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An Evaluation of Supplier Selection for Pneumatic System Components in Maintenance Management Utilizing the Analytical Hierarchy Process in a Paper Packaging Manufacturing

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Abstract

To ensure the continuity of the production process, it is essential for the company to focus on maintenance management, particularly in selecting high-quality pneumatic system components with a long lifespan. This study aims to determine the criteria and weights for choosing suppliers of these components in a paper packaging manufacturing. The supplier alternatives evaluated are PT. SMCAI, PT. FI, and PT. RMW, using the Analytical Hierarchy Process (AHP). The analysis of the four criteria reveals the following weights: cost (0.46), quality (0.23), service (0.16), and delivery (0.15). Based on these evaluations, PT. SMCAI ranks highest with a weight of 0.41, followed by PT. FI at 0.40, and PT. RMW with the lowest weight of 0.19. These results guide the company in selecting the most suitable supplier to maintain smooth production operations.

Keywords: Supplier Selection, Maintenance Management, Analytical Hierarchy Process

1. Introduction

Intense business competition reflects the rising pressures of global competition, driving each company to offer its best products. In such an environment, companies must sustain and ensure uninterrupted production processes to avoid disruptions. One critical approach to maintaining production flow is through effective machine maintenance management, or preventive maintenance. Maintenance management encompasses a range of activities designed to prevent machinery breakdowns, aiming to extend the lifespan and performance of equipment or assets. Preventing breakdowns is a fundamental aspect of preventive maintenance strategy, focusing on avoiding or reducing potential damage to machine components. Machinery reliability significantly influences a company's production process, making well-managed maintenance crucial. To ensure smooth production, companies must secure high-quality machine components with long lifespans. The success of selecting the right components heavily depends on the role of suppliers

In the context of maintenance management, suppliers not only provide spare parts but often play a key role in offering technical services such as repairs, inspections, and training. Consequently, supplier selection must consider various criteria, including component quality, delivery reliability, technical support, pricing, and the ability to provide after-sales services (Li, 2007). Poor supplier selection can lead to increased maintenance costs, reduced machinery performance, and operational disruptions.

PT. X is a paper packaging manufacturing company that requires three different types of machines for its operations: the corrugator machine, flexo machine, and vega machine. For each of these machines, a critical component needed is the pneumatic system, which utilizes pressurized air or gas as a driving medium to transmit energy.

Pneumatic systems are critical components in Vega, Flexo, and Corrugator machines. Pneumatic systems are part that ensuring precision, operational efficiency, and reliability in the paper packaging industry (Emerson, 2020; Control Design, 2020). Across the packaging industry, the importance of pneumatic systems lies in their ability to enhance automation, streamline processes, and minimize operational downtime, thus driving production efficiency. Case studies demonstrate that organizations implementing advanced pneumatic technologies experience

increased reliability and higher throughput, underlining the pivotal role these systems play in sustaining competitive advantages (Pneumatics Today, 2023). Moreover, the significance of pneumatic systems extends beyond packaging to other industrial applications. As highlighted by Rahimdel et al. (2013), the performance of drilling machines is heavily influenced by the condition of their pneumatic systems, necessitating maintenance interventions every seven hours under extreme operating conditions to sustain optimal functionality.

This paper packaging company sources pneumatic system components from suppliers. However, PT. X's supplier selection process for these components is considered inefficient. A recurring issue with suppliers is their inability to meet the company's specified criteria. The purchasing department frequently prioritizes suppliers offering the lowest prices, but these suppliers do not always provide components that meet quality standards. Conversely, the Head of the Maintenance Department expects the received pneumatic system components to align with specified requirements.

A commonly used decision-making method for supplier selection in maintenance management is the Analytical Hierarchy Process (AHP). AHP is a decision-making approach that simplifies complex problems by breaking them down into a hierarchy, making it easier to understand. Each element in the hierarchy is assigned a weight based on its level of importance (Saaty, 1980). AHP is a decision-support methodology designed to address complex problems by decomposing them into smaller components, categorizing these components, and organizing them within a hierarchical framework. To determine prioritized criteria, AHP employs pairwise comparisons using a predefined measurement scale. The primary input for this method is expert judgment, which introduces an element of subjectivity into the decision-making process. Additionally, AHP incorporates mechanisms to ensure data validity by setting limits on acceptable levels of inconsistency. (Saaty & Kearns, 1985).

AHP offers advantages in handling decisions involving various qualitative and quantitative criteria, providing a clear structure for decision-making and facilitating consistency in evaluations. Research indicates that AHP can enhance the quality of supplier selection decisions by providing a systematic and measurable approach (Haq & Kannan, 2006). AHP is an effective and widely used tool in supplier selection due to its ability to address multiple criteria through a systematic and hierarchical approach. Although it has limitations, particularly concerning subjectivity and calculation complexity, AHP's strengths in providing a clear and measurable framework make it one of the preferred methods in supply chain management.

