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Selection of Raw Material Suppliers for Injection Shoe Making Using the Fuzzy Analytical Hierarchy Process (FAHP) Method at PT. XYZ

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A B S T R A C T

Companies in the fashion sector are required to continue to maintain the quality of their products to survive in the local and international markets. This makes a company in Sidoarjo that produces injection shoes contribute to maintaining product quality by maintaining the quality of raw materials. Suppliers play an important role in ensuring the quality of raw materials. The company must be able to choose the right supplier in order to ensure the availability, quality, and quantity of raw materials that meet the company's criteria. This research aims to determine the best flyknit raw material suppliers based on predetermined criteria using the fuzzy analytical hierarchy process method. In this study, there are 5 main criteria in choosing a flyknit supplier, namely price, quality, delivery, service, and communication system. The results showed that the order of the best flyknit raw material suppliers at PT XYZ with the greatest value was supplier 4 with a value of 0.179. Then in second place is supplier 2 with a value of 0.178, in third place is supplier 6 with a value of 0.177, in fourth place is supplier 3 with a value of 0.175, fifth place is supplier 1 with a value of 0.161. and the last order is supplier 5 with a value of 0.129. In conclusion, the FAHP method can be effectively used in selecting suppliers of flyknit raw materials at PT. XYZ because this method provides more objective and structured results.

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1. INTRODUCTION

In the era of increasing and intense industrial competition, every company is encouraged to provide and improve the best quality products to consumers. In addition, the company must be able to maintain and maintain the continuity of the production process so that the company does not experience obstacles. One of the things that can affect the continuity of the production process is the availability of raw materials which is closely related to suppliers. Suppliers play an important role in the availability of raw materials for ongoing production activities in a company. In this case the company needs to

work with suppliers to continue its production activities (Hendriana & Addin, 2021). In choosing the best supplier, it must be done properly, because it can affect the operational continuity of a company, and can reduce purchasing costs (Mahlyda & Mahdiana, 2019). Meanwhile, if the selection of suppliers is not carried out properly, then production activities will not run according to schedule due to delays in the delivery of raw materials by suppliers, the quality of raw materials that do not meet the criteria expected by the company so that it will have an impact on the products sold by the company (Talangkas & Pulansari, 2021).

PT XYZ is a company engaged in fashion. The company produces various types of shoes. The types of shoes produced start from sports shoes, school shoes, and many more. In order for the company to meet consumer demand, and to increase its competitiveness in the local and international markets, it relies on several suppliers in supplying raw material needs, especially for fabric raw materials. The type of fabric used is flyknit. This type of fabric is used because it provides a sense of comfort and lightness to the user and has many unique motifs.

The company experienced problems in selecting raw material suppliers for flyknit fabrics. The problem that occurs is the late delivery of raw materials by suppliers, where the raw materials do not arrive on time as the company wants. The company chooses suppliers who are able to provide the desired raw material specifications at competitive prices. However, in practice, the raw materials obtained from suppliers have defects such as striped fabrics, damaged knit fabrics, inaccurate amounts of fabric and so on. Therefore, this factor becomes an obstacle and can result in obstruction of production at PT XYZ.

Based on this background, the company needs a method to select the best flyknit fabric raw material supplier so that the company can meet consumer demand and can increase its competitiveness in local and international markets. To be able to solve this problem, researchers used the Fuzzy Analytical Hierarchy Process (FAHP) method. Fuzzy AHP was developed by Chang in 1996 which is a development of the AHP (Analytical Hierarchy Process) method which decomposes complex multi-factor or multi-criteria problems into a hierarchy, so that the problem will appear more structured and systematic besides having a system that is easy to understand and use (Sihite & Suhendar, 2021). The fuzzy AHP method can close the weaknesses of AHP, namely the measurement of criteria in supplier selection is still subjective and vague or uncertain in the supplier evaluation process. In addition, the Fuzzy AHP method can also minimize uncertainty that can occur in decision making (Doaly et al., 2019). In minimizing uncertainty in the AHP scale, the TFN (Triangular Fuzzy Number) approach is used (Ridwan et al., 2019). So that the fuzzy AHP method is an effective method for obtaining weighting results from each criterion by producing an assessment of supplier performance from each weighting result which is converted into a ranking form.

With the implementation of research using the Fuzzy Analytical Hierarchy Process (FAHP) method, it is hoped that it will be a consideration for companies in determining the best suppliers and is expected to help solve existing problems, so that companies can achieve their goals, namely getting the best raw material suppliers based on predetermined criteria so that production activities do not experience obstacles.

