Thread Locker Supplier Selection Analysis Using Fuzzy Analytical Hierarchy Process Method

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Abstract. The purpose of this research is to find the best supplier in PT TBV with priority criteria based on company criteria. For determining the best supplier, the company will obtain the best raw materials and ensure that the production process is runs well. The alternative suppliers evaluated are Supplier X, Supplier Y, and Supplier Z, using the Fuzzy-AHP method. Fuzzy AHP was developed to cover the weaknesses of the AHP method. Combining the strengths of the Fuzzy method with AHP is one approach to overcoming the limitations of the Analytic Hierarchy Process. The approach in this research is mixed methods. This method is a combination of quantitative and qualitative methods. Data collection in this study used several techniques, namely interviews and questionnaires. The analysis was carried out on five criteria, namely price, quality, service, delivery, and supplier profile so that the following weights were obtained: price (0.38), quality (0.41), service (0.00), delivery (0.00), and supplier profile (0.21). Based on the results of the calculation of the final weight, supplier Z occupies the highest position with a weight of 0.4227, followed by supplier Y with a final weight of 0.3027, and the last supplier suggested is supplier X with a weight of 0.2746. These results are a guide for companies in choosing the most suitable suppliers to maintain smooth production operations.

Keywords: Fuzzy-AHP, Thread Locker, and Supplier Selection.

1 Introduction

According to Gazali et al. (2015), raw material procurement is the main factor when carrying out production process activities. Insufficient raw materials will hinder the company's production process, so the raw material procurement factor is very important in winning the competition. To fulfil the right raw materials, companies depend on suppliers.

PT TBV is one of the growing of manufacturing. PT TBV produces various kinds of valves for the industrial world. The quality of the valve produced is influenced by the raw materials and equipment used, this makes PT TBV very dependent on suppliers. Hex head bolt is one type of bolt used by PT TBV in the valve production process. This thread locker is a supporting material in the production process at PT TBV. During the production process, looseness and leakage of hex head bolts were found several times. This greatly affects the quality of the valve, considering the price of the valve is also expensive. In selecting suppliers, the purchasing department still uses basic criteria. Until now, the company has not used quantitative or qualitative techniques in supplier selection. In urgent conditions, the purchasing department only looks for supplier criteria that have a fast delivery process without considering other criteria so that the needs of the production team can be met quickly. The criteria used for selecting thread locker suppliers at PT TBV consist of price, quality, service, delivery and supplier profile. There are several indicators of these criteria, namely price criteria that focus on the lowest price that has been offered, quality criteria that focus on the best quality provided by the supplier, namely having high resistance to vibration and pressure (permanent), having a fast drying time to reduce downtime, resistant to chemicals, and easily applied to head bolts, service criteria that focus on the ability to handle customer complaints, delivery criteria that focus on the suitability of the agreed delivery time and supplier profile criteria that focus on having a good reputation, history, and having adequate facilities.

Based on research conducted by Imas Prisma and Farida Pulansari (2024) supplier evaluation was carried out using several criteria, namely product quality, delivery performance, pricing factor, communication system, warranty and claim policies, and performance history. The ranking has a total value of 0.3395. Next research from Andre Sihite and Endang Suhendar (2021) with price, delivery, quantity accuracy, quality, and service criteria, obtained the results of Fuzzy AHP calculations, the delivery criteria are ranked 1 with a weight of 0.3049. TOPSIS calculation results, Supplier A as rank 1 with a weight of 0.7636. Based on research conducted by Muhammad Galih Wonoseto and Muhammad Yolan Alfiandy (2023) has criteria for salary, term, other loans, membership status, previous payment accuracy expenses, employment, loan objectives, and loan amount. As a result, this decision support system can assist cooperative administrators in providing funding loan decisions based on the criteria that have been made. Next research from conducted by Chia Ken Tsai and Naragain Phumcusri (2021), with criteria for cost, quality, reliability, risk, financial status, service/partnership. Based on research conducted by Abimbola H. Afolayana, Bolanle A. Ojokoha, Adebayo O. Adetunmbi (2020) support models for contractor selection. Based on research conducted by Akhmad Ghiffary Budianto (2016) based on Fuzzy AHP with Fuzzy TOPSIS Method with 9 criteria, namely cost, quality, delivery, technology, flexibility, relationships, design, environmental management systems and green image. Supplier 1 is the best with a closeness coefficient value of 0.666.