Based on the background of the problem and relevant previous research, the researcher conducted a study titled "An Evaluation of Supplier Selection for Pneumatic System Components in Maintenance Management Utilizing the Analytical Hierarchy Process in a Paper Packaging Manufacturing." This study aims to evaluate the selection of the best pneumatic system component supplier that can meet the company's criteria and to analyze the strengths and weaknesses of each pneumatic system component supplier currently partnering with the company.

2. Literature Review

Maintenance Management

The role of maintenance management in the industry continues to evolve with the rising costs of purchasing new technologies. Maintenance activities are conducted to ensure that manufacturing processes operate effectively and efficiently, ultimately impacting productivity, quality, and customer satisfaction as expected. This is achieved through the repair, replacement, adjustment, and modification of all machines and equipment according to production needs (Yuliandra & Jaeba, 2017). Therefore, effective machine maintenance management is crucial in assisting companies in achieving these objectives (Yuliandra & Jaeba, 2017). In simple terms, maintenance can be defined as all activities undertaken to ensure that machines and equipment continue to operate well. While this definition remains relevant, perspectives on the concept of maintenance and its scope continue to evolve over time.

Supplier Selection

Supplier selection can significantly impact a company's operational performance, particularly in financial aspects (Hati and Fitri, 2017). This impact is unavoidable, as collaborating with the right and best suppliers can significantly reduce costs, especially in production management, where total purchases typically account for 50-90% of total revenue (Asamoah et al., 2012). Thus, supplier selection becomes a critical issue for companies.

Supplier selection is a strategic activity when suppliers provide items to be used in the long term as primary suppliers (Revi et al., 2018). Selection criteria are essential aspects of choosing suppliers as they reflect supply chain strategies and the characteristics of the items to be supplied. Generally, companies use basic criteria such as product quality, price, and delivery timeliness. However, some companies have specific criteria deemed important and aligned with their needs in selecting suppliers.

PT. X has yet to establish specific criteria for evaluating supplier selection. The criteria set for this research are based on Wirdianto & Unbersa (2008), which define four criteria for selecting pneumatic system component suppliers at PT. X: Cost, Quality, Delivery, and Service.

Supplier performance should be monitored regularly, which is important for evaluation purposes that can enhance performance and consider whether the search for alternative suppliers is necessary for production continuity (Rohimat, 2018). Supplier performance assessment should be conducted differently when evaluating supplier candidates. Supplier performance evaluation is generally performed after the supplier selection process and is carried out periodically.

Analytical Hierarchy Process

The Analytical Hierarchy Process (AHP) is a decision-making method that breaks complex problems into a more understandable hierarchy, where each element is weighted based on its level of importance (Saaty, 1980). AHP is a multi-criteria decision-making method developed by Thomas L. Saaty in 1980. This method assists decision-makers in situations involving various criteria by structuring the problem into a hierarchical framework consisting of objectives, criteria, sub-criteria, and alternatives. AHP provides a systematic and measurable framework for evaluating and prioritizing alternatives based on predefined criterion weights.

Basic Concepts of AHP

AHP works by breaking down complex decision-making problems into a more comprehensible hierarchical structure. The main steps in AHP include:

a. Building the Hierarchy: The first step is to construct a hierarchy consisting of the primary objective at the top, followed by relevant criteria and sub-criteria, with alternatives at the lowest level.

b. Pairwise Comparison: Each element in the hierarchy is compared in pairs to determine its relative importance concerning other elements, using a numerical scale ranging from 1 (equally important) to 9 (extremely more important).

c. Calculating Priority Weights: Priority weights are calculated based on the results of the pairwise comparisons. This method employs matrix techniques to obtain weights that indicate the relative importance of each criterion and alternative.

d. Measuring Consistency: AHP provides a consistency measure (Consistency Ratio) to ensure that pairwise judgments are not overly subjective or random. A low consistency value indicates that the comparisons are reasonably consistent.

e. Aggregation and Selection of Alternatives: After the priority weights are calculated, alternatives are evaluated based on the established criteria, and the alternative with the highest score is selected as the best option.

AHP Steps in Supplier Selection

The AHP process begins by forming a decision hierarchy, which includes the primary objective (selecting the best supplier), evaluation criteria, and supplier alternatives. Subsequently, pairwise comparisons are conducted among criteria to determine the weight of each criterion. After obtaining criterion weights, the next step is to perform pairwise comparisons among supplier alternatives against each criterion. The final outcome is a score for each supplier, indicating priority or preference in the selection process.

Advantages of AHP

The Analytic Hierarchy Process (AHP) has several advantages that contribute to its popularity in various applications:

a. Systematic and Structured Approach: AHP provides a structured and systematic method, which facilitates decision-makers in dissecting and analyzing complex problems.

b. Combination of Qualitative and Quantitative Data: AHP allows for the integration of both qualitative and quantitative data, making it applicable to a wide range of decision-making issues.

c. Flexibility and Adaptability: AHP can be utilized in diverse contexts, including business, government, education, and strategic planning.

