Machine Selection with Fuzzy AHP in a Dairy Factory

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ABSTRACT

A machine selection is an important decision-making process for many corporations. To decrease the negative outcomes of machine choosing decisions, this buying process should be managed carefully. The selection of new machines is a very complex process requiring advanced knowledge and experience. A small mistake may lead to several problems for the engineers, managers and for the machine manufacturers. In this study, the machine buying process of a dairy factory in Aegean Region has been investigated. Firstly, in the study, it is discussed the importance of machine selection in terms of company success strategically. Then, Fuzzy Analytic Hierarchy Process (AHP), which is one of the multi-criteria decision-making methods, is analysed theoretically. In the literature review part, Fuzzy Analytic Hierarchy Process (AHP) applications are given by comparing in different sectors. In the application part, by using Fuzzy Analytic Hierarchy Process (AHP) method, it is ranked among the vendors for the factory's purchasing process of a Cream Separator in order to use in the production process.

Key Words: *Fuzzy AHP, Cream Separator, Machine Selection*

JEL Classification: *M11, C61*

Bir Süt Ürünleri Fabrikasinda Bulanik AHS ile Makine Seçimi

ÖZ

Makine seçimi pek çok kuruluş için önemli bir karar verme sürecidir. Makine seçim kararlarının olumsuz sonuçlarını azaltmak için bu satın alma süreci çok dikkatli bir biçimde ele alınmalıdır. Yeni makinelerin seçimi ileri düzeyde bilgi ve uzmanlık gerektiren çok karmaşık bir süreçtir. Küçük bir hata mühendisler, yöneticiler ve makine imalatçıları için çeşitli sorunlara yol açabilir. Bu çalışmada, Ege Bölgesindeki bir süt ürünleri fabrikasında makine satın alma süreci araştırılmıştır. Çalışmada ilk olarak makine seçiminin şirketler açısından stratejik önemine değinilmiştir. Daha sonra çok kriterli karar verme yöntemlerinden biri olan Bulanık Analitik Hiyerarşi Süreci teorik olarak incelenmiştir. Literatür taraması kısmında ise Bulanık Analitik Hiyerarşi Süreci farklı sektörlerdeki kullanımları ile karşılaştırılarak verilmiştir. Çalışmanın uygulama kısmında ise fabrikanın üretim sürecinde kullanmak için krema ayırma makinesi satın alma aşamasında Bulanık Analitik Hiyerarşi Süreci yöntemi kullanılarak tedarikçiler arasında sıralama yapılmıştır.

Anahtar Kelimeler: *Bulanık AHS, Krema Ayırma Makinesi, Makine Seçimi*

JEL Sınıflandırması: *M11, C61*

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I. INTRODUCTION

Decision making can basically be defined as the choice of the most suitable alternative from a set of options in accordance with at least one purpose or one criterion. Therefore, the elements of a decision making problem can be considered such as decision-maker, options, criteria, results, environment, and the priorities of decision maker. Decision making process is a crucial activity for many organizations as it leads them to both loss of time and loss of money. Hence, considering the complexity of decision making, scientific criteria became more of an issue as the organizations need to have reliable and accurate forecast results for their decision making phases. Decision making process can be considered as a system which contains within itself a lot of elements, and these elements interact with each other. When there is a change in one or more of these elements, this change can affect the entire system (Özyörük & Özcan, 2008).

A machine selection is an important decision-making process for many corporations. To decrease the negative outcomes of machine choosing decisions, this buying process should be managed carefully. The accuracy of production, JIT process, quality, number of defected products and cost of manufacturing are all important aspects that need to be considered and they all change according to the type of the machine chosen. On the other hand, the selection of new machines is a very complex process requiring advanced knowledge and experience. A small mistake may lead to several problems for the engineers, managers and for the machine manufacturers.

In this study, we would like to investigate the machine buying process of a dairy product factory in Aegean Region, Turkey. The factory is providing high quality standards in its sector by having 750 ton production capacity monthly. The firm has broad dairy product portfolio such as milk, yogurt, ayran, cheese, olive, olive oil etc. In this point, the firm needs to meet the customer satisfaction fully by utilizing advanced manufacturing systems and techniques. Therefore, by having cutting edge technology, it will be easy for the firm to produce the products that cover the consumer demands. Thus, the firm needs to have a brand new cream separator as its production capacity increased from 5000 lt milk processing to 25000 lt milk processing per day.

