Selection of Pin Component Suppliers for Checking Fixture Products Using an Analytical Hierarchy Process Approach

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ABSTRACT

The objective of this study is to employ a multi-criteria decision-making system technique to identify the most optimal supplier in the automotive components sector. When selecting a supplier, it is crucial to evaluate the pros and downsides of each source in order to secure the most suitable one. Bahana, Ltd is a company that specializes in the production of plastic components, molds, jigs, and equipment. During the production process of inspecting fixture items, pin components are required to assemble the components that need to be assembled. At now, there are no explicit guidelines for choosing suppliers, and the selection process relies solely on subjective evaluations. Consequently, it is necessary to establish supplier selection criteria through the utilization of the Analytical Hierarchy Process (AHP) methodology. This strategy is highly suitable for resolving decision-making challenges. Bahana, Ltd employs pairwise comparisons to evaluate four criteria: pricing, quality, communication, and location. Bahana, Ltd has the highest criteria value of 0.36 in terms of quality, followed by a value of 0.33 in terms of pricing. Hence, the paramount criteria in supplier selection are quality and pricing. According to the AHP calculation results, PT A was determined to be the optimal choice as it obtained the highest weight value in comparison to other suppliers.

Keywords: Analytical Hierarchy Process, Expert, Supplier

1. Introduction

Bahana, Ltd is a manufacturer of plastic components, molds, jigs, and fixtures. Checking fixtures is a supporting component that greatly influences product quality. That product can optimize the function and geometry of another product. Checking fixtures helps in checking the dimensions and geometry of components or products. One of the components contained in the checking fixture product is the pin. The function of the pin component is to ensure that the hole-checking fixture made in the product is the correct size and can be used properly. The pin ordering process is carried out after the consumer requests to make a checking fixture. Specifications for different pin sizes can be ordered based on the size of the checking fixture.

Suppliers are parties who sell or supply raw materials in the form of raw materials to be processed into certain goods or services. Suppliers play an important role in providing raw materials for the ongoing production activities of a company. In this case, the company must collaborate with suppliers to achieve satisfactory production results. Choosing a supplier is a challenging task. Procurement of goods or raw materials often faces problems such as delays in delivery, which automatically hampers the supplier company's production activities, prices of raw materials that do not match consumer goals, and raw material quality does not match consumer desires (Abdulla, Baryannis, & Badi, 2023).

Therefore, supplier selection needs to consider the advantages and disadvantages of each supplier, avoid possible errors later, simplify the process of supplier selection, and hope to choose the right supplier. Bahana, Ltd knows that suppliers are one of the most critical links in the smooth production process, so a supplier selection

decision support system is needed to avoid mistakes in supplier selection (Manik, 2023).

Decision-makers must think objectively when choosing suppliers. Sometimes, decision-making is only intuitive or subjective and based on experience alone; there is no clear selection procedure or method, or it is only based on general criteria (Ali, Nipu, & Khan, 2023). When a supplier is selected, problems often occur, namely quality, quantity, and delivery time that does not match what was promised when ordering, which disrupts the delivery of goods to customers. If the supplier is less responsible and responsive in fulfilling orders, it will cause problems, namely stockouts and long lead times. Production will stop because the goods or materials we order do not arrive as requested, and this will definitely cause many losses to the company. Therefore, companies need to assess suppliers carefully and precisely. Errors in selecting suppliers can affect production activities both in terms of quantity and quality, meaning that supplier selection is important to achieve a competitive advantage in the market (Hamdan, Cheaitou, Shikhli, & Alsyouf, 2023).

The current condition in determining suppliers Bahana, Ltd only uses its own perception and does not have specific criteria in selecting suppliers. Especially for pin components, which currently have four potential suppliers, Bahana, Ltd needs help determining which supplier is the best among these several suppliers. Therefore, criteria are needed in selecting suppliers (Hasiani, Haryanti, Rinawati, & Kurniawati, 2021).

In making the criteria that will be used in the assessment, it is necessary to be carried out by several experts and look at the literature study (Agraeni, & Gustian, 2022). This aims to obtain criteria that match the needs of Bahana, Ltd and obtain the best results.