Based on research conducted by Agung Santoso, Rita Rahmawati, and Sudarno (2016) with the criteria of products offered, environment, atmosphere and goods sold. With the final result there are main criteria, the Goods criteria have the highest priority weight of 34.1%. Next research from Sebro Mulasi (2015) using Fuzzy AHP and Goal Programing methods with a price criteria, quality, capacity/quantity, flexibility, and service criteria with the final decision of the selected alternative supplier who will supply in December 2015 - February 2016 first is Toncan with a weight of 0.2935 with an order quantity of 6 tons per month.

T. Varshney et al. (2024) investigate automatic generation control (AGC) in a two-area power system by employing the Fuzzy Analytic Hierarchy Process (FAHP), a multi-attribute decision-making (MADM) approach, to assign weights to different sub-objective functions. Similarly, Ahmed and Kilic (2020) assess the effectiveness of nine FAHP methods, including five prominent ones from previous studies, using the Compatibility Index Value (CIV) as the main performance measure. Their analysis evaluates the impact of three experimental factors: matrix size (n), fuzzification level (α), and consistency ratio (C.R), with four fuzzification levels tested 0.25, 0.50, 0.75, and 1.00.

In selecting suppliers, the purchasing department still uses basic criteria. Until now, the company has not used quantitative or qualitative techniques in supplier selection. Therefore, researchers suggest by fuzzy analysis hierarchy process (AHP) method for selecting the best supplier and prioritizing criteria.

2 Literature Review

2.1 Supplier Selection

A supplier is an individual or a company that provides resources for the needs of companies and competitors that produce certain goods and services (Pujawan, 2005). Suppliers have an important role in business operations so that the process runs well. In the business process, suppliers are one of the unavoidable parts. Supplier selection is very important for long-term sustainability. Mistakes in choosing suppliers can cause several losses for the company, such as time or material. Delays in the production process due to improper supplier selection also cause delays in fulfilling customer requests. Therefore, by choosing the right supplier according to the criteria, it will minimize the risk of loss for the Company.

2.2 Analytical Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) is one of the most oftenly adopted methods in the framework of Multi-Criteria Decision-Making (MCDM) due to its ability to decompose complex problems into a systematic hierarchical structure. This method provides an effective framework for addressing complex decision-making problems. AHP applies mathematical procedures to incorporate subjective judgments from individuals or groups across related criteria, enabling systematic evaluation and analysis of results (Moslem et al., 2022). Developed by Thomas L. Saaty, AHP serves as a decision-support tool that helps structure assessment problems and solve the weight relative of existing criteria (Wahyu & Pulansari, 2024).

According to Nugraha (2017), the Analytic Hierarchy Process (AHP) is a one of methodologies for making the decision that operates on the basis of multiple criteria. Its fundamental principle lies in pairwise comparisons, where criteria are evaluated relative to one another according to their importance. Through this approach, AHP decomposes complex, multi-criteria problems into a hierarchical structure. Such a hierarchy organizes the decision problem into several levels, beginning with the overarching goal at the top, followed by factors, criteria, and sub-criteria, with the set of alternatives positioned at the lowest level (Sihite & Suhendar, 2021). Nevertheless, one limitation of AHP is its dependence on subjective judgments in the evaluation process. To mitigate this drawback, the integration of fuzzy logic has been proposed, as it facilitates a more objective and accurate assessment of criteria (Yonhendri & Basit, 2017).

2.3 Fuzzy Analytical Hierarchy Process (F-AHP)

Fuzzy-AHP is a hybrid method that combines the Analytic Hierarchy Process (AHP) with fuzzy logic (Santoso et al., 2016). The Fuzzy Analytic Hierarchy Process (FAHP) is a multi-criteria decision-making approach that uses fuzzy logic to assign weights to various factors. Based on these fuzzy principles, a decision matrix is developed, where each element represents the relative performance of one decision-making alternative compared to another (Varshney et al., 2024). FAHP is specifically implemented for determining the weight criterion, rather than evaluating qualitative values. Compared to traditional AHP, FAHP offers a better approach for handling uncertainty and ambiguity in the process of making decision.

The Fuzzy AHP methodology was developed to mitigate the inherent limitations of the conventional Analytic Hierarchy Process (AHP). By integrating the strengths of fuzzy logic with AHP, this hybrid approach provides a means of addressing the methodological constraints of the traditional framework. It facilitates decision-makers in articulating their preferences within a defined but flexible interval (Afolayan et al., 2020). As an extension of the classical AHP, Fuzzy AHP has been employed to determine the relative weight of decision criteria, underscoring the increasing relevance of fuzzy set theory in the domain of multicriteria decision-making (Moslem et al., 2022).