Limitations of AHP

Despite its numerous advantages, the Analytic Hierarchy Process (AHP) also presents several limitations:

a. Subjectivity: The outcomes of AHP are heavily reliant on the subjective judgments of decision-makers, which can affect the consistency and validity of the results.

b. Complexity of Calculations: As the number of criteria and alternatives increases, the complexity of calculations rises, making it more challenging to manage AHP manually.

c. Consistency Issues: Maintaining consistency in pairwise comparisons often poses a challenge, particularly when there are many elements to compare.

3. Research Method

The following is the research flow shown in Figure 1.

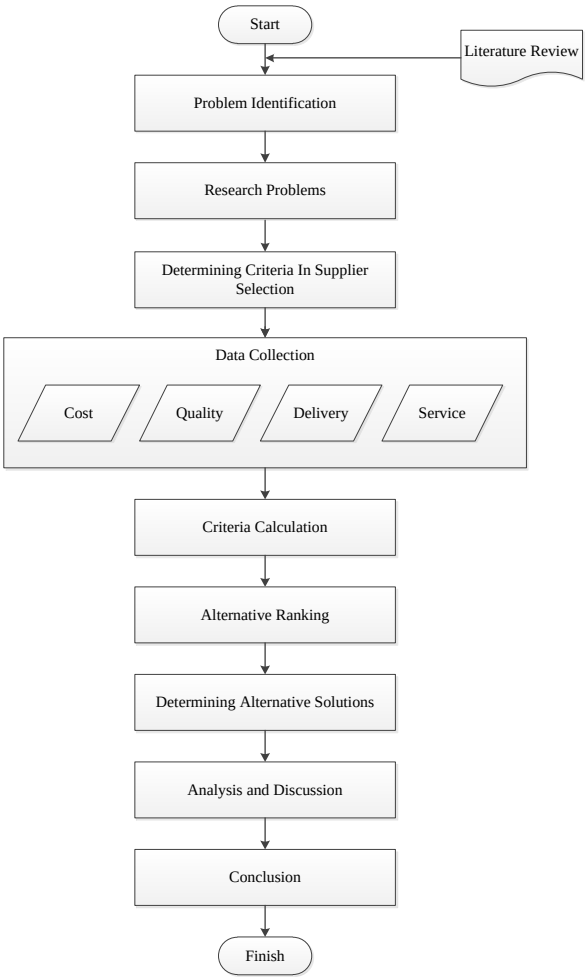

Figure 1: Research Flow

Data were collected using several methods, including interviews, the distribution of questionnaires for pairwise comparisons, observations, and literature studies. This research was conducted at PT. X, a paper packaging company, employing the Analytical Hierarchy Process (AHP) methodology.

4. Research Results

Constructing the Hierarchy and Problem Definition

The hierarchy for selecting suppliers of pneumatic system components through the Analytic Hierarchy Process (AHP) is outlined below and depicted in Figure 2. At the top level, the primary objective is to assess the selection of suppliers for pneumatic system components. The second level identifies the criteria that impact this selection, which include cost, quality, delivery, and service. Finally, the third level lists the alternative suppliers identified for pneumatic system components: PT. SMCAI, PT. FI, and PT. RMW.

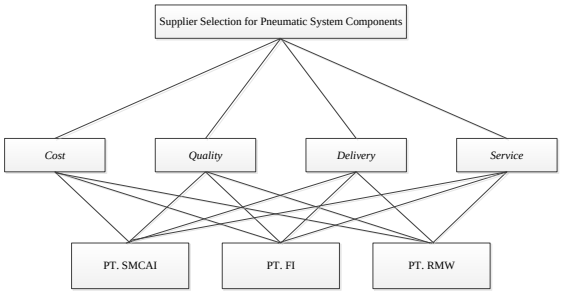

Figure 2: Hierarchy of Supplier Selection for Pneumatic System Components

Source: Processed Data, 2024

The Figure 2 llustrates a hierarchical decision model developed using the Analytical Hierarchy Process (AHP) for selecting suppliers of pneumatic system components. The hierarchy is organized into three levels. The primary objective, labeled as "Supplier Selection for Pneumatic System Components," resides at the top of the hierarchy. This represents the overarching decision problem that needs to be addressed. Four key criteria influence the supplier selection decision are cost: the financial implications of purchasing from a supplier, quality: the standard or specification of the products provided by the supplier, delivery: the reliability and timeliness of the supplier in delivering components, and service: the level of support and service offered by the supplier, such as maintenance or after-sales assistance. These criteria are interlinked with the suppliers below, reflecting their impact on the decision. The bottom level lists the three supplier candidates are PT. SMCAI, PT. FI, and PT. RMW. Each alternative is connected to all the criteria, indicating that the suppliers will be evaluated based on how well they fulfill these criteria. Explanation of the hierarchical structure is in table 1.