2. LITERATURE REVIEW

A. Supply Chain Management

Supply chain is a network consisting of a group of companies that are interconnected with each other, which has the aim of making products and services so that they can be utilized or enjoyed by end consumers (Pujawan & Mahendrawathi, 2017). The supply chain has an important role in the smooth running of a business, where the supply chain can be said to be a logisticts network that acts on five parties horizontally, namely suppliers, factories, distributors, retailers, and also consumers who must work together to create profitable profits for a company (Novadila & Ernawati, 2021). Meanwhile, supply chain management is a supply chain, supply chain, logistics network, a coordinated system consisting of organizations, human resources, information activities, and

other resources that are mutually involved in moving a product or service both in physical and virtual form from a supplier to a customer (Arif, 2018).

The supply chain has three kinds of flow, namely goods flow, money flow and information flow. These three flows must be managed and regulated optimally so that if they are optimally regulated they can synergize supply chain management with the parties involved properly (Vistasusiyanti et al., 2017). For the role of the flow of goods is that goods that are upstream will flow downstream. For example, raw materials sent from suppliers will go to the factory to carry out the production process into a finished product, after being produced the product is sent to the distributor and forwarded to the retailer and continued to the end user. For the role of money flow is that money that was originally downstream will flow upstream. For example, the payment obtained from the end user is paid to retail and then used by retail to buy goods from the factory. From the factory, it will be paid to suppliers to purchase raw materials that will be used to produce goods. To produce a superior supply chain, the role of information flow is needed, where information will allow those who play a role to make the right decisions. For example, information about the availability of production raw materials owned by suppliers is often needed by companies as well as information about the delivery status of raw materials is also needed by companies.

One element that has an important role in supply chain decision making is procurement management. According to Arsana, (2016) procurement management is a process that ensures that companies obtain and manage all supplies of materials, products, goods, and services appropriately, taking into account quality, quantity, price, time, source and place, so that they can run efficiently and have a positive impact on the profitability and operations of the company. The task of procurement management is to provide the inputs needed by the company in the form of goods or products or services used for production activities or other activities within the company.

B. Supplier Selection

The activity of choosing a supplier is a strategic activity that can be seen from various factors such as sustainability factors and risk factors, especially if the supplier supplies critical components that will be used in the long term as an important supplier (Alikhani et al., 2018). Selection of suppliers must be right if it is not right or not in accordance with the wishes, the company will experience losses caused by delays in delivery, it can result in the production process also being hampered and in delivery to the customer will also experience delays so that it can disappoint the customer, besides that if the supplier sends materials that are not in accordance with predetermined specifications or are of poor quality, it will also disappoint consumers in the end. Therefore, choosing the right supplier will result in considerable savings, as well as minimize the risks that occur (Pujotomo et al., 2018).

Supplier selection is a complicated job because it involves more than one criterion, which must meet customer needs. Choosing criteria must of course reflect the supply chain strategy and the characteristics of the material being supplied. Citing the source Imran et al., (2020) that Dickson's research is known as Dickson's Vendor Selection Criteria which explains that the criteria for selecting suppliers are divided into 23 criteria, where the supplier selection criteria are very diverse, namely:

Table 1. Supplier selection/evaluation criteria according to Dickson

Criteria	Score Criteria
Quality	3.5
Delivery	3.4
Performance history	3.0
Warranties and claim policies	2.8
Price	2.8
Tehcnical capability	2.8

Financial position	2.5
Procedural compliance	2.5
Communication sistem	2.5
Reputation and position in industry	2.4
Desire for business	2.4
Management and organization	2.3
Operating controls	2.2
Repair service	2.2
Attitudes	2.1
Impression	2.1
Packaging ability	2.0
Labor relations records	2.0
Geographical location	1.9
Amount of past	1.6
Training aids	1.5
Reciprocal arrangements	0.6

(Source : Pujawan, 2017)

C. Analytical Hierarchy Process

The Analytical Hierarchy Process method is a decision support method with many criteria and can provide a ranking or ranking on existing alternatives. This decision support model will decompose complex multi-factor or multi-criteria problems into a hierarchy. Hierarchy is defined as a representation of a complex problem in a multilevel structure where the first level is the goal, followed by the level of factors, criteria, sub-criteria, and so on to the last level of alternatives (Dahriansah et al., 2020).

