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Selecting Image Processing Supplier for Quality Control AI Software in Metal Cataphoretic Painting Firm by Using Fuzzy AHP and Fuzzy Topsis

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Abstract: Nowadays many companies try to adopt Industry 4.0 technology in their production lines, supply chains, etc. Industry 4.0 makes a company more profitable and automatized. There are many beneficial impacts of Industry 4.0 in companies unless there is a wrong application. Companies usually buy Artificial Intelligence software and they implement applications for them. The selection of the supplier is the most important part of applying this technology in a company. The application of Industry 4.0 in companies starts with defining the issue or eligible ways of developing. After AI solution is selected, the next phase is defining needs, budget and materials. All phases depend on the supplier. There are many qualitative and quantitative criteria in selecting the supplier of quality control AI software and this causes a lot of complicated processes. As Industry 4.0 is more popular globally, there is a significant increase in supplier numbers. When companies need to select a supplier, they want the selection process simpler and more accurate. Uncertainty in the future makes supplier selection more difficult. Therefore, Fuzzy AHP and Fuzzy TOPSIS methodologies are proper and when companies deal with uncertain situations. As a case study, Karakaya86 firm wants to implement Image Processing technology with Artificial Intelligence in their Quality Control processes for cataphoretic painting metal to the surface, and the study shows which supplier will fit with their needs for quality control defect software by using Fuzzy AHP and Fuzzy TOPSIS. We have not seen any paper similar to our study.

Keywords: quality control defect detection, chemistry, artificial intelligence, image processing, supplier selection, fuzzy topsis, fuzzy ahp

Introduction

Cataphoretic painting is an important technological improvement for painting and protecting parts from outer impacts. For controlling the quality of the painted part, it must be inspected visually after coating. There are different defects may be done in the painting process such as roughness, crates, redissolutions, dirt, streaking, etc. Every type of defect needs a specific variety of actions (Bračun & Lekše, 2019), so that, quality control is a difficult process to automate for having complicated processes to identify all types of defects. So, it generally makes this process manual and human required with a huge amount of time and less reliable results. To automate the quality control phase needs visual inspection systems and computerized identification. Although improvements are applied easily in production processes, they can not be applied as easily in quality control processes for being complicated and mutable. Hence, companies want to work with the best supplier. However,

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in competitive markets there are a lot of similar alternatives, and sometimes seeing differences between them is not easy as thought. Instead of selecting a supplier with instinctive approach, selecting with well-known methods provide the highest potential. In this circumstance, Karakaya86 wants to implement image processing technology in their quality control processes for eliminating manual processes and human errors. In this case, Fuzzy AHP and Fuzzy TOPSIS will be applied for selecting the best image processing supplier.

Purpose of Thesis

In the cataphoretic coating sector, there is no important research about selecting a supplier for implementing image processing to the quality control process. This thesis aims to define the most important criteria and uses them with the fuzzy logic to obtain accurate decision.

Cataphoretic Coating

Cataphoretic painting is called different in different countries such as e-coating, CED (Cathodic Electro Deposited) coating, cathodic dip painting (CDP), electro coating, and cataphoretic coating, and German based publication described as KTL coating (Kathodische Tauchlackierung, which means cathodic dip painting). (Almeida et al., 2003; Fedel et al., 2010). This method can be applied to any electrically conductive surface. This technological painting method makes huge differences in the metal coating industry. Hylák states that, "Cataphoretic painting is considered as a tremendously economical method of corrosion protection for metals in these times. The concept of a special organic coating method is a technology that produces an electrophoretic coating on parts, and it is known by effective at small dimensions and complex geometric shapes. Coating by electrophoresis is based on the electrodeposition of the particles in the solution of the paint by the electric current. The difference in potential between the anode and the cathode creates the conditions where the surface is covered with a thin coating of the excluded paint." (Hylák, 2019). This well-known method is significantly important for protecting parts from environmental impacts and prevent defects made by them. Cataphoretic coating is used by numerous industries to coat products in different kinds of categories such as, agricultural equipment, automobiles, automotive parts, marine components, metal office furniture, lawn & garden equipment and furniture, and much more.