In this paper, we aim to analyze the machine selection process of a company by using the fuzzy analytic hierarchy process method which is one of the multi-criteria decision-making methods. For this reason, firstly, the fuzzy analytic hierarchy process is examined, and in the literature review part it is given the fuzzy analytic hierarchical process methods with applicability of different fields. In the application part, we give the background information about the company which will make the machine selection and also the company's machine selection process is analyzed in view of the criteria obtained from company by comparing the machine vendors.

II. FUZZY-AHP

People have difficulties on their daily life while making decisions for both tangible and intangible issues, and as a result uncertainty arises. When people need to make their decisions on these uncertain situations, they try to search solutions and fuzzy logic was set forth. Basically, fuzzy logic is very similar to human reasoning, and it is an approach of decision making which has a range of possibilities between YES and NO. Since fuzzy logic is very close to the logic of human thought, the decisions which have been taken by using fuzzy logic methods are more accurate.

Analytic hierarchy process (AHP) is one of the most commonly used multi-criteria decision-making methods, was firstly introduced by Thomas L. Saaty in 1980. Due to the fact that AHP is not fully applicable to decision making in case of uncertainty, the fuzzy AHP technique was developed with the combination of AHP and fuzzy logic which is accepted as an advanced analytical method. AHP can be combined with both quantitative and qualitative methods as it is a systematical decision making technique. However, while setting up comparison matrixes, it is necessary to do pair-wise comparison matrix as the alternatives or attributes increase in the hierarchy because of the efficiency of the model (Bouyssou et al., 2000).

In general, decision maker would find it more reliable to make intermittent assessment rather than making assessment which includes accurate values. Hence, in literature there are quite a few studies related with fuzzy analytic hierarchy method which are put forth by various authors, and one of these studies are put forward by Chang.

To apply the process depending on the hierarchy, according to the method of Chang's (1992) extent analysis, each criterion is taken and extent analysis for each criterion, g_i; is performed, on respectively. Therefore, m extent analysis values for each criterion can be obtained by using following notation (Chang, 1992; Kahraman et al, 2004: 176; Kulak and Kahraman, 2005: 199; Tolga et al, 2005: 6-7; Chang, 1996, 650; Eroğlu, 2014, 52):

$$M_{g_i}^1, M_{g_i}^2, M_{g_i}^3, M_{g_i}^4, M_{g_i}^5, ..., M_{g_i}^m$$

where g_i is the goal set (i = 1, 2, 3, 4, 5, ...n) and all the $M_{g_i}^j$ (j = 1, 2, 3, 4, 5, ..., m) are Triangular Fuzzy Numbers (TFNs). The steps of Chang's analysis can be given as in the following:

Step 1: The fuzzy synthetic extent value (S_i) with respect to the i^{th} criterion is defined as following equation 1.

$$S_i = \sum_{j=1}^{m} M_{g_i}^j \otimes [\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^j]^{-1} \tag{1}$$

To obtain equation 2;

$$\sum_{j=i}^{m} M_{g_i}^j \tag{2}$$

perform the "fuzzy addition operation" of *m* extent analysis values for a particular matrix given in equation 3 below, at the end step of calculation, new *(l,m,u)* set is obtained and used for the next:

$$\sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j\right) \tag{3}$$

Where *l* is the lower limit value, *m* is the most promising value and *u* is the upper limit value.

and to obtain following equation 4;

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} \tag{4}$$

perform the "fuzzy addition operation" of $M_{g_i}^{j}$ (j = 1, 2, 3, 4, 5, ..., m) values give as equation 5:

$$\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j} = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i\right) \tag{5}$$

and then compute the inverse of the vector in the equation 6 such that

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{g_i}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i}\right) \tag{6}$$