According to Peng et al. (2021), the theoretical foundation and computational process of fuzzy mathematics are relatively straightforward, allowing for the representation of fuzzy boundaries and a more objective reflection of real-world conditions. In the Fuzzy Analytic Hierarchy Process (FAHP), weights are derived from fuzzy pairwise comparison matrices. These weights are then used, along with the scores of alternatives for each criterion, to rank the available options. As such, calculating weights from the comparison matrices is a critical step in the FAHP method (Ahmed & Kilic, 2020). The FAHP approach is qualitative criteria, while triangular fuzzy numbers (TFNs) are effective in handling uncertainty stemming from linguistic expressions and subjective preferences (Tsai & Phumchusri, 2021). As a result of applying the Fuzzy AHP method, it is expected that the system will display a ranking based on the preference value from the fuzzy AHP calculation results (Wonoseto & Alfiandy, 2023).

According to Saaty (2008), supplier selection is conducted using Multiple Criteria Decision-Making (MCDM), where specific criteria guide the identification of the optimal alternative. Before applying Fuzzy AHP (F-AHP), the problem is first structured and analyzed through AHP to verify the consistency within the matrix of comparisons. The following are the steps of AHP calculation (Fajri et al., 2018).

a. Define problems and determine solutions into a hierarchical structure (Figure 1).

b. Making pairwise comparisons (Table 3).

c. Calculating priority vector weights (Table 3)

d. Normalize the matrix with the following steps:

   1. The values contained in one column are summed up.

   2. Determine the weight vector priority by calculating the the result of dividing the value in the table pairwise comparison by the value numbers of each column. (Table 16)

e. Weighting (Eigen Vector): weighting by sum the values in each row and dividing it by the number of criteria. (Table 16)

f. Consistency measurement is conducted to evaluate the degree of reliability in the judgments provided. The procedure for assessing consistency consists of the following steps:

   1. Multiply each entry in the first column by the relative priority of the corresponding element and continue this process for all elements.

   2. Sum the values in each row, then divide the result by the respective relative priority.

   3. Add together the obtained quotients to determine the value of λ max.

$$\lambda \max = \frac{total\ summation\ matrix}{sum\ of\ criteria}$$

g. Calculate the maximum CI and CR. (Table 10)

CI value is obtained from the formula:

$$CI = \left(\frac{\lambda \max - n}{n-1}\right) \quad (2)$$

The formula for Consistency Ratio (CR) is as follows:

$$\mathrm{CR} = \frac{CI}{RI} \quad (3)$$

The RI value depends on the order of the matrix n. The RI value can be seen in the table 11.

After completing the AHP stage and obtaining consistency, then continued with the Fuzzy stage as follows (Nurcahyani, 2014)

a. Conversion of pairwise comparison matrix to TFN scale (Table 13)

b. Calculate the fuzzy synthesis value synthesis extent (Si) of the pairwise comparison matrix. (Table 14)

$$\mathrm{Si} = \sum_{j=1}^{m} M_{gi}^{i}\ x \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1} \quad (4)$$

c. Determining the vector value (V) and the value of the fuzzified ordinate (d') (Table 15)

Should the findings obtained from the fuzzy matrix $M_2 \geq M_1$ where $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ then the value vector can be seen in the following equation:

$$V(M_2 \geq M_1) = \begin{cases} 1 & \text{if } m_2 \geq m_1 \\ 0 & \text{if } l_1 \geq l_2 \\ \frac{l1 - l2}{(m2 - u2) - (m1 - l1)} & \end{cases} \quad (5)$$

If the result of the fuzzy value > k, M_i (i=1, 2,,,k) then the value vector can be defined as the following equation:

$$V(M \geq M_1, M_2, ..., M_k) = V(M \geq M_1) \text{ and } V(M \geq M_2) \text{ and}$$

$$V(M \geq M_k) = \min V(M \geq M_i) \quad (6)$$

Defuzzification ordinates can be seen in the following equation:

$$d'(Ai) = \min V(Si \geq Sk) \quad (7)$$

d. Normalizing the weight value of the fuzzy vector (W) (Table 16)

The value of the normalized weight vector is like the following formula:

$$W' = (d'(A_1), d'(A_2), \ldots d'(A_n))^T \quad (8)$$

e. Calculation of alternatives based on criteria and decision results and then sorted into a ranking. (Table 28)

2.4 Purchasing

According to Hidayat (2019) purchasing is one of the company's activities carried out with the aim of obtaining the goods needed by buying them from suppliers. According to Djokopranoto and Indrajit (2005), purchasing refers to the activity of obtaining and ordering goods and services that support the production function in carrying out its operations. Purchasing is very important for the company. Purchasing is needed by the company to meet the needs of both goods and services needed by the company. By looking at certain criteria according to the needs.