Cataphoretic Coating Process

Cataphoretic coating has several steps that should be done properly. Sometimes different processes can be added to customize the final product. These steps are: pretreatment which contains acid and phosphate baths, rinsing the excess chemicals, cataphoretic coating, oven, and quality control. The whole process needs nearly fifteen baths depending on the product and required conditions.

Cataphoretic Coating Quality Control

Cataphoretic coating has different quality control processes, first cataphoretic process quality control must be done before pretreatment for controlling products' condition such as dirt and shape. Another quality control process can be done after the rinsing processes. The other quality control process is finished products' controlling. The traditional quality control process is carried out manually for detecting finished products' defects. There are a significant variety of defects that may be found in this process, such as craters which have 1mm length bowl shaped depressions, randomly distributed small pinholes, dirt and rinsing based defects, air entrapment, gloss variations, thin coating, and orange peel. This method may lead to human mistakes and errors, and this evaluation is subjective, depends on employees.

Image Processing

Image processing has different varieties of use cases, such as checking for presence, object detection, localization, measurement, differentiation, identification, and verification. The information which is coming from the camera is not directly processed in applications. Firstly, the quality of an image should be preprocessed for enhancing image quality. For instance, noise reduction, brightness, and contrast enhancement are preprocesses for increasing image quality. After an image has been restored, the processing starts. Arithmetic and logical operations are used for detecting and differentiating the image.

Figure 1. Dirt based defects after cataphoretic coating.

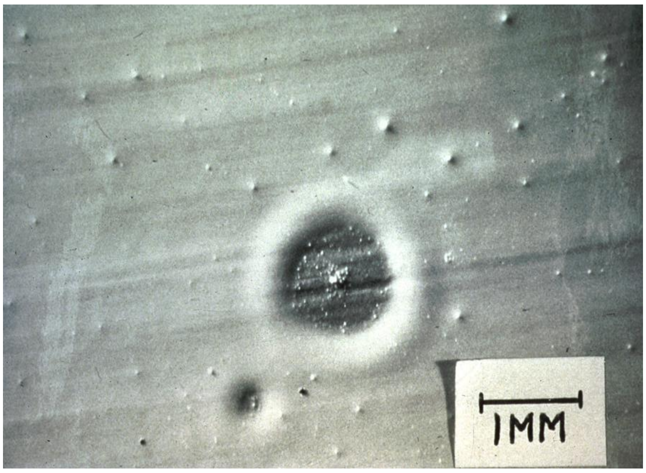

Figure 2. Crater defects after cataphoretic coating.

Figure 3. Pinhole defects after cataphoretic coating.

There are some specific solutions for image processing in cataphoretic coating. Coating defects are generally differentiated with the different lighting conditions. There are no important differences in pigmentation. Thus, the system should take images in different lighting conditions and be considered as one image. The information obtained from the last image gives specific features about the finished part. Artificial intelligence algorithms should be in this part for learning new defects (Bračun & Lekše, 2019).

Supplier Selection

Selecting of the supplier is trending in the competitive markets for choosing the best alternative for the company's needs. Selection is based on creating criteria and measures to evaluate differences between alternatives. Multi criterion decision making is important for evaluating criteria and alternatives. In this case, decreasing alternatives makes the selection process simpler (Kahraman et al, 2003).

Generally creating criteria is based on the performance of supplier and product, cost criterion, reputation, and expertise. This process needs an important amount of knowledge, insights, and analysis. After creating criteria, there should be an evaluation of criteria by experienced professionals. Once the criteria importance's is determined alternatives should be evaluated. Important objectives in the supplier selection process are minimization of purchase risk and cost, maximization of the efficiency of supplier, and performance.

Method

Fuzzy Sets Theory

Fuzzy sets were introduced to find out how to deal with human thought's uncertainty, vagueness, and subjectivity in 1965 by Zadeh (Zadeh, 1996). After that theory, uncertainties became essential to science and this theory shows researchers how to deal with uncertain situations (vague, inconsistent, imprecision). Zadeh introduces a theory whose values are sets with the upper and the lower limit and the outcome is in that boundaries instead of binary values. This theory also allows attribute quantitative values to linguistic, qualitative, variables. For instance, there is no single quantitative value that defines exactly the term young or old. Young and old words depend on the humans thought, some of them prefer young as a 20 and some others 30. When we evaluate the young word with the fuzzy set, young may be considered between 20 and 30 (Klir & Yuan, 1995). Fuzzy Set Theory uses fuzzy logic and creates a new concept which is works between 0 and 1. Elements in a fuzzy set have varying degrees of membership.