TABLE 1

EXPLANATION OF THE HIERARCHY FOR SUPPLIER SELECTION OF PNEUMATIC SYSTEM COMPONENTS

Goal	**Explanation**
Selecting Suppliers for Pneumatic System Components	The goal is to offer the company informed considerations for selecting suppliers of pneumatic system components, incorporating the Analytical Hierarchy Process (AHP) to systematically evaluate and prioritize supplier options.
Criteria	**Sub-Criteria**
Cost	1. The price aligns with the purchasing budget. 2. The price remains fixed during the validity period. 3. Discounts are provided for bulk purchases.
Quality	1. The quality of the pneumatic system components meets the specifications. 2. The pneumatic system components have passed testing. 3. The components have a long lifespan.
Delivery	1. The quantity of pneumatic system components delivered matches the purchase order (PO). 2. Timely delivery is ensured. 3. No requests for extension of the delivery

	time are made.
Service	1. Providing warranty guarantees. 2. Offering assistance in emergency situations. 3. Effectively addressing customer complaints.

Source: Processed Data, 2024

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 simultaneously to assess their relative significance. A numerical scale from 1 to 9 is utilized, which is regarded as the most effective method for articulating preferences (Saaty & Sodenkamp, 2010). The values assigned on this pairwise comparison scale reflect the intensity of the decision-maker's subjective preferences, as detailed in Table 2.

TABLE 2

PAIRWISE COMPARISON SCALE

Intensity of Importance	Description
1	Both elements are equally important
3	One element is slightly more important than the other
5	One element is more important than the other
7	One element is clearly more important than the other
9	One element is absolutely more important than the other
2, 4, 6, 8	Intermediate values between two adjacent levels of importance
Reciprocal	If activity i is assigned a certain value when compared to activity j, then activity j has the reciprocal value when compared to activity i

Source: Saaty & Sodenkamp, 2010

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 COMPARISON VALUES OF CRITERIA

Criteria	Cost	Quality	Delivery	Service
Cost	1	3	2	3
Quality	1/3	1	3	1
Delivery	1/2	1/3	1	1
Service	1/3	1	1	1

Source: Processed Data, 2024

Table 3 presented is a pairwise comparison matrix used in the Analytical Hierarchy Process (AHP). This matrix evaluates the relative importance of decision criteria Cost, Quality, Delivery, and Service, based on expert judgment. AHP employs a structured methodology to decompose complex decisions into simpler comparisons and derive priority weights for each criterion.

The following presents a comparison of alternatives based on four criteria. The first comparison, shown in Table 4, is of alternatives based on the cost criterion.

TABLE 4

PAIRWISE COMPARISON VALUES OF ALTERNATIVES

FOR THE COST CRITERION

Alternatives	PT. SMCAI	PT. FI	PT. RMW
PT. SMCAI	1	5	3
PT. FI	1/5	1	1/3
PT. RMW	1/3	3	1

Source: Processed Data, 2024

Table 4 presented is a pairwise comparison matrix of three alternatives, PT. SMCAI, PT. FI, and PT. RMW, analyzed using the Analytical Hierarchy Process (AHP) method. Each value represents the relative preference of one alternative over another with respect to the cost criterion, based on expert judgment, facilitating a systematic and consistent decision-making approach.

The second comparison is the pairwise comparison of alternatives based on the quality criterion, as shown in Table 5.

TABLE 5

PAIRWISE COMPARISON VALUES OF ALTERNATIVES

FOR THE QUALITY CRITERION

Alternatives	PT. SMCAI	PT. FI	PT. RMW
PT. SMCAI	1	1/3	1
PT. FI	3	1	5
PT. RMW	1	1/5	1

Source: Processed Data, 2024

Table 5 presented is a pairwise comparison matrix of three alternatives, PT. SMCAI, PT. FI, and PT. RMW, analyzed using the Analytical Hierarchy Process (AHP) method. Each value represents the relative preference of one alternative over another with respect to the quality criterion, based on expert judgment, facilitating a systematic and consistent decision-making approach.

The third comparison is the pairwise comparison of alternatives based on the delivery criterion, as shown in Table 6.

TABLE 6

PAIRWISE COMPARISON VALUES OF ALTERNATIVES

FOR THE DELIVERY CRITERION

Alternatives	PT. SMCAI	PT. FI	PT. RMW
PT. SMCAI	1	1/3	3
PT. FI	3	1	5
PT. RMW	1/3	1/5	1

Source: Processed Data, 2024

Table 6 presented is a pairwise comparison matrix of three alternatives, PT. SMCAI, PT. FI, and PT. RMW, analyzed using the Analytical Hierarchy Process (AHP) method. Each value represents the relative preference of one alternative over another with respect to the delivery criterion, based on expert judgment, facilitating a systematic and consistent decision-making approach.