Step 2: The degree of possibility of

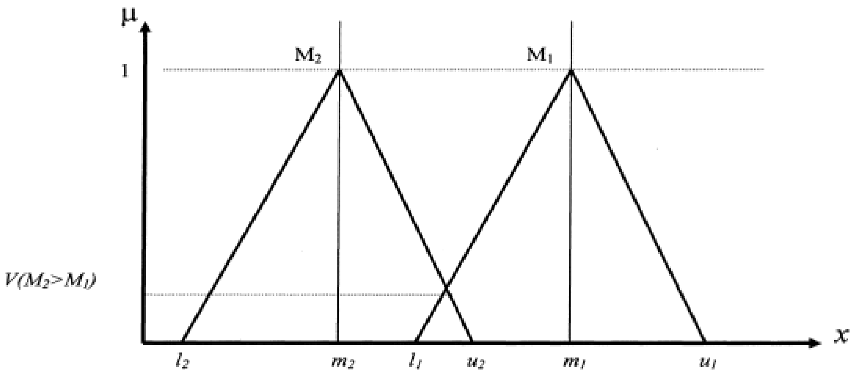
M2 = (l2, m2, u2) $\geq$ *M1 = (l1, m1, u1)* is defined as equation 7

$$V(M_2 \geq M_1) = \sup_{y \geq x}[\min(\mu_{M_1}(x), \mu_{M_2}(y))] \tag{7}$$

and *x* and *y* are the values on the axis of membership function of each criterion. This expression can be equivalently written as given in equation 8 below:

$$V(M_2 \geq M_1) = \begin{cases} 1, & if\ m_2 \geq m_1, \\ 0, & if\ l_1 \geq u_2, \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & otherwise, \end{cases} \tag{8}$$

Figure 1: The Intersection between M1 and M2



Reference: Zhu, et al, 1999, p.452

where *d* is the highest intersection point μ_{M_1} and μ_{M_2} (see Figure 1) (Zhu, et al, 1999,p. 451).

To compare *M1* and *M2*; we need both the values of $V(M2 \geq M1)$ and $V(M1 \geq M2)$:

Step 3. The degree possibility for a convex fuzzy number to be greater than k convex fuzzy numbers

Mi (i = 1, 2, 3, 4, 5, ..., k) can be defined by equation 9:

$$V(M \geq M1, M2, M3, M4, M5, M6, ..., Mk) = V[(M \geq M1) \text{ and } (M \geq M2) \text{ and } (M \geq M3) \text{ and } (M \geq M4) \text{ and ..... and } (M \geq Mk)] = \min V(M \geq Mi), i = 1, 2, 3, 4, 5, ..., k. \quad (9)$$

Assume the expression in equation 10 is:

$$d\imath(Ai) = \min V(Si \geq Sk) \quad (10)$$

For $k = 1, 2, 3, 4, 5, ..., n; k \neq i$. Then the weight vector is given by equation 11:

$$W\imath = (d\imath(A1), d\imath(A2), d\imath(A3), d\imath(A4), d\imath(A5), ..., d\imath(An))T \quad (11)$$

Where *Ai (i = 1, 2, 3, 4, 5, 6, …., n)* are *n* elements.

Step 4. Via normalization, the normalized weight vectors are given in equation 12 below:

$$W = (d(A1), d(A2), d(A3), d(A4), d(A5), d(A6), ..., d(An))T \quad (12)$$

Where *W* is nonfuzzy numbers.

To evaluate the questions, people only select the related linguistic variable, then for calculations they are converted to the following scale including triangular fuzzy numbers developed by (Chang, 1996) and generalized for such analysis as given in Table 1 below:

Table 1: TFN Values

Statement	TFN
Absolute (row to column)	(7/2, 4, 9/2)
Very strong (row to column)	(5/2, 3, 7/2)
Fairly strong (row to column)	(3/2, 2, 5/2)
Weak (row to column)	(2/3, 1, 3/2)
Equal	(1, 1, 1)
Weak (column to row)	(2/3, 1, 3/2)
Fairly strong (column to row)	(2/5, 1/2, 2,/3)
Very strong (column to row)	(2/7, 1/3, 2/5)
Absolute (column to row)	(2/9, 1/4, 2/7)

Reference: Developed from Tolga et al, 2005: 22

III. LITERATURE REVIEW

In the literature there have been many studies about Fuzzy-AHP methodology like machine selection, green issues, banking system, supplier selection, service quality and integration with the quantitative methods.