Fuzzy AHP

Analytic Hierarchy Process (AHP) is created by Thomas L. Saaty in 1977 for including non-quantitative data into decision making process. It is widely used to make decisions in multi criteria in a hierarchy system. AHP is known for being simple and accurate to make decisions in a certain environment (Roy & Dutta, 2018). AHP calculates criteria weights based on pairwise comparisons. The simplicity of this method makes it one of the most widely used multi criteria decision making (MCDM) methods. In the other hand AHP has drawbacks such as depends on experts' preferences and uncertain judgment.

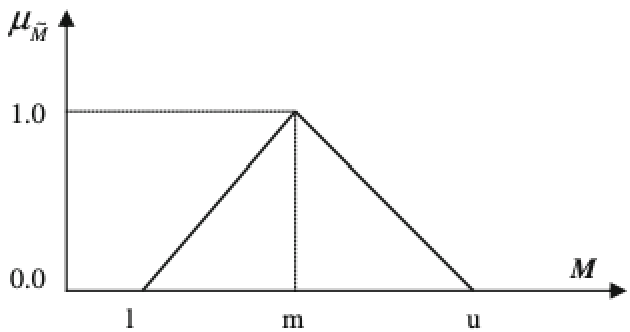

Figure 4. Lower and upper boundaries of TFN.

For example, decision makers may not be giving their opinion exactly or giving value to words that can not express their thoughts (Somsuk & Laosirihongthong, 2013). When the traditional AHP Method and fuzzy logic come together, AHP gains more accurate judgments. It allows decision makers to express their thoughts as a fuzzy set instead of single numbers. (Somsuk & Laosirihongthong, 2013) Decision makers give their pairwise comparison opinions as triangular fuzzy numbers (TFNs). A TFN consist of triplets, such as (a,b,c) a is lower bound which limits the value on the lower side, c is upper bound which is also limits the possible evaluation in the upper side, and b is the most favorable value. (Somsuk & Laosirihongthong, 2013)

Fuzzy TOPSIS

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) method is developed by Hwang and Yoon in 1981. TOPSIS method is one of the most known MCDM methods. This method is based on the concept that chooses to the shortest distance from Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS). In the traditional method, the weight of criteria and performance rating defined as crisp values. (Nădăban et al., 2016). Cheng introduced the extension of the triangular fuzzy TOPSIS method to express decision makers' thoughts correctly.

He also states that crisp data are inadequate for many situations and using linguistic variables may be a more realistic approach to decision makers opinion. We can transform the decision matrix into a fuzzy decision matrix and create a weighted normalized fuzzy decision matrix after adding the fuzzy ratings of the decision makers (Kekilli et al., 2021). We used positive ideal solution (PIS) and negative ideal solution (NIS) according to TOPSIS concept. Later, in this article, a vertex method is proposed to calculate the distance between two triangular fuzzy gradations. Using the Euclidian distance method, we can calculate the distance of each alternative to PIS and NIS, respectively. Finally, a closeness coefficient of each alternative is defined to determine the ranking order of all alternatives. A higher value of the closeness coefficient indicates that an alternative is simultaneously closer to the PIS and farther from the NIS (Chen, 2000).

Proposed Methodology

Table 1. Criteria of MCDM

CRI	Criteria	Unit
C1	Defect Detection Rate	Fuzzy
C2	Solution Speed	Fuzzy
C3	Customization	Fuzzy
C4	AI Software Implementation Time	Fuzzy
C5	Total Cost	Fuzzy
C6	Reputation of Supplier	Fuzzy
C7	Expertise in Coating Sector	Fuzzy

