of polyethylene consumed, (21) is polypropylene consumption (22) and (23) and (24) respectively are Related to water and electricity and compact steam consumption per each ton of production.

By solving the model in Ligo11 software the optimum production composition of the factory has been obtained.

Comparing favorable condition (obtained from solving the model) and the current condition

Production composition at the factory being studied is determined in the way that the unit of production planning, after receiving the demand from the company's sales department, holds a meeting with some officials and experts of the company and determines the amount of production of each of the products by mutual agreement for a production period (quarterly) which proceeds. Members in this meeting according to some of the company's goals and current situation based on their experience and mutually determine the amount of the production of each product. Table 7 shows a single minutes planning for the first quarter of 1391, the amount of each of the products that are mentioned in this minutes and the results of the research model.

Table 7. number of production of each product regarding the current and favorable condition of the factory

Products	Total production at the current condition	Total production in the desired condition (research model)
tee 90 °	25000	*Discontinued*
Conversion tee	70000	*95000*
Gear completely Bush	28000	*Discontinued*
Reel	18000	*Discontinued*
Gear completely gooseneck	15000	*Discontinued*
Mixed faucet set	21000	*Discontinued*
Main tap	45000	*50000*
Rolling gooseneck	32000	*32000*
gooseneck 45 °	25000	*Discontinued*
Cap	22000	*Discontinued*
One hit faucet	32000	*28636.36*
Gooseneck 90 °	63000	*92000*
Bridge	50000	*46802.33*
Gear Cap	60000	*75000*
Conversion	32000	*Discontinued*
Bracket	45000	*45000*
Socket	19000	*Discontinued*
Mixed tap set cap	17000	*21000*

CONCLUSION

This research was done according to the need for using an appropriate tool to make decisions in our complicated environment of us. The main goal of this research is to present a suitable method for decision-making about prioritizing and optimizing production composition for achieving which 3 methods of FAHP, F tops is and linear programming were used in a way that using their strength points and omitting all 3 methods defects, an incorporated method was provided. This method in addition to considering qualitative and quantitative indices is able to prevent from inexact mental decision-makings due to using Fuzzy space and regarding the various limitations obtain the optimum production composition and priority. Briefly can be said that logically, considering numerous objectives existing in a problem outweighs considering one or fewer objectives and also structured and regular decision making is preferred compared to unstructured and fairly mental decision-makings.

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