The fourth comparison is a pairwise comparison of the alternatives based on service criteria, as shown in Table 7.

TABLE 7

PAIRWISE COMPARISON VALUES OF ALTERNATIVES FOR THE SERVICE CRITERION

Alternatives	PT. SMCAI	PT. FI	PT. RMW
PT. SMCAI	1	1/3	3
PT. FI	3	1	5
PT. RMW	1/3	1/5	1

Source: Processed Data, 2024

Table 7 presented is a pairwise comparison matrix of three alternatives, PT. SMCAI, PT. FI, and PT. RMW, analyzed using the Analytical Hierarchy Process (AHP) method. Each value represents the relative preference of one alternative over another with respect to the service criterion, based on expert judgment, facilitating a systematic and consistent decision-making approach.

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 8.

TABLE 8

SUMMATION OF VALUES IN CRITERIA COLUMNS

Criteria	Cost	Quality	Delivery	Service
Cost	1,000	3,000	2,000	3,000
Quality	0,333	1,000	3,000	1,000
Delivery	0,500	0,333	1,000	1,000
Service	0,333	1,000	1,000	1,000
Total	2,166	5,333	7,000	6,000

Source: Processed Data, 2024

Table 8 represents the pairwise comparison matrix of four criteria, Cost, Quality, Delivery, and Service, analyzed within the framework of the Analytical Hierarchy Process (AHP). Each value reflects the relative importance of one criterion compared to another based on expert judgment, with the totals calculated to facilitate normalization and weight derivation.

b. Divide each row sum by the total cell value to obtain the priority value for each criterion, as shown in Table 9.

TABLE 9

PRIORITY VALUES OF CRITERIA

Criteria	Cost	Quality	Delivery	Service	Priority
Cost	1,000	3,000	2,000	3,000	0,452
Quality	0,333	1,000	3,000	1,000	0,234
Delivery	0,500	0,333	1,000	1,000	0,151
Service	0,333	1,000	1,000	1,000	0,163
Total	2,166	5,333	7,000	6,000	1,000
EigenValue					4,2603
CI					0,0868
CR					0,0964

Source: Processed Data, 2024

Based on Table 9, it is evident that the cost criterion has the highest priority with a weight of 0.452.

c. Calculate the Eigenvalue using the following method:
= (2.167 x 0.452) + (5.333 x 0.234) + (7.000 x 0.151) + (6.000 x 0.163)
= 4.2603

d. Calculate the Consistency Index (CI) using the following method:
= (4.2603-4) / (4-1)
= 0.0868

e. Calculate the Consistency Ratio (CR) using the following method:
= CI/RI
= 0.0868/0.9
=0.0964

Table 9 provided summarizes the results of an Analytical Hierarchy Process (AHP) assessment, which was used to evaluate four criteria, Cost, Quality, Delivery, and Service, in a decision-making process. The table includes the pairwise comparison matrix, the total value for each criterion, the calculated priority weight for each, and the consistency measures (Eigenvalue, Consistency Index (CI), and Consistency Ratio (CR)). The consistency ratio is calculated by dividing the CI by the Random Consistency Index (RI), which depends on the size of the matrix. A CR value of 0.0964 is below the threshold of 0.1, indicating that the matrix exhibits a high degree of consistency, and the judgments made by the decision-maker are reliable.

The RI (Random Index) value is based on Table 10.

TABLE 10

RANDOM INDEX

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

Source: Saaty & Sodenkamp, 2010

Since the Consistency Ratio (CR) value is less than 0.1 (10%), this result is acceptable, indicating that the pairwise comparison matrix among the criteria is reliable. The percentage results for each criterion can be seen in Figure 3.

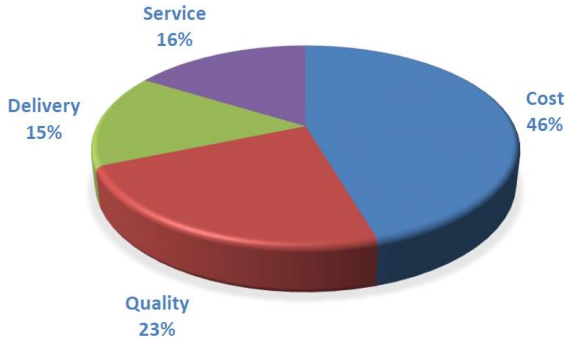

Figure 3: Percentage Results of Decisions for Criteria
Source: Processed Data, 2024

Based on Figure 3, the highest priority is the cost criterion (46%), followed by quality (23%), service (16%), and the lowest is delivery (15%), these values are obtained from the priorities in table 9.