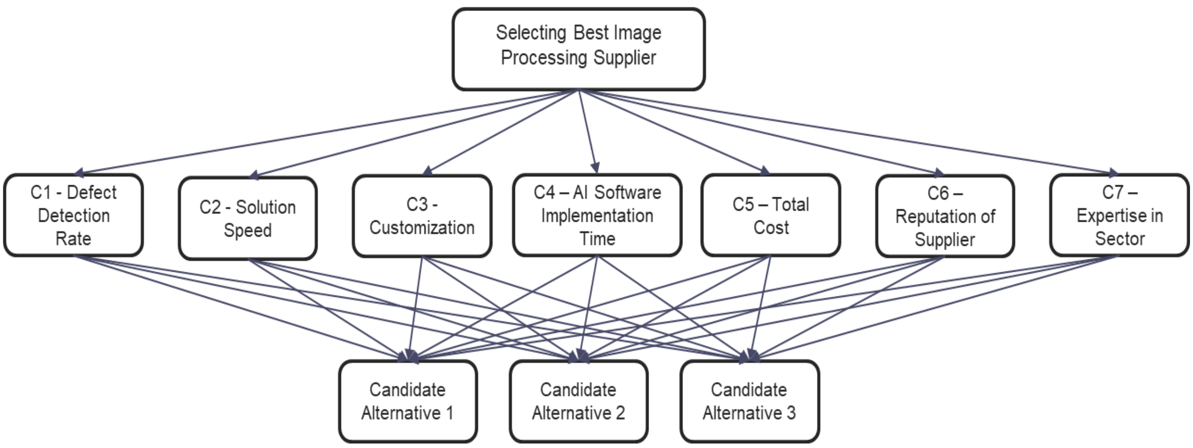

Figure 5. Hierarchical model of MCDM

The first criterion of the supplier selection MCDM is defect detection rate. This criterion is calculated with detected defects / total defects (percentage). The second criterion is solution speed. How much time is spent for processing images for detecting defects. The third one is customization. How many types of product can be automated with the algorithm. Others are total cost which contains annual maintenance and initial cost this criterion is also fuzzy because there is no exact cost value in the current phase and maintenance cost of the next year or breakdowns can't be predicted exactly, reputation in supplier, expertise in coating sector. The first level of the hierarchical model defines the objective of MCDM which is selecting the best supplier for implementing image processing software in the quality control process. The second level explains the criteria and the last one shows the alternatives.
Step 2 is selecting alternatives. Alternatives are selected from the real market but called as A1, A2, and A3 instead of sharing their names. A1 is a local image processing supplier which is experienced in the sector with giving consultancies and had made different varieties of quality control process automated. A2 is not an experienced firm in the market but they have capabilities of transforming traditional quality control processes to automated with AI image processing quality control. A3 is a global firm that has a lot of experience in the sector for a long time and they used high quality equipment for transforming processes.
Step 3 is asking several experts' opinions for evaluating criteria importance.
Step 4 is calculating criteria weights according to experts' opinions and Fuzzy AHP calculation methodology.
Step 5 is asking several experts to their thoughts about alternatives considering criteria.
Step 6 is converting this information to the Fuzzy TOPSIS methodology and calculating average values of decision makers.
Step 7 is making a normalized fuzzy decision matrix according to the average matrix.
Step 8 is multiplying normalized fuzzy decision matrix with criteria weights obtained from Fuzzy AHP.
Step 9 is calculating distances from Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS).
Step 10 Select the best possible alternative which has the biggest Closeness Coefficient (CC).

Application

Karakaya86

Karakaya86 company, which adopts customer satisfaction as a principle, started its working life in Kartal in 1986 with zinc electrolysis activity. In 1997, it continued by establishing the first commercial cataphoretic coating line in Turkey. To provide high quality service to its customers with economical solutions, it started its investment studies in 2003. The company, which performs the coating processes of metal parts of the automotive and white goods sector, extends the service life of metal parts with many coating methods such as cataphoretic coating. The company has more than 350 employees, 1 central factory, 3 branches, and 1 R&D Center. The whole production area is 56.000 m2 with +25.000 m2 closed indoor area. There are more than 500 different product types coated in Karakaya86 in different lines. Applying image processing to all products and all lines may not be feasible thus, the products and their lines which has more production than others selected.

Fuzzy AHP Application

Before obtaining experts' opinion, the importance of criterion is determined as linguistic variables and their respective TFN's like in Table1.