3 Research Methods

Fuzzy Analytical Hierarchy Process (F-AHP) method is the technique used for analyzing the data in this research, with a mixed analytical tool that is a combination of quantitative and qualitative. The goal is to get a comprehensive understanding. The research was conducted in a structured manner. There were three respondents selected as sources of information, the selection of respondents was carried out using purposive sampling technique, where the three of them are purchasing manager, purchasing supervisor, quality control supervisor.

The first stage, researchers conducted interviews to determine the problems to be studied and collect data on selection criteria and alternative thread locker suppliers. The next stage, giving questionnaires to respondents who are experts in decision making (decision makers) to determine the value (weight) of the criteria importance level as well as alternative suppliers. The last stage, which is the process of analyzing, comparing and combining the data that has been obtained to form a research result. The results of this study will obtain which criteria and alternatives have the highest value (weight). The following is the research flow shown in Figure 1.

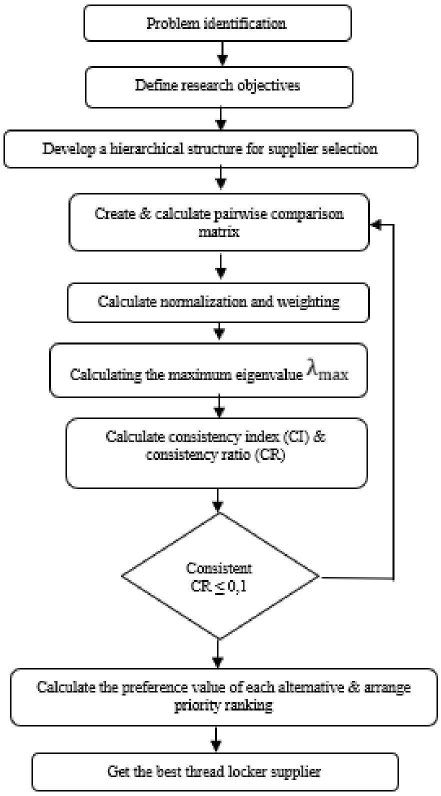

Fig. 1. Research Flow

4 Research Result

4.1 Constructing the Hierarchy and Problem Definition

At this stage, the hierarchy is structured according to a defined sequence, with the primary objective positioned at the top level, followed by the second level comprising the criteria of price, quality, service, delivery, and supplier profile, and the third level consisting of the alternatives X, Y, and Z.

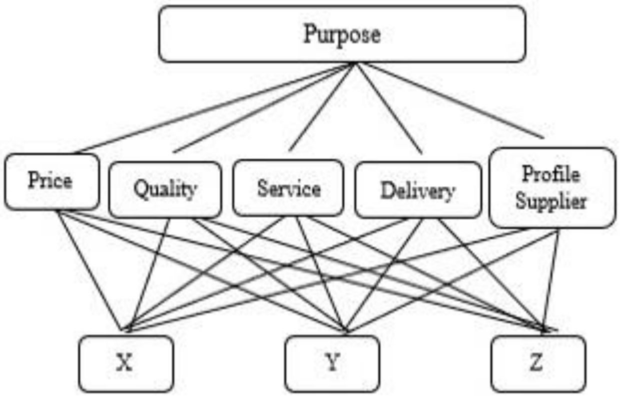

Fig. 2. Hierarchy of Supplier Selection

Figure 2 presents the hierarchical decision model constructed through the Analytic Hierarchy Process (AHP) for evaluating and selecting a thread locker supplier. The hierarchy is structured into three levels, with the overarching goal, designated as "thread locker supplier," positioned at the top level. It represents the overarching decision problem that needs to be addressed. There are five main criteria that influence supplier selection decisions supplier selection decisions are cost: the financial considerations of purchasing from a supplier, quality: the standard or specifications of the products provided by the supplier, service: the level of support and services offered by the supplier, such as support and services offered by the supplier, such as maintenance or after-sales assistance delivery: the reliability and timeliness of the supplier in delivering components, and supplier profile: the reputation of the supplier to the customer. These criteria are interrelated with the suppliers below, reflecting their impact on the decision. reflect their impact on the decision. The bottom level lists three candidate suppliers are X, Y, Z. Each alternative is connected to all criteria, indicating that suppliers will be evaluated based on how well they meet those criteria. An explanation of the hierarchical structure can be seen in table 1.