Determining Priorities for Alternatives

After conducting a pairwise comparison among the alternatives based on the criteria, the comparison results are synthesized to obtain the overall priorities. Next, the Eigenvector values (Lambda max) are calculated, along with the Consistency Index (CI) and Consistency Ratio (CR), as follows:

a. Calculate the priority of alternatives with respect to the cost criterion, as shown in Table 11.

TABLE 11

PRIORITIES OF ALTERNATIVES WITH RESPECT TO THE COST CRITERION

Alternatives	PT. SMCAI	PT. FI	PT. RMW	*Priority*
PT. SMCAI	1,000	5,000	3,000	0,63335
PT. FI	0,200	1,000	0,333	0,10616
PT. RMW	0,333	3,000	1,000	0,26050
Total	1,533	9,000	4,333	1,000
Eigen Value				3,0554
CI				0,0277
CR				0,0477

Source: Processed Data, 2024

1) Calculate the Eigenvalue using the following method:
   = (1,533 x 0.63335) + (9.000 x 0.10616) + (4.333 x 0.26050)
   = 3.0554

2) Calculate the Consistency Index (CI) using the following method:
   = (3.0554-3)/2
   = 0.0277

3) Calculate the Consistency Ratio (CR) using the following method:
   = CI/RI
   = 0.0277/0.58
   =0.0477

Table 11 provided is based on the pairwise comparison of three suppliers (PT. SMCAI, PT. FI, PT. RMW) using the Analytic Hierarchy Process (AHP), a decision-making method that helps prioritize alternatives based on multiple criteria. In this case, the criterion is cost. The goal is to determine which supplier is the most cost-effective by comparing their performance using pairwise comparison matrices and calculating priority weights. The Eigenvalue is calculated as 3.0554, which is a measure of the consistency of the pairwise comparison matrix. A value close to the number of alternatives (3 in this case) indicates a consistent matrix. The Consistency Index (CI) is 0.0277, and the Consistency Ratio (CR) is 0.0477. A CR value less than 0.1 indicates an acceptable level of consistency, confirming that the pairwise comparisons are logically consistent.

Based on the AHP analysis for the cost criterion, PT. SMCAI, despite being the highest in cost, holds the highest priority weight (0.63335) among the three suppliers. This suggests that PT. SMCAI might offer additional value beyond cost, such as quality, reliability, or other factors that justify its higher cost. PT. RMW, with a score of 0.26050, has a moderate cost structure but is still less competitive than PT. SMCAI in terms of affordability. This places PT. RMW in a mid-tier position, meaning that while it may not be as affordable as PT. SMCAI, it still offers reasonable pricing. PT. FI, with a score of 0.10616, has the highest cost among the three suppliers. This lower ranking in cost suggests that PT. FI may not be the most cost-effective choice for organizations seeking to minimize expenses, although its higher performance in other criteria might justify the price.

b. Calculate the priority of alternatives with respect to the quality criterion, as shown in Table 12.

TABLE 12

PRIORITY VALUES OF ALTERNATIVES WITH RESPECT TO THE QUALITY CRITERION

Alternatives	PT. SMCAI	PT. FI	PT. RMW	Priority
PT. SMCAI	1,000	0,333	1,000	0,18675
PT. FI	3,000	1,000	5,000	0,65549
PT. RMW	1,000	0,200	1,000	0,15776
Total	5,000	1,533	7,000	1,000
Eigen Value				3,0432
CI				0,0216
CR				0,0372

Source: Processed Data, 2024

Table 12, the decision-making process for selecting a supplier is based on the quality criterion using the Analytic Hierarchy Process (AHP). The three suppliers—PT. SMCAI, PT. FI, and PT. RMW—are evaluated based on their quality attributes. The objective is to assess the relative performance of these suppliers in terms of quality and derive a priority ranking, which reflects the best supplier choice based

on quality. The Eigenvalue of 3.0432 suggests that the comparison matrix is fairly consistent. A value close to 3 (the number of alternatives) indicates that the judgments made in the pairwise comparisons are coherent. The CI value of 0.0216 is very small, indicating that the matrix is consistent, which is a positive indicator of the reliability of the decision-making process. The CR value is 0.0372, which is below the threshold of 0.1. This confirms that the pairwise comparisons are consistent and that the results can be considered reliable.

Based on the analysis using the AHP method for the quality criterion, PT. FI is the highest ranked supplier based on quality, with a priority weight of 0.65549. This indicates that PT. FI is perceived as offering the best quality relative to PT. SMCAI and PT. RMW. From a quality standpoint, PT. FI should be the preferred choice, as it provides the best value in terms of performance and reliability. PT. SMCAI, with a score of 0.18675, ranks significantly lower in quality. While still providing acceptable quality, it may not meet the standards of organizations that require high-quality products or services. PT. RMW, with the lowest score of 0.15776, shows the weakest performance in quality. This suggests that PT. RMW's products or services may not be as reliable or durable as those offered by the other two suppliers, making it a less desirable option for quality-focused buyers.

c. Calculate the priority of alternatives with respect to the delivery criterion, as shown in Table 13.