Fuzzy AHP has been used for the marine engine selection problem in the shipping industry (Bulut et al., 2015). Fuzzy AHP is applied to form the structure of the Tunnel boring machine selection problem and to determine weights of the evaluation criteria, and fuzzy TOPSIS method is utilized to acquire final ranking (Yazdani-Chamzini & Yakhchali,2012).

AHP and TOPSIS under uncertainty expressed by using an interval-valued fuzzy method have been integrated for the selection of the best waste management practices under an uncertain environment in Setubal Peninsula, Portugal (Pires et al., 2011). Fuzzy logic, which is a popular method of incorporating uncertain parameters into the decision-making process has been blended with analytic hierarchy process to form a selection (decision-making) model for different green initiatives in the fashion industry (Wang et al., 2012).

A way to calibrate the membership functions with comparisons given by the decision-maker on alternatives with known measures has been proposed in a study measuring the most important factors in selecting current bank account (Ishizaka & Nguyen, 2013). The Fuzzy Analytic Hierarchy Process and the Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) have been integrated into the assessment of the financial performance of banks in Serbia covering the period between the years 2005 and 2010 (Mandic et al., 2014).

Comparative analysis of methods Fuzzy TOPSIS (Fuzzy Technique for Order of Preference by Similarity to Ideal Solution) and Fuzzy Analytic Hierarchy Process has been presented in the context of supplier selection decision making (Junior et al., 2014). A new AHP method based on a new effective and feasible representation of uncertain information with fuzzy preference relation has been proposed for the supplier selection problem, which extends the classical analytic hierarchy process (AHP) method (Deng et al., 2014). A fuzzy analytic hierarchy process has been used by combining the decision-maker's preferences, in a ranking of suppliers that makes it possible to select the most suitable supplier(s) in the airline retail industry (Rezaei et al., 2014). Supplier selection problem of a well-known washing machine company in Turkey has been investigated and a fuzzy analytic hierarchy process based methodology has been used to select the best supplier firm providing the most customer satisfaction for the criteria determined (Kılınççı & Önal, 2011).

Managerial and policy recommendations have been provided to enable more effective strategic decision in universities (Somsuk & Laosirihongthong, 2014). The fuzzy analytic hierarchy process method has been proposed to evaluate the work safety in hot and humid environments (Zheng et al., 2012). Fuzzy–AHP methodology has been proposed for comparative evaluation of a number of computerized maintenance management systems alternatives (Duran, 2011). A hybrid application between an expert elicitation based improved analysis hierarchy process and fuzzy set theory, and the occurrence possibility of Fire and explosion accidents of steel oil storage tanks is estimated for an oil depot in China has been made to perform fault tree analysis (Shi et al., 2014).

A new methodology has been proposed to provide a simple approach to assess alternative projects and help the decision-maker to select the best one for National Iranian Oil Company by using six criteria of comparing investment alternatives as criteria in an AHP and fuzzy TOPSIS techniques (Amiri, 2010). A fuzzy set theory based analytic hierarchy process framework for prioritizing Customer satisfaction attributes in target planning has been presented in automotive industry (Nepal et al., 2010). The aeroengine health assessment problem as a multi-criteria decision-making problem and proposes a three-step evaluation model, which combines the techniques of fuzzy analytic hierarchy process, fuzzy preference programming and technique for order performance by similarity to ideal solution has been modelled with an empirical study of a real case involving eleven evaluation criteria and ten initial commercial aeroengines of Air China Ltd (Wang et al., 2010). An integrated approach of analytic hierarchy process (AHP) improved by rough sets theory (Rough-AHP) and fuzzy TOPSIS method has been proposed to obtain final ranking in performance management system (Aydoğan, 2011). A method has been proposed for transforming a fuzzy prioritization problem into a constrained nonlinear optimization model and several illustrative examples using existing fuzzy AHP methods have been given to demonstrate the effectiveness of the proposed method (Javanbarg et al., 2012). Using the revised fuzzy analytic hierarchy process has been introduced a new decision process to include time dependency of decisions and statistical weighting from the standard analysis of variance (ANOVA), via a case study in the selection of wafer slicing and coating process for a three-year operation time (Rajput et al., 2011). A combination of fuzzy Analytic Hierarchy Process and fuzzy Decision

Making Trial and Evaluation Laboratory (DEMATEL) method in human resource for science and technology (Chou et al., 2012).