According to Setiawan & Hartini, (2022), there are three basic principles that must be used in conducting an analysis using the Analytical Hierarchy Proces AHP method, namely:

1. The principle of hierarchical organization. In this principle, the problem is the first step in defining the problem so that it becomes more detailed and clear. The decision taken will be a goal that will be broken down into clearer components until the most measurable stage is reached.
2. The principle of determining priorities. In determining the priority of a component in the hierarchy, it can be seen as the weight or contribution of the component to the goal or target to be achieved in the AHP model. This is based on the basic human decision-making ability to use information and knowledge to estimate the importance of one thing when compared to another through the process of comparing things in pairs. This process is called the pairwise comparison method. This method can be used to analyze the priority of elements in a hierarchy.
3. The principle of logical consistency. In using this principle, AHP combines both qualitative and quantitative aspects in order to express judgments and preferences in a concise and compact manner. For qualitative aspects, AHP defines the problem and judgment to get the problem solution while for quantitative aspects, AHP performs numerical comparison and judgment to get the problem solution.

According to Irawan et al., (2019) the following steps of the AHP method were carried out in the study:

1. Define the problem and determine the solution, then develop a hierarchy of the problem. Hierarchy building is done by setting objectives that are the goals of the system as a whole.
2. Determining element priorities. The initial stage in determining the priority of elements is to make pair comparisons by comparing elements in pairs according to the criteria given. The pairwise comparison matrix uses numbers to present the relative importance of an element to other elements.
3. Synthesis. The stages carried out in synthesizing this are the first stage of summing up the values of each column in the matrix. The second stage is to divide each value of the column by the total column concerned to obtain matrix normalization. The third stage is to add up the values of each row and divide them by the number of

elements in order to get the average matrix normalization.

4. Measuring Consistency. The stages carried out in measuring consistency are the first stage of multiplying each value in the first column with the relative priority of the first element, the value in the second column with the relative priority of the second element, and so on. The second stage sums up each row. The third stage is the result of the row summation divided by the relative priority element concerned. The fourth stage is to calculate the eigenvalue (λ max) by summing the above quotient with the number of elements.
5. Calculating Consistency Index (CI)
   $$CI = \frac{\lambda \max - n}{n - 1} \quad (1)$$
   Where:
   CI = Consistency Index
   λ max = Eigen value
   n = Number of matrices being compared
6. Calculate the Consistency Ratio (CR)
   $$CR = \frac{CI}{RI} \quad (2)$$
   Where:
   CI = *Consistency Index*
   RI = *Random Index*
   Checking the consistency of the hierarchy. If the value is greater than 10%, then the judgment data assessment must be corrected. However, if the consistency ratio is less than or equal to 0.1, then the calculation results can be declared consistent.

D. Fuzzy Analytical Hierarchy Process

Fuzzy AHP method can be used as an alternative selection in problem solving by combining the concepts of fuzzy theory and hierarchical structure analysis. This method can be used as a cover for the weaknesses of the AHP method because it can correct the uncertainty that arises in deciding the level of importance of performance indicators by decision makers. The fuzzy AHP method uses fuzzy numbers for the pairwise comparison matrix. Pairwise comparison matrix operations are carried out using triangular fuzzy numbers. Triangular Fuzzy Number (TFN) is one of the fuzzy logic membership functions whose membership is defined by three real numbers expressed as the lowest (l), middle value (m), and highest value (u). From the criteria and alternatives carried out according to AHP theory then transformed using triangular fuzzy numbers to create a pairwise comparison matrix (Adikoro & Wurjaningrum, 2022).

According to farid, M. M., Suhendar, (2019) there are stages to perform calculations in determining the weight of supplier performance assessments using the Fuzzy Analytical Hierarchy Process (FAHP) Method, namely as follows:

1. Organize and create a hierarchy of existing problems.
2. Transform the pairwise matrix into TFN scale
3. Determining the priority Si value
   $$Si = \sum_{j=1}^{m} M_i^j \, x \, [\sum_{i=1}^{n} \sum_{j=1}^{m} M_i^j]^{-1} \quad (3)$$
   Where:
   $$\sum_{j=1}^{m} M_i^j = \sum_{j=1}^{m} lj, \sum_{j=1}^{m} mj, \sum_{j=1}^{m} uj \quad (4)$$
   While:
   $$\frac{1}{\sum_{i=1}^{n} \sum_{j=1}^{m} M_i^j} = \frac{1}{\sum_{i=1}^{n} ui, \ \sum_{i=1}^{n} mi, \ \sum_{i=1}^{n} li} \quad (5)$$
   Description:
   M = triangular fuzzy number
   m = number of criteria
   j = column
   i = row
4. Determining the vector value (V)
   In determining the vector value, if the results obtained on each fuzzy matrix are $M_2 \geq M_1$, $M_2 = (l_2, m_2, u_2)$ and $M_1 = (l_1, m_1, u_1)$ then the vector value can be formulated as:
   $$V(M_2 \geq M_1) = \text{Sup}[(\mu M_1(x), \min(\mu M_2(y)))] \quad (6)$$
   or equal to the following formula:
   $$V(M_2 \geq M_1) = \begin{cases} 1, if \ m_2 \geq m_1, \\ 0, if \ I_i \geq I_2, \\ \dfrac{I_1 - I_2}{(m_2 - u_2) - (m_1 - I_1)} \end{cases} \quad (7)$$
5. Determining the Defuzzification ordinate value (d')
   $V(M \geq M_1, M_1, \ldots\ldots, M_k) = V(M \geq M_1)$ dan $V(M \geq M_2)$ dan $V(M \geq M_k) = \min V(M \geq M_i)$. (8)
   Assume that,
   $d'(Ai) = \min V(Mi \geq Mk)$ (9)
   For k = 1,2,...,n; k ≠ i, the weight vector value is obtained.
6. Normalization Fuzzy vector weight value W
   $$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T \quad (10)$$
   Where:

d' = weight vector value of each criterion
A_i = 1, 2, ..., n is n decision elements
After normalizing the equation W', the normalized weight vector value is like the following formula:

$$W = (d(A_1), d(A_2), \dots, d(A_n))^T \quad (11)$$

W is a non-fuzzy number

3. RESEARCH METHOD

This research was conducted at PT XYZ which is located in one of the industrial areas in Sidoarjo, East Java. The initial stage in conducting research is to conduct a literature study which has the aim of exploring information related to the problem under study based on literature such as books, journals and so on. In this study, data was collected in two ways, the first is direct interviews with reliable sources, this is done to determine the performance level of flyknit fabric raw material suppliers. Second, the respondents filled out a questionnaire. The questionnaire is divided into two, the first is a questionnaire on the level of importance (weight) of the criteria, and the second is a supplier assessment questionnaire where filling out the questionnaire must be done sequentially. Respondents are purchasing manager, production manager, finance manager, and logistics manager.

After the data is obtained through interviews and distributing questionnaires, the next step is data processing using the AHP method to calculate the weight and level of importance between criteria, followed by the FAHP method to convert the results of pairwise comparisons into fuzzy logic values so that supplier ranking and supplier performance are obtained. Based on the results of data processing, the results are then analyzed to get the best flyknit fabric supplier priorities. The steps of problem solving (Flowchart) can be seen in Fig. 1.

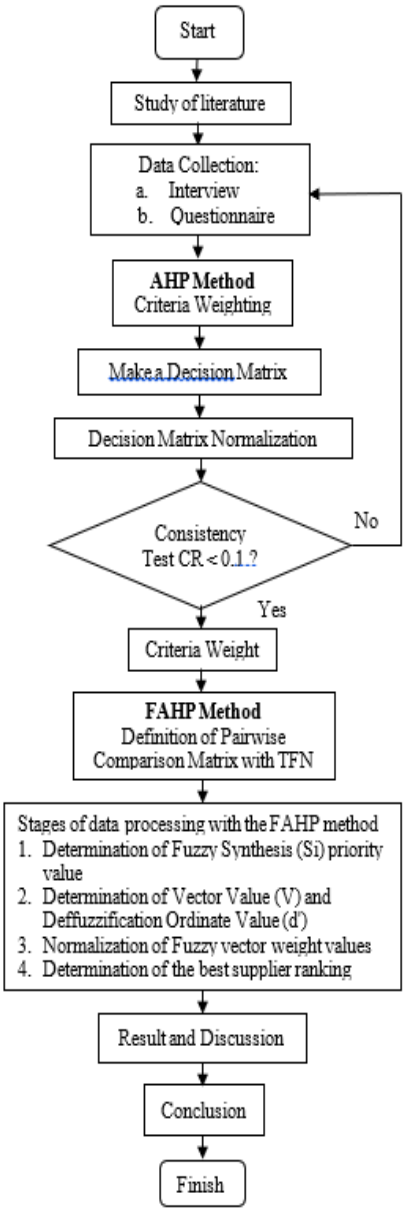

Fig. 1. Problem solving steps (flowchart)

4. RESULT AND DISCUSSION

In making decisions to choose the best raw material suppliers, companies need to assess suppliers based on criteria and sub-criteria, so that supplier performance will be assessed using these criteria and sub-criteria as a consideration in choosing the best supplier. In determining the criteria and sub-criteria for assessing the performance of suppliers, it is determined by interviewing the company and based on the criteria in Table 1. Based on the results of these interviews, the criteria used to evaluate suppliers are obtained. The criteria in question are price, quality, delivery, service, and information systems. Then from these criteria are derived into sub-criteria. There are six alternatives, including supplier 1, supplier 2, supplier 3, supplier 4, supplier 5, and supplier 6. The following are the criteria and sub-criteria for selecting suppliers. Table 2 summarizes these criteria.