Table 2. Linguistic variables with TFN's

Triangular Fuzzy Numbers	Linguistic Variable
(1,1,1)	Equal Importance
(2,3,4)	Moderate Importance
(4,5,6)	Strong Importance
(6,7,8)	Very Strong Importance
(9,9,9)	Extremely Strong Importance
Others	Intermediate Values

Importance of criteria asked the 3 experienced professionals. Their responses are expected to be like in Table 5.1. One of them is the director of R&D center at cataphoretic coating, the other one is production planner and C level manager at the coating firm, and the last one is experienced in consultancy about manufacturing.

Table 3. Pairwise comparison matrix according to DM1's response

DM1	C1			C2			C3		
C1	1,00	1,00	1,00	2,00	3,00	4,00	6,00	7,00	8,00
C2	0,50	0,33	0,25	1,00	1,00	1,00	4,00	5,00	6,00
C3	0,17	0,14	0,13	0,25	0,20	0,17	1,00	1,00	1,00
C4	0,14	0,13	0,11	0,20	0,17	0,14	0,50	0,33	0,25
C5	0,14	0,13	0,11	0,20	0,17	0,14	0,20	0,17	0,14
C6	0,11	0,11	0,11	0,14	0,13	0,11	0,14	0,13	0,11
C7	0,14	0,13	0,11	0,20	0,17	0,14	0,20	0,17	0,14

After all calculations are done with the rules of Fuzzy AHP and geometric mean method criteria weights are shown in Table 4.

Table 4. Average and normalized criteria weights according to all DM's

DM	AW	NW	RANK
C1	0,406298	0,40269	1
C2	0,287789	0,285234	2
C3	0,097849	0,09698	3
C4	0,052273	0,051809	5
C5	0,091806	0,09099	4
C6	0,023643	0,023433	7
C7	0,049302	0,048864	6
Total	1,00896		

After the calculations have been done, Criterion1 which is defect detection rate is selected as the most important criterion for all decision makers. Criterion2 which is solution speed is the second important criterion. Importance of criterion:

$$C1>C2>C3>C5>C4>C7>C6$$

Fuzzy TOPSIS Application

Firstly, linguistic variables and their respective TFN's are determined.

Table **Hata! Belgede belirtilen stilde metne rastlanmadı.**. Linguistic variables and TFN's

	TFN's		
Very Poor (VP)	0	0	0,2
Poor (P)	0,1	0,2	0,3
Medium Poor (MP)	0,2	0,35	0,5
Fair (F)	0,4	0,5	0,6
Medium Good (MG)	0,5	0,65	0,8
Good (G)	0,7	0,8	0,9
Very Good (VG)	0,8	1	1

Table 6. DM1's evaluation of alternatives w.r.t. each criterion

DM1	C1			C2			C3		
A1	0,7	0,8	0,9	0,5	0,65	0,8	0,7	0,8	0,9
A2	0,5	0,65	0,8	0,2	0,35	0,5	0	0	0,2
A3	0,8	1	1	0,7	0,8	0,9	0,5	0,65	0,8

Table 6 (Continued). DM1's evaluation of alternatives w.r.t. each criterion

C4			C5			C6			C7		
0,7	0,8	0,9	0,7	0,8	0,9	0,2	0,35	0,5	0,5	0,65	0,8
0,4	0,5	0,6	0,4	0,5	0,6	0,5	0,65	0,8	0,5	0,65	0,8
0,5	0,65	0,8	0,5	0,65	0,8	0,7	0,8	0,9	0,7	0,8	0,9

Table 7. DM2's evaluation of alternatives w.r.t. each criterion

DM2	C1			C2			C3		
A1	0,7	0,8	0,9	0,5	0,65	0,8	0,5	0,65	0,8
A2	0,8	1	1	0,2	0,35	0,5	0,2	0,35	0,5
A3	0,2	0,35	0,5	0,7	0,8	0,9	0,5	0,65	0,8

Table 7 (Continued) DM2's evaluation of alternatives w.r.t. each criterion

C4			C5			C6			C7		
0,4	0,5	0,6	0,7	0,8	0,9	0,4	0,5	0,6	0,4	0,5	0,6
0,1	0,2	0,3	0,2	0,35	0,5	0,7	0,8	0,9	0,2	0,35	0,5
0,5	0,65	0,8	0,1	0,2	0,3	0,8	1	1	0,2	0,35	0,5

After obtaining experts opinions about alternatives each criterion's normalized fuzzy matrixes, weighted fuzzy matrixes and their distance from PIS and NIS calculated separately. L M U represents the average values of lower middle and upper values. After that normalized fuzzy decision matrix shown in the tables. Weighted represents the weighted normalized fuzzy decision matrix with the criteria weights calculated at the Fuzzy AHP application (Table 14). Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 5

Table 8. Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 1.