The AHP method is used to provide choices regarding the selection of pin component suppliers to be chosen by Bahana, Ltd (Lukmandono, Basuki, Hidayat, & Setyawan, 2019); (Wardhana & Prastawa, 2017). This method is very appropriate for problem-solving in making a decision. This method uses a hierarchy in the completion process by requiring objective data (Muhammad, Rahmanasari, Vicky, Maulidiyah, Sutopo, & Yuniaristanto, 2020). Selection criteria and alternatives to be chosen by Bahana, Ltd.

Therefore, it is necessary to conduct a study to determine the highest order of criteria and alternatives for calculating weights to determine which supplier is the best for producing checking fixtures, especially pin components at Bahana, Ltd.

2. Methodology

The research method used is the AHP. The steps for selecting a supplier are as follows:

1. Arranging a Hierarchical Structure

When the problem has been identified, a hierarchy arrangement is carried out along with the desired goals. (Muhammad, Rahmanasari, Vicky, Maulidiyah, Sutopo, & Yuniaristanto, 2020). Before creating a hierarchical structure, the criteria to be used by Bahana, Ltd were determined through in-depth interviews with experts, and a literature review can be seen in Table 1.

Table 1. Determination of Criteria and Sub-criteria

Criteria	Sub Criteria	Source
Price	The selling price of pins/kg	1. (Hasiani, Haryanti, Rinawati, & Kurniawati, 2021)
	Payment method	2. (Ngatawi, 2022)
	Timeframe provided	3. (Putra Pratama, 2023)
		4. (Kusaeri, Hermansyah, & Bashori, 2016)
		5. *Finance*

		Bahana, Ltd Unindo Teknik
Quality	Product tidiness Packaging Accuracy	1. (Hasiani, Haryanti, Rinawati, & Kurniawati, 2021) 2. (Ngatawi, 2022) 3. (Putra Pratama, 2023) 4. (Kusaeri, Hermansyah, & Bashori, 2016) 5. (Ngatawi, 2022) 6. Divisi Produksi Bahana, Ltd Unindo Teknik
Location	Mileage of suppliers Shipping method Delivery speed	1. (Ngatawi, 2022) 2. (Putra Pratama, 2023) 3. *Marketing* PT Bahan Unindo Teknik
Communication	Kindness in negotiating Ease of contacting suppliers Speed in responding to consumers	1. (Hasiani, Haryanti, Rinawati, & Kurniawati, 2021) 2. (Ngatawi, 2022) 3. (Putra Pratama, 2023) 4. (Ngatawi, 2022) 5. *Marketing* Bahana, Ltd Unindo Teknik

2. Determine the priority of elements

a. To establish the precedence of the elements, the initial stage involves comparing pairs. Specifically, the process involves comparing components in pairs based on the specified criteria. (Kusaeri, Hermansyah, & Bashori, 2016)

b. The pairwise comparison matrix is filled using numbers to represent the relative importance of an element to other elements using the Saaty scale 1 to 9 (1=equally. 3 = moderate. 5 = strong. 7 = very strong. 9 = extreme) (Amrina & Imansuri, 2015).

c. Aggregation of the Opinions of all Experts
The aggregation of the opinions of all experts is carried out for each comparison matrix of each respondent so that a new pairwise comparison matrix is obtained, which is a combination of the answers of all experts using geometric mean with a formula (Hapsari, 2018):

$$\sqrt[n]{a_1 x a_2 x.....x a_n} = a_w \quad ...\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

(n = number of respondents. a_w = combined assessment. a_1 = assessment of the 1st respondent).

3. Determine the Synthesis of Priority Matrix

The results of the pairwise comparisons are presented in the form of a pairwise comparison matrix. Namely, a pairwise comparison matrix that contains the preference level using the AHP rating scale from several alternatives for each criterion (Pramukti & Andryana, 2022); (Wicaksono, Fathimahhayati, & Sukmono, 2020).

Prioritization is carried out to obtain priority element weights in the hierarchy. Local weights are obtained after obtaining a pairwise comparison matrix, which is normalized. Matrix normalization is done by comparing each pairwise comparison value with the number of columns in question.