Table 2. Supplier selection criteria and sub criteria

Criteria	Sub Criteria
Price (P)	Price level (P1)
	Discount (P2)
Quality (Q)	Suitability of goods specifications (Q1)
	Defect of goods (Q2)
Delivery (D)	On-time delivery (D1)
	Accuracy and appropriateness of the quantity of goods (D2)
Service (S)	Responsive to customer complaints (S1)
Communication system (C)	Consistency with information exchange (C1)

(Source: table dicson and interview)

Solving a complete problem into elements into a hierarchical form in the decision-making process where each element or element is interconnected. Problem solving is carried out on each element until no further solving is possible so that several levels of the existing problem are obtained. Several criteria are used to identify the hierarchy of problems in a hierarchical system. The hierarchical structure starts with the highest level, namely the top position is what goal is to be achieved. At the next level there are several levels of criteria and then sub criteria. In the hierarchical structure alternatives and solutions are at the lowest level. Figure 2 shows the system hierarchy that will be used in this research.

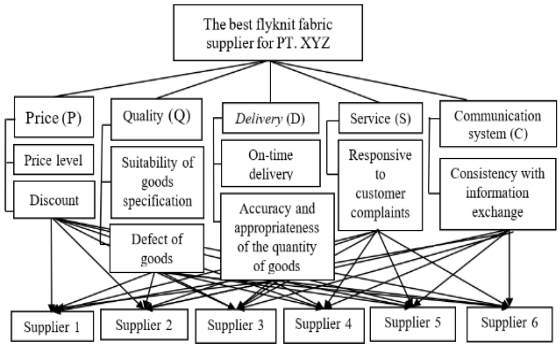

Fig. 2. Hierarchy structure

After filling in the data on the questionnaire, the next step is to recapitulate the results on the questionnaire regarding the level of importance between the criteria and the supplier evaluation. From the results of the assessment on the questionnaire, data processing will then be carried out. Later the data obtained will be processed further in stages until the appropriate final results are obtained.

The first step in the AHP calculation is to compile a pairwise comparison matrix of the criteria obtained from the recapitulation of respondents' evaluations. The results of the supplier performance evaluation are entered into a pairwise comparison matrix for each criterion.

Table 3. Initial matrix of paired comparisons between criteria

	Price	Quality	Delivery	Service	Communication system
Price	1	1	1	2	1
Quality	1	1	3	4	4
Delivery	1	0,333	1	3	3
Service	0,5	0,25	0,333	1	1
Communication system	1	0,25	0,333	1	1
Total	**4,5**	**2,83**	**5,66**	**11**	**10**

(Source: processed data)

From the pairwise comparison matrix of the criteria above, there is a relationship between criteria that is worth 1. The meaning of the value 1 is that the two related criteria have the same level of importance. The criteria relationships that have a value of 1 are price - quality, price - delivery, price - communication system, quality - price, delivery - price, communication system - price, communication system - service, and service - communication system.

From the pairwise comparison matrix above, it is known that there is a relationship between

criteria with a value of 2. The meaning of value 2 is that it shows that between the two criteria that are related have properties that are slightly more important than the other criteria. The criteria relationship that has a value of 2 is price - service. While the relationship between criteria that is worth 0,5 which means the opposite of value 2. The relationship between criteria that has a value of 0,5 is service – price.

From the pairwise comparison matrix above, there is a relationship between criteria that is worth 3. The meaning of the value of 3 is that it shows that between the two related criteria it has a slightly more important nature than the other criteria. The criteria relationships that have a value of 3 are quality - delivery, delivery - service, delivery - communication system. While the relationship between criteria worth 0,33, which means the opposite of value 3. The relationship between criteria that has a value of 0,33 is delivery - quality, service - delivery, and communication system -delivery. From the pairwise comparison matrix above, there is a relationship between criteria that is worth 4. The meaning of the value 4 indicates that between the two criteria that are related have properties close to being very more important than the other criteria. The criteria relationships that have a value of 4 are quality - service and quality - communication system. While the relationship between criteria is worth 0,25 which means the opposite of value 4. The criteria relationships that have a value of 0,25 are service - quality and communication system - quality.