Alt/CR	Criteria	DM1			DM2			L	M	U	Max
A1	C1	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	1
A2		0,5	0,65	0,8	0,8	1	1	0,5	0,825	1	
A3		0,8	1	1	0,2	0,35	0,5	0,2	0,675	1	

Table 8 (Continued). Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 1.

Normalized			Weighted			Distance	
L	M	U	L	M	U	d-	d*
0,7	0,8	0,9	0,2819	0,3222	0,3624	0,12	0,02
0,5	0,825	1	0,2013	0,3322	0,4027	0,08	0,05
0,2	0,675	1	0,0805	0,2718	0,4027	0,02	0,12
		A+	0,2819	0,3322	0,4027		
		A-	0,0805	0,2718	0,3624		

Table 9. Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 2.

Alt/CR	Criteria	DM1			DM2			L	M	U	Max
A1	C2	0,5	0,65	0,8	0,5	0,65	0,8	0,5	0,65	0,8	0,9
A2		0,2	0,35	0,5	0,2	0,35	0,5	0,2	0,35	0,5	
A3		0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	

Table 9 (Continued). Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 2.

Normalized			Weighted			Distance	
L	M	U	L	M	U	d-	d*
0,5	0,65	0,8	0,2013	0,2617	0,3222	0,07	0,08
0,2	0,35	0,5	0,0805	0,1409	0,2013	0,12	0,20
0,7	0,8	0,9	0,2819	0,3222	0,3624	0,12	0,02
		A+	0,2819	0,3222	0,3624		

Table 10. Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 3.

Alt/CR	Criteria	DM1			DM2			L	M	U	Max
A1	C3	0,7	0,8	0,9	0,5	0,65	0,8	0,5	0,725	0,9	0,9
A2		0	0	0,2	0,2	0,35	0,5	0	0,175	0,5	
A3		0,5	0,65	0,8	0,5	0,65	0,8	0,5	0,65	0,8	

Table 10 (Continued)**.** Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 3.

Normalized			Weighted			Distance	
L	M	U	L	M	U	d-	d*
0,5	0,725	0,9	0,2013	0,292	0,3624	0,07	0,06
0	0,175	0,5	0	0,0705	0,2013	0,16	0,25
0,5	0,65	0,8	0,2013	0,2617	0,3222	0,07	0,08
		A+	0,2013	0,292	0,3624		
		A-	0	0,0705	0,2013		

Table 11. Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 4.

Alt/CR	Criteria	DM1			DM2			L	M	U	Max
A1	C4	0,7	0,8	0,9	0,4	0,5	0,6	0,4	0,65	0,9	0,9
A2		0,4	0,5	0,6	0,1	0,2	0,3	0,1	0,35	0,6	
A3		0,5	0,65	0,8	0,5	0,65	0,8	0,5	0,65	0,8	

Table 11 (Continued). Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 4.

Normalized			Weighted			Distance	
L	M	U	L	M	U	d-	d*
0,4	0,65	0,9	0,1611	0,2617	0,3624	0,05	0,08
0,1	0,35	0,6	0,0403	0,1409	0,2416	0,11	0,20
0,5	0,65	0,8	0,2013	0,2617	0,3222	0,07	0,08
		A+	0,2013	0,2617	0,3624		
		A-	0,0403	0,1409	0,2416		

Table 12. Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 5.

Alt/CR	Criteria	DM1			DM2			L	M	U	Max
A1	C5	0,7	0,8	0,9	0,7	0,8	0,9	0,7	0,8	0,9	0,9
A2		0,4	0,5	0,6	0,2	0,35	0,5	0,2	0,425	0,6	
A3		0,5	0,65	0,8	0,1	0,2	0,3	0,1	0,425	0,8	

Table 12 (Continued). Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 5.