A fuzzy AHP has been structured to evaluate the proposed service quality framework in healthcare sector in Turkey with a case study (Büyüközkan et al., 2011). The electronic service quality framework by the aid of service quality (SERVQUAL) methodology as the theoretical instrument has been illustrated with a web service performance example of healthcare sector in Turkey by using a combined multiple criteria decision making (MCDM) methodology containing fuzzy analytic hierarchy process and fuzzy technique for order performance by similarity to ideal solution (TOPSIS) (Büyüközkan & Çifçi, 2012).

IV. APPLICATION

In this study, the machine buying process of a dairy factory in Aegean Region, in Turkey has been investigated. The factory decided to buy a Cream Separator to use in the production process to meet the increased demand in the sector. The firm has been actively taking place in the sector since 2005 and making progress within experienced and professional staff. The firm is making its name swiftly with its 750 ton productive capacity by providing pre-sales and post-sales services. The firm which has ISO 22000:2005 and ISO 9001 quality certificates aimed to define the quality policy of its supply chain partners. In accordance with total quality philosophy, the firm has the full customer satisfaction insight by providing high quality products and services. The factory of the firm was set up on a total of 10 acres of land which has 8000 square meters of outdoor area and 2000 square meters of indoor area.

When the factory plant was first established, totally 5000 litre milk was processed on a daily basis. As 5000 litre milk was processed, it was enough to have a machine which has 5000 lt/hr cream separating performance. However, when the milk processing capacity increased, this machine would be insufficient. As the milk processing capacity reaches 25000 lt daily, now it has become necessary to buy a new separator, because the old machine is separating 25000 lt milk approximately in six hours. New separator which has 10000 lt/hr performance will perform same procedure in approximately 2,5 (two and half) hour. Thus, proposals have been taken from three different vendors.

A cream separator is a machine that separates two mixed substances of different density (as cream and milk or oil and sludge) by centrifugal force. Whole milk is conducted into a bowl, commonly through a central tubular shaft. A spindle rotates the bowl at a rate of from 6.000 to 9.000 rpm, and a series of identical conical disks separates the milk into vertical layers. The heavier skim milk collects on the outer circumference of the rapidly whirling bowl, and the lighter cream tends to remain in the center. The pressure of the whole-milk supply above the bowl then forces the cream and skim milk out of the machine and into separate collecting vessels. The cream separator makes it possible to control the amount of fat (called butterfat) remaining in the milk. The gravity method ordinarily leaves one fourth of the fat in the milk, while the cream separator leaves only 0,01% to 0,02% of the fat in the skim milk. Since the latter process is

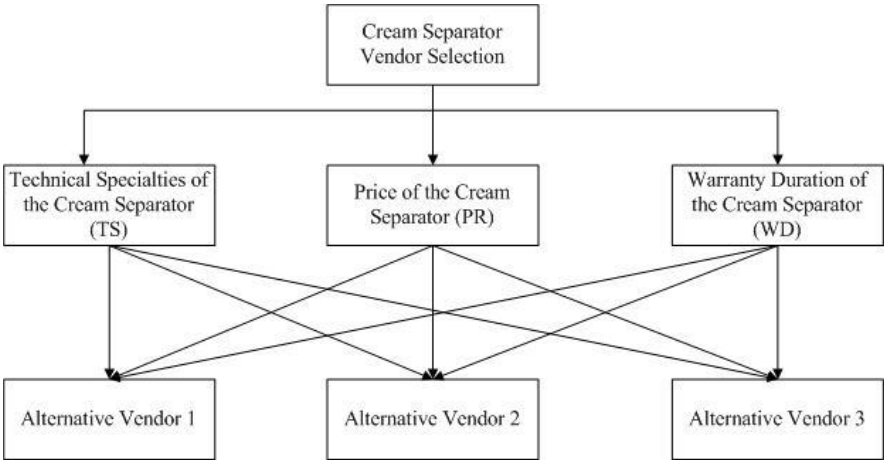
much faster than the gravity method, there is less chance for harmful bacterial action.
As we can understand from the process, a high-quality separator machine is very important element of production process, and directly affects the profitability of the firm.