The next step is to normalize the pairwise comparison matrix. The normalization matrix is created by dividing the column elements by the total value of the column. The results of the normalization calculation of the pairwise comparison matrix in Table 4.

Table 4. Normalization of pairwise comparison matrix between criteria

	Price	Quality	Delivery	Service	Communication system	Average
Price	0,222	0,3534	0,1767	0,1818	0,1	0,207
Quality	0,222	0,3534	0,53	0,3636	0,4	0,374
Delivery	0,222	0,1166	0,1767	0,2727	0,3	0,218
Service	0,111	0,0883	0,0583	0,0909	0,1	0,90
Communication system	0,222	0,0883	0,0583	0,0909	0,1	0,112
Total	**1**	**1**	**1**	**1**	**1**	**1**

(Source: processed data)

Based on the table of normalization results of the pairwise comparison matrix of the criteria above, the average value of the price criteria is 0.207, for the quality criteria is 0.374, for the delivery criteria is 0.218, for the service criteria is 0.90, and for the communication system criteria is 0.112.

The next step is to calculate the consistency ratio, this calculation is used to determine whether the data is consistent. In calculating the consistency of the pairwise comparison matrix, it is done by multiplying each matrix column by each matrix row.

Table 5. Eigen vector results matrix paired criteria

Criteria	Eigen Vector
Price	1,090
Quality	2,040
Delivery	1,153
Service	0,470
Communication system	0,574

(Source: processed data)

After obtaining the value of the eigen vector, the calculation of the eigen value (λ max) is then carried out. The result of the eigen value (λ max) is 5.278. The Consistency Index (CI) value is 0.0696. The consistency ratio (CR) value is 0.062. Because the CR value is still within the tolerance limit (0.1), so the

pairwise comparison matrix of criteria is considered consistent and does not need to be re-evaluated.

After going through the consistency test stage and the results of the consistency test are declared consistent or acceptable, the next step is to define the pairwise comparison matrix by converting it to a triangular fuzzy number (TFN) scale.

Table 6. The result of converting the value of the comparison matrix into a value in TFN

	Price			Quality			*Delivery*			Service			Communication system		
	l	m	u	l	m	u	l	m	u	l	m	u	l	m	u
P	1	1	1	1	1	3	1	1	3	1	2	4	1	1	3
Q	1	1	3	1	1	1	1	3	5	2	4	6	2	4	6
D	1	1	3	0,2	0,33	1	1	1	1	1	3	5	1	3	5
S	0,25	0,5	1	0,167	0,25	0,5	0,2	0,33	1	1	1	1	1	1	3
C	1	1	3	0,167	0,25	0,5	0,2	0,33	1	1	1	3	1	1	1

(Source: processed data)

Based on the conversion results above, it is known that the price criterion with price has a pairwise comparison matrix value of 1, so the conversion result with the TFN scale becomes (1,1,1) with a lower value (l) = 1, a median value (m) = 1, and an upper value (u) = 1. Then the quality criteria with price is obtained which has a pairwise comparison matrix value of 1, so the conversion result with the TFN scale becomes (1,1,3) with a lower value (l) = 1, a median value (m) = 1, and an upper value (u) = 3. For delivery criteria with prices that have a pairwise comparison matrix value of 1, so the conversion results with the TFN scale become (1,1,3) with a lower value (l) = 1, median value (m) = 1, and upper value (u) = 3. For service and price criteria that have a pairwise comparison matrix value of 1/2, so the conversion results with the TFN scale become (0. 25, 0.5, 1) with a lower value (l) = 0.25, a median value (m) = 0.2, and an upper value (u) = 1. And for the communication system and price criteria that have a pairwise comparison matrix value of 1, so the conversion results with the TFN scale become (1,1,3) with a lower value (l) = 1, a median value (m) = 1, and an upper value (u) = 3. And so on.

The next stage is to calculate the priority fuzzy synthesis value (Si). The purpose of calculating the priority fuzzy synthesis value (Si) is to obtain a relative weight for decision-making elements and can determine the degree of membership so that the fuzzy vector value can be obtained.