Table 1. Explanation Of the Hierarchy for Supplier Selection

Goal	Explanation
Selecting Suppliers for Pneumatic System Components	to find out the calculation model for selecting thread locker suppliers at PT TBV using the Fuzzy Analytical Hierarchy Process method, and analysis which thread locker suppliers should be selected by PT TBV by looking at priority criteria.
Criteria	**Sub-Criteria**
Price	1. Lowest price offered 2. Price according to purchasing budget

Quality	1. Best quality provided 2. Quality as per production requirement
Service	Ability to handle customer complaints
Delivery	Conformity to the agreed delivery time
Profile Supplier	Has a good reputation

4.2 Pairwise Evaluation of Criteria and Alternatives

In the Analytic Hierarchy Process (AHP), criteria and alternatives are evaluated using pairwise comparisons. This technique involves comparing two elements together to assess their relative significance. A numerical scale from 1 to 9 is used, which is considered the most effective method of articulating preferences. Pairwise comparisons are calculated based on considering the value of the importance of one element compared to another, as detailed in Table 2.

Table 2. Pairwise Comparison Scale

Intensity of Important	Description
1	Both criteria hold equal importance
3	One criterion is slightly more significant than the other
5	One criterion is judged to be more important than the other.
7	One criterion is perceived as distinctly more important than the other.
9	One criterion is extremely more important than the other
2, 4, 6, 8	Represent intermediate values between the two neighboring levels importance

Once the pairwise evaluation data has been completed and collected, the pairwise comparisons between criteria are summarized, as shown in Table 3.

Table 3. Pairwise Evaluation of Criteria and Alternatives

	Price	**Quality**	**Service**	**Delivery**	**Profile Supplier**
Price	1	½	6	2	3
Quality	2	1	5	3	4
Service	1/6	1/5	1	1/4	1/4
Delivery	½	1/3	4	1	3
Profile Supplier	1/3	1/4	4	1/3	1

Table 3 presented is the pairwise comparison matrix used in the Analytic Hierarchy Process (AHP).

Table 4. Pairwise Comparison Values of Alternatives for The Price Criterion

Alternative	X	Y	Z
X	1	5	3
Y	1/5	1	1/4
Z	1/3	4	1

Table 4 displays the pairwise comparison matrix of the three alternatives X, Y, and Z evaluated through the Analytical Hierarchy Process (AHP) method.

Table 5. Pairwise comparison values of alternatives for the quality criterion

Alternative	X	Y	Z
X	1	1/3	1/4
Y	3	1	2
Z	4	1/2	1

Table 5 represents the relative preference of one alternative over another with respect to the quality criteria, based on expert judgment, facilitating a systematic and consistent decision-making approach.

Table 6. Pairwise Comparison Values of Alternatives for The Service Criterion

Alternative	X	Y	Z
X	1	1/4	1/5
Y	4	1	1/2
Z	5	2	1

Table 6 presented is a pairwise comparison matrix of three alternatives, X, Y, and Z, analysis using the Analytical Hierarchy Process (AHP) method.

Table 7. Pairwise Comparison Values of Alternatives for the Delivery Criterion

Alternative	X	Y	Z
X	1	3	2
Y	1/3	1	2
Z	1/2	1/2	1

Table 7 represents the relative preference relative preference of one alternative over another with respect to the delivery criteria.

Table 8. Pairwise Comparison Values of Alternatives for the Profile Supplier Criterion

Alternative	X	Y	Z
X	1	1/6	1/4
Y	6	1	3
Z	4	1/3	1

Table 8 presented is a pairwise comparison matrix of three alternatives X, Y, and Z.

4.3 Determining Priorities for Criteria

The determination of priorities for criteria is carried out by calculating the relative comparison values, which are used to rank all the criteria. This comparison process is synthesized to obtain the overall priorities through the following stages:

a. Sum all values in each criteria column, as shown in Table 9.

Table 9. Summation of Value in Criteria Column

Criteria	Price	Quality	Service	Delivery	Profile Supplier
Price	1	½	6	2	3
Quality	2	1	5	3	4
Service	1/6	1/5	1	1/4	¼
Delivery	1/2	1/3	4	1	3
Profile Supplier	1/3	1/4	4	1/3	1
Total	4,00	2,28	20,00	6,58	11,25

Table 9 represents the pairwise comparison matrix of five criteria, Price, Quality, Service, Delivery, and Profile Supplier, analysis within the framework of the Analytical Hierarchy Process (AHP).

b. Measuring consistency with the aim of knowing how good the consistency is, as shown in Table 10.