Since the factory is located in the coastal part of Aegean Region, transportation cost has not been measured. The vendors have been rated according to their performance on three factors:

1. Technical Specialties of the Cream Separator (TP)
2. Price of the Cream Separator (PR)
3. Warranty Duration of the Cream Separator (WD)

Company received offers from three vendors. The hierarchical structure of cream separator vendor selection process can be seen in Figure 2.

Figure 2: Hierarchical Structure For Cream Separator Vendor Selection



First importance levels of each criterion should be assessed for the dairy factory. After learning the importance level of the each criterion, then in the second part of the analysis, the vendors can be compared according to those criteria. Fuzzy pairwise comparison matrix for criteria can be seen on Table 2.

Table 2: Fuzzy Pairwise Comparison Matrix With Respect To Vendor Selection

	TS			PR			WD		
TS	1	1	1	2/3	1	3/2	5/2	3	7/2
PR	2/3	1	3/2	1	1	1	7/2	4	9/2
WD	2/7	1/3	2/5	2/9	1/4	2/7	1	1	1

From the fuzzy numbers in Table 2, following calculations are performed to reach the importance values of the first level (see equation 1):

$$S_{TS} = (4{,}16667; 5; 6)\otimes\left(\frac{1}{14{,}68571};\frac{1}{12{,}58333};\frac{1}{10{,}84127}\right)$$
$$S_{PR} = (5{,}16667; 6; 7)\otimes\left(\frac{1}{14{,}68571};\frac{1}{12{,}58333};\frac{1}{10{,}84127}\right)$$
$$S_{WD} = (1{,}50794; 1{,}58333; 1{,}68571)\otimes\left(\frac{1}{14{,}68571};\frac{1}{12{,}58333};\frac{1}{10{,}84127}\right)$$

After the calculations from the vectors given above, following values are obtained according to the equation 10.

$$V(S_{TS} \geq S_{PR}) = 0{,}71728$$
$$V(S_{TS} \geq S_{WD}) = 1$$
$$V(S_{PR} \geq S_{TS}) = 1$$
$$V(S_{PR} \geq S_{WD}) = 1$$
$$V(S_{WD} \geq S_{TS}) = 0$$
$$V(S_{WD} \geq S_{PR}) = 0$$

Finally, the weight vector from Table 2 is found after the normalization of possibility values of TS, PR, WD as W_{Goal} given below:

$$W_{Goal} = (0{,}41768; 0{,}58232; 0)^T$$

It means according to decision maker, the most important criterion in the first level is "Price of the Cream Separator" with %58,232 importance value, and the second one is "Technical Specialties of the Cream Separator" with %41,768, where "warranty duration of the Cream Separator" has not any significancy.

Table 3: Fuzzy Pairwise Comparison Matrix With Respect To "Technical Specialties of The Cream Separator"

	Vendor 1			Vendor 2			Vendor 3		
Vendor 1	1	1	1	5/2	3	7/2	2/3	1	3/2
Vendor 2	2/7	1/3	2/5	1	1	1	7/2	4	9/2
Vendor 3	2/3	1	3/2	2/9	1/4	2/7	1	1	1

From the fuzzy numbers in Table 3, following calculations are performed to reach the importance values of the first level (see equation 1):

$$S_{V_1} = (4{,}16667; 5; 6)\otimes\left(\frac{1}{14{,}68571};\frac{1}{12{,}58333};\frac{1}{10{,}84127}\right)$$
$$S_{V_2} = (4{,}78571; 5{,}33333; 5{,}9)\otimes\left(\frac{1}{14{,}68571};\frac{1}{12{,}58333};\frac{1}{10{,}84127}\right)$$
$$S_{V_3} = (1{,}88889; 2{,}25; 2{,}78571)\otimes\left(\frac{1}{14{,}68571};\frac{1}{12{,}58333};\frac{1}{10{,}84127}\right)$$

After the calculations from the vectors given above, following values are obtained according to the equation 10.

$$V(S_{V_1} \geq S_{V_2}) = 0{,}89573$$
$$V(S_{V_1} \geq S_{V_3}) = 1$$
$$V(S_{V_2} \geq S_{V_1}) = 1$$
$$V(S_{V_2} \geq S_{V_3}) = 1$$
$$V(S_{V_3} \geq S_{V_1}) = 0$$
$$V(S_{V_3} \geq S_{V_2}) = 0$$

Finally, the weight vector from Table 3 is found after the normalization of possibility values of $Vendor_1, Vendor_2, Vendor_3$ as W_{TS} given below:

$$W_{TS} = (0{,}47250; 0{,}52750; 0)^T$$

This means according to decision maker, the most important vendor with respect to "Technical Specialties of The Cream Separator" is $Vendor_2$ with %52,750 importance value, and the second one is $Vendor_1$ with %47,250, where $Vendor_3$ has not any importance.