Table 7. Fuzzy synthesis value (Si) priority of criteria pairwise comparison matrix

	$\mathbf{Si} = \sum_{j=1}^{m} M_i^j x \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_i^j \right]^{-1}$		
	l	**m**	**u**
Price	0,077	0,177	0,631
Quality	0,108	0,382	0,947
Delivery	0,064	0,245	0,676
Service	0,040	0,091	0,293
Communication system	0,052	0,105	0,383

(Source: processed data)

Based on the table of fuzzy synthesis values (Si) of pairwise comparison matrix priorities for criteria, it is obtained that the price criteria obtain a lower (l) = 0.077, median (m) = 0.177, upper (u) = 0.631. For quality criteria, the value of lower (l) = 0.108, median (m) = 0.382, upper (u) = 0.947. For the delivery criteria, the value of lower (l) = 0.064, median

(m) = 0.245, upper (u) = 0.676. For service criteria, the value of lower (l) = 0.040, median (m) = 0.091, upper (u) = 0.293. And for the communication system criteria, the value of lower (l) = 0.052, median (m) = 0.105, upper (u) = 0.383.

After carrying out the stages of determining the priority fuzzy synthesis value (Si), the next stage is to perform calculations to determine the vector value (V) and the defuzzyfication ordinate value (d'). To determine the vector value, it can be calculated by comparing the fuzzy synthetic extent value (Mi≥Mk). The results of the comparison will be taken the smallest value and the results of the comparison will be the vector weight value.

Table 8. Vector table (V) and defuzzyfication ordinates (d')

Price		Quality		*Delivery*		Service		Communication system	
VP (VQ,VD,VS,VC)		VQ (VP, VD, VS, VC)		VD (VP, VQ, VS, VC)		VS (VP, VQ, VD, VC)		VC (VP, VQ, VD, VS)	
VP ≥ VQ	0,718	VQ ≥ VP	1	VD ≥ VP	1	VS ≥ VP	0,716	VC ≥ VP	0,811
VP ≥ VD	0,892	VQ ≥ VD	1	VD ≥ VQ	0,805	VS ≥ VQ	0,388	VC ≥ VQ	0,498
VP ≥ VS	1	VQ ≥ VS	1	VD ≥ VS	1	VS ≥ VD	0,597	VC ≥ VD	0,695
VP ≥VC	1	VQ ≥ VC	1	VD ≥ VC	1	VS ≥ VC	0,943	VC ≥ VS	1

(Source: processed data)

After carrying out the calculation stage to determine the vector value (V) and the defuzzyfication ordinate value (d') for all criteria, the next stage is to determine the vector weight. After obtaining the results of the value of the vector weight, the next stage is to normalize the value of the fuzzy vector weight. At this stage it is done by dividing each element of the vector weight by the number of weights itself. The results of normalization will produce W variables or non-fuzzy numbers. If the W variable is totaled, it will produce a value of 1.

Table 9. Normalized value of fuzzy vector

	Price	**Quality**	***Delivery***	**Service**	**Communication system**	**Total**
W'	0,718	1	0,805	0,388	0,498	3,409
W	0,210	0,293	0,236	0,113	0,146	1

(Source: processed data)

Based on the table above, the normalized weight vector value of each criterion is obtained. The value of the price criteria is 0.210, the quality criteria is 0.293, the delivery criteria is 0.236, the service criteria is 0.113, and the communication system criteria is 0.146, with a total value of 1.

After performing the normalization stage on each fuzzy vector weight value, the weight value will be obtained and the fuzzy AHP calculation is declared complete. The value of the Fuzzy Analytical Hierarchy Process (FAHP) calculation will be processed into supplier rankings.

Table 10. Results of calculating the weights of criteria, sub-criteria and suppliers

Criteria	Weight Result	Sub criteria	Weight Result	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5	Supplier 6
Price	0,210	Price level	0,667	0,1248	0,1876	0,1876	0,1876	0,1248	0,1876
		Discount	0,332	0,0965	0,1996	0,1524	0,1995	0,1524	0,1996

Criteria	Weight Result	Sub criteria	Weight Result	Supplier 1	Supplier 2	Supplier 3	Supplier 4	Supplier 5	Supplier 6
Quality	0,293	Suitability of goods	0,500	0,2118	0,1704	0,1177	0,1704	0,1177	0,2118
		Defect of goods	0,500	0,1720	0,1720	0,2234	0,1720	0,1720	0,0884
Delivery	0,236	On-time delivery	0,700	0,1282	0,1885	0,2296	0,1885	0,0768	0,1885
		Accuracy and appropriateness of the quantity of goods	0,299	0,2263	0,1811	0,1811	0,1152	0,1152	0,1811
Service	0,113	Responsive to customer complaints	1,000	0,1524	0,1524	0,1996	0,1996	0,0965	0,1996
Communication system	0,146	Consistency with information exchange	1,000	0,1796	0,1796	0,1022	0,1796	0,1796	0,1796

(Source: processed data

The results of the calculation of the weight of the price (P), quality (Q), delivery (D), service (S), and communication system (C) criteria are 0.210, 0.293, 0.236, 0.113, and 0.146, respectively. For the results of the sub-criteria Price level (P1), Discount (P2), Suitability of goods (Q1), Defect of goods (Q2), On-time delivery (D1), Accuracy and appropriateness of the quantity of goods (D2), Responsive to customer complaints (S1), and Consistency with information exchange (C1) are 0.667, 0.332, 0.500, 0.500, 0.7002, 0.2998, 1.000, and 1.000, respectively.