Table 10. Summation of Value in Criteria Column

Criteria	Price	Quality	Service	Delivery	Profile Supplier	Total	Eigen Vector	Summation Matrix
Price	0,25	0,22	0,30	0,30	0,27	1,34	0,268	5,34
Quality	0,50	0,44	0,25	0,46	0,36	2,00	0,400	5,34
Service	0,04	0,09	0,05	0,04	0,02	0,24	0,048	5,09
Delivery	0,13	0,15	0,20	0,15	0,27	0,89	0,178	5,37

Profile Sup-plier	0,08	0,11	0,20	0,05	0,09	0,53	0,106	5,13
Total						5,00	1,000	26,27
λ max								5,25
CI								0,064
RI								1,12
CR								**0,057**

Table 10 provided summarizes the assessment results Analytical Hierarchy Process (AHP), which was used to evaluate five criteria, namely Cost, Quality, Service, Delivery, and Supplier Profile, in the decision-making process. The table includes a pairwise comparison matrix, the total score for each criterion, the calculated eigen vector calculated for each criterion, and consistency measures (Consistency Index (CI), and Consistency Ratio (CR)).

Table 11. Random Index (RI)

n	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
RI	0	0	0,58	0,9	1,12	1,24	1,32	1,41	1,45

After the pairwise comparison results are declared consistent, the next step is to transform the data into the form of TFN (Triangular Fuzzy Number) based on the following table 12:

Table 12. Triangular Fuzzy Number (TFN)

Intensity Of Interest AHP	**The Linguistic Set**	**TFN**	**Reciprocal**
1	Just Equal	(1, 1, 1)	(1, 1, 1)
2	Intermediate	(1/2, 1, 3/2)	(2/3, 1, 2)
3	Moderately Important	(1, 3/2, 2)	(1/2, 2/3, 1)
4	Intermediate	(3/2, 2, 5/2	(2/5, 1/2, 2/3)
5	Strongly Important	(2, 5/2, 3)	(1/3, 2/5, 1/2)
6	Intermediate	(5/2, 3, 7/2)	(2/7, 1/3, 2/5)
7	Very Strong	(3, 7/2, 4)	(1/4, 2/7, 1/3)
8	Intermediate	(7/2, 4, 9/2)	(2/9, 1/4, 2/7)
9	Extremely Strong	(4, 9/2, 9/2)	(2/9, 2/9, 4)

c. Then the results of the transformation can be seen in the following table 13:

Table 13. AHP to TFN Scale Transformation

	Price			Quality			Service			Delivery			Profile Supplier			$\sum_{j=1}^{m} M_{gi}^{i}$		
	l	m	u	l	m	U	l	m	u	l	M	u	l	m	u	L	m	u
Price	1	1	1	0,66	1	2	2,5	3	3,5	0,5	1	1,5	1	1,5	2	5,67	7,5	10
Quality	0,5	1	1,5	1	1	1	2	2,5	3	1	1,5	2	1,5	2	2,5	6	8	10
Service	0,29	0,33	0,4	0,33	0,4	0,50	1	1	1	0,4	0,5	0,66	0,4	0,5	0,66	2,42	2,73	3,23
Delivery	0,66	1	2	0,5	0,66	1	1,5	2	2,5	1	1	1	1	1,5	2	4,67	6,17	8,50
Profile Supplier	0,5	0,66	1	0,4	0,5	0,66	1,5	2	2,5	0,5	0,66	1	1	1	1	3,9	4,83	6,17
$\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}$																22,65	29,23	37,9
$\left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}$																0,026	0,034	0,044

d. Next is to calculate the fuzzy synthesis extend (Si) of the pairwise comparison matrix. Which can be seen in the following table 14:

Table 14. Fuzzy Synthesis Extend (SI)

Criteria	Si		
	L	**m**	**U**
Price	0,15	0,26	0,44
Quality	0,16	0,27	0,44
Service	0,06	0,09	0,14
Delivery	0,12	0,21	0,38
Profile Supplier	0,10	0,17	0,27

e. The next stage calculates the fuzzification ordinate value (d') with the results described in the following table:

Table 15. Fuzzified Ordinate Value (d')

V (C1 ≥ C2, C3, C4, C5)	0,94
V (C2 ≥ C1, C3, C4, C5)	1,00
V (C3 ≥ C1, C2, C4, C5)	0,00
V (C4 ≥ C1, C2, C3, C5)	0,00
V (C5 ≥ C1, C2, C3, C4)	0,51

f. The last stage calculates the normalization of the fuzzy vector weight value (W). The results can be seen in the following table 16:

Table 16. Normalization of Fuzzy Vector Weight (W)

Price	**0,38**
Quality	**0,41**

Service	**0,00**
Delivery	**0,00**
Profile Supplier	**0,21**

4.4 Determining Priorities for Alternatives

After conducting pairwise comparisons between alternatives based on criteria, the comparison results are synthesized to obtain overall priorities. Next, calculate the eigen vector of alternatives with respect to the price criterion, as shown in Table 17.