After the normalization matrix is obtained, the local weight calculation is obtained from the sum of the pairwise comparisons for each criterion divided by the number of criteria. The local weight calculation is done using the following formula. (Wicaksono, Fathimahhayati, & Sukmono, 2020).

$$B_i = \frac{\sum_{i=1}^{m} x'_{i,j}}{m} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

4. Consistency Test

The evaluation results are widely acknowledged if the consistency ratio is less than or equal to 0.1. The calculation of the consistency ratio is conducted using a four-stage process as outlined below (Khairun Nisa, Subiyanto, & Sukamta, 2019):

a. Calculation of the Weight Sum Factor (WSF)

In this process, the weight that has been obtained for each criterion is multiplied by the evaluation results that have been carried out. The equation used is as follows:

$$WSF_i = \sum_{j=1}^{m} (x_{i,j} \times B_j) \ldots\ldots\ldots\ldots\ldots\ldots\ldots(3)$$

b. Calculation of the consistency factor (CF)

In this process, the weight of the criteria is multiplied by the results of the evaluation that has been carried out. The equation used is as follows:

$$CF_i = \frac{WSF_i}{B_i} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

c. Calculation of the consistency index (CI)

In this process, the consistency index is obtained by using the following equation (Mustika, 2017):

$$CI = \frac{\overline{CF}-m}{m-1} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(5)$$

d. Calculation of the consistency ratio (CR)

The consistency ratio is obtained by dividing the consistency index with the ratio index. The equation that can be used is as follows:

$$CR = \frac{CI}{RI} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(6)$$

3. Result and Discussion

1. Hierarchical Structure Selection of Sub-Contractors

In using the analytical hierarchy process (AHP) method, it is necessary to create a hierarchy that describes the problem to be solved (Wulandari, 2017). The following is the hierarchy of supplier selection for pin components at Bahana, Ltd., which can be seen in Figure 1.

Based on the hierarchical structure, there are four criteria for selecting suppliers: cost, location, quality, and communication. Each of these criteria has a sub-criteria. Furthermore, there are 3 alternative suppliers to be selected.

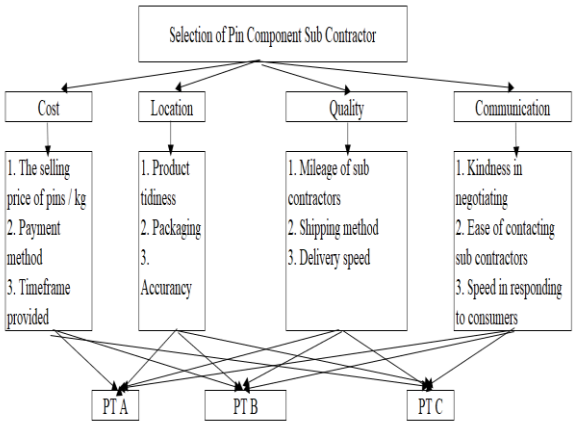

Figure 1. Hierarchical Structure of Supplier Selection

d. Paired Comparison Questionnaire Data Collection

Then, the stage of filling out questionnaires to three experts with positions as marketing at Bahana, Ltd (6 years experience). head of production at Bahana, Ltd (5 years experience) and finance at Bahana, Ltd (2 years experience). Paired comparison questionnaires were filled out by experts using the Saaty scale of 1 to 9 (1=equally. 3 = moderate. 5 = strong. 7 = very strong. 9 = extreme).

e. Calculating of Pairwise Comparisons Matrix and Local Weight

After collecting pairwise comparison questionnaire data, the geometric mean is calculated. The purpose of calculating the

geometric mean is to combine all of the respondent's answers using the formula (1).

For example, local weight calculation for the criteria for supplier (Table 2 and Table 3) selection criteria and sub-criteria (Table 4) at Bahana, Ltd using formula (2):

Table 2. Pairwise comparison calculation matrix

Criteria	Price	Quality	Location	Communication
Price	1.00	1.10	2.62	1.44
Quality	0.91	1.00	2.62	2.62
Location	0.38	0.38	1.00	1.26
Communication	0.69	0.38	0.79	1.00
Total	2.98	2.86	7.04	6.32

Table 3. Calculation of Criteria Local Weight

Criteria	Cost	Quality	Location	Communication	Local Weight
Price	0.34	0.38	0.37	0.23	0.33
Quality	0.31	0.35	0.37	0.41	0.36
Location	0.13	0.13	0.14	0.20	0.15
Comunication	0.23	0.13	0.11	0.16	0.16
Total					1.00