TABLE 13

PRIORITY VALUES OF ALTERNATIVES WITH RESPECT TO THE DELIVERY CRITERION

Alternatives	PT. SMCAI	PT. FI	PT. RMW	Priority
PT. SMCAI	1,000	0,333	3,000	0,26050
PT. FI	3,000	1,000	5,000	0,63335
PT. RMW	0,333	0,200	1,000	0,10616
Total	4,333	1,533	9,000	1,000
Eigen Value				3,0554
CI				0,0277
CR				0,0477

Source: Processed Data, 2024

Table 13 is to assess and rank three suppliers (PT. SMCAI, PT. FI, and PT. RMW) based on their delivery performance. The decision-making process utilizes the Analytic Hierarchy Process (AHP) methodology, which helps prioritize alternatives (suppliers) by comparing them against one another on the specific criterion of delivery. The goal is to understand which supplier offers the best delivery performance, including factors like lead times, on-time delivery, reliability, and flexibility in meeting deadlines. The Eigenvalue of 3.0554 indicates that the pairwise comparison matrix is quite consistent, as it is close to the expected value of 3 (the number of alternatives). This suggests that the judgment process is coherent. The CI value of 0.0277 is low, which confirms that the comparisons are consistent and the matrix is logically sound. The CR value of 0.0477 is well below the threshold of 0.1, further confirming the consistency and reliability of the pairwise comparison matrix.

Based on the delivery criterion analysis using the AHP method, PT. FI is ranked the highest for delivery performance, with a priority weight of 0.63335. This indicates that PT. FI is considered the most reliable supplier in terms of delivery speed, reliability, and timeliness. For operations where delivery performance is a key factor, PT. FI should be prioritized as the supplier of choice. PT. SMCAI ranks second with a score of 0.26050. This suggests that its delivery performance is adequate but not as strong as PT. FI's. Organizations that prioritize fast and reliable delivery may find PT. SMCAI less appealing compared to PT. FI. PT. RMW, with the lowest score of 0.10616, has the weakest performance in delivery. If timely delivery is critical to the organization, PT. RMW's performance may be considered a disadvantage.

d. Calculate the priority of alternatives with respect to the service criterion, as shown in Table 14.

TABLE 14

PRIORITY VALUES OF ALTERNATIVES WITH RESPECT TO THE SERVICE CRITERION

Alternatives	PT. SMCAI	PT. FI	PT. RMW	*Priority*
PT. SMCAI	1,000	0,333	3,000	0,26050
PT. FI	3,000	1,000	5,000	0,63335
PT. RMW	0,333	0,200	1,000	0,10616
Total	4,333	1,533	9,000	1,000
Eigen Value				3,0554
CI				0,0277
CR				0,0477

Source: Processed Data, 2024

Table 14 is to assess and rank three suppliers—PT. SMCAI, PT. FI, and PT. RMW—based on their service performance. In supplier selection, service quality is a critical criterion that includes factors such as customer support, responsiveness, problem-solving, and after-sales service. By applying the Analytic Hierarchy Process (AHP), we can systematically evaluate and prioritize these suppliers based on service-related attributes. The outcome will help identify which supplier provides the most reliable and effective service, facilitating a better selection decision for the organization. The Eigenvalue is 3.0554, which is close to the expected value of 3, indicating that the pairwise comparison matrix is consistent and reliable. The CI value of 0.0277 is low, confirming that the judgments made during the pairwise comparisons are consistent and the overall analysis is trustworthy. The CR value of 0.0477 is well below the threshold of 0.1, indicating that the consistency of the pairwise comparisons is within an acceptable range. This strengthens the validity of the analysis results.

Based on the service criterion analysis using the AHP method, PT. FI ranks the highest in terms of service quality, with a priority weight of 0,63335. This reflects PT. FI's superior service performance, which likely includes excellent customer support, fast response times, and efficient problem-solving. For businesses that prioritize high-quality service, PT. FI is the most suitable choice. PT. SMCAI ranks second with a score of 0.26050. Its service is satisfactory but does not match the level of PT. FI's offerings. PT. RMW, with the lowest score of 0.10616, provides the weakest service, which could be a major drawback for customers who value responsiveness and after-sales support.

Global Synthesis

After calculating the Consistency Ratio (CR), the next step is to compute the Global Synthesis for decision-making. This is done by multiplying the priority values of the alternatives by the priority values of the criteria, as shown in Table 15. When visualized in graphical form, it can be seen in Figure 4.