Table 17. Priorities of Alternatives with Respect to The Price Criterion

Alternative	X	Y	Z	Total	Eigen Vector	Summation Matrix
X	0,65	0,50	0,71	1,85	0,618	3,170
Y	0,13	0,10	0,06	0,29	0,097	3,005
Z	0,22	0,40	0,24	0,85	0,285	3,080
Total				4,17	1,00	9,254
λ max						3,08
CI						0,042
RI						0,58
CR						**0,0731**

After the pairwise comparison results is a consistent, next step is to transform the data into the form of TFN (Triangular Fuzzy Number). Next is to calculate the fuzzy synthesis extend (Si), calculates the fuzzification ordinate value (d'). The final step involves calculating the normalization of the fuzzy vector weight value (W), with the outcomes presented in Table 18:

Table 18. Normalization of Fuzzy Vector Weight (W) for Price Criterion

X	**0,55**
Y	**0,00**
Z	**0,45**

Calculate the priority of alternatives the quality criterion. Can be seen in table 19:

Table 19. Priorities of Alternatives with Respect to The Quality Criterion

Alternative	X	Y	Z	Total	Eigen Vector	Summation Matrix
X	0,13	0.18	0,08	0,38	0,128	3,026
Y	0,38	0,55	0,62	0,51	0,512	3,156

Z	0,50	0,27	0,31	0,36	0,360	3,131
Total				4,18	1,00	9,313
λ max						3,10
CI						0,052
RI						0,58
CR						**0,089**

After the pairwise comparison results is a consistent, next step is to transform the data into the form of TFN (Triangular Fuzzy Number). Next to calculate the fuzzy synthesis extend (Si), calculates the fuzzification ordinate value (d'). The last stage calculates the fuzzy vector weight value (W) as the final result. These results can be seen in the following table 20:

Table 20. Normalization of Fuzzy Vector Weight (W) for Quality Criterion

X	**0,16**
Y	**0,39**
Z	**0,45**

Next, calculate the eigen vector of alternative the service criterion.

Table 21. Priorities of Alternatives with Respect to The Service Criterion

Alternative	X	Y	Z	Total	Eigen Vector	Summation Matrix
X	0,10	0.08	0,12	0,30	0,099	2,992
Y	0,40	0,31	0,29	1,00	0,335	3,028
Z	0,50	0,62	0,59	1,70	0,566	3,055
Total				3,00	1,00	9,074
λ max						3,02
CI						0,012
RI						0,58
CR						**0,0214**

Once the pairwise comparison results are confirmed to be consistent, the data are converted into Triangular Fuzzy Numbers (TFN). This is followed by the calculation of the fuzzy synthetic extent (Si) and the fuzzification ordinate value (d'). The final step involves normalizing the fuzzy vector weight (W), with the results presented in Table 22.

Table 22. Normalization of Fuzzy Vector Weight (W) for Service Criterion

X	**0,00**
Y	**0,47**

Z	**0,53**

Calculate the eigen vector of alternatives with respect to the delivery criterion.

Table 23. Priorities of Alternatives with Respect to The Delivery Criterion

Alternative	X	Y	Z	Total	Eigen Vector	Summation Matrix
X	0,55	0,67	0,40	1,62	0,539	3,185
Y	0,18	0,22	0,40	0,80	0,267	3,060
Z	0,27	0,11	0,20	0,58	0,195	3,040
Total				4,22	1,00	9,284
λ max						3,09
CI						0,047
RI						0,58
CR						**0,0817**

After the pairwise comparison results is a consistent, next step is to transform the data into the form of TFN (Triangular Fuzzy Number). Next is to calculate the fuzzy synthesis extend (Si), calculates the fuzzification ordinate value (d'). The last stage calculates the fuzzy vector weight value (W). The final step shown in table 24.

Table 24. Normalization of Fuzzy Vector Weight (W) for Delivery Criterion

X	**0,37**
Y	**0,29**
Z	**0,34**

Calculate the eigen vector of alternatives with respect to the profile supplier criterion.

Table 25. Priorities of Alternatives with Respect to The Profile Supplier Criterion

C	X	Y	Z	Total	Eigen Vector	Summation Matrix
X	0,09	0,11	0,06	0,26	0,088	2,991
Y	0,54	0,67	0,71	1,92	0,639	3,106
Z	0,36	0,22	0,24	0,82	0,273	3,059
Total				4,10	1,00	9,157
λ max						3,05
CI						0,026
RI						0,58
CR						**0,0452**

After the pairwise comparison results is a consistent, the next step is to transform the data into the form of TFN (Triangular Fuzzy Number). Next is to calculate the fuzzy synthesis extend (Si), calculates the fuzzification ordinate value (d'). The last stage calculates the fuzzy vector weight value (W). The results can be seen in the following table 26:

Table 26. Normalization of Fuzzy Vector Weight (W) for Supplier Criterion

X	**0,00**
Y	**0,68**
Z	**0,32**

4.5 Global Synthesis

Based on the Consistency Ratio (CR) calculation, the next stage is to conduct a Global Synthesis for decision-making. In this step, the priority values of each alternative are multiplied by the priority values of the corresponding criteria. The outcome of this process is displayed in Table 27.

Table 27. Global Synthesis Decision Making

	Price	**Quality**	**Service**	**Delivery**	**Profile Supplier**	**W**
	0,38	0,41	0	0	0,21	
X	**0,55**	0,16	0,00	**0,37**	0,00	**0,2746**
Y	0,00	0,39	0,47	0,29	**0,68**	**0,3027**
Z	0,45	**0,45**	**0,53**	0,34	0,32	**0,4227**
	1,00	1,00	1,00	1,00	1,00	1,00

Table 28. Supplier Final Ranking

Rank	**W**	**Supplier**
1	0,4227	Z
2	0,3027	Y
3	0,2746	X

5 Discussion

X should be considered as a top choice if minimizing costs is the most important factor. It has the best performance in cost efficiency, providing the most competitive prices.

However, it should be noted that X has the lowest ratings in terms of quality, delivery, and supplier profile which may make it less attractive if these factors are prioritized. Based on the final assessment, X occupies the last recommended position in supplier selection as it has the lowest weight of 0.2746.

Based on the calculation results, Y is the preferred choice if the supplier profile is the main decision-making factor. however, this supplier is the most superior only on the supplier profile criteria. even so, supplier Y occupies the second recommended position after calculating the final weight with a value of 0.3027.

While supplier Z is ranked at the top in the two criteria of quality and service, it has the weakest performance in terms of price, delivery, and supplier profile, although its cost is in the middle position. Even so, Z is the most recommended supplier based on the final calculation with a weight of 0.4227 The company ranks highest in all three suppliers compared, making it the best choice overall when these aspects are more important than cost.

The findings obtained through the F-AHP method are generated by considering several criteria. By considering both quantitative and qualitative aspects, companies can make more informed strategic decisions that suit their operational needs and long-term goals.

This research is the same to research by Wahyu & Pulansari (2024), but there are differences in criteria and final result. The selection of a polyester fabric supplier is based on seven main criteria: product quality, delivery performance, pricing factor, communication system, warranty and claim policies, performance history, and geographic location. The calculation results indicate that the top-ranked supplier achieved a total score of 0.3395.

6 Conclusion

The research results indicate that there are five criteria along with their respective weights considered in the selection of suppliers for thread locker. Supplier Z is the most recommended supplier because it has the highest final weight that excels in quality and service criteria with a final weight of 0.4227, although in the price criteria the weight value obtained is in the second position, supplier Z can be selected if the company considers criteria other than price, then followed by supplier Y which excels in the supplier profile criteria with a final weight of 0.3027 and supplier X occupies the lowest position with a final weight value of 0.2746. Fuzzy-AHP method covers shortcomings of the conventional AHP method where the AHP method has many subjectivities of the selection of available criteria. Fuzzy-AHP can represent uncertainty with a sequence of numerical scales so that the level of subjectivity can be reduced.

This research has several limitations that need to be considered. This research only focuses on analyzing supplier selection at PT TBV. Several departments are involved in this research, namely the purchasing department as a buyer who deals directly with suppliers, the quality control department as a division that checks whether the goods or materials purchased are in accordance with the desired quality and the company manager as the authorized party in making decisions. Suggestions for further research are expected to conduct research in companies using more criteria and suppliers so that the results obtained are better.

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