Table 4: Fuzzy Pairwise Comparison Matrix With Respect To "Price of The Cream Separator"

	Vendor 1			Vendor 2			Vendor 3		
Vendor 1	1	1	1	3/2	2	5/2	7/2	4	9/2
Vendor 2	2/5	1/2	2/3	1	1	1	5/2	3	7/2
Vendor 3	2/9	1/4	2/7	2/7	1/3	2/5	1	1	1

From the fuzzy numbers in Table 4, following calculations are performed to reach the importance values of the first level (see equation 1):

$$S_{V_1} = (6; 7; 8) \otimes \left(\frac{1}{14{,}85238}; \frac{1}{13{,}08333}; \frac{1}{11{,}40794}\right)$$
$$S_{V_2} = (3{,}9; 4{,}5; 5{,}16667) \otimes \left(\frac{1}{14{,}85238}; \frac{1}{13{,}08333}; \frac{1}{11{,}40794}\right)$$
$$S_{V_3} = (1{,}50794; 1{,}58333; 1{,}68571) \otimes \left(\frac{1}{14{,}85238}; \frac{1}{13{,}08333}; \frac{1}{11{,}40794}\right)$$

After the calculations from the vectors given above, following values are obtained according to the equation 10.

$$V(S_{V_1} \geq S_{V_2}) = 1$$
$$V(S_{V_1} \geq S_{V_3}) = 1$$
$$V(S_{V_2} \geq S_{V_1}) = 0{,}20385$$
$$V(S_{V_2} \geq S_{V_3}) = 1$$
$$V(S_{V_3} \geq S_{V_1}) = 0$$
$$V(S_{V_3} \geq S_{V_2}) = 0$$

Finally, the weight vector from Table 4 is found after the normalization of possibility values of $Vendor_1, Vendor_2, Vendor_3$ as W_{PR} given below:

$$W_{PR} = (0{,}83067; 0{,}16933; 0)^T$$

This means according to decision maker, the most important vendor with respect to "Price of The Cream Separator" is $Vendor_1$ with %83,067 importance value, and the second one is $Vendor_2$ with %16,933, where $Vendor_3$ has not any importance.

Next step is to calculate the global importance levels of alternative vendors.

The global importance level of $Vendor_1$ can be calculated as given below.

$$W_{V_1} = (0{,}58232)(0{,}47250) + (0{,}41768)(0{,}83067) = 0{,}62210$$

$$W_{V_2} = (0{,}58232)(0{,}52750) + (0{,}41768)(0{,}16933) = 0{,}37790$$

$$W_{V_3} = (0{,}58232)(0) + (0{,}41768)(0) = 0$$

According to global importance levels, Vendor_1 should be selected with %62,210 value.

CONCLUSION

For the companies, managers need to make decisions in every field whether they are long term or short term. Machine selection is one of the medium-term factors of production process which is crucial as for the future of the firm. In today's competitive environment, the success of the firms depends on the accuracy of the decisions which are taken with the assistance of analytical approaches.

In this point vendor selection becomes very crucial as it is directly related with meeting the customer expectations, since it will affect the quality and momentum of the production process. The reason is; production process involves the key operational points such as the procurement of materials and the delivery of the materials. During this process, the factors such as quality, quantity, price and warranty duration of materials given by the vendors are very important with regard to customers. Hence, the decision making process gains much more importance for vendor selection as the analytical approach needs to be adopted rather than intuitive approach.

In this study, by using the fuzzy AHP method, the vendors are categorized in accordance with the values which are obtained from the factors such as technical specialties of the cream separator, price of the cream separator, and warranty duration of the cream separator.

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