An example of calculating the local weight of the price criteria is as follows using the formula (2).

$$x'_{i,j} = \frac{x_{i,j}}{\sum_{i=1}^{m} x_{i,j}} = \frac{1.00}{2.98} = 0.34$$

$$B_i = \frac{\sum_{i=1}^{m} x'_{i,j}}{m} = \frac{0.34 + 0.38 + 0.37 + 0.23}{4} = 0.34$$

Table 4. Calculation of Local Weight of Sub-Criteria

Price	The selling price of pins/kg	Payment method	Timeframe provided	Local Weight
The selling price of pins/kg	0.62	0.68	0.48	0.59
Payment method	0.21	0.24	0.38	0.28
Timeframe provided	0.17	0.08	0.13	0.13
Total				1.00
Quality	**Product tidiness**	**Packaging**	**Accuracy**	**Local Weight**
Product tidiness	0.22	0.38	0.20	0.26
Packaging	0.07	0.11	0.14	0.11
Accuracy	0.72	0.51	0.66	0.63
Total				1.00
Location	**Mileage of suppliers**	**Shipping method**	**Delivery speed**	**Local Weight**
Mileage of suppliers	0.25	0.40	0.22	0.29
Shipping method	0.09	0.15	0.20	0.15
Delivery speed	0.66	0.44	0.58	0.56
Total				1.00
Communication	**Kindness in negotiating**	**Ease of contacting suppliers**	**Speed in responding to consumers**	**Local Weight**
Kindness in negotiating	0.52	0.54	0.46	0.51
Ease of contacting suppliers	0.33	0.34	0.40	0.36
Speed in responding to consumers	0.16	0.12	0.14	0.14
Total				1.00

This stage is calculating the weight of interest in each alternative. The geometric mean value has been calculated using the formula (1). The calculation results are as follows in Table 5:

Table 5. Selection of alternative suppliers

Alternative	Global Weight	Priority
PT A	0.556	1
PT B	0.302	2
PT C	0.142	3

f. Calculating of Consistency Ratio

Next is the measurement of consistency. This is meant to see the inconsistency of the responses given by the respondents. So, if it is inconsistent, then filling in the values in the paired matrix on the criteria and alternative elements must be repeated. The value of the consistency ratio (CR) received must be <0.1, as shown in Tables 6 and 7 below.

Table 6. Consistency Ratio for Criteria and Sub-criteria

Criteria	Consistency Ratio	Sub Criteria	Consistency Ratio
Price	0.02	The selling price of pins/kg	0.08
		Payment method	
		Timeframe provided	
Quality		Product tidiness	0.10
		Packaging	
		Accuracy	
Location		Mileage of suppliers	0.09
		Shipping method	
		Delivery speed	
Communication		Kindness in negotiating	0.01
		Ease of contacting suppliers	
		Speed in responding to consumers	

Table 7. Consistency Ratio for Selection of Suppliers

Criteria	Alternative Suppliers	Consistency Ratio
Price	PT A	0.07
	PT B	
	PT C	
Quality	PT A	0.09
	PT B	
	PT C	
Location	PT A	0.09
	PT B	
	PT C	
Communication	PT A	0.08
	PT B	
	PT C	

4. Conclusion

There are four criteria determined by Bahana, Ltd, namely the price aspect, quality aspect, communication aspect, and location aspect, in calculations using pairwise comparisons. Bahana, Ltd has the highest criterion value on the quality aspect of 0.36, followed by the price aspect of 0.33. This makes the quality and price aspects the most important in supplier selection.

Calculations on sub-criteria can support calculations from the criterion aspect. The price aspect has the highest sub-criteria at a selling price/kg 0.59. The quality aspect has the highest sub-criteria for pin accuracy of 0.63. The location aspect has the highest sub-criteria for delivery speed of 0.56. At the same time, the communication aspect has the highest sub-criteria on the ease of contacting suppliers at 0.61.

The alternative in selecting a supplier that is a priority is PT A. Therefore, when selecting a supplier, PT A is the right choice to purchase pin components.

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