TABLE 15

GLOBAL SYNTHESIS

	Cost	Quality	Delivery	Service	Priority
PT. SMCAI	0,63335	0,18675	0,26050	0,26050	0,41192
PT. FI	0,10616	0,65549	0,63335	0,63335	0,40001
PT. RMW	0,26050	0,15776	0,10616	0,10616	0,18807
Total	1,00000	1,00000	1,00000	1,00000	1,00000

Source: Processed Data, 2024

Calculate the Global Synthesis to generate priority values using the following method:

PT. SMCAI

= (0,63335 x 0,452) + (0,18675 x 0,234) + (0,26050 x 0,151) + (0,26050 x 0,163)

= 0, 41192

PT. FI

= (0,10616 x 0,452) + (0,65549 x 0,234) + (0,63335 x 0,151) + (0,63335 x 0,163)

= 0,40001

PT. RMW

= (0,26050 x 0,452) + (0,15776 x 0,234) + (0,10616 x 0,151) + (0,10616 x 0,163)

= 0,18807

Table 15 to evaluate and rank three suppliers, PT. SMCAI, PT. FI, and PT. RMW, using four essential criteria: Cost, Quality, Delivery, and Service. The goal is to determine which supplier offers the best overall performance when considering all these factors. To achieve this, the Analytic Hierarchy Process (AHP) was applied, a multi-criteria decision-making method, to compare the suppliers based on these four dimensions. The table presents the normalized priority weights for each supplier across all four criteria, allowing for a comprehensive evaluation of each alternative. PT. SMCAI has the highest overall priority weight of 0.41192. This indicates that, despite being weaker in terms of quality, delivery, and service, PT. SMCAI's excellent cost performance gives it the best overall ranking. This makes PT. SMCAI the best choice if cost-efficiency is the most crucial factor in the decision-making process. PT. FI has a priority weight of 0.40001, making it a close second. While PT. FI excels in quality, delivery, and service, its high-cost structure reduces its overall score. Nevertheless, PT. FI remains the best choice if quality, delivery, and service are prioritized over cost. PT. RMW ranks last with a priority weight of 0.18807. Despite its moderate performance in cost, PT. RMW is outperformed in all other criteria (quality, delivery, and service). As a result, it is the least favorable choice when considering all four criteria.

From Figure 4, it can be observed that the highest priority value is PT. SMCAI, with a percentage of 41%, followed by PT. FI at 40%, and the lowest is PT. RMW at 19%.

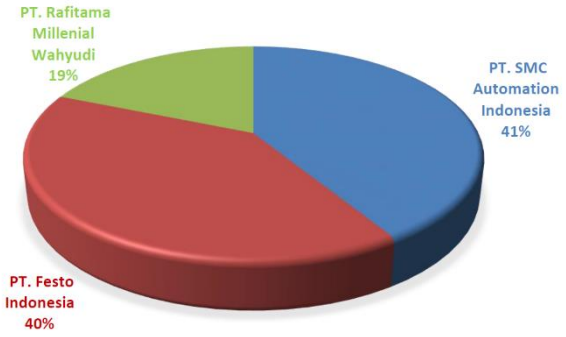

Figure 4: Percentage Results of Decision Priority Values

Source: Processed Data, 2024

Based on the analysis of the four criteria, Cost, Quality, Delivery, and Service, the following conclusions can be made, PT. SMCAI should be considered the top choice if minimizing cost is the most critical factor. It performs best in cost efficiency, providing the most competitive pricing. However, it should be noted that PT. SMCAI's lower rankings in quality, delivery, and service might make it less attractive if these factors are prioritized. PT. FI is the preferred choice if quality, delivery, and service are the primary decision-making factors. It ranks highest in these three criteria, making it the best overall performer when these aspects are more important than cost. However, its cost is relatively high. PT. RMW ranks last across all four criteria. It has the weakest performance in terms of quality, delivery, and service, despite moderate cost. Therefore, PT. RMW should only be considered if other factors such as cost are more important than the overall service level. The results of the AHP method provide a robust and systematic way to evaluate and

compare suppliers based on multiple criteria. By considering both quantitative and qualitative aspects, organizations can make more informed, strategic decisions that align with their operational needs and long-term goals.

5. Conclusions

The research results indicate that there are four criteria along with their respective weights considered in the selection of suppliers for pneumatic system components: cost has the highest weight of 0.46, quality has a weight of 0.23, service has a weight of 0.16, and delivery has the lowest weight of 0.15. Based on the assessment of these criteria, the best alternative is PT. SMCAI, with a weight of 0.41, followed by PT. FI with a weight of 0.40, and PT. RMW with a weight of 0.19. Therefore, PT. SMCAI is established as the best supplier of pneumatic system components for the paper packaging company. The pairwise comparison assessment in the Analytical Hierarchy Process (AHP) is an effective technique for managing the complexity of decision-making problems by providing a structured way to express preferences and compare the elements of each criterion. This method facilitates a more objective and informed decision-making process. However, the potential for inconsistencies and the need for additional evaluations should be taken into account to ensure reliable results.

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