Normalized			Weighted			Distance	
L	M	U	L	M	U	d-	d*
0,7	0,8	0,9	0,2819	0,3222	0,3624	0,12	0,02
0,2	0,425	0,6	0,0805	0,1711	0,2416	0,09	0,18
0,1	0,425	0,8	0,0403	0,1711	0,3222	0,07	0,17
		A+	0,2819	0,3222	0,3624		
		A-	0,0403	0,1711	0,2416		

Table 13. Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 6.

Alt/CR	Criteria	DM1			DM2			L	M	U	Max
A1	C6	0,2	0,35	0,5	0,4	0,5	0,6	0,2	0,425	0,6	1
A2		0,5	0,65	0,8	0,7	0,8	0,9	0,5	0,725	0,9	
A3		0,7	0,8	0,9	0,8	1	1	0,7	0,9	1	

Table 13 (Continued). Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 6.

Normalized			Weighted			Distance	
L	M	U	L	M	U	d-	d*
0,2	0,425	0,6	0,0805	0,1711	0,2416	0,09	0,18
0,5	0,725	0,9	0,2013	0,292	0,3624	0,07	0,06
0,7	0,9	1	0,2819	0,3624	0,4027	0,13	0,02
		A+	0,2819	0,3624	0,4027		
		A-	0,0805	0,1711	0,2416		

Table 14. Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 7.

Alt/CR	Criteria	DM1			DM2			L	M	U	Max
A1	C7	0,5	0,65	0,8	0,4	0,5	0,6	0,4	0,575	0,8	0,9
A2		0,5	0,65	0,8	0,2	0,35	0,5	0,2	0,5	0,8	
A3		0,7	0,8	0,9	0,2	0,35	0,5	0,2	0,575	0,9	

Table 15. Normalized fuzzy decision matrix, weighted normalized fuzzy decision matrix, and distances from PIS and NIS for criterion 7.

Normalized			Weighted			Distance	
L	M	U	L	M	U	d-	d*
0,4	0,575	0,8	0,1611	0,2315	0,3222	0,06	0,10
0,2	0,5	0,8	0,0805	0,2013	0,3222	0,05	0,15
0,2	0,575	0,9	0,0805	0,2315	0,3624	0,02	0,13
		A+	0,1611	0,2315	0,3624		

A-	0,0805	0,2013	0,3222

After all calculations completed, all distances between alternatives and PIS and NIS are used to determine which alternative has nearest solution to PIS and farthest from NIS. It is also called Closeness Coefficient (CC) and the bigger ratios are much closer than others.

Table 16**.** Alternative evaluation with closeness coefficient.

ALT\CRI	Di-	Di+	CC	Rank
A1	0,5787	0,5438	0,5156	1
A2	0,6709	1,0747	0,3844	3
A3	0,5102	0,6234	0,45	2

A1>A3>A2

Conclusion

As technology continues to advance at this rate, the rate of competition in the market will increase. So, customers will start asking companies for more. Especially B2B businesses will have difficulty in meeting the needs of their customers unless they follow the technology. on the other hand, Industry 4.0 accelerated the development of technology even more. Here, the market adapts to this and implements industry 4.0 applications very quickly. In fact, it has adapted so quickly that leads to many alternatives in the market have been able to do this job, so, the alternatives in the market have increased. Therefore, the supplier selection process has become a more challenging and complex process for companies. In this study, the company Karakaya86, which made cataphoretic coatings for the metal parts, decided to transform the quality control process of the most used production lines from the traditional manual inspection method, with automated AI image processing technology. Fuzzy AHP and FUZZY TOPSIS, two of the most well-known MCDM methods, were used to select the supplier according to their needs. For the Fuzzy AHP process, 3 expert opinions were received and a pairwise comparison was requested among 7 criteria. At the end of this process, Defect Detection Rate and Solution Speed emerged as the two most important criteria. Then, the Fuzzy TOPSIS stage was started to evaluate the alternatives with calculated criteria weights in Fuzzy AHP. At this stage, the opinions of 2 experts in the market and sector were taken. Fuzzy TOPSIS is based on the working principle of taking the distances from the best and worst solutions, and after the necessary calculations have been made, it has been revealed that the 1st alternative has a higher potential than the others and is more compatible with the needs of the company.

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Scientific Ethics Declaration

The authors declare that the scientific ethical and legal responsibility of this article published in EPSTEM journal belongs to the authors.

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