Meanwhile, the price level weight value (P1) for supplier 1 is 0.1248, supplier 2 is 0.1876, supplier 3 is 0.1876, supplier 4 is 0.1876, supplier 5 is 0.1248, and supplier 6 is 0.1876. For the discount weight (P2) for supplier 1 is 0.0965, supplier 2 is 0.1996, supplier 3 is 0.1524, supplier 4 is 0.1995, supplier 5 is 0.1524, and supplier 6 is 0.1996. For the weight of Suitability of goods (Q1) for supplier 1 is 0.2118, supplier 2 is 0.1704, supplier 3 is 0.1177, supplier 4 is 0.1704, supplier 5 is 0.1177, and supplier 6 is 0.2118. For the weight of Defect of goods (Q2), for supplier 1 is 0.1720, supplier 2 is 0.1720, supplier 3 is 0.2234, supplier 4 is 0.1720, supplier 5 is 0.1720, and supplier 6 is 0.0884. For the On-time delivery (D1) weight, for supplier 1 is 0.1282, supplier 2 is 0.1885, supplier 3 is 0.2296, supplier 4 is 0.1885, supplier 5 is 0.0768, and supplier 6 is 0.1885. For the weight Accuracy and appropriateness of the quantity of goods (D2), for supplier 1 is 0.2263, supplier 2 is 0.1811, supplier 3 is 0.1811, supplier 4 is 0.1152, supplier 5 is 0.1152, and supplier 6 is 0.1811. For the weight Responsive to customer complaints (S1), for supplier 1 is 0.1524, supplier 2 is 0.1524, supplier 3 is 0.1996, supplier 4 is 0.1996, supplier 5 is 0.0965, and supplier 6 is 0.1996. For the weight of Consistency with information exchange (C1), for supplier 1 is 0.1796, supplier 2 is 0.1796, supplier 3 is 0.1022, supplier 4 is 0.1796, supplier 5 is 0.1796, and supplier 6 is 0.1796

After obtaining the weight value of each criterion, sub-criteria and supplier, then

proceed to the last stage, namely ranking. The results of supplier ranking are used to determine the best supplier. The following are the results of ranking flyknit fabric suppliers for PT. XYZ.

Table 11. Best Flyknit Fabric supplier risk results

Ranking	Supplier	Total
1	Supplier 4	0,179
2	Supplier 2	0,178
3	Supplier 6	0,177
4	Supplier 3	0,175
5	Supplier 1	0,161
6	Supplier 5	0,129

(Source: processed data)

Based on the table above, the flyknit fabric supplier ranking result that has the highest value with a value of 0.179 is supplier 4. Then in second place is supplier 2 with a value of 0.178, in third place is supplier 6 with a value of 0.177, in fourth place is supplier 3 with a value of 0.175, in fifth place is supplier 1 with a value of 0.161. and the last order is supplier 5 with a value of 0.129.

Therefore, the result of this study is that PT. XYZ as a company in charge of selecting suppliers is advised to choose supplier 4 as a supplier of raw materials for its production activities. Supplier 4 is significantly better in terms of overall criteria compared to other alternatives, so the decision to choose this supplier is very appropriate. In addition, in terms of criteria and sub-criteria, they are consistently related to quality, so supplier 4 has a close relationship with a much better quality level than other alternatives. The quality aspect is very important and the main thing as an output of the results of good collaboration between companies.

5. CONCLUSION

The conclusions resulting from research and data processing using the fuzzy analytical hierarchy process method obtained the results of the ranking of the best suppliers of flyknit fabric raw materials at PT. XYZ in a row are Supplier 4, Supplier 2, Supplier 6, Supplier 3, Supplier 1, and Supplier 5. In using the Fuzzy AHP method can effectively be used in the selection of suppliers of flyknit fabric raw materials at PT. XYZ because it helps in reducing uncertainty and complexity in decision making besides this method provides more objective and